Urban Billboard Tower
design of a multipurpose lightweight structure

A Master's Thesis submitted for the degree of
"Master of Engineering"

supervised by
Arch. Dipl.-Ing. Jürgen Hennicke

Dipl. Ing. Andrei Dragoş Dumitrescu

1028480

Vienna, 28.11.2013

Affidavit

I, **DIPL. ING. ANDREI DRAGOS DUMITRESCU**, hereby declare

1. that I am the sole author of the present Master's Thesis, "URBAN BILLBOARD TOWER", 90 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

Vienna, 28.11.2013

Signature

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Abstract

The present work focuses on the development of a lightweight membrane billboard tower as an alternative to the existing outdoor advertising means, an alternative which integrates into the general architecture of a city and enriches the urban aesthetics.

In order to underline its utility for the community and draw a comprehensive image of this project, the author has chosen an approach which takes into account several perspectives and has analyzed the project as a result of these perspectives.

To this end, the project has been located on a time axis and on a historical background. Further on, the author has placed the lightweight membrane billboard tower in an existing location, the characteristics of which have determined the form, the building solution as well as the possibilities which arise from these.

Last but not least, since every project needs financing, an outlook of the possibilities that could be taken into account by a possible investor is given.

1. Introduction

Why did I choose this topic?

Outdoor advertising is only a marketing instrument, disregarding the effects it has on the general urban aesthetics. It has become a visual polluting element widely rejected by the members of the community and a debate subject at a local and national level.
As an active member of the community, I have decided to make my contribution and take up the challenge to design an outdoor advertising solution that would give a sense of character to an area and help improve the social life of the community our children will live in.

The main research questions that have guided this work can be summarized as follows:

Current situation (What is the case? How does reality look like?)

- Which types of billboards already exist?
- Where are they located and do they have other purpose than advertising?
- How do they impact the urban aesthetics?

Explanation (Why is this the case?)

- What are the legal limitations in this case?
- Have any measures been taken to improve this situation?
- Are costs a major factor for the current situation?

Forecast (What is the expected development? Which modifications will occur?)

- Which is the advantage of the multipurpose lightweight billboard structure?
- Which possibilities can follow from this?
- Will this become more than a marketing instrument?
- Who are the direct and indirect beneficiaries?

Design (Which special aspects must be taken into consideration for the design of such a special construction, from a designer's point of view?)

- Why is this structure special in terms of design?
- What lead to this particular design?
- What are the challenges arising from this structure? Are there more types of challenges?

- What are the solutions to tackle the challenges arising from such a complex structure?
- Are there any solutions to make this product financially self-sustainable?

Criticism/evaluation (How is a certain condition to be evaluated, considering explicitly stated criteria?)

- Which are the strengths and weaknesses of such a model?
- Which are the benefits of this structure? The costs of such a model are justifiable as compared to the advantages it brings?

The aim of the present work is to draw up the feasibility study for the development of an urban billboard tower.

2. Background information

Historians place the origins of advertising in a distant past, not hesitating to identify different forms from the very prehistoric age of humanity. The first forms of advertising appeared in the age of goods exchange and emerged from the need to identify the source of those goods, i.e. the producer. The need to "advertize", to "announce" is specific to human nature and the fact that advertising means dated 3000 b.C. were discovered among the oldest artifacts which belonged to ancient civilizations seems to be a confirmation of this reality. Persuasive communication which can be placed back to Antiquity initially had a purely informative character and only subsequently become subject of embellishment with aesthetic and emotional elements, that increased its chances to be accepted and remembered.
Thus, three essential periods in the history of advertising can be identified:

- Pre-marketing period – until the emergence of mass communication means
- Mass communication period – which can be placed between 1800 and 1950
- Scientific advertising period – starts in the '50s to present time.

2.1. Advertising in Romania

2.1.1. Dawns of advertising in Romania

Market sellers advertized their products with small wood panels placed on their carts and shop owners placed outdoor advertising means such as paper ads next to the shop entrance, on the door and later on spaces especially designed for advertising.
The development of trade and trade relations leads to the set up of the first Romanian company which deals with the publication of "announcements" by David Adania, in 1880.
In Romania, the first form of commercial advertising was made by the market "announcers" who advertized their own products, newspaper headlines, the arrival of a ship with imported goods into a port, the name of the goods importers and useful information for those who came for supplies.
The turn of the century brings a new development with the first newspapers and magazines dedicated to advertising: „La Publicitè Roumaine" and „Anunţătorul"(The Announcer) in 1886, „Monitorul" in 1907 and the list can continue.

The industrial and general development of the Romanian society is reflected in the development of an advertising industry, with its own styles and strategies nothing less than those in Western Europe and the United States.

The period between the two World Wars is one of unequaled economical boost, which leaves its mark on all aspects of society. The Romanian advertising industry is not exclusively influenced by the international experience and this is demonstrated by the fact that local brands are advertized alongside international trademarks and the outdoor advertising means become a widely spread practice.

Fig. 1 - Image of market ”announcer“

http://povestisasesti.com/2013/03/27/romania-neasemuita-in-ilustratele-unui-soldat-german-din-primul-razboi-mondial/

Fig. 2 – Image of market sellers

http://povestisasesti.com/2013/03/27/romania-neasemuita-in-ilustratele-unui-soldat-german-din-primul-razboi-mondial/

Fig. 3 – Image of advertisments on shop walls and windows
http://www.gandul.info/stiri/cum-aratau-alegerile-in-perioada-interbelica-de-la-mogulul-malaxa-la-nae-cap-de-fier-si-staff-ul-sau-de-campanie-5152221

Starting with 1937, the neon tubes are produced and used in Romania, only one year after their appearance and use in outdoor advertising in the United States and 25 years after their appearance in Paris. During the war, the ads and billboards using

neon tubes, which had turned Bucharest night life into a cosmopolite show, are banned.

Fig. 4 – Image of neon tube billboards around 1937
http://www.ziarulring.ro/stiri/45277/hai-sa-ti-arat-bucurestiul-noaptea

2.1.2. The Communist period

The Communist period is characterized mainly by the interruption of all links with the international trends and the extension of socialist type rigor over all domains of the social life and any type of communication, including commercial mass communication through outdoor means. Cancelling all ties with the past is a priority of this period. Old achievements are eliminated as expressing of old and dangerous mentalities, issuing from an obsolete and unjust economic system. The state monopole is set up and any competition which would lead to advertising is removed. After the 1950s, the commercial function of outdoor advertising means is replaced by propaganda, presentation of great achievements of the regime on imposing mosaics on building facades or walls or advertisements for soviet propaganda movies.

Fig. 5 – Image of Communist Mosaics

Fig. 6 – Image of large billboards advertising for Communist film festivals

Fig. 7 – Image of Communist propaganda displayed on billboards
http://chirac.wordpress.com/tag/str-victoriei/

2.1.3. Current situation

After the Anti-communist Revolution in 1989 and the reconnection of the Romanian society to the capitalist reality, it seems that we want to make up for the lost time in

all domains, and outdoor advertising is no exception. Once censorship was eliminated, creativity and diversity is expressed abundantly in all public manifestations but the question which arises is “Is today outdoor advertising something more than the announcements made by the market sellers at the turn of the century?”. By the scenery which dominates most Romanian cities, one would say the answer is “No”.

Fig. 8 – Image of billboards after 1989

Fig. 9 – Example of cross-road in Constanţa

Fig. 10 – Image of street-crossing banner

Due to the vast coverage with reduced costs and especially due to the impact it generates on the target public, outdoor advertising is used at a large scale in Romanian cities, compared to the advertising using other media channels.

It is present in a variety of forms, from billboards to banners, stoppers, meshes, flags, bus station and bus advertising and in a variety of colors and sizes. It is present in the city centers, avenues, residential areas, commercial areas, without any limitation.

But costs are not the only cause for the use at large scale of the means.

In the city I live in, Constanţa, the first City Council Regulation on Outdoor Advertising was issued as late as 2012, following entry into force of the related law issued by the Romanian Government. Unfortunately, the limitations imposed by the law refer strictly to the size of the outdoor means and their safety and it bans the placement of such means on historical monuments, statues, trees, at crossroads, on the sidewalks but it does not make any reference to the observance of regulations in terms of urban aesthetics or urban design.

2.2. Outdoor advertising as element of urban aesthetics

Although advertising is defined as *„the science, business or profession of creating and disseminating advertising messages, a social institution that affects the daily life of each individual, a force that shapes popular culture, a component of marketing or a source of information about products, services, events, individuals or institutions"*[1], it seems that the social and cultural functions have not been yet taken into account and emphasis is placed on the commercial and economic perspective on things.

Outdoor advertising in not only a marketing element, it is also an urban design element. Billboards, meshes, transits, bus-shelters and city lights shape the urban landscape and therefore our evolution in the urban space.

Lately, outdoor advertising has been widely perceived as a visual pollution element and the forms of attitude against it have become radical. Many municipal authorities have gone as far as forbidding it. It is the case of Brazilian authorities from the city of Sao Paolo in 2007 and the London authorities one hundred years ago. Others have imposed drastic measures; it is the case of the city of Moscow.

There have been some attempts to demonstrate that outdoor advertising can make the cities attractive but for these attempts to bring more results, designers should keep in mind Howard Gossage's famous advice: *"when baiting a mousetrap with cheese, always leave room for the mouse"*.

In order to be accepted in life of the city and in its architecture, the outdoor means must comprise elements from the natural or urban environment, elements of urban architecture and technology.

[1] Baker, 2008, 6

3. Concept and design

In light of the above, as an active member of my community, I felt compelled to react and propose an alternative to the existing situation. To this end, as study location I chose to refer to the City Park Shopping Mall situated in the city of Constanta, Romania.

3.1. Description of the study location

The city of Constanţa is situated in the South-Eastern part of Romania, in the historical province of Dobruja. It is the capital of Constanţa County and the second most important city of Romania as well as the largest port on the Black Sea, with a population over 280,000 people.

Fig. 11 – Romania, Constanta map

As seen in the enclosed pictures, the study area is placed in the city newly emerged center and has the following neighbors:

- North – Tăbăcărie Park
- East – Tăbăcărie Lake
- West – Soveja Street
- South - Al. Lăpuşneanu Boulevard

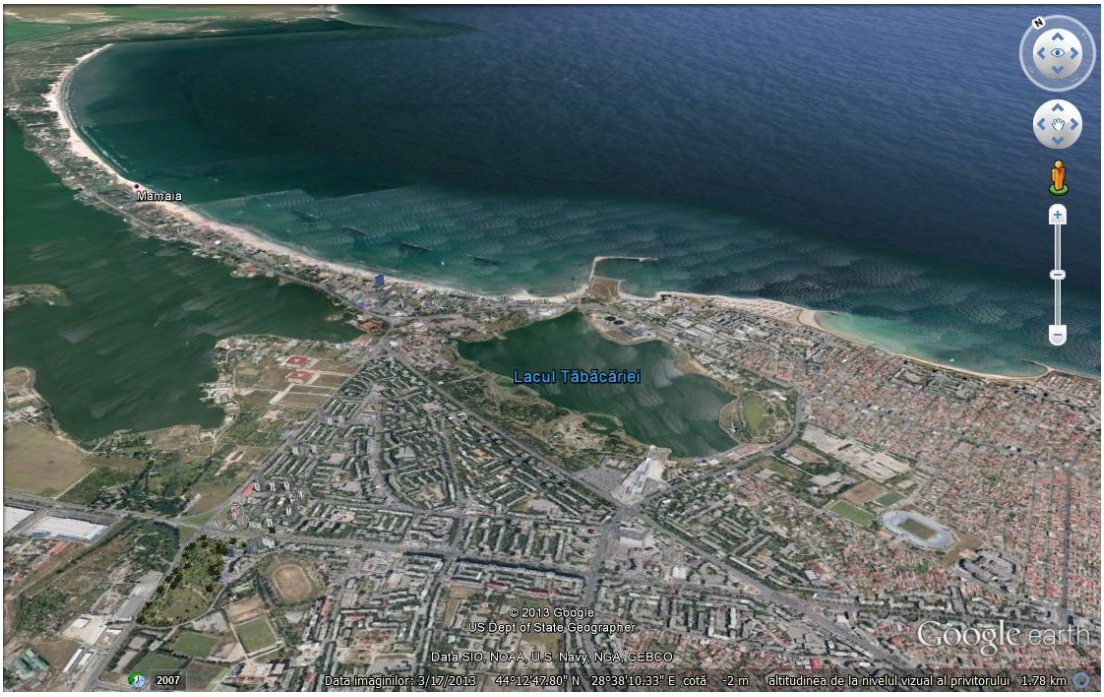


Fig. 12 – Google Earth view of studied location

Fig. 13 – Google Earth view of studied location

3.2. Why lightweight?

To give an answer to this question, I could not think of another type of structure which can better integrate a natural element into the urban architecture and community life than a lightweight structure, defined by Frei Otto as *"natural construction"*[2] as part of a larger vision which involved a *"peaceful and free society in harmony with itself and nature"*[3].

In the 1980s Frei Otto's favorite game was to show visitors of the Institute of Lightweight Structures an aerial view of the university campus and to say to them: "Show me where my institute is." The visitor's hesitation, long search and sudden surprise at finally spotting the Institute building were the best praise for the architect. This meant he had reached his goal: his building *"is part of nature, a part of the whole"*[4].

"Natural architecture must be adaptable and alterable.[5]"

"Modern lightweight structures correspond in form and function to the natural laws of form, strength and mass."[6]

"The objects have mass, have one form and are usually in movement […] they are mostly put together from smaller objects in an arranged or arbitrary way. Evolutionary processes stamp their mark on the form of the objects."[7]

- Given the fact that the structure is a non-permanent one, at least not in the same shape due to the constraints regarding advertising time, the lightweight solution is easy to exploit, meaning that it can be convertible, at least partly.
- Lightweight means easiness to move and remove.
- Lightweight equates with the possibility to add or remove parts and transform the structure into a multipurpose one, bearing in mind that, because the investment only in such a project for the sole use of billboard tower is too high, it should generate profit and become a successful business.

[2] Windfried Nerdringer, 2005, p. 40
[3] Windfried Nerdringer, 2005, p.15
[4] http://www.uni-stuttgart.de/impulse/imp/start.php?id=6&lang=en
[5] Lightweight Structure in Architecture and Nature – a publication for the exhibition "Natural Structures" in the Shussev Museum of Architecture in Moscow, 1983, p. 37
[6] Idem, p. 39
[7] Otto, Burkhardt, 1980, p. 19

- This type of approach provides to possibility to implement forms and ideas that cannot be achieved with other types of regular constructions.
- Most probably, it will provide an image impact with less material and therefore weight, illustrating the famous saying “Less in more”.
- By its design and construction, this structure can become a part of the community life and a landmark in the city social life.
- This solution is environmentally friendly.

3.3. Formfinding process

In the formfinding process, I wanted to find several elements appropriate for the location, which is bordered by the lake and the park and situated in a port city, such as natural elements belonging to the park and lake environments – flowers, trees etc. – or port specific technology – sails, boats, fish nets etc.

Finally, I decided to follow the natural shapes due to the fact that the port specific elements have already been implemented in the building of the shopping mall through sails which decorate its top.

3.3.1. Inspiration

Lotus flower as Christmas decoration in a city center. It opens and closes its petals and changes colors.

Fig. 14 - Lotus flower decoration
Ihttp://www.mentondailyphoto.com/2012/12/christmas-in-menton-lotus-flower.html

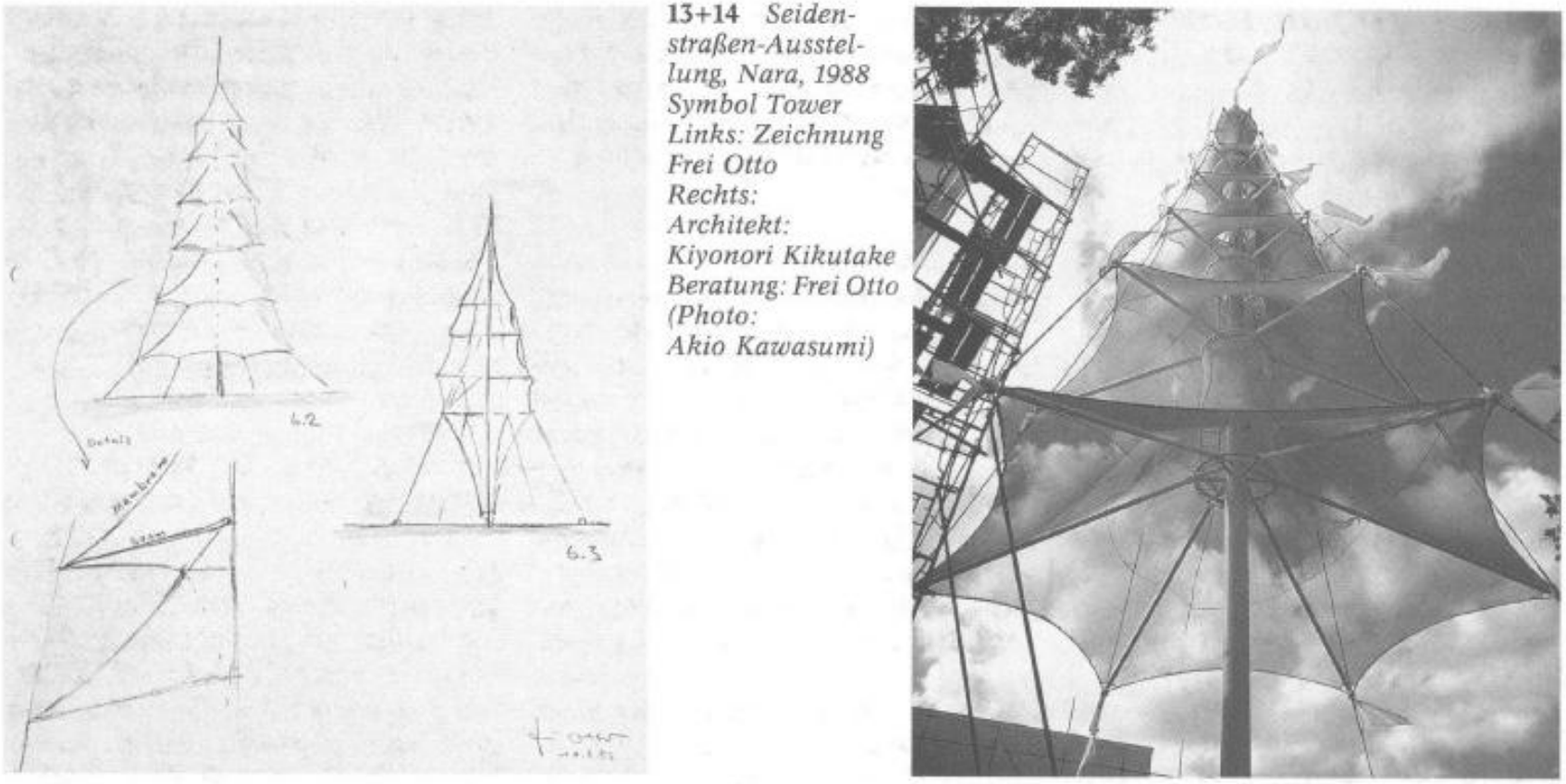


Fig. 15 – Sketches of symbol tower by Frei Otto and image of erected tower

Symbol tower in the shape of a tree. It is composed of overlapping 6 point-cones with decreasing size from lower to upper level. This project was inspiring from the point of view of the cable system. [8]

[8] Kikutake: Mebrankonstructionen, p. 49

Fig. 16 – Conic shaped canopy at the London Festival of Architecture in 2008

http://www.architen.com/projects/london-festival-of-architecture

Conic shaped canopy created entirely from fabric panels manufactured in a PVC coated polyester mesh and printed in shades of pink. The fabric panels are fitted onto a cable net structure. Stretching 10 m in the air, the structure was open at the bottom to allow the public to walk underneath and experience the structure from another angle.

This structure was presented to mark the launch of the London Festival of Architecture in 2008 and it was designed by Foster and Partners.

Fig. 17 – View from the bottom of conic shaped canopy

Fig. 18 – Render of membrane forest proposal
http://www.l-a-v-a.net/projects/uae-geometrical-forest/

Proposal for the integration of an architectural forest into the environment in the presidential palace in Abu Dabi - UAE. Attached to the tree structure is a lightweight membrane, with tree leaves filtering the Arabic sun. The tree structure consists of four identical types of trees growing into a second type that formes the dome which spans the center of the court.

The model was created by LAVA design office in 2009.

Fig. 19 – Image of membrane forest individual tree

Fig. 20 – Example of printed sails
http://www.tensilefabric.co.uk/fabric-structures/tensile-fabric-portfolio/project.aspx?type=interior&ref=1892

Large printed sail arrangement used for indoor advertising in a shopping center in Cumbernauld. The sails are arranged in a sunken area to lower the perceived ceiling height as well as make the area cosy and welcoming for the customers.[9]

[9] http://www.tensilefabric.co.uk/fabric-structures/tensile-fabric-portfolio/project.aspx?type=interior&ref=1892

Fig. 21 – Example of sail print
http://www.tensilefabric.co.uk/fabric-structures/tensile-fabric-portfolio/project.aspx?type=interior&ref=1729

Printed sail fastened with stainless steel fork terminals on strap clamps around the columns within the interior space.

Fig. 22 – Example of fully printed half cone structure
http://www.tensilefabric.co.uk/fabric-structures/tensile-fabric-portfolio/project.aspx?type=exhibition&ref=1085

Fully printed half cone structure created in the traditional cone formation with tapered panels stitched together to form the overall half cone shape. The photografic image was added to the fabric before manufacture, with the original shape being split into panels, printed and then re-registered at manufacture stage.

Fig. 23 – Example of continuous tree-like structure
http://www.tensilefabric.co.uk/fabric-structures/tensile-fabric-portfolio/project.aspx?type=exhibition&ref=1566

Structure reflecting a simple tree. The shape was obtained by stitching printed tapered straps of fabric onto an internal framework which consists of a single vertical column with a steel ring at high and low level to tension the fabric between.

Fig. 24 – Example of large printed sails
http://www.tensilefabric.co.uk/fabric-structures/tensile-fabric-portfolio/project.aspx?type=exhibition&ref=1122

Large advertising area obtained with inovative sail system which uses existing building structure as fixing points and excludes massive steel structures and conventional shapes.

Fig. 25 – Image of branded entrance feature
http://www.architen.com/projects/broadmead-fabric-sail

Feature reflecting the city of Bristol naval identity, integrated in the urban scenery at a shopping district entrance. The installation comprises a sail which can be printed or branded, fixed to a large steel frame.

Fig. 26 – Example of branched central mast
http://www.pinterest.com/pin/326018460496380651/

Structure designed and erected to provide shade and rain protection with aesthetic elements for a shopping mall in Santa Fe, Mexico. The central support is an inclined branching structure.

3.3.2. Own work

Before making any proposal, one must bear in mind that an architectural work is not only an art work but also a project which must be implemented and financed. Therefore, I tried to put together the points of view of the people involved in the development of the project.

What the architect wants:

- To provide visibility for the largest part of the surface from the viewer's height
- To ensure the advertisements can be changed with ease and provide functionality to the project
- To identify a solution where the steel structure is as hidden as possible
- To design a structure with large volume and exposed surface but with lightweight look

What the future investor wants:

- To have a large outdoor advertising surface
- To make the structure a generator of profit by the possible correspondent commercial space (terrace, non-permanent stores etc.)
- To transform the structure into an interest point which would attract customers both for itself and the shopping mall
- Maximum number of viewers for the marketing message

3.3.2.1. Project Lotus Flower

For an optimum use of the area natural resources, I have considered the option of placing a lightweight structure in the form of a lotus flower on the surface of the lake.

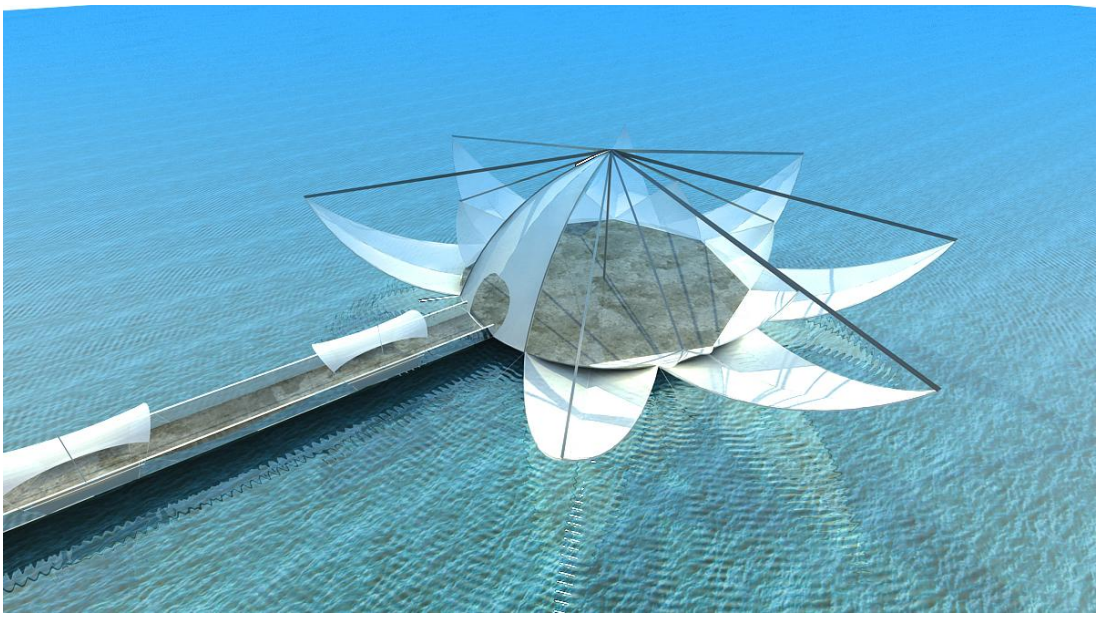


Fig. 27 – Render of Lotus Flower

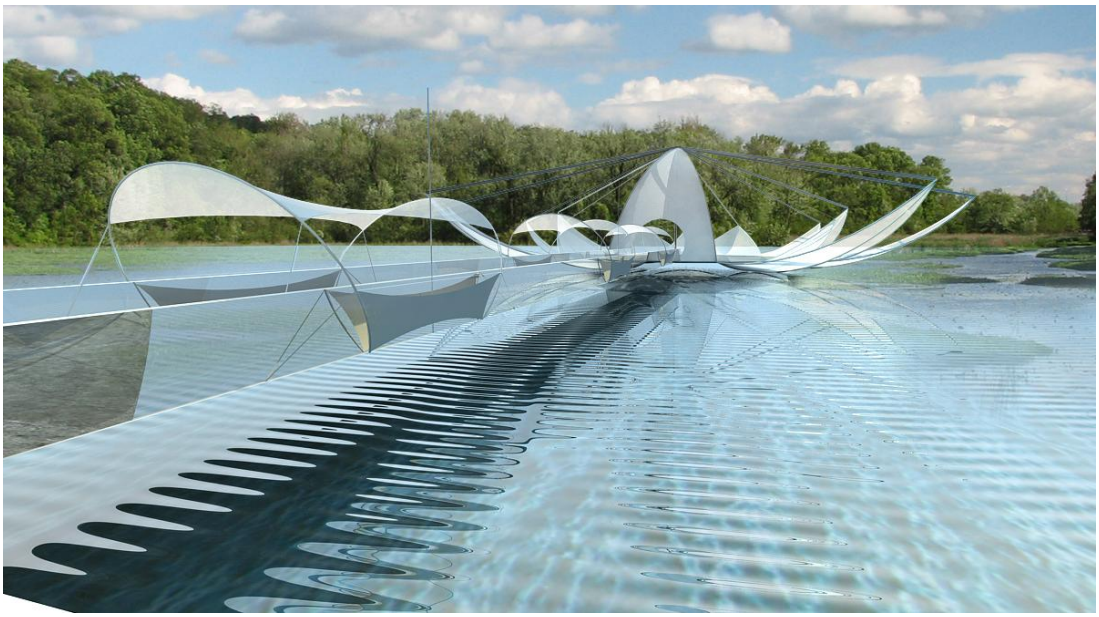


Fig. 28 – Render of Lotus Flower – side view

This particular location provides visibility for outdoor advertising to the people strolling in the park but it is less oriented towards participants to city traffic and thus limits the main advantage of outdoor ads, that is the large number of viewers for the advertisement.

On the other hand, it may very well be shelter for a club or restaurant, which offers the possibility for indoor advertising.

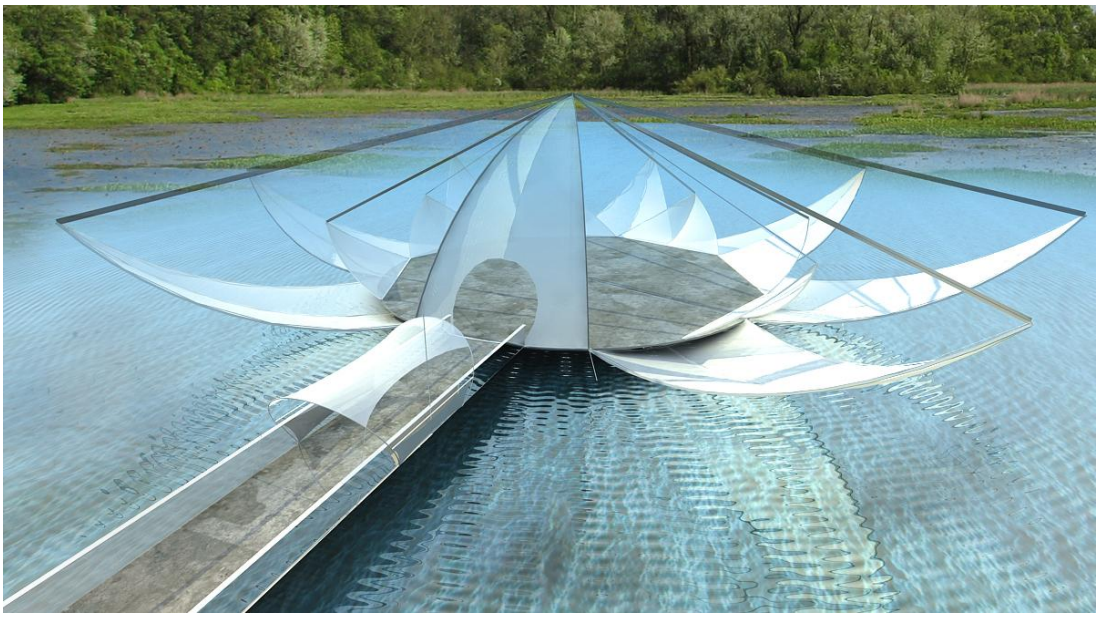


Fig. 29 – Render of Lotus Flower – entrance view

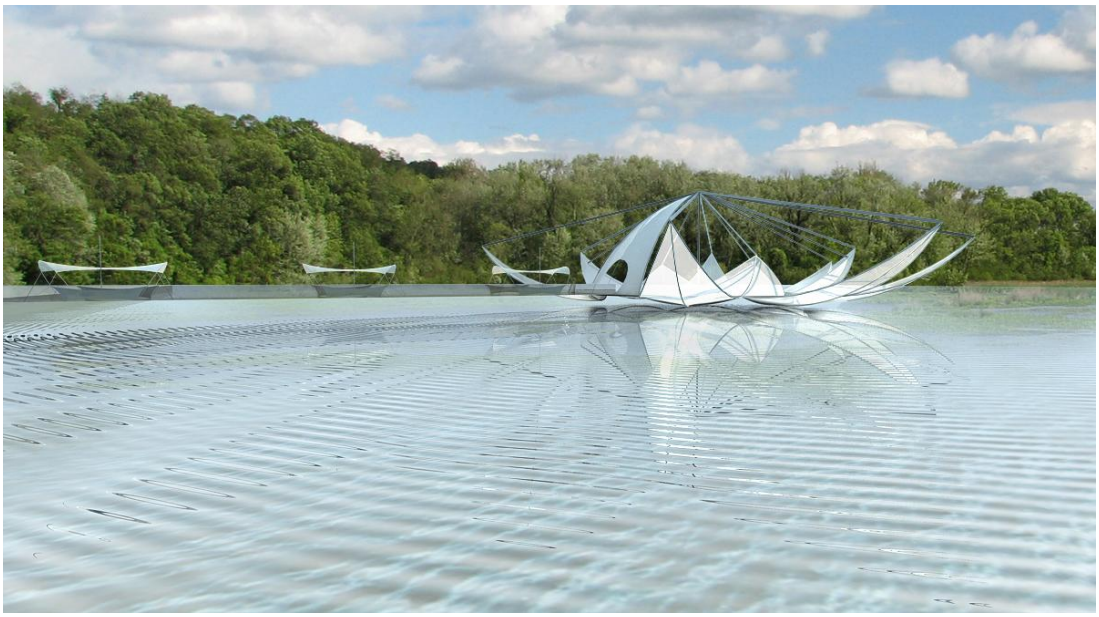


Fig. 30 – Render of Lotus Flower – water level view

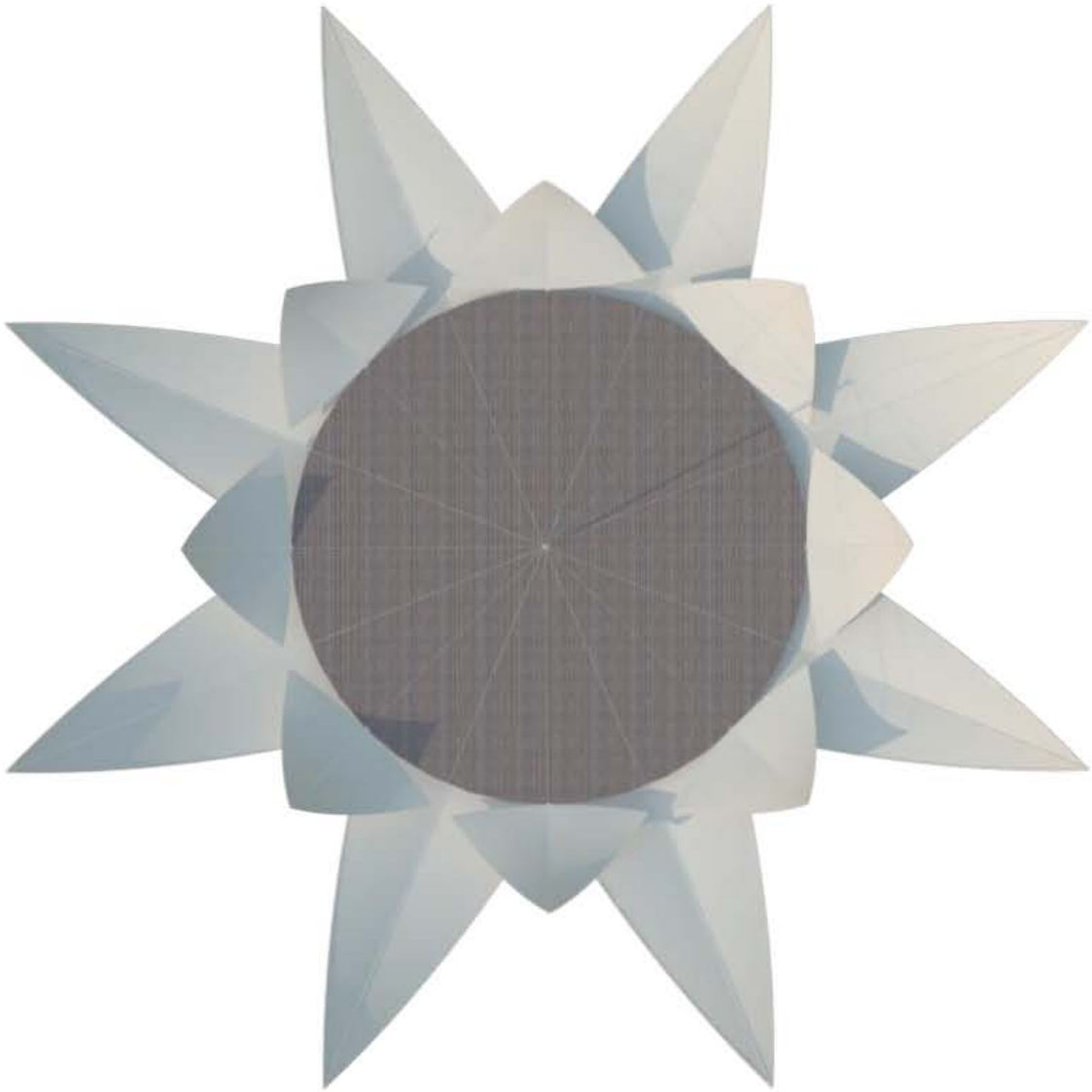


Fig. 31 – Lotus flower plane view

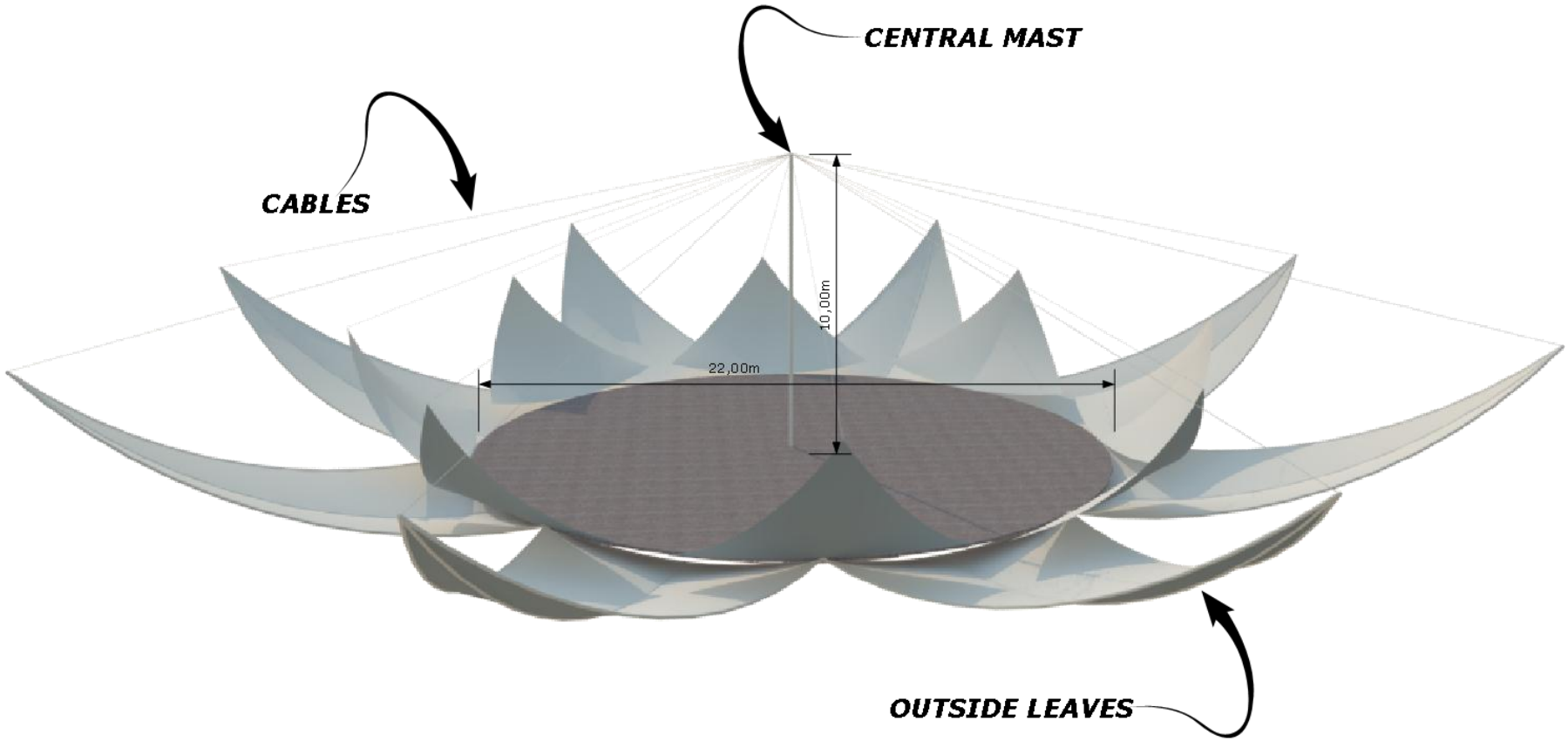


Fig. 32 – Lotus Flower - structure components

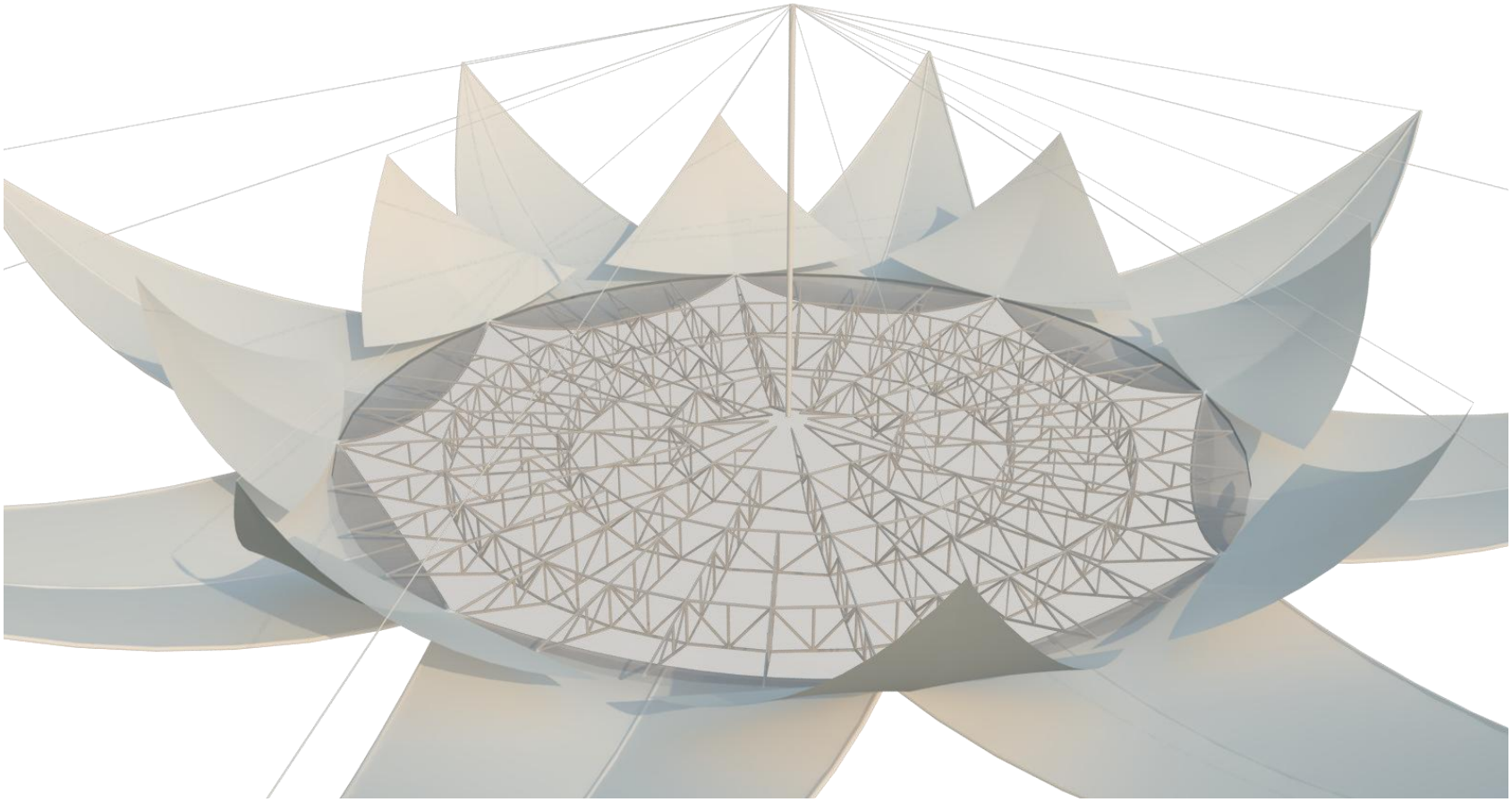


Fig. 33 – Lotus Flower deck infrastructure

However, this solution would trigger other costs related to an access way to the actual objective, leaving aside costly foundations.

3.3.2.2. Project Cone Tree

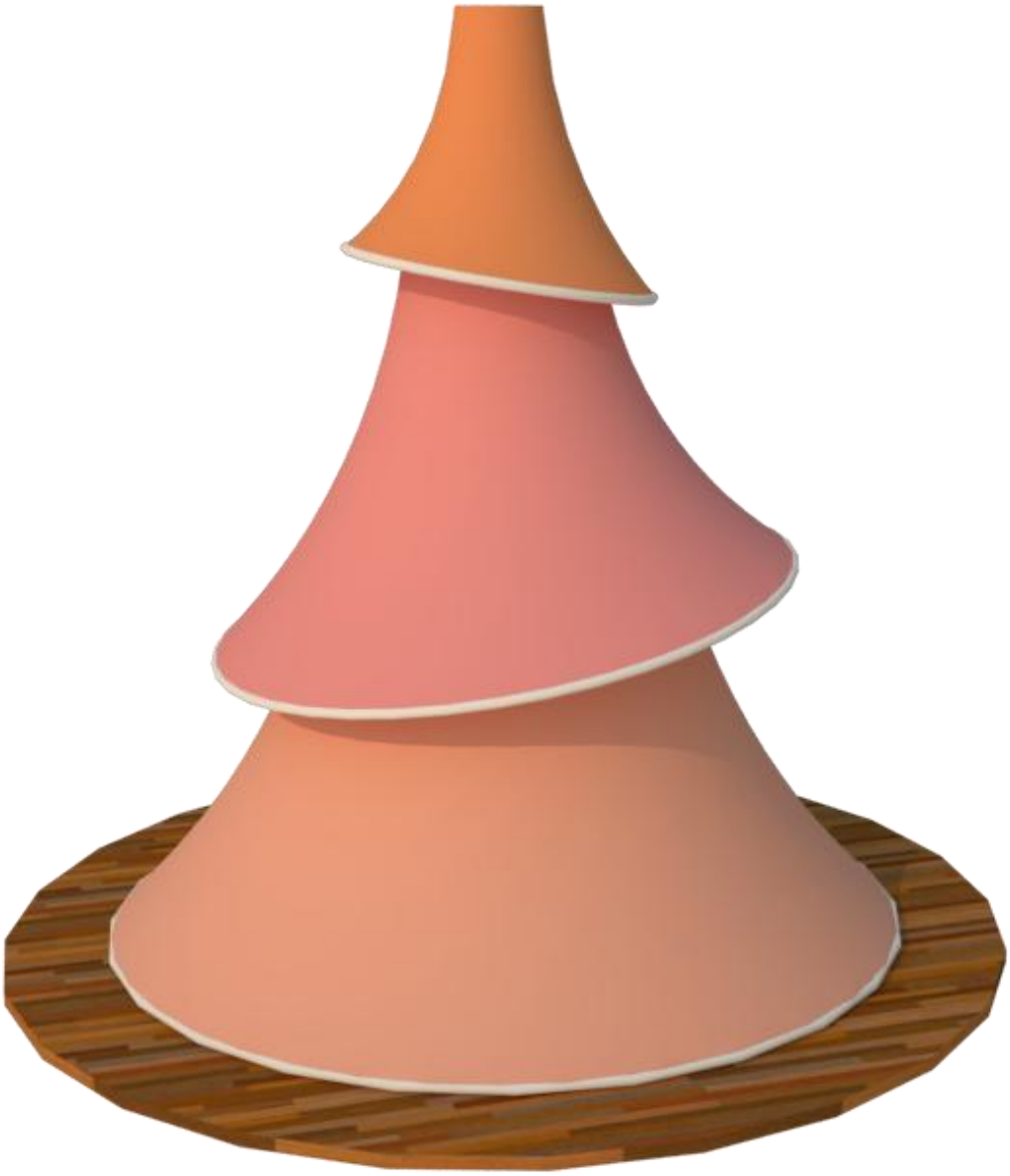


Fig. 34 – View of Cone Tree

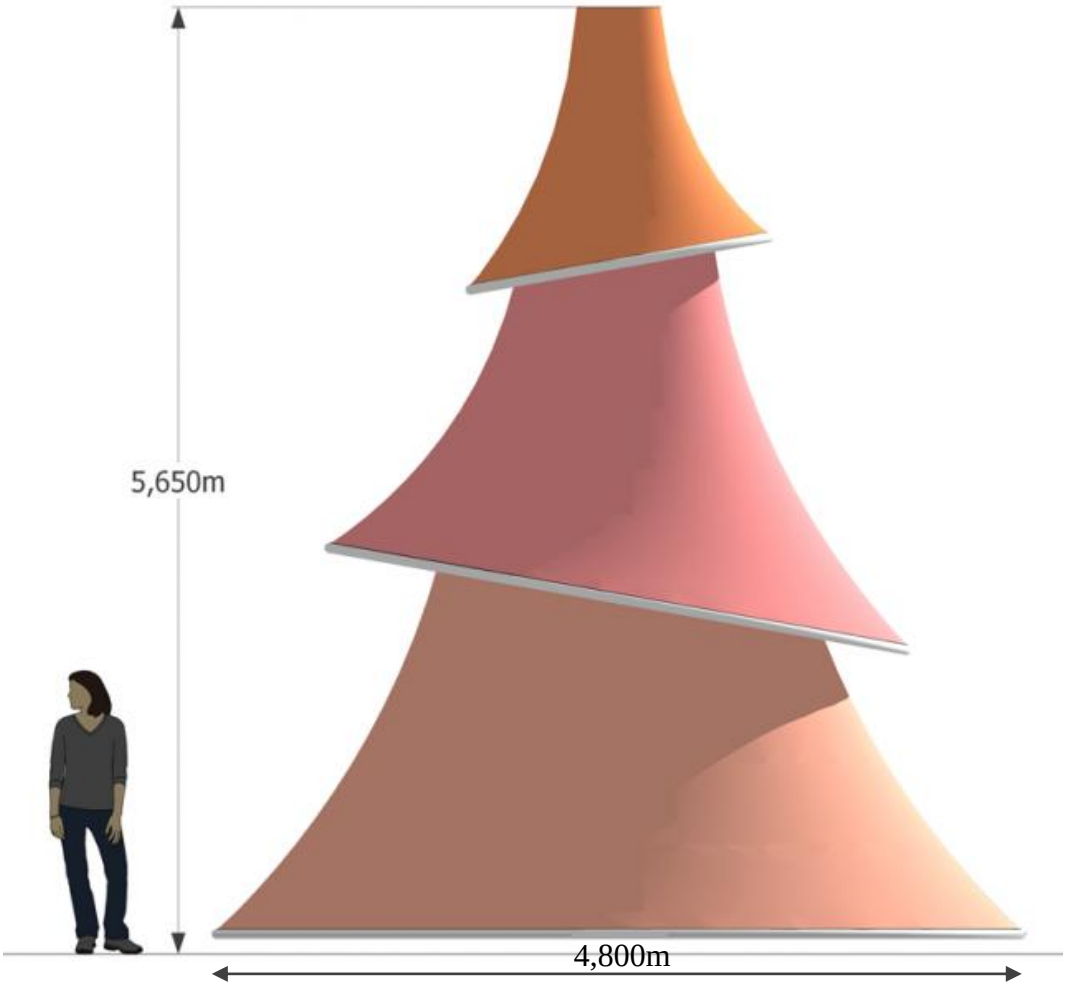


Fig. 35 – Cone Tree - side view

The Cone Tree has resulted from overlapping three round rigid edge cones. The advantage of this form is that for the erection of the structure no foundations are necessary. Counterweights can be applied at the base in order to provide stability. Unfortunately, in this version, changing the advertisements would be a uselessly difficult operation, mainly due to their size and conical shape.

What is more, the convertibility and multifunctionality requirements cannot be tackled.

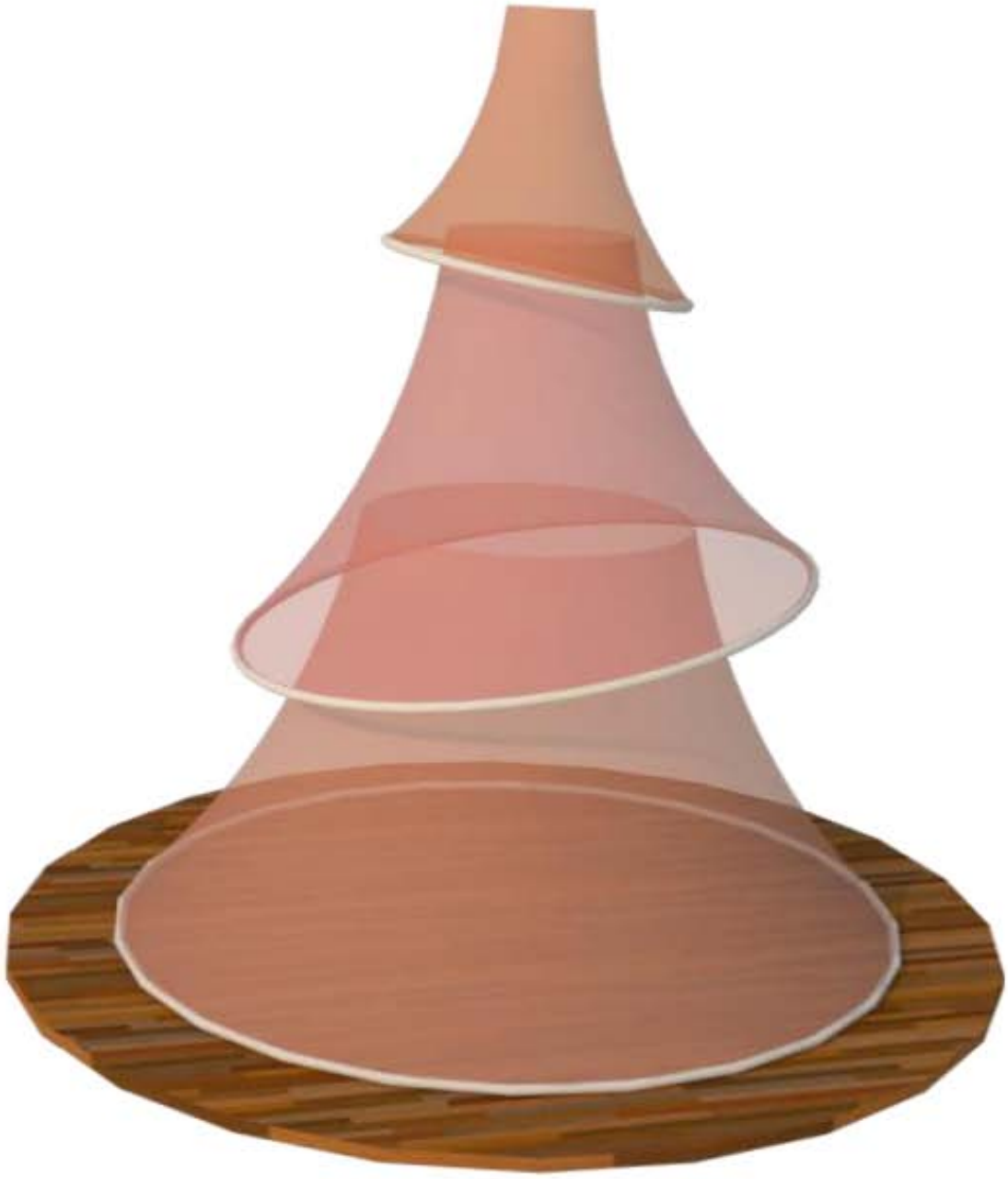


Fig. 36 – Cone tree – Cone overlapping

Fig. 37 – Cone Tree – example of advertising

3.3.2.3. Project Urban Billboard Tower

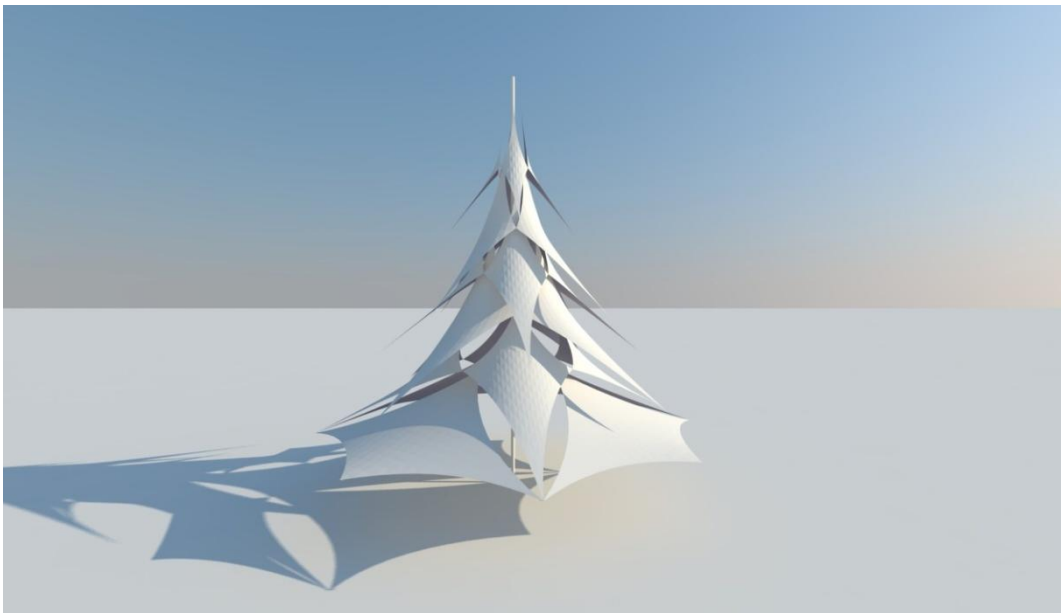


Fig. 38 –Urban billboard tower with hypar base

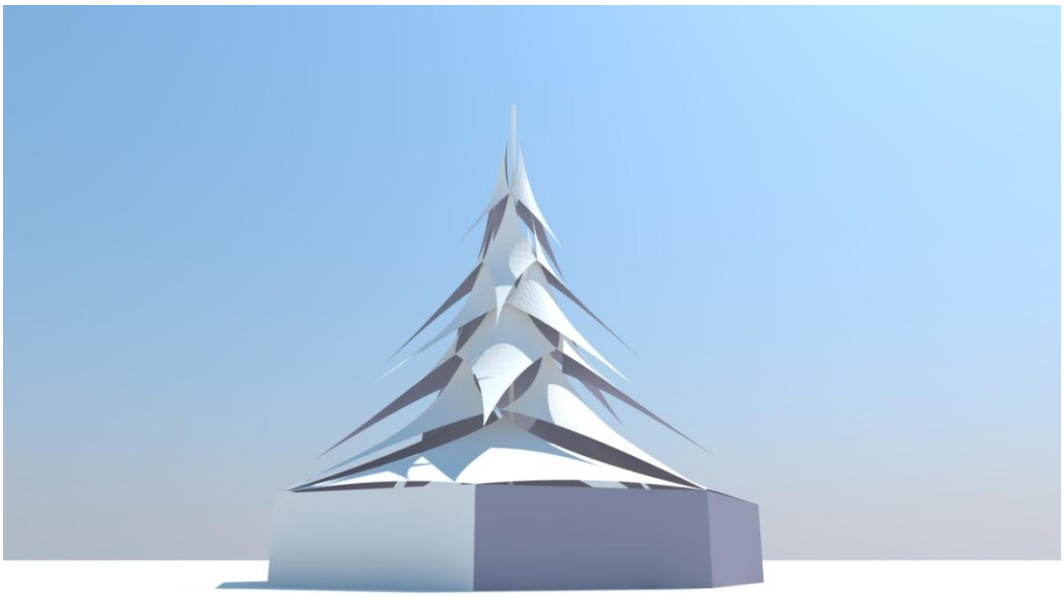


Fig. 39 – Urban billboard tower with hypar base and enclosure

In an attempt to provide easy replacement of advertisements and multiple membrane support for marketing messages, I chose to divide the entire membrane area into small pieces in the form of hypar leaves. The hypars are bordered by cables and fixed

in points for better tension and handling.

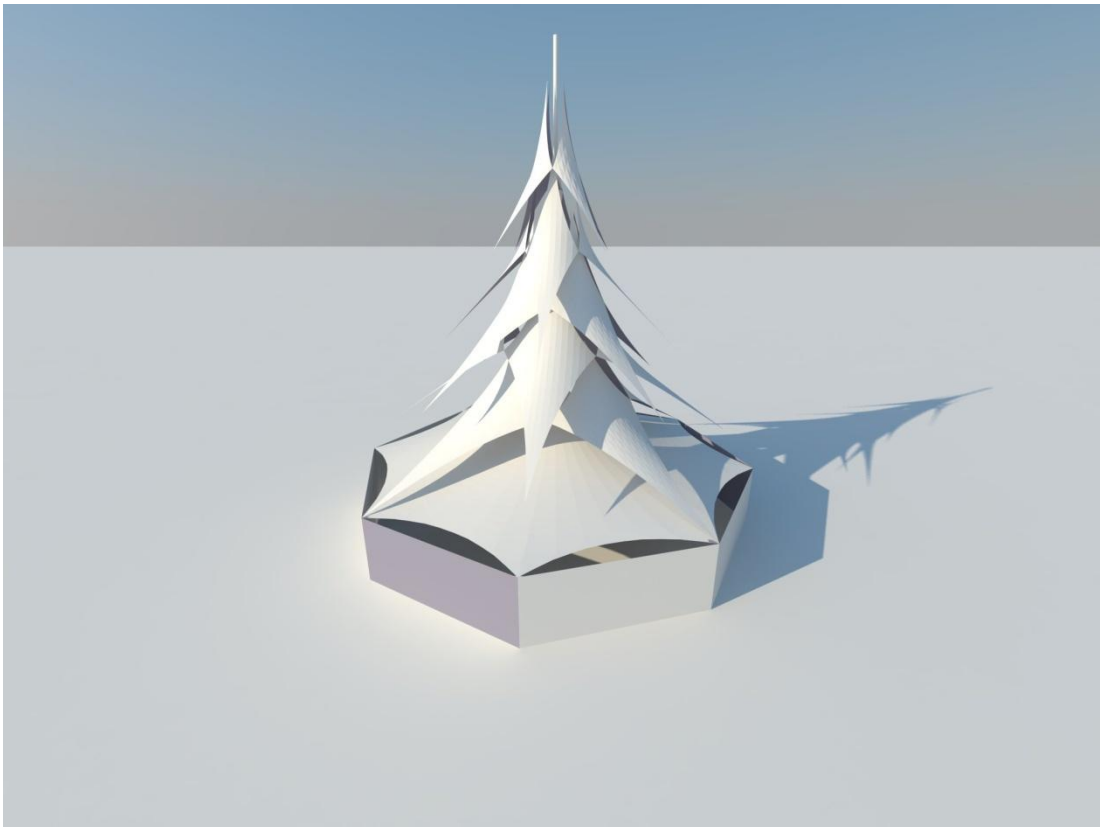


Fig. 40 – Urban billboard tower with base cone and enclosure

In order to meet the multipurpose requirement and to create a point of interest, the lowest layer of leaves has been transformed into a cone. The result is a permanent waterproof covering under the leaves used as billboards. Although these hypars are the largest in surface, they did not provide good visibility of messages from a person's height, so nothing is lost in the end.

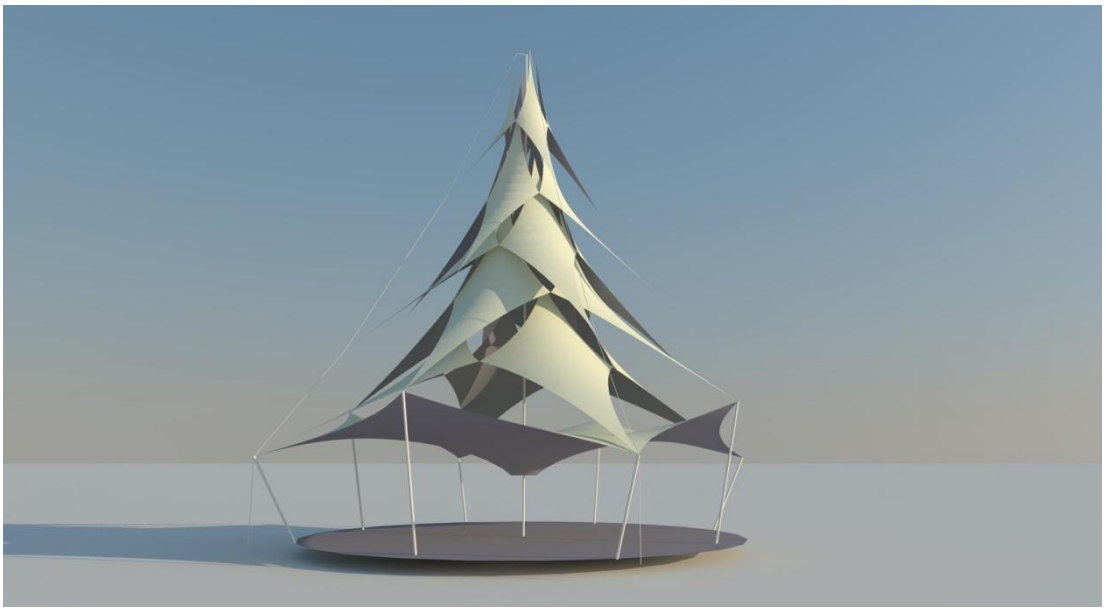


Fig. 41 – Urban billboard tower with base funnel – people height view

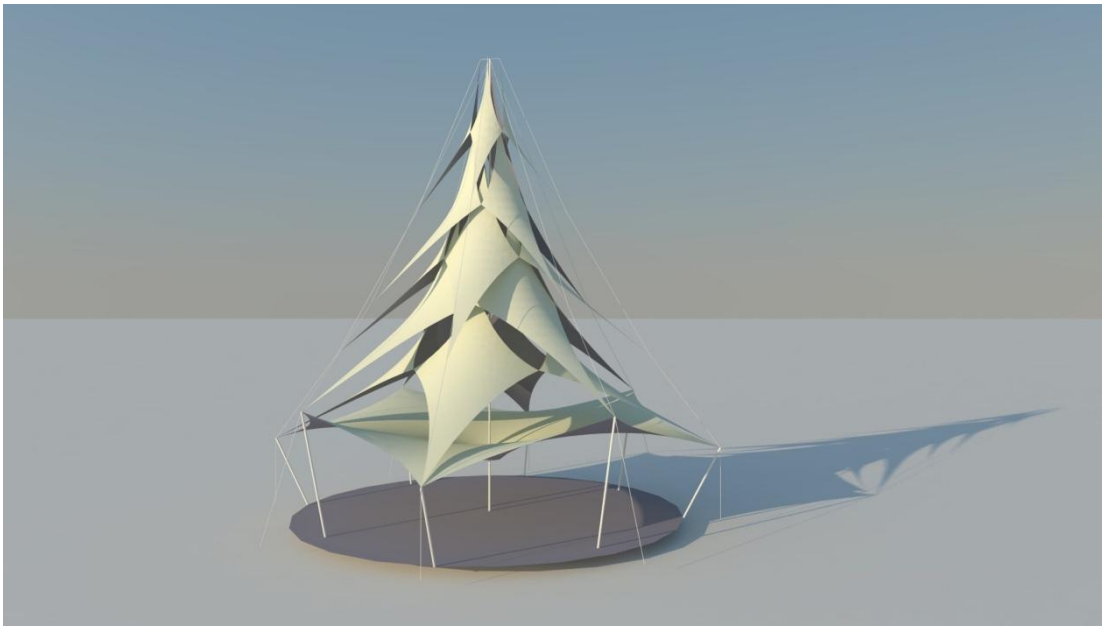


Fig. 42 – Urban billboard tower with base funnel – upper level view

Version with funnel. The disadvantage of this form is that other solutions for water drainage must be designed and applied.

3.4. Final form

Finally, given the proposed location for the erection, the aim of the construction, as well as the advantages and disadvantages of each proposed structure form, I find the urban billboard tower project as the best option for implementation.

Due to the dimensions of the structure, 14.15m in hight and 14.00m in diameter, this version best integrates in the proposed public space, being able to create a landmark in this area of the city.

Fig. 43 – Urban billboard tower – side view

Firstly, it provides an actual display area, on the leaves, of 121.37 sqm, laid on the 5 rows, divided into variable area parts, the average amounting up to approximately 6 sqm per piece. The leaves must be made of printable mesh-type membrane in order to reduce the force of the wind which is applied on them, especially on the higher leaves level.

This particular version provides rain protection due to the eight-point cone at the base, which is 14.00 m in diameter, a minimum of 2.10m and a maximum of 4.50m

in height and has a designed area of 191.24sqm. The cone must be produced of tensile membrane, taking into account the fact that, unlike the leaves, which are only temporary, it is a permanent structure and it must also carry snow loads.

Fig. 44 - Urban billboard tower – view from above

The steel structure comprises a central mast, cables tensioning the leaves and hinged struts with tensioning cables.

The central mast which is a branched tree-type structure from the base up to the cone ring, that is the visible part, becomes a spatial structure over the cone ring in order to provide attachment points for the leaves.

4. Design basics

Layout plan

The chosen location is situated close to Mamaia Resort, an area which is currently developping as a new city center of Constanta, at the crossroad of Soveja Street and Alexandru Lapusneanu Boulevard.

Tabacarie Lake is situated in the North-Eastern part. It is the perfect spot for water sports, boat trips and other leasure activities.

Fig. 45 – Layout plan

From an architectural and urban point of view, the studied layout is bordered by blocks of flats up to 4-story high, which go as high as 14 and 15m. The shopping mall is a building which is developped mostly at ground level, with underground, ground and one floor.

Site plan

The acces to the shopping mall is made through a small pedestrian area, where terraces are set up in summertime and occasionally different events, such as concerts or thematical fairs, are organised.
It is also a meeting point and a stroll area.
A small-size spray fountain was build near the entrance area and this is the exact location where I propose to install the billboard tower. In fact, it shall installed right in the middle of the fountain.

Fig. 46 – Site plan

Fig. 47 – Street view of shopping mall

The existing spray fountain is located at approximately 25.00m from the shopping mall building.
The distance between the fountain and the Soveja Street road axis is 30.00m and between the fountain and the Al. Lapusneanu Boulevard road axis is 50.00m.
The fountain has a circular water tank made of reinforced concrete. Its diameter is of 10.00m and its depth of 1.00m. The water tank wall has a +10...+60cm elevation over the developed land.

From the information provided by the owner, the site comprises underground water supply networks, sewage networks, rain water collection networks and electricity networks.

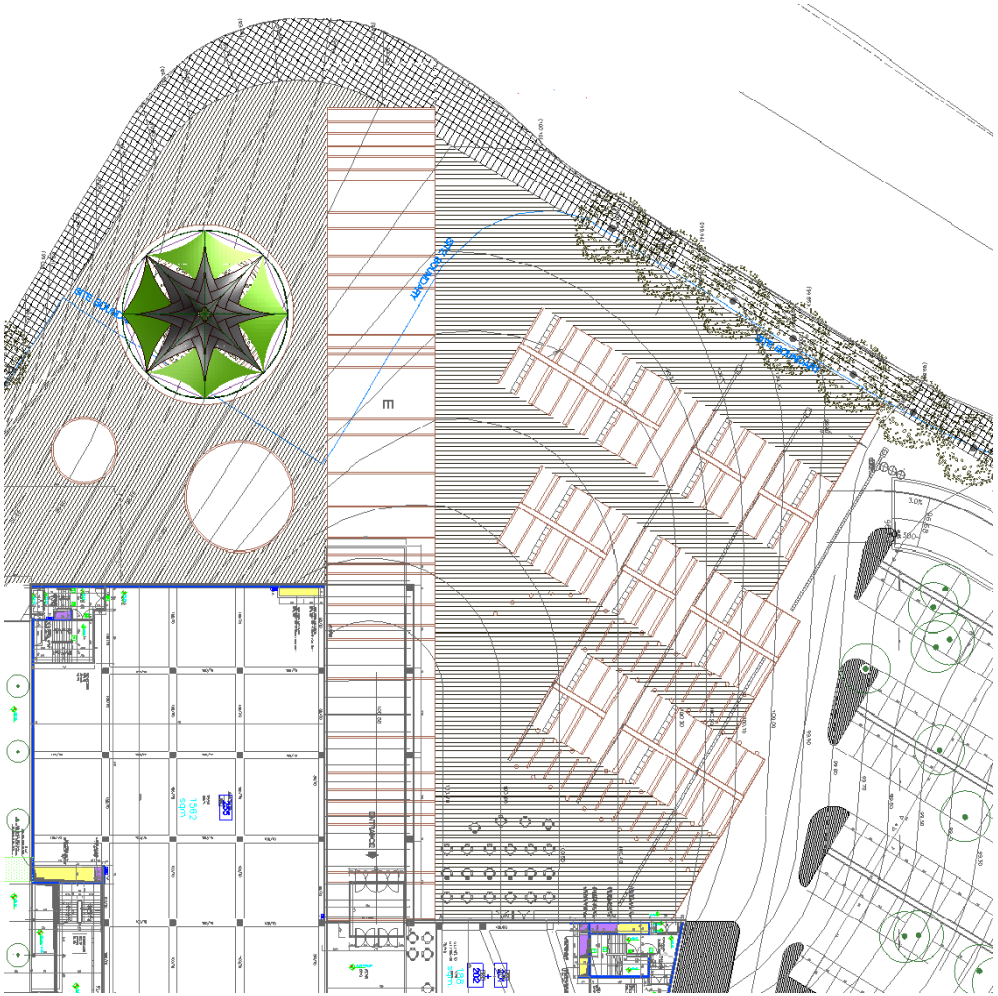


Fig. 48 – Layout plan - detail

5. Design studies

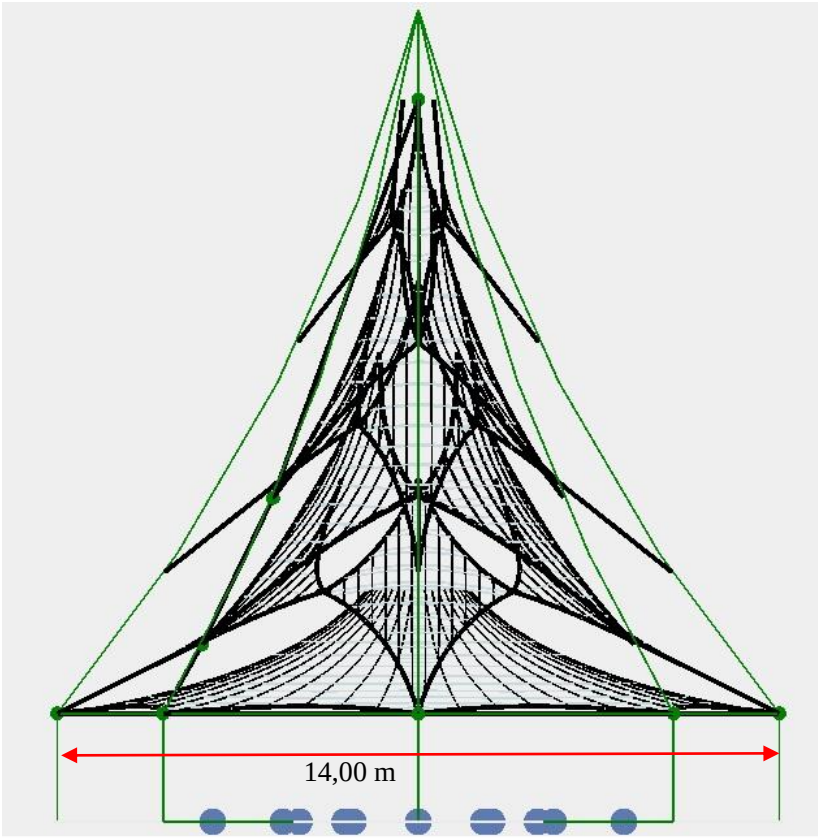


Fig. 49 – Formfinder Software view 1

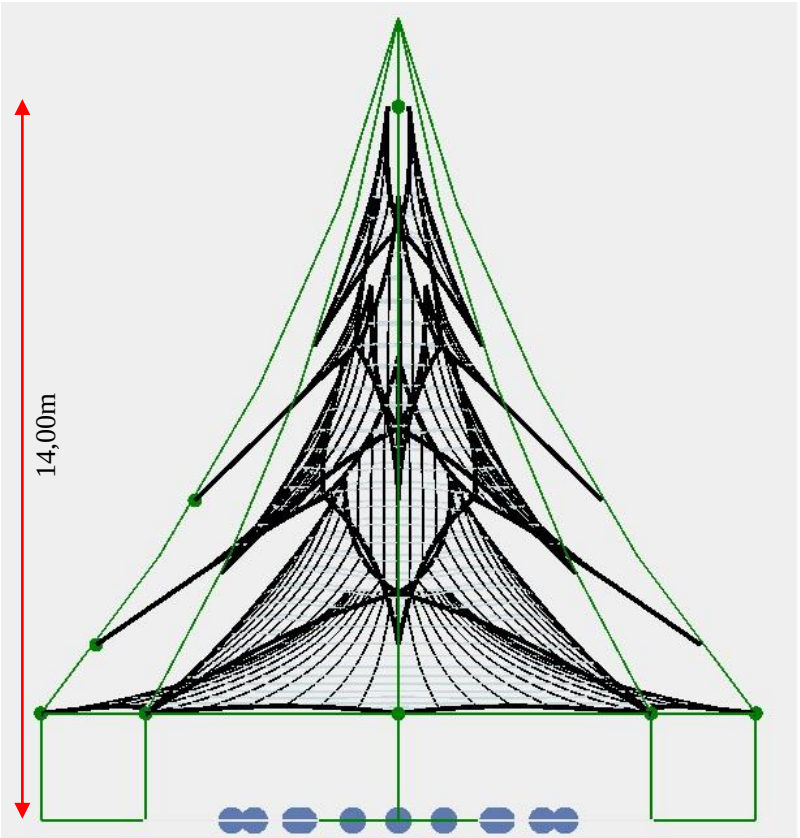


Fig. 50 - Formfinder Software view 2

For the formfinding process, the most important aspects were the cable net and the points.

The leaves are HYPAR-based shapes, with the upper corner being fixed to the central mast, the lower corner fixed to the longitudinal tensioning cable and the right and left corners attached to the adjacent membranes from the same level. For the formfinding stage, a regular net with 0.50m spacing and 1.00kN/m was generated.

There are five levels of leaves with the elevations and areas:

- Level 1 - from +2.10m to +6.65m elevation. Area = 10.04sqm/piece
- Level 2 – from +3.44m to +9.10m elevation. Area = 8.41sqm/piece
- Level 3 – from +4.84m to +10.50m elevation. Area = 6.07sqm/piece
- Level 4 – from +6.28m to +12.25m elevation. Area = 4.09sqm/piece
- Level 5 – from +9.30m to +14.00m elevation. Area = 1.85sqm/piece

The base eight-point cone has the base points at +2.10m elevation and the top ring at +4.50m elevation. The external diameter of the cone is14.00m. The top ring is 2.00 in diameter and it shall be supported by a branched tree-type central mast. The net is radial type with 0.50m spacing and 1.30kN/m weft prestress and 1.00Kn/m warp prestress.

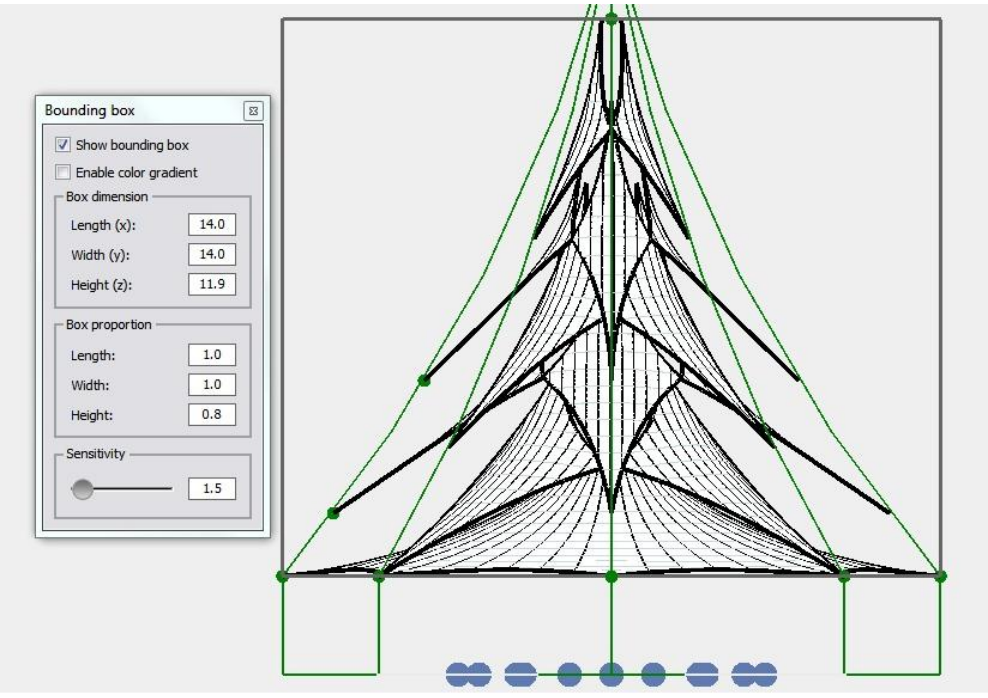


Fig. 51 – Formfinder Software bounding box

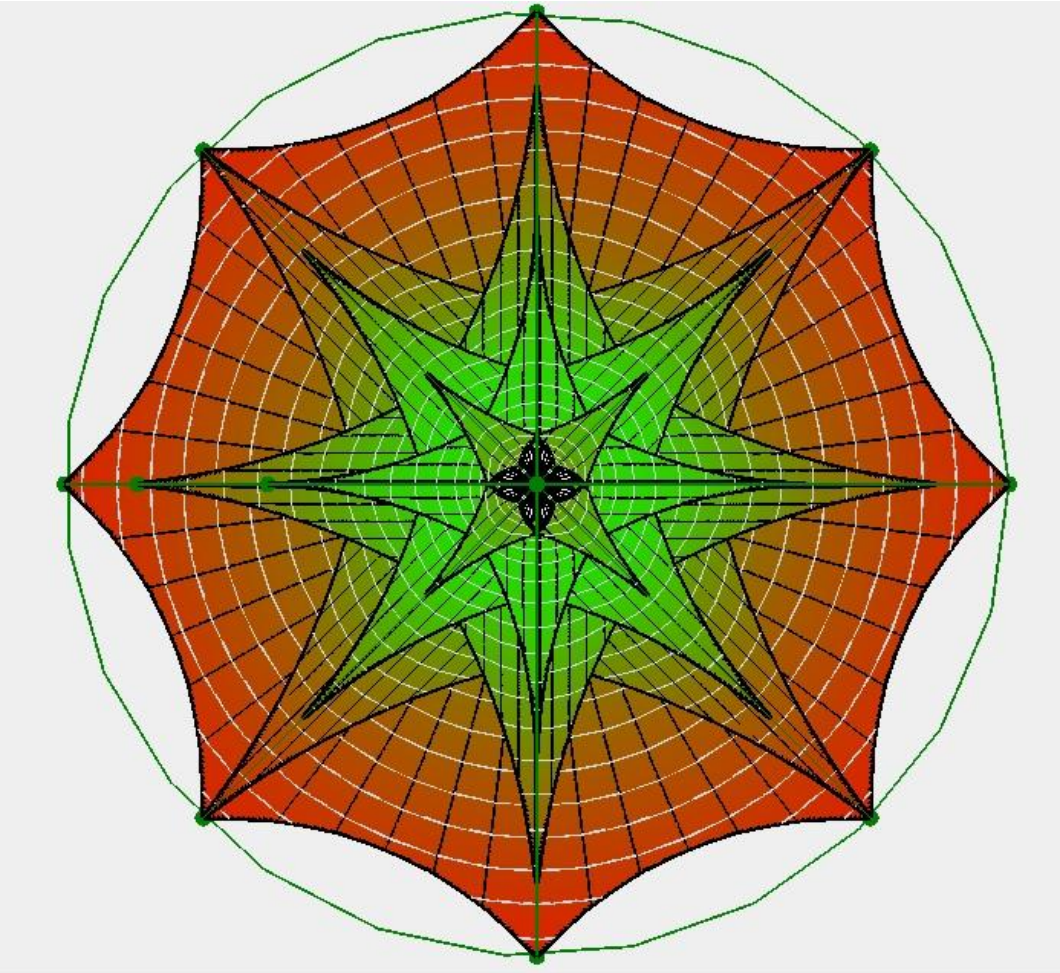


Fig. 52 – Formfinder Software gradient top view

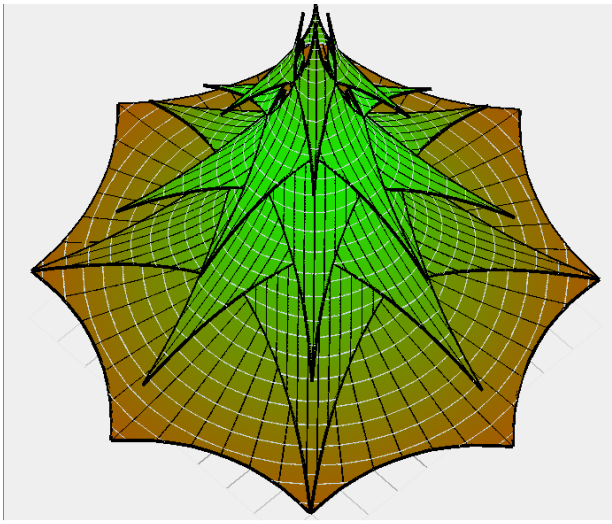


Fig. 53- Gradient view from above

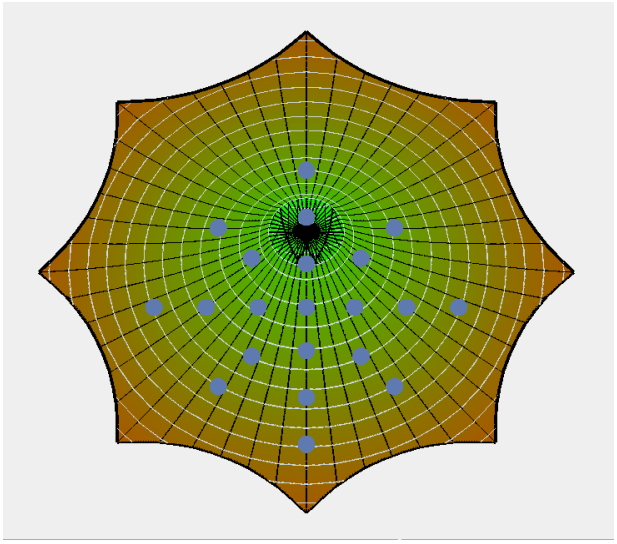


Fig. 54 – Gradient view fro, the bottom

For an optimum form study, I have built a mock-up made of rudimentary materials such as Lycra, wood sticks and metal wire.

Fig. 55 – Urban billboard tower study mock-up

This structure was envisaged for the preliminary calculation.

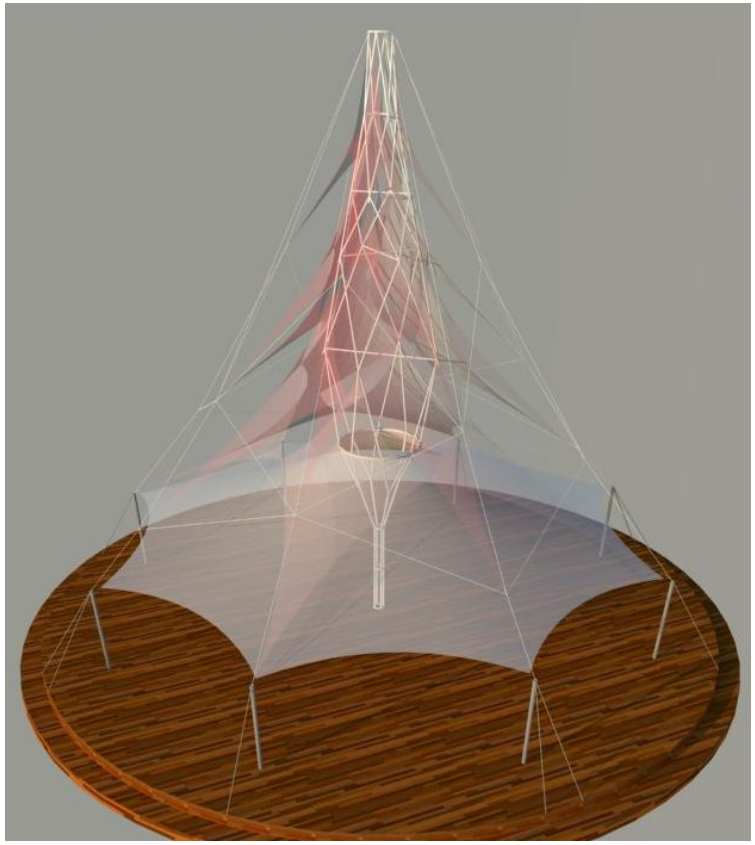


Fig. 56 - General view

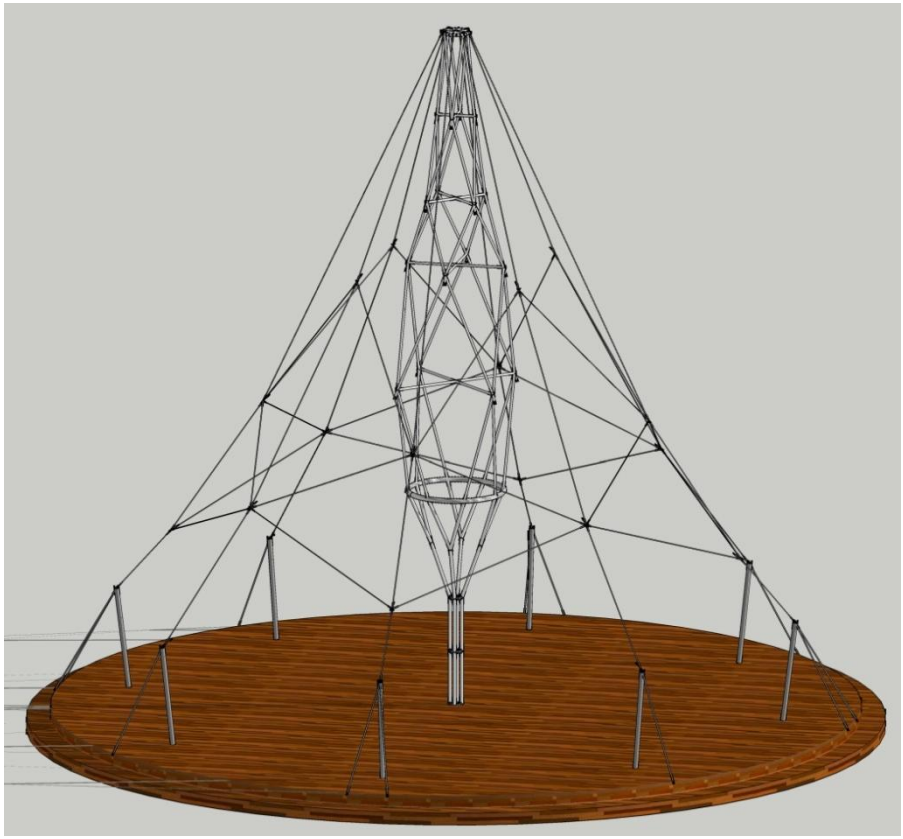


Fig. 57 - Steel structure and cable system

In order to highlight the way membrane leaves are fixed to the steel structure and cable system, I have drawn up two longitudinal cross-sections.

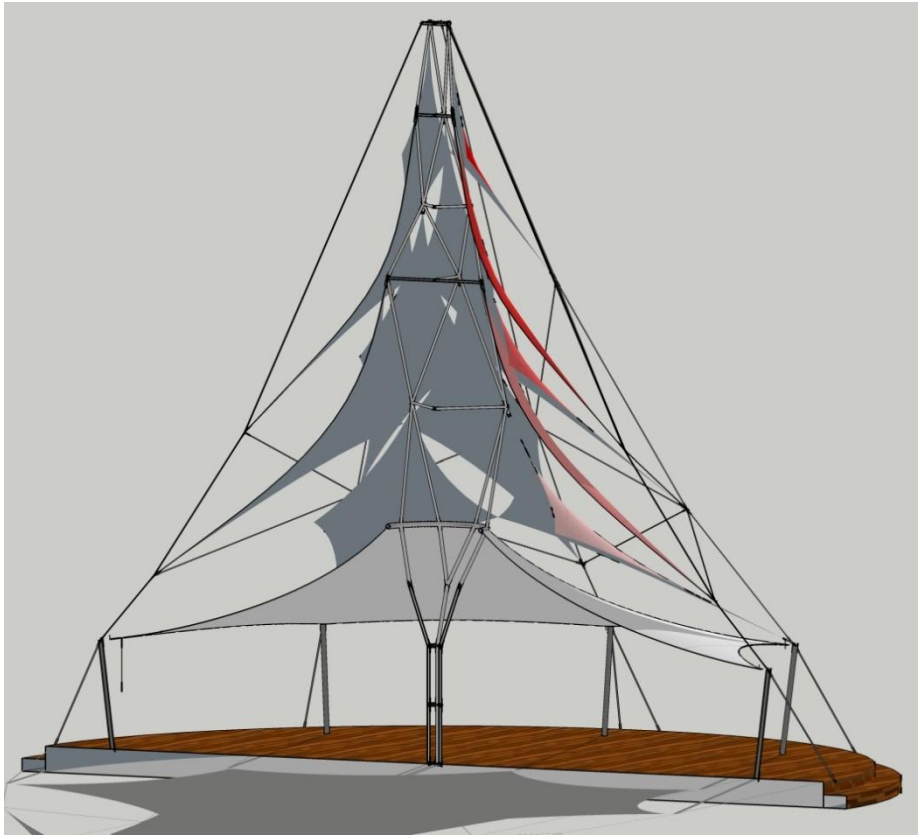


Fig. 59 - Vertical cross-section 1-1

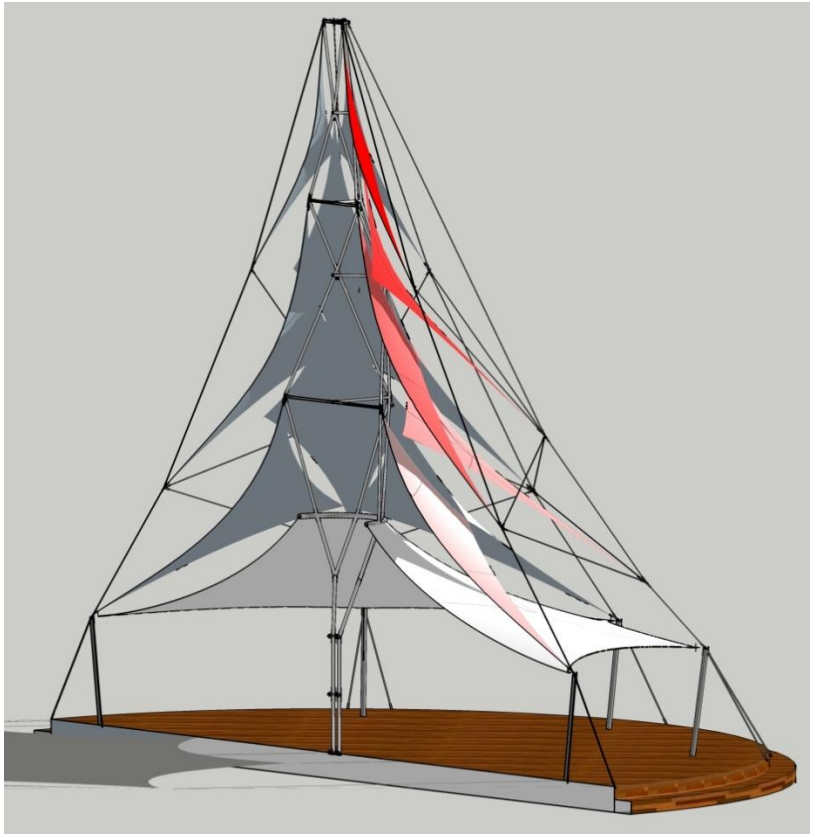


Fig. 58 - Vertical cross-section 2-2

MATERIALS USED

				N/mm2 ultimate	N/mm2 yield		
PROFILE	**MATERIAL**	**EN 10027-1**	**EN 10027-2**	**STRENGTH**	**STRENGTH**	**CORROSION PROTECTION TYPE**	**DIN EN NORM**
STEEL TUBES	**STEEL**	**S355JR**	**1.0038**	**490-630**	**355**	**GALVANIZED**	**10025**
BOLTS	**STEEL**	**S355JR**	**1.0570**	**490-630**	**355**	**GALVANIZED**	**10025**
FITTINGS	**STAINLESS STEEL**		**1.4401**				
CABLES	**STEEL**			**1570**		**GALVANIZED**	
MEMBRANE	**PES+PVC**						

Material	$D_Q = E_Q$	
	Kette [KN/m]	Schuss [KN/m]
PVC-beschichtes Polyestergewebe	800-1200	500-800
PTFE-beschichtetes Glasfasergewebe	1500-4000	800-1500

Materialtyp	Flächengewicht nach DIN 55352 [g/m²]	Zugfestigkeit Kette/Schuss nach DIN 53354 [N/50mm]	Bruchdehnung Kette/Schuss nach DIN 53354 [%]	Weiterreiß-festigkeit Kette/Schuss nach DIN 53363 [N]
I	800	3000/ 3000	15/20	310/350
II	900	4400/ 3950	15/20	520/580
III	1050	5750/ 5100	15/25	800/950
IV	1300	7450/ 6400	15/30	1100/1400
V	1450	9800/ 8300	20/30	1800/1600
Brandschutzklasse nach DIN 4102			B1	
Knickbeständigkeit			Sehr gut	
UV-Beständigkeit			gut	
Transluzenz [%], Standardbereich			-20	
Lebenserwartung [Jahre]			>20	

Tab. 4.5 *Kenndaten Polyestergewebe, PVC-beschichtet*

STATICAL CALCULATION ACCORDING WITH

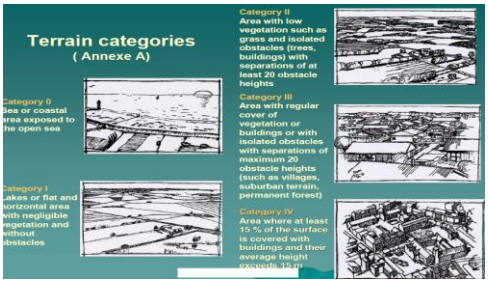
NORM SR **EN 1191-1-3**	**snowloads**
NORM SR **EN 1191-1-4**	**windloads**

SOFTWARE USED

FORMFINDER	**Formfinding**
EASY 10	**Analysis membranstructure**
RSTAB 7	**Analysis primarystructure**

Windload:

basic velocity pressure	$q_b = 0.50 kN/m^2$
wind velocity	$v_{b,0} = 28.3$ m/s = 101.8km/h
terrain category	4
canopy blockage	1



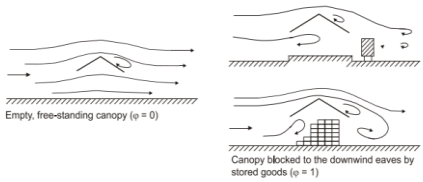


Figure 7.15 — Airflow over canopy roofs

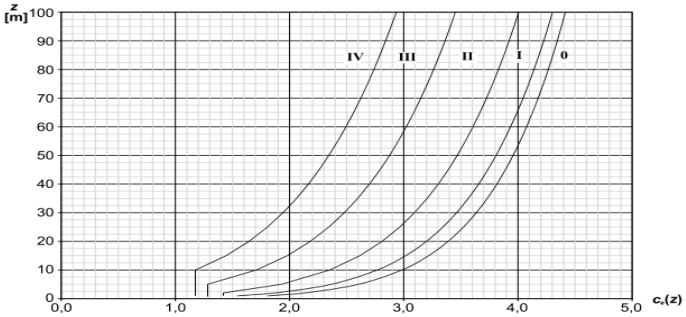


Figure 4.2 — Illustrations of the exposure factor $c_r(z)$ for c_0=1,0, k_r=1,0

peak velocity pressure: $q_b = q_b \times c_{e(z)} = 0.5 \times 1.5 = 0.75\ kN/m^2$

Snowload:

Snow load for Constanta, Romania: $s_{ik} = 2kN/m^2$

Load combinations

For a rough estimation of primary structure two possible load combinations was created:

1. Vant (Wind)

For cone - DEAD LOAD x 1.35 + 100%[10] x WIND LOAD (+*x direction*) x 1.50

For leafs - DEAD LOAD x 1.35 + 60%[11] x WIND LOAD (+*x direction*) x 1.50

2. Zapada (Snow)

For cone - DEAD LOAD x 1.35 + SNOW LOAD x 1.50

For leafs - DEAD LOAD x 1.35 + 60% x WIND LOAD (+*x direction*) x 1.50

[10] 100% because membrane for cone is a closed material
[11] 60% because a mesh material will be used for leaves

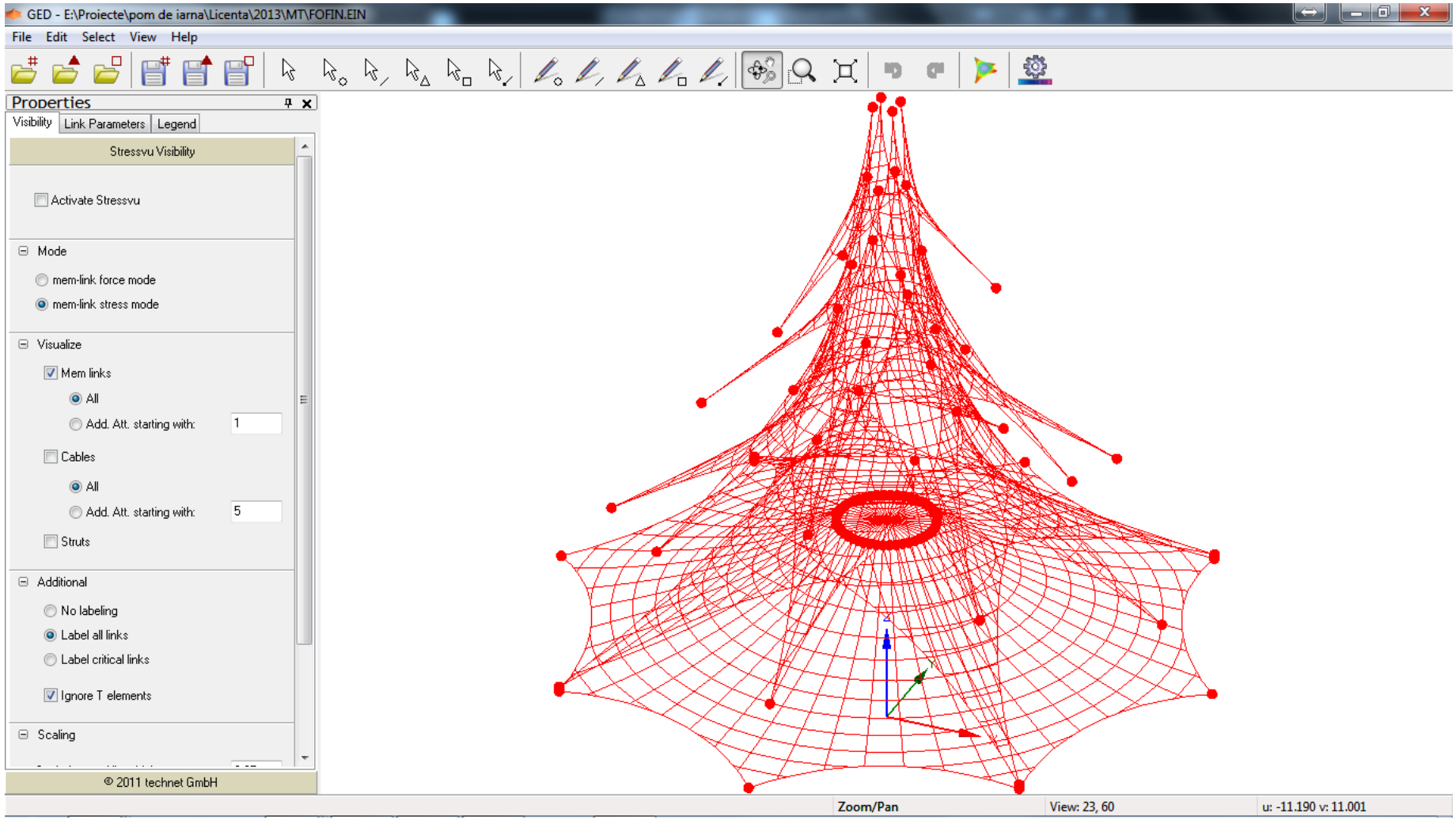


Fig. 60 - View of Formfinder imported model

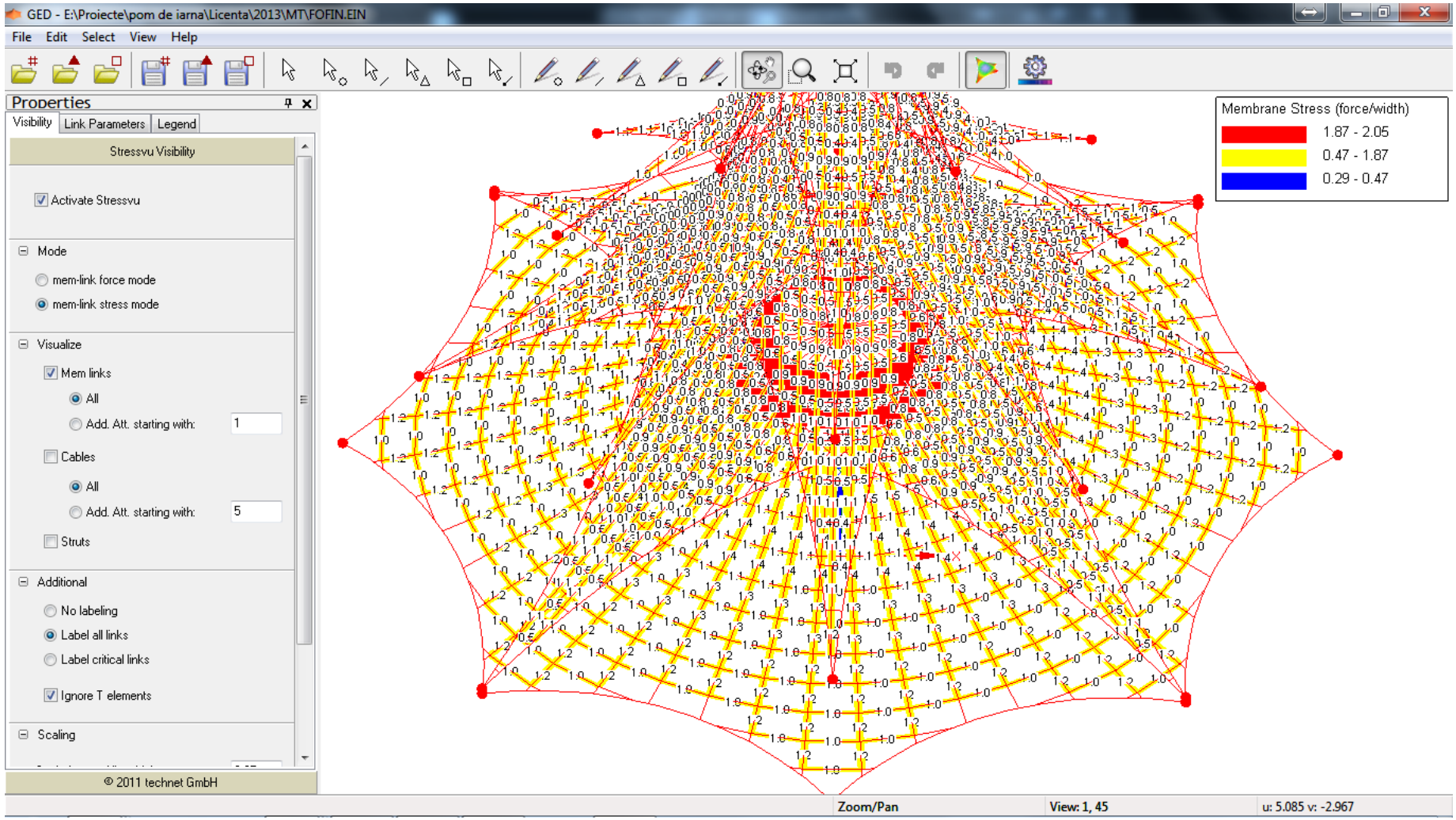


Fig. 61 - View of membrane stress in formfinding situation

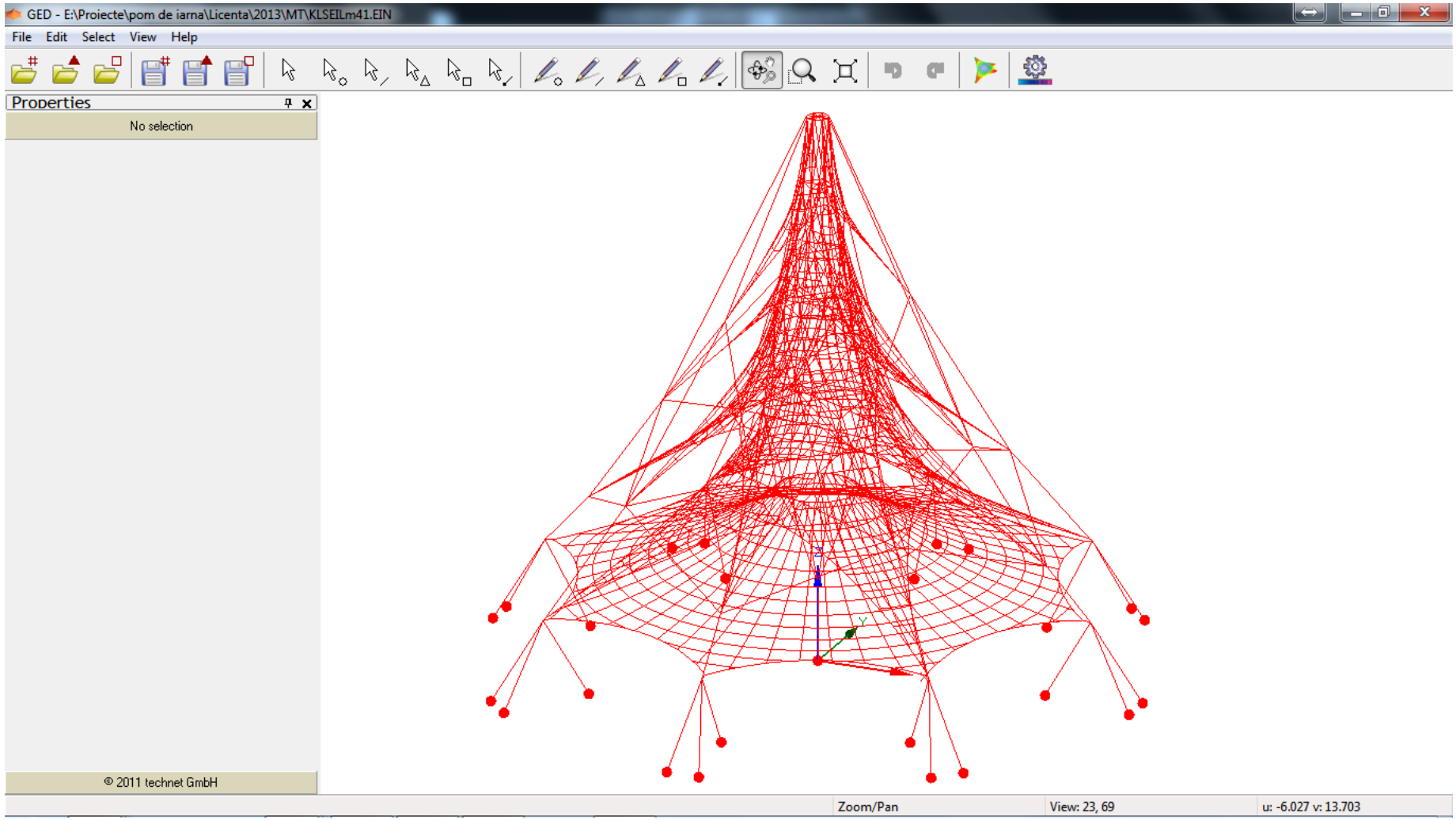


Fig. 62 - View of imported primary structure

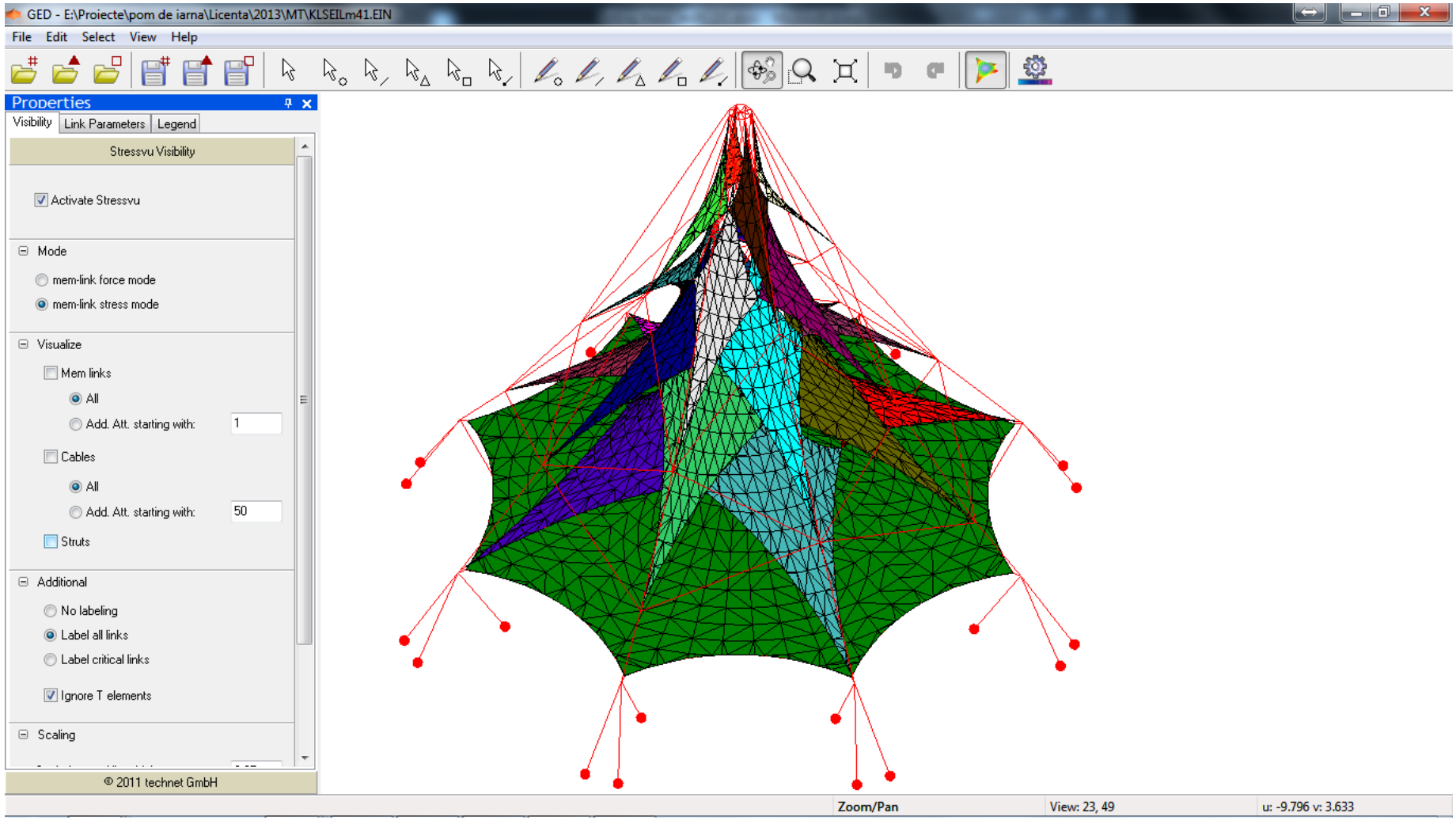


Fig. 63 - View of membrane parts

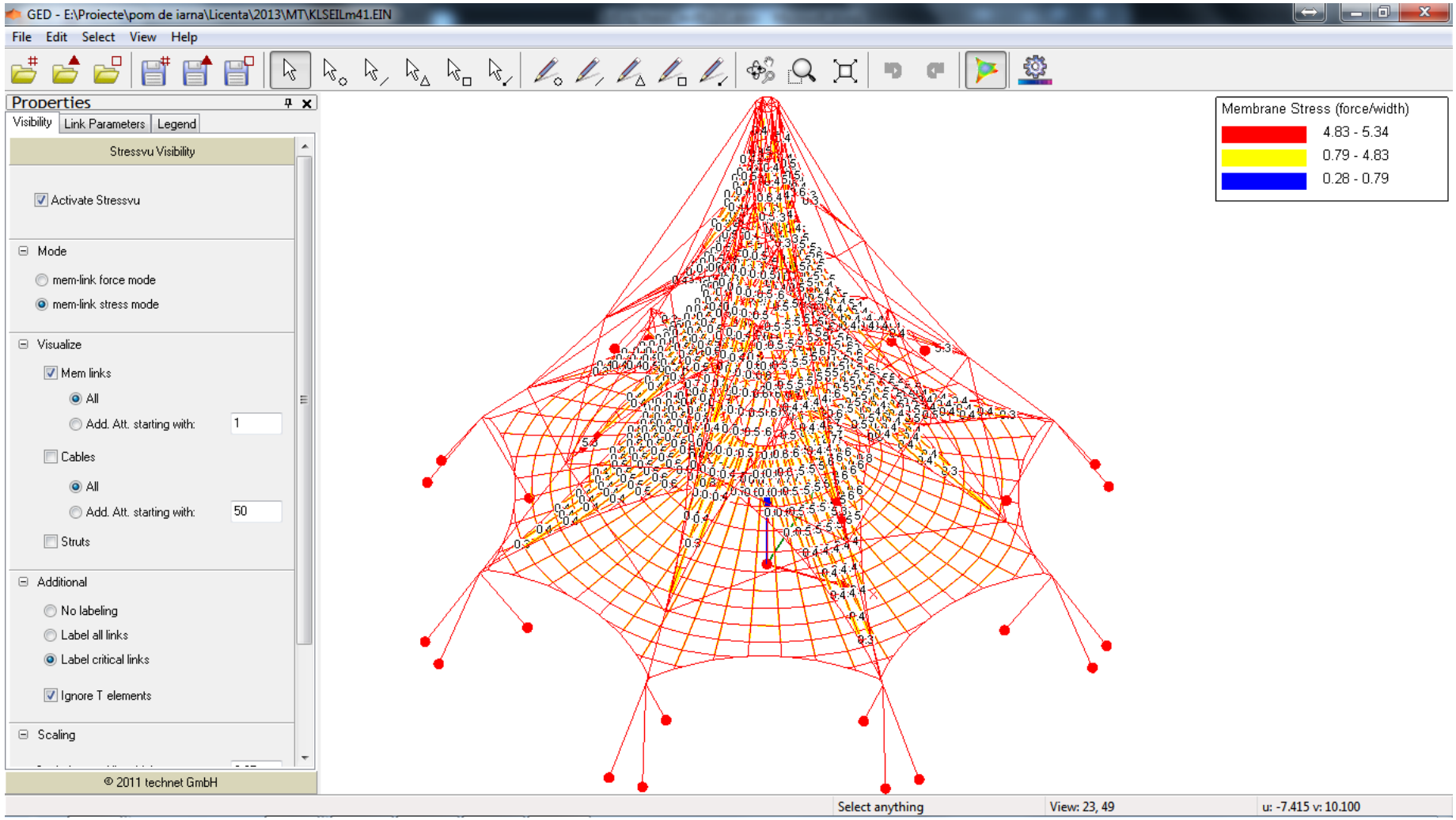


Fig. 64 -View of membrane stress in statical module

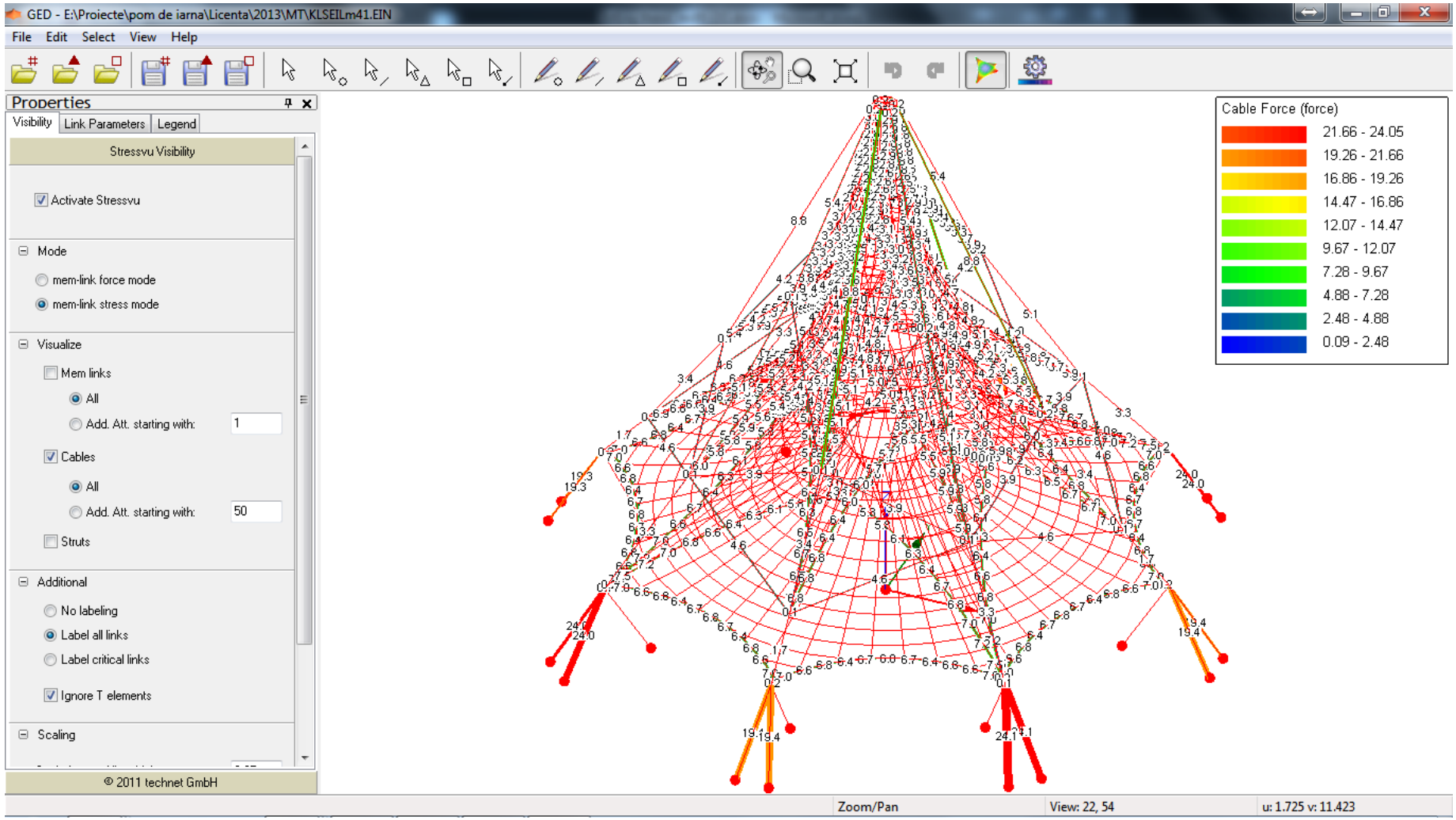


Fig. 65 - View of cable force in statical module

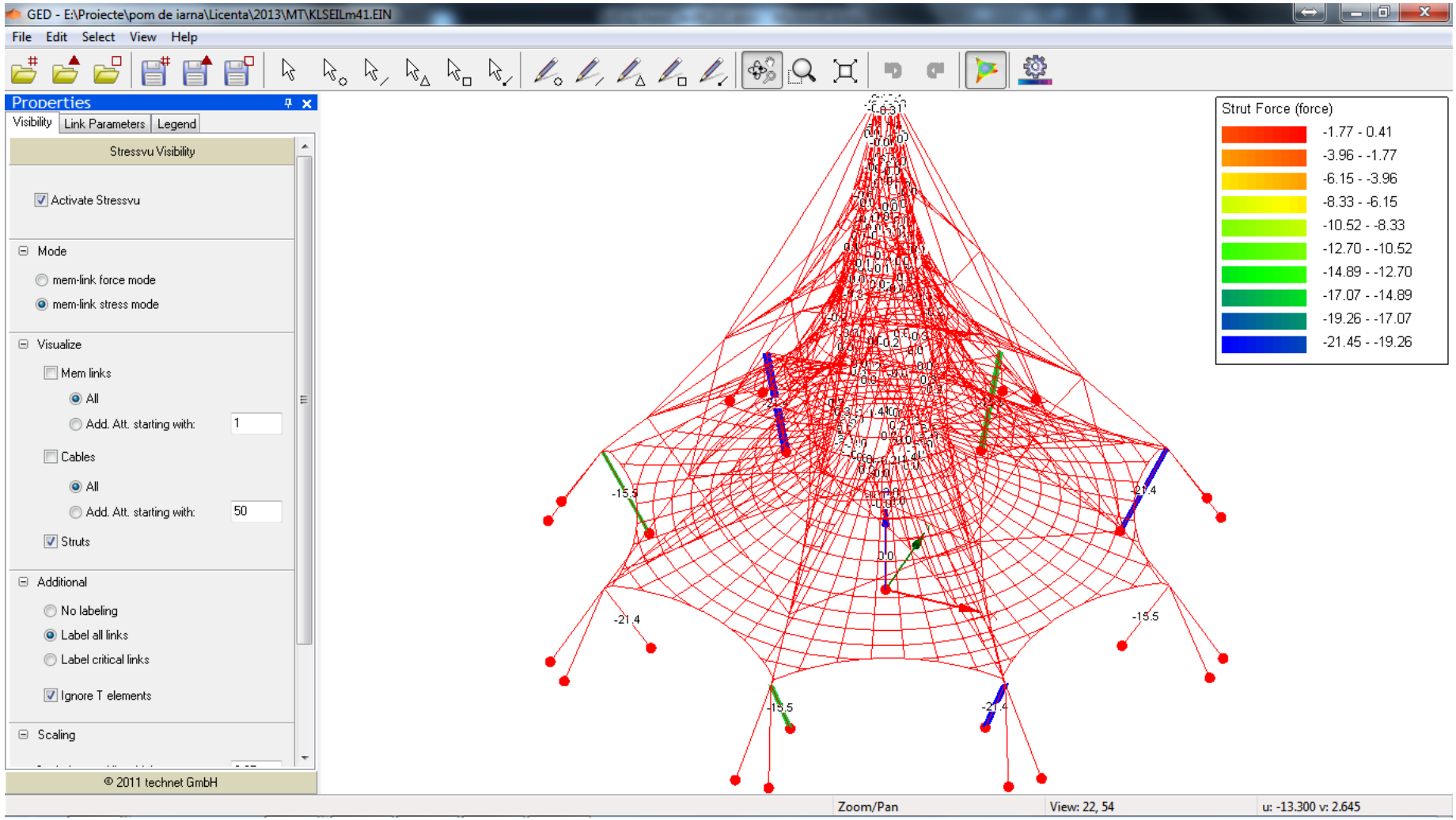


Fig. 66 - View of strut force in statical module

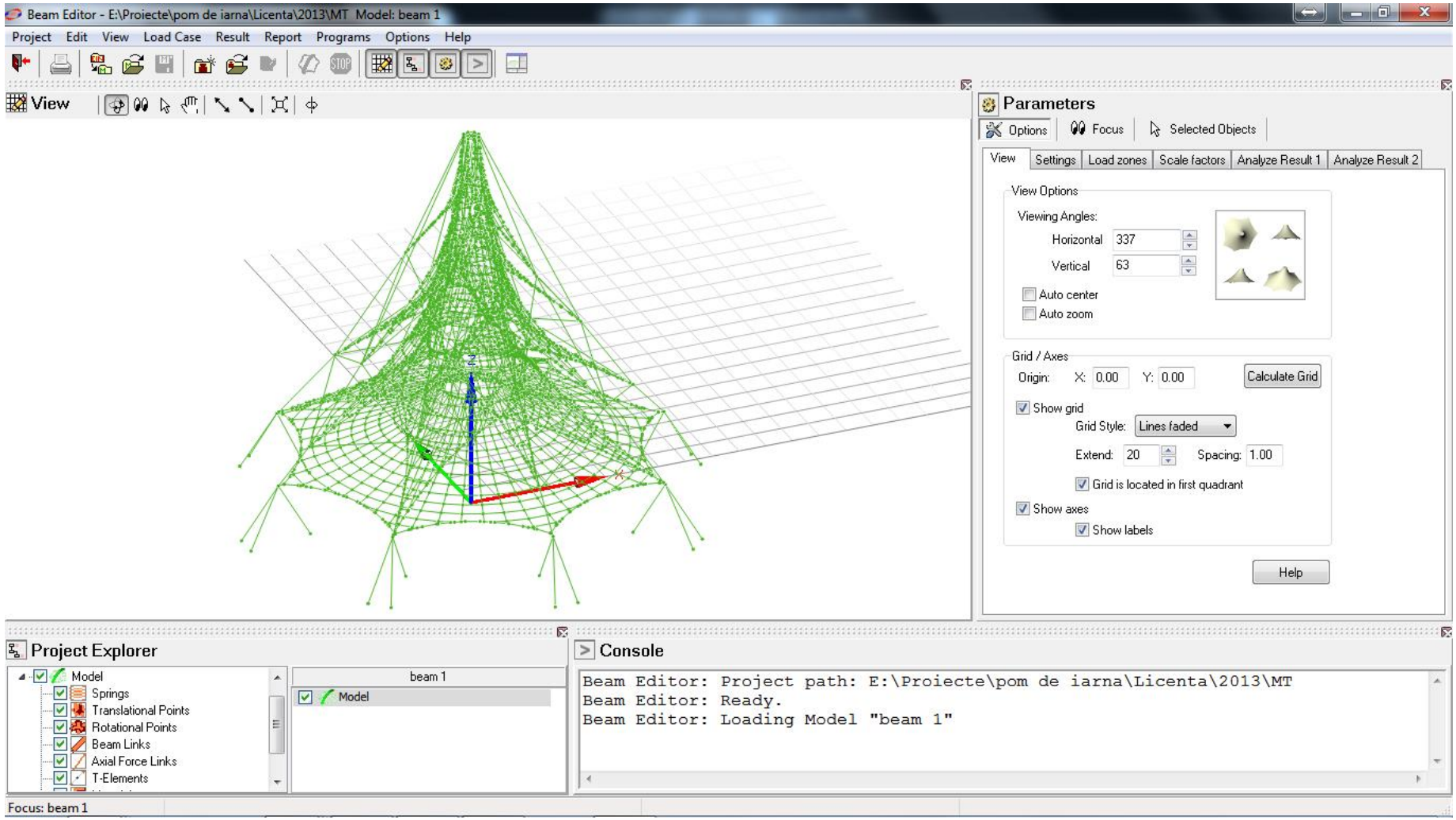


Fig. 67 - View of imported model in Beam

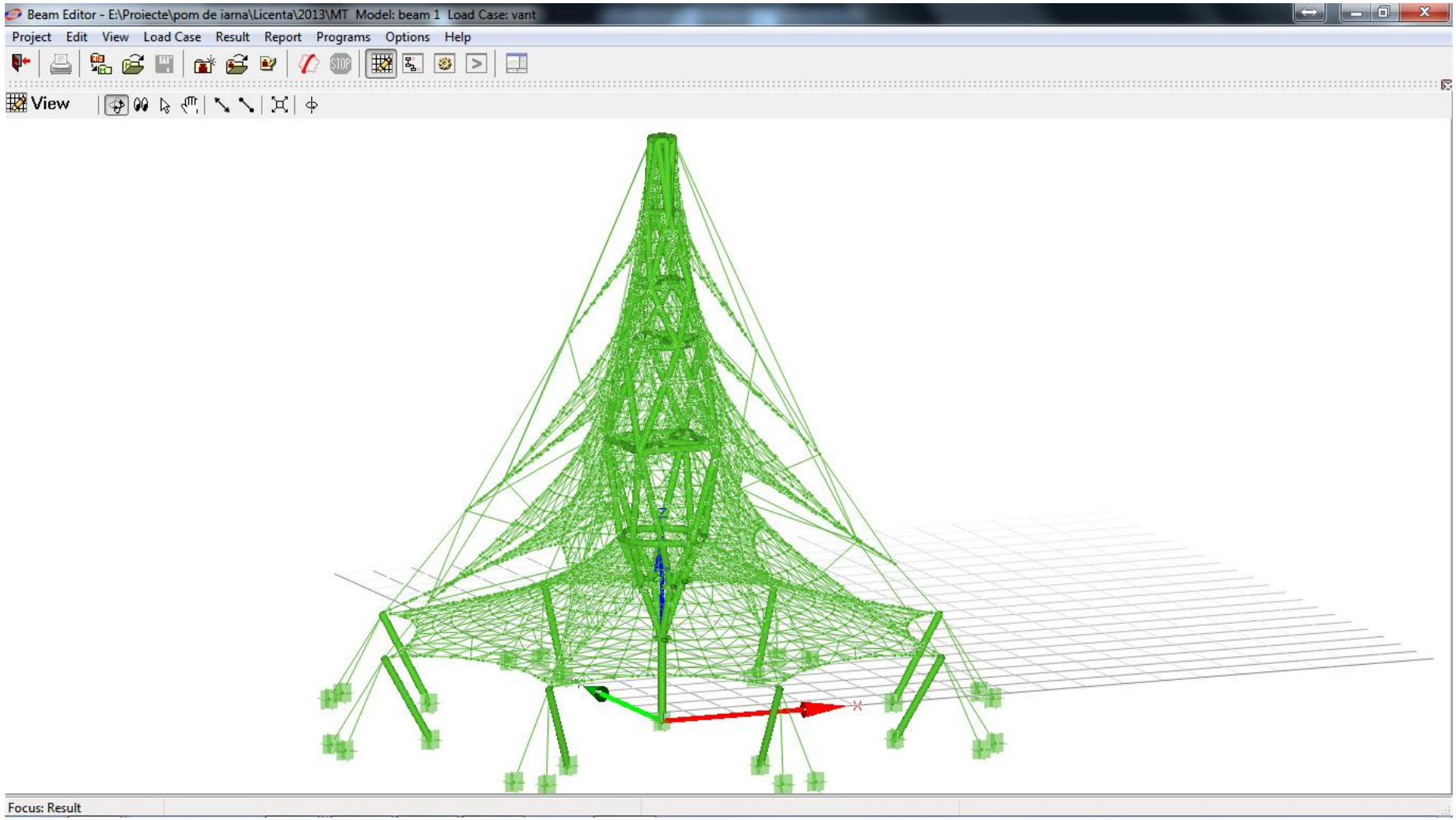


Fig. 68 - View of primary structure details

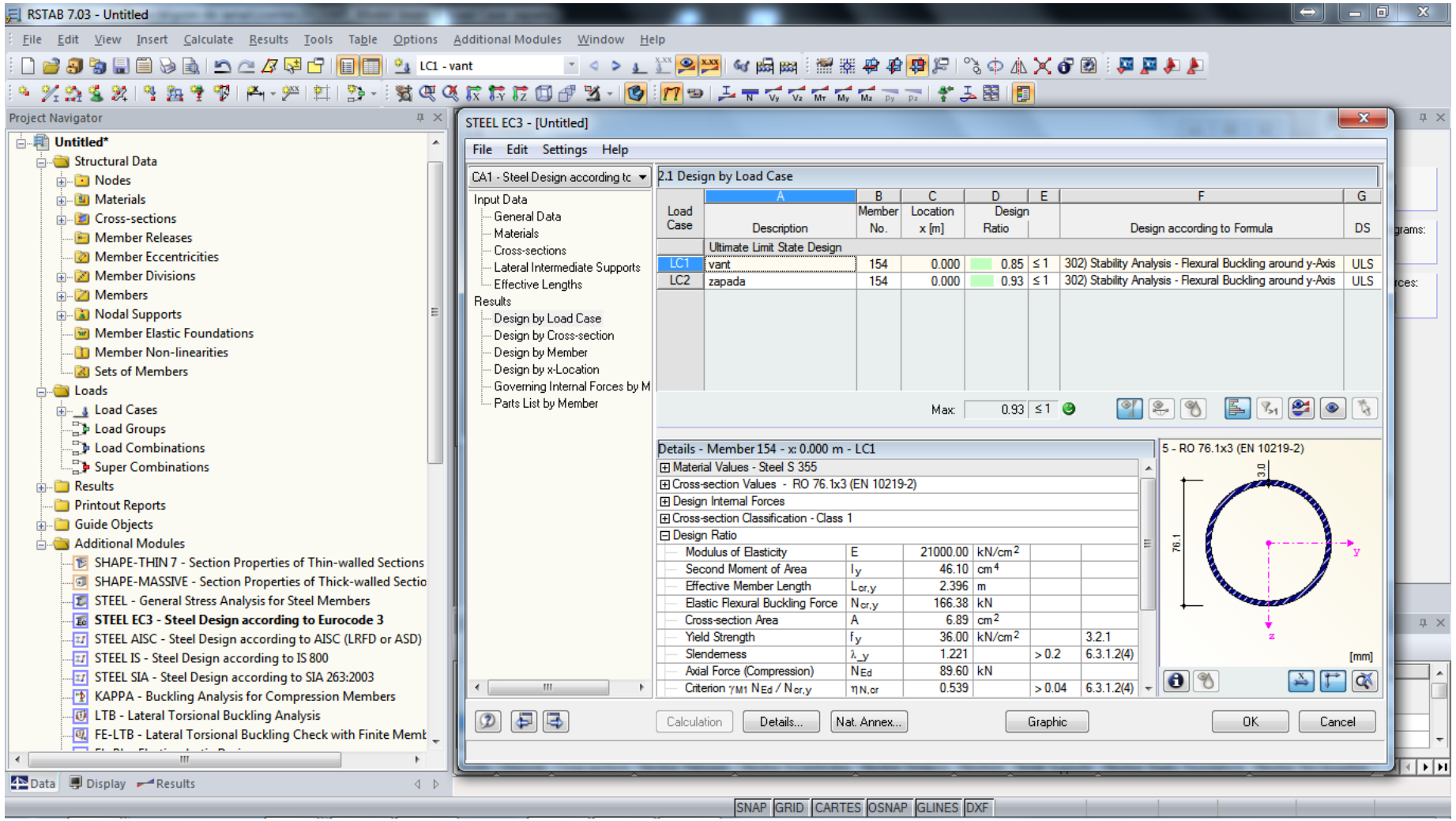


Fig. 69 - View of EC3 compliance of structure

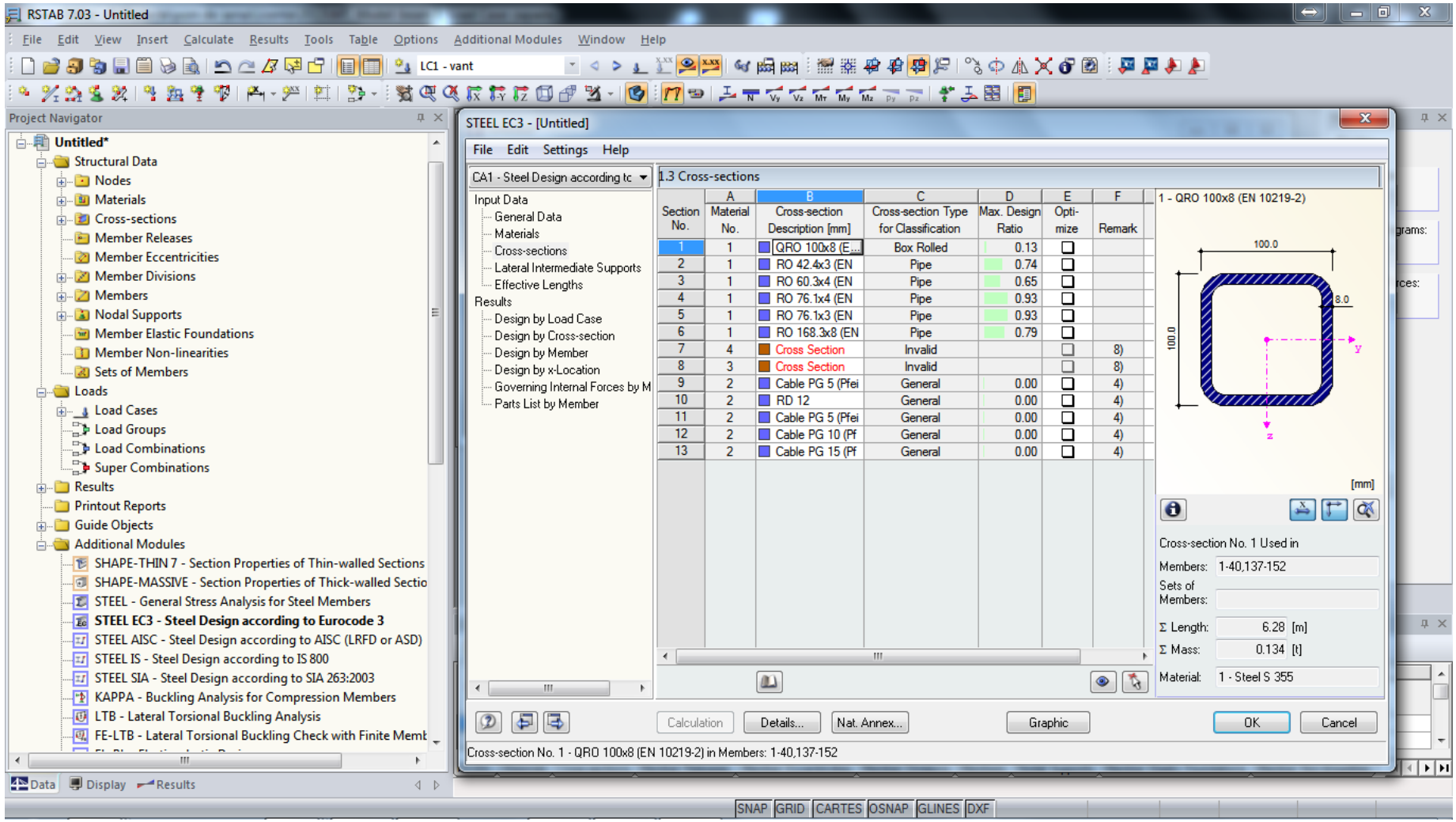


Fig. 70 - View of cross-section maximum design ratio

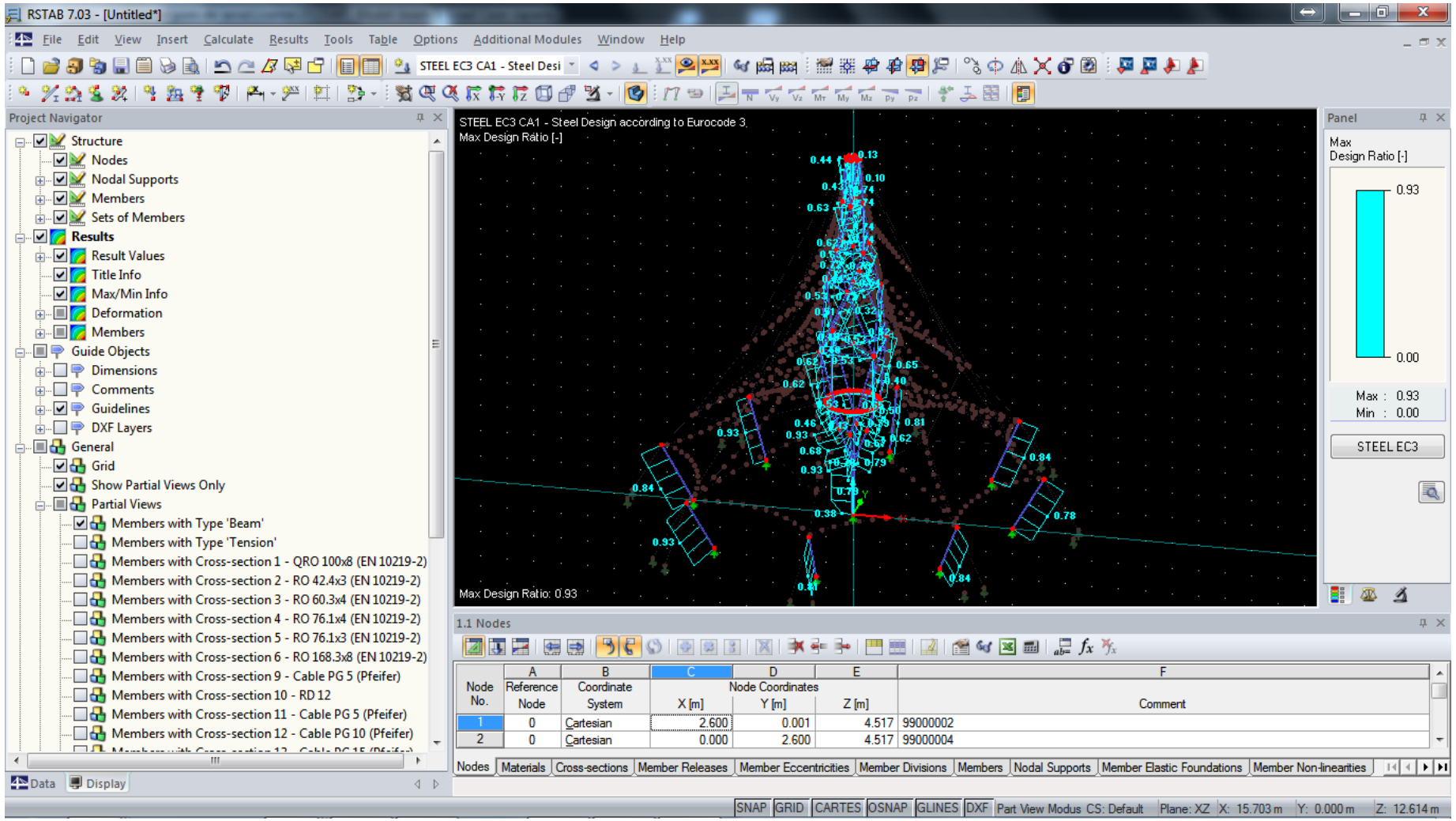


Fig. 71 - Graphical view of steel design according to Eurocode3 Maximum Design Ratio

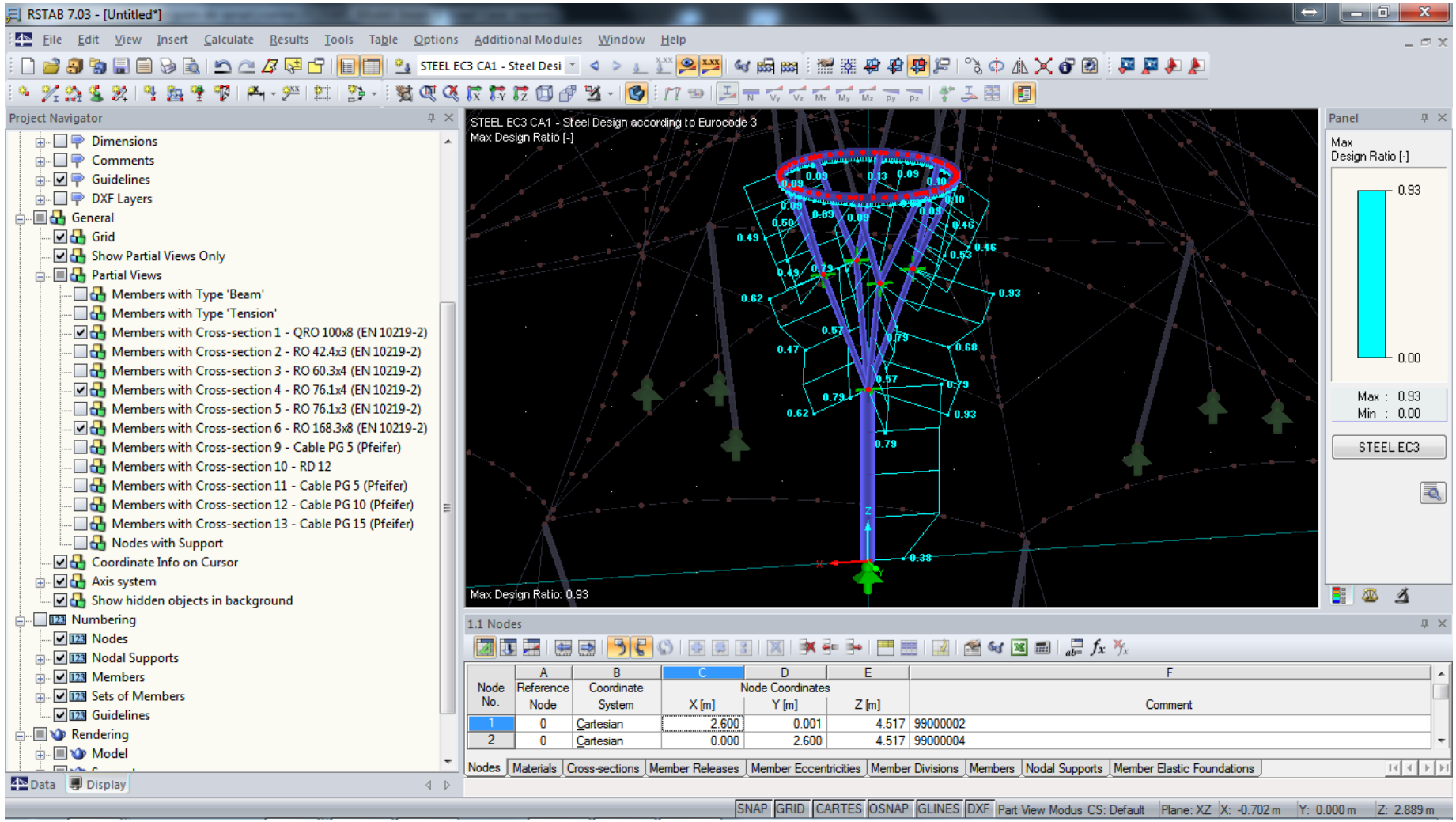


Fig. 72 - Graphical view of steel design according to Eurocode3 Maximum Design Ratio - Central mast detail

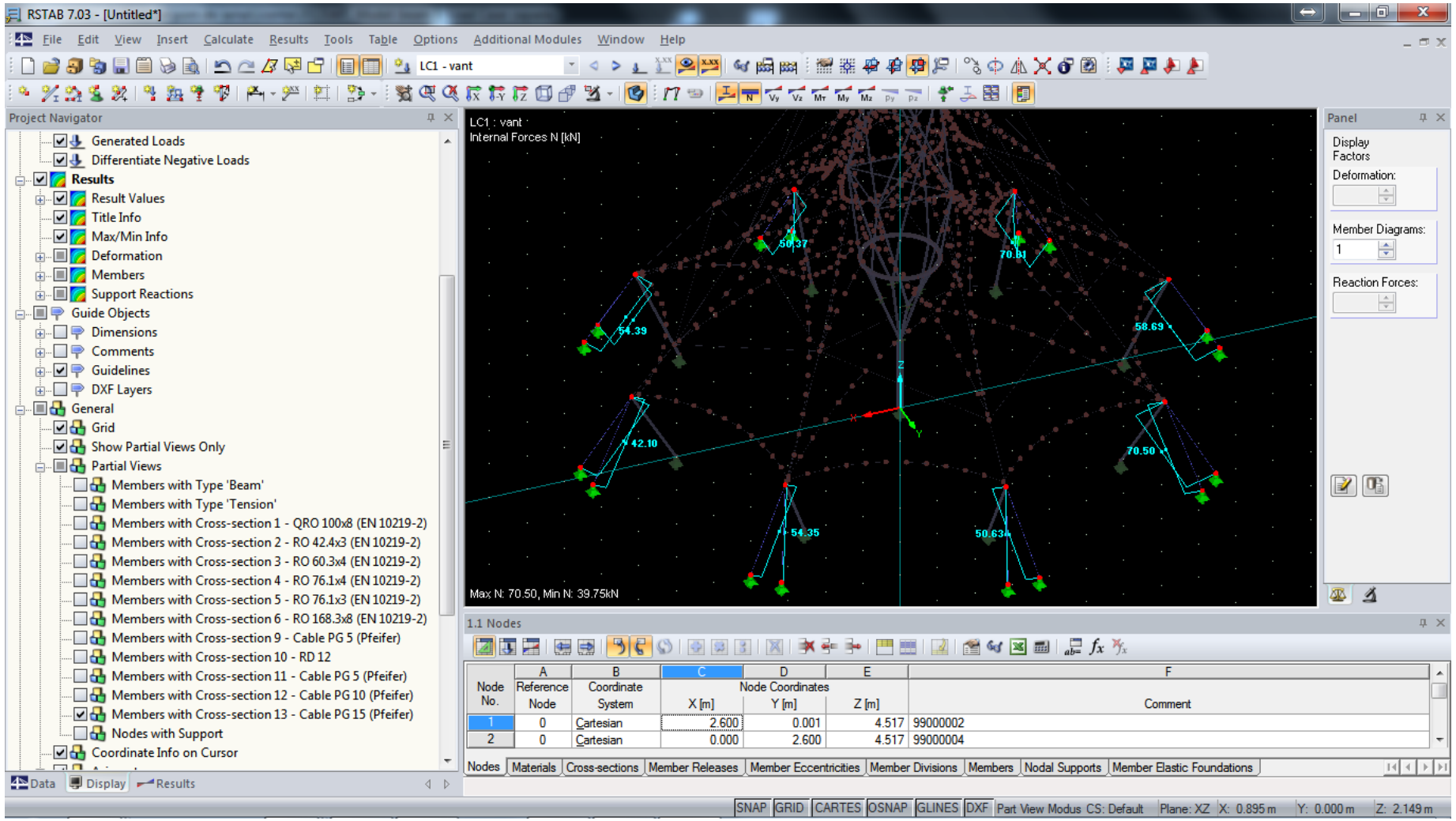


Fig. 73 - View of maximum internal forces of strut cables

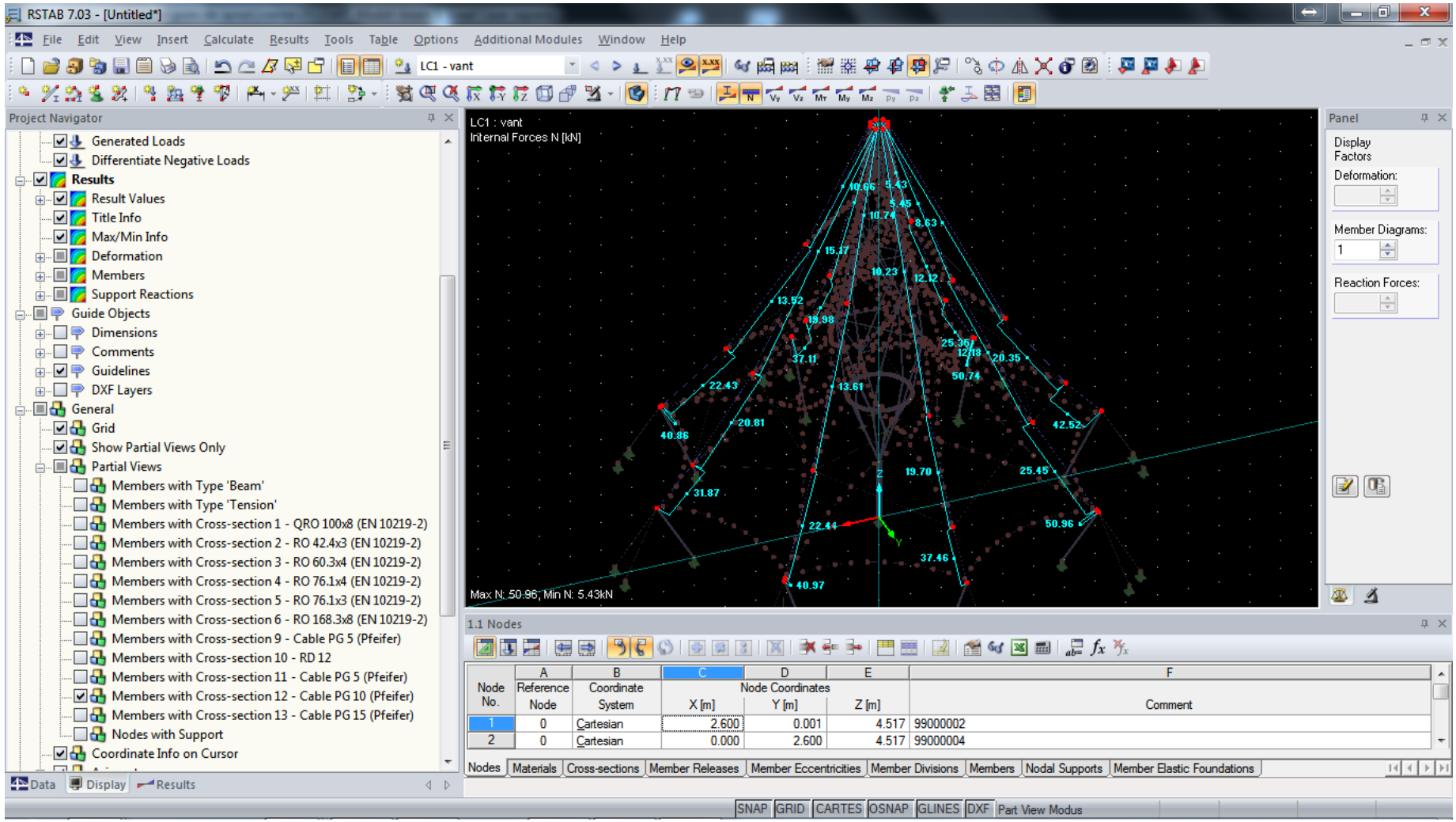


Fig. 74 -View of maximum internal forces in primary cables

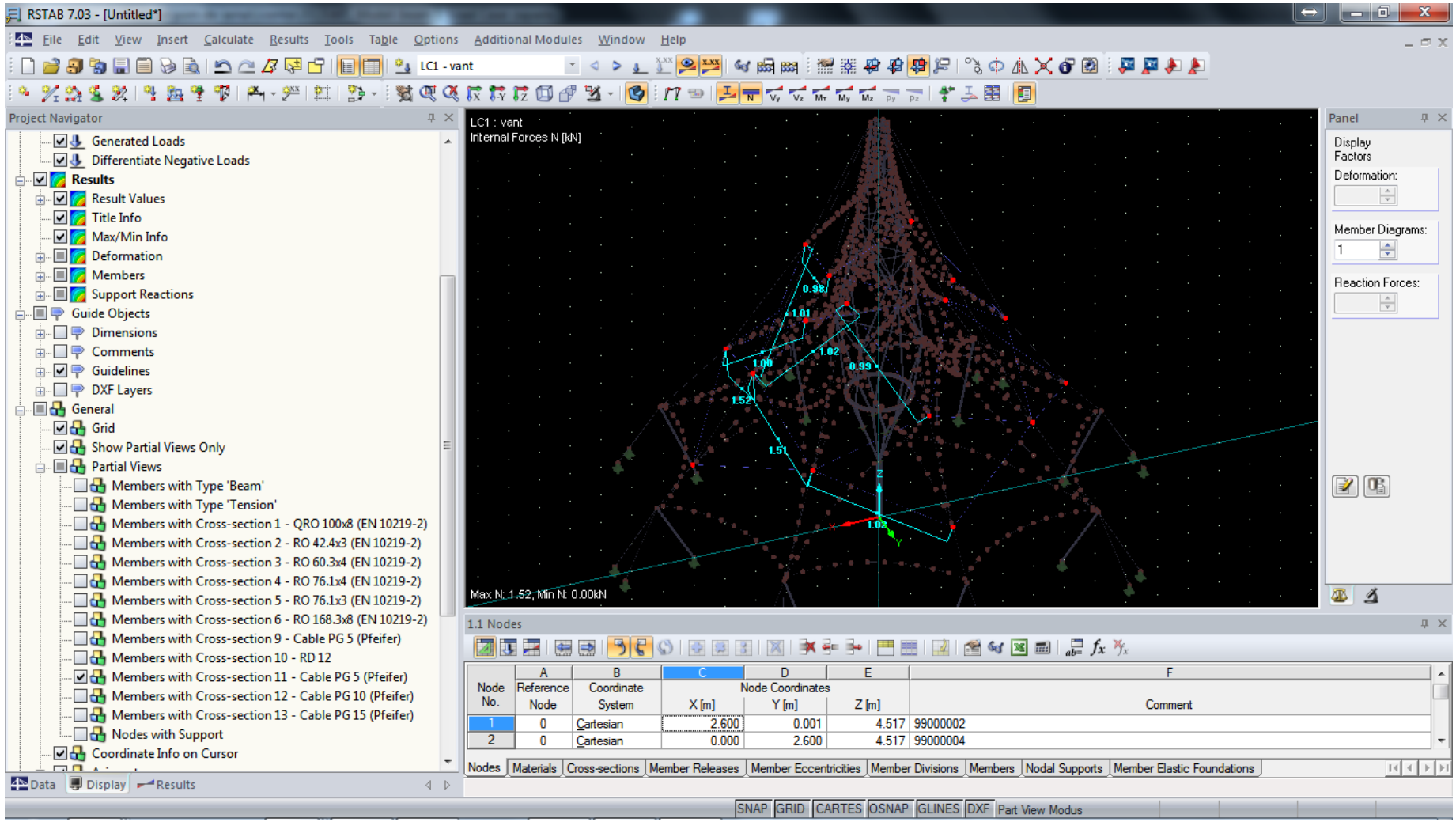


Fig. 75 - View of maximum internal forces in secondary cables

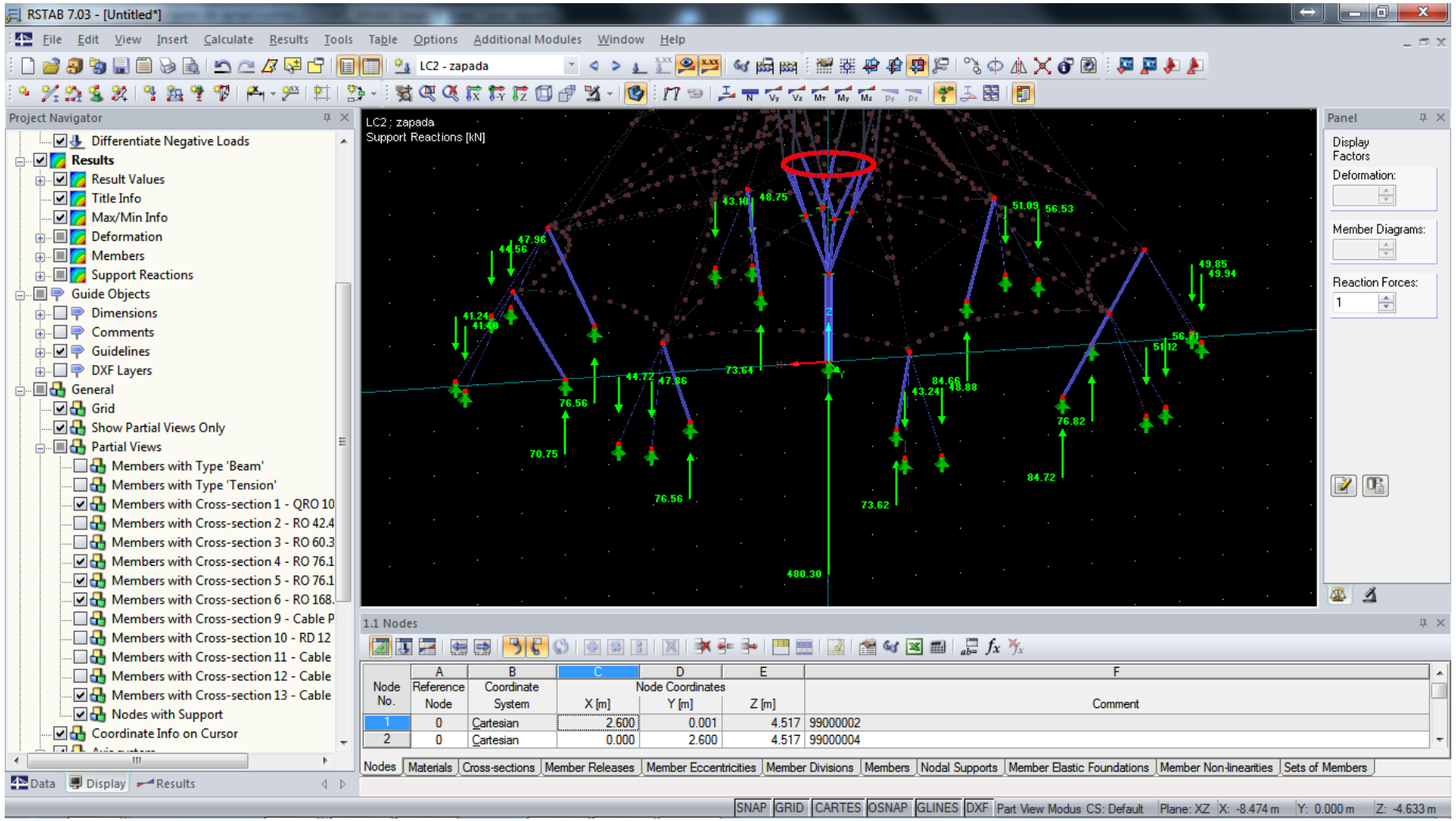


Fig. 76 - View of maximum support reactions - snow load combination

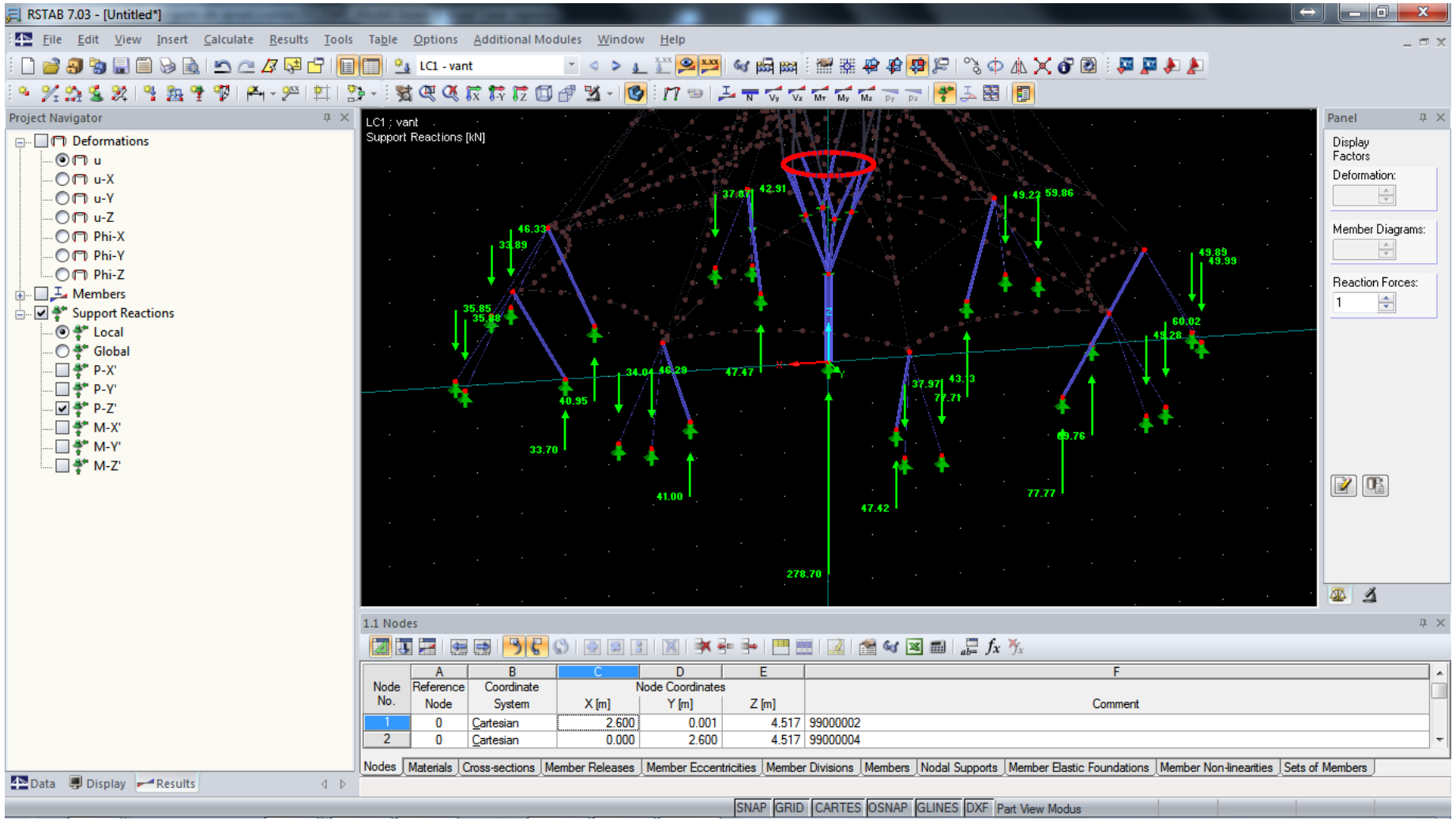


Fig. 77 - View of maximum support reactions - wind load combination

6. Results

In order for the structure to comply with Eurocode 3, some changes had to be made. First of all, the inclination of the struts was optimized (for lighter tubes), giving up usable space under the cone in favor of dimensioning. The inclination is up to 30 degrees and each strut has two cables. The lower central mast, which was initially a composed section of four round tubes, one for each branch, was exchanged for a single round tube with larger diameter given that, following statical calculation iteration, the four initial tubes diameters were oversized and no free space was left between them.

Fig. 79 - Before statical calculation

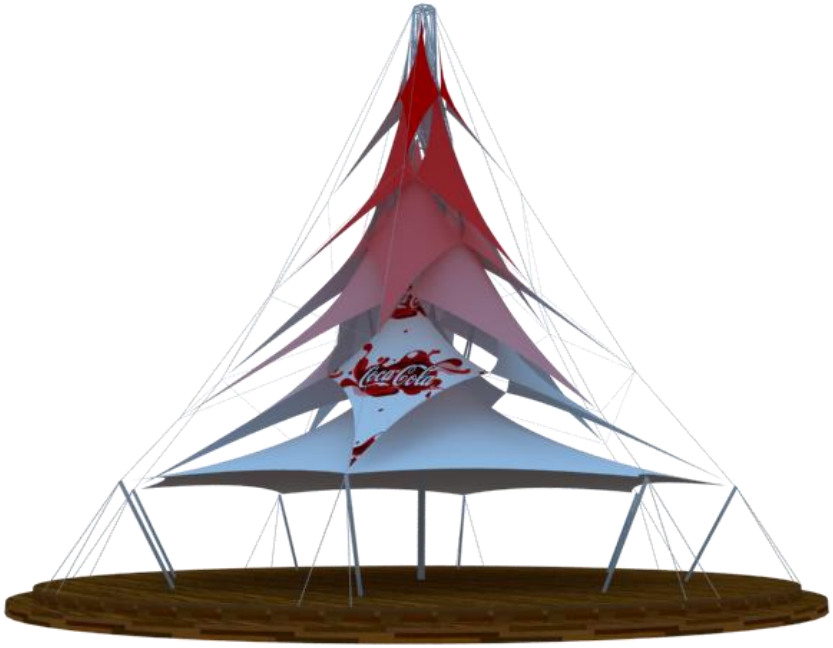


Fig. 78 - After statical calculation

Following statical calculations, the main elements of the structure have been dimensioned, as follows:

Lower central mast:

- Base part Ø168.3x8mm
- Branches Ø76.1x4mm
- Top ring 100x100x8mm

Upper central mast:

- Part 1 Ø60.3x4mm
- Part 2 Ø42.4x3mm

Struts:

- Tube Ø76.1x3mm
- Cables Ø12mm (1x19)

Cable system:

- Primary cables Ø10mm (1x19)
- Secondary cables Ø5mm (1x19)

TOTAL WEIGHT OF STEEL STRUCTURE: 1013.01KG

Total length of cables per section:

- Ø5mm (1x19) = 105m
- Ø10mm (1x19) = 115m
- Ø12mm (1x19) = 40m

Total membrane surface:

- Overall membranes = 248.21m^2
- Valmex Structure Type II FR900 = 126.84 m^2 (51%)
- Tent mesh (advertising) = 121.37 m^2 (49%)

The advertising surface obtained (121.37 m^2) can be equated with 20 pieces of regular 2x3m billboard.

Result *TOTAL WEIGHT OF STEEL / EFFECTIVE MEMBRANE SURFACE*:

4.08kg/m^2

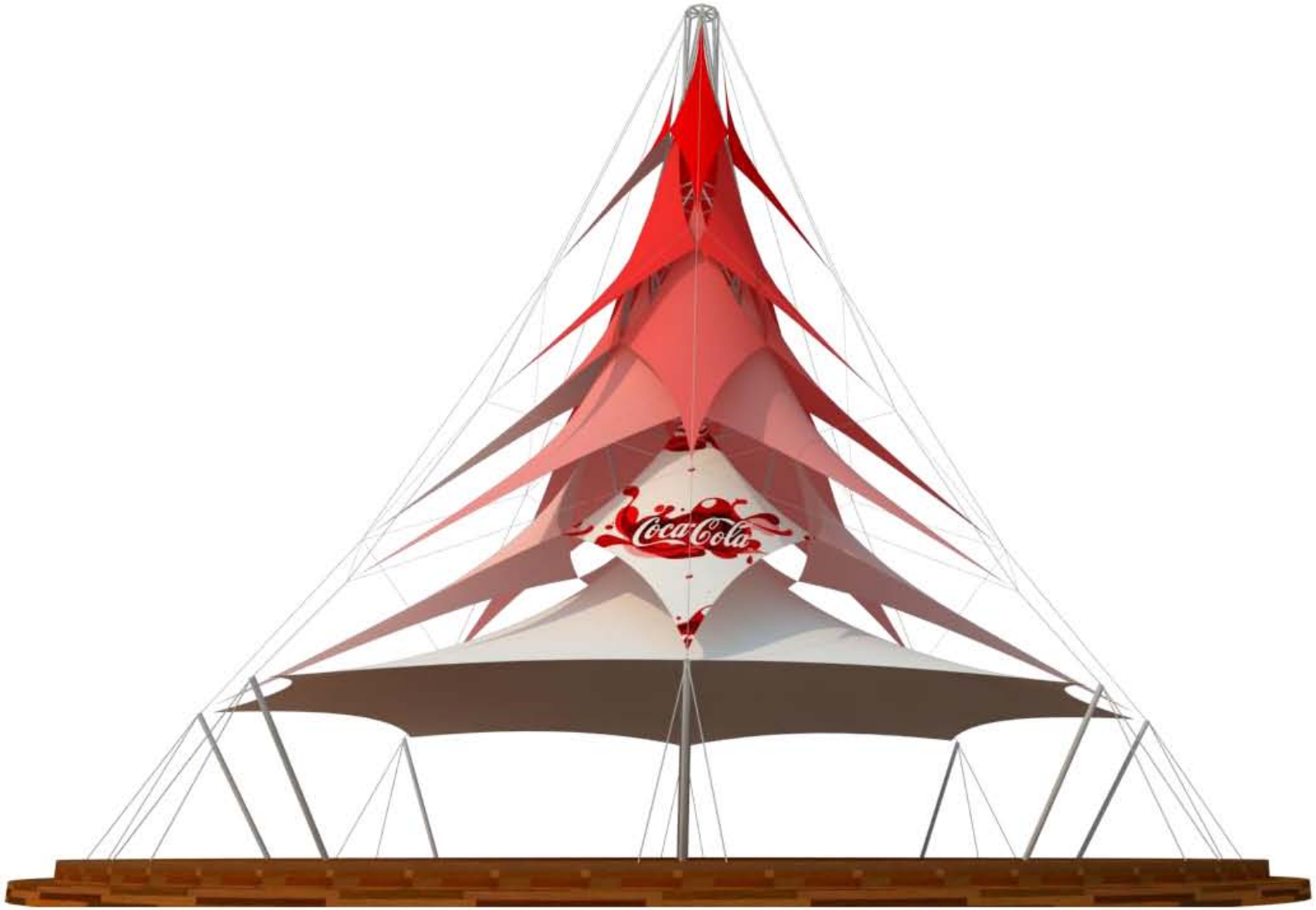


Fig. 80 – Urban billboard tower final form – side view

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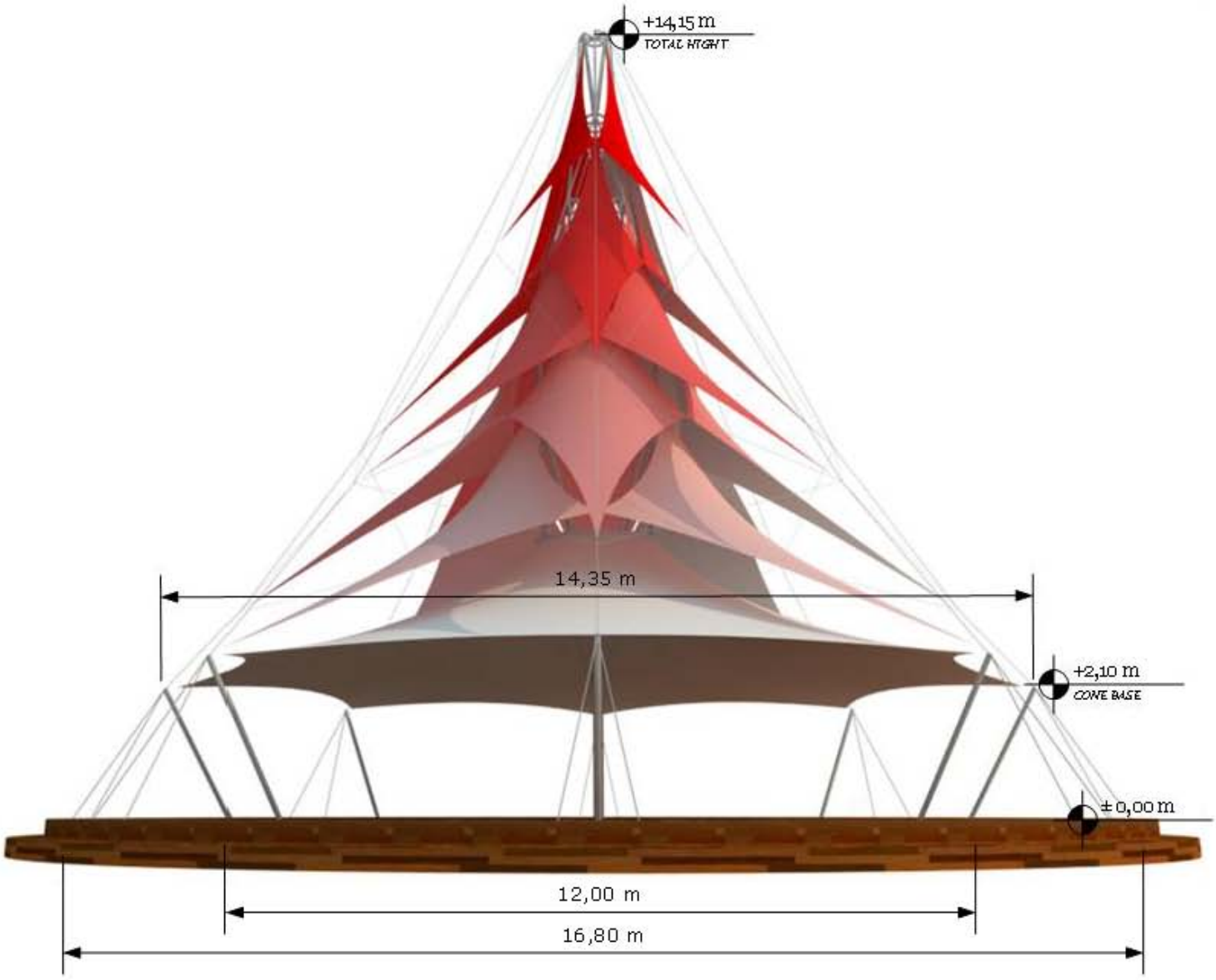

Fig. 81 - Urban billboard tower final form – side view

Fig. 82 - Urban billboard tower final form – 3D simulation view from above

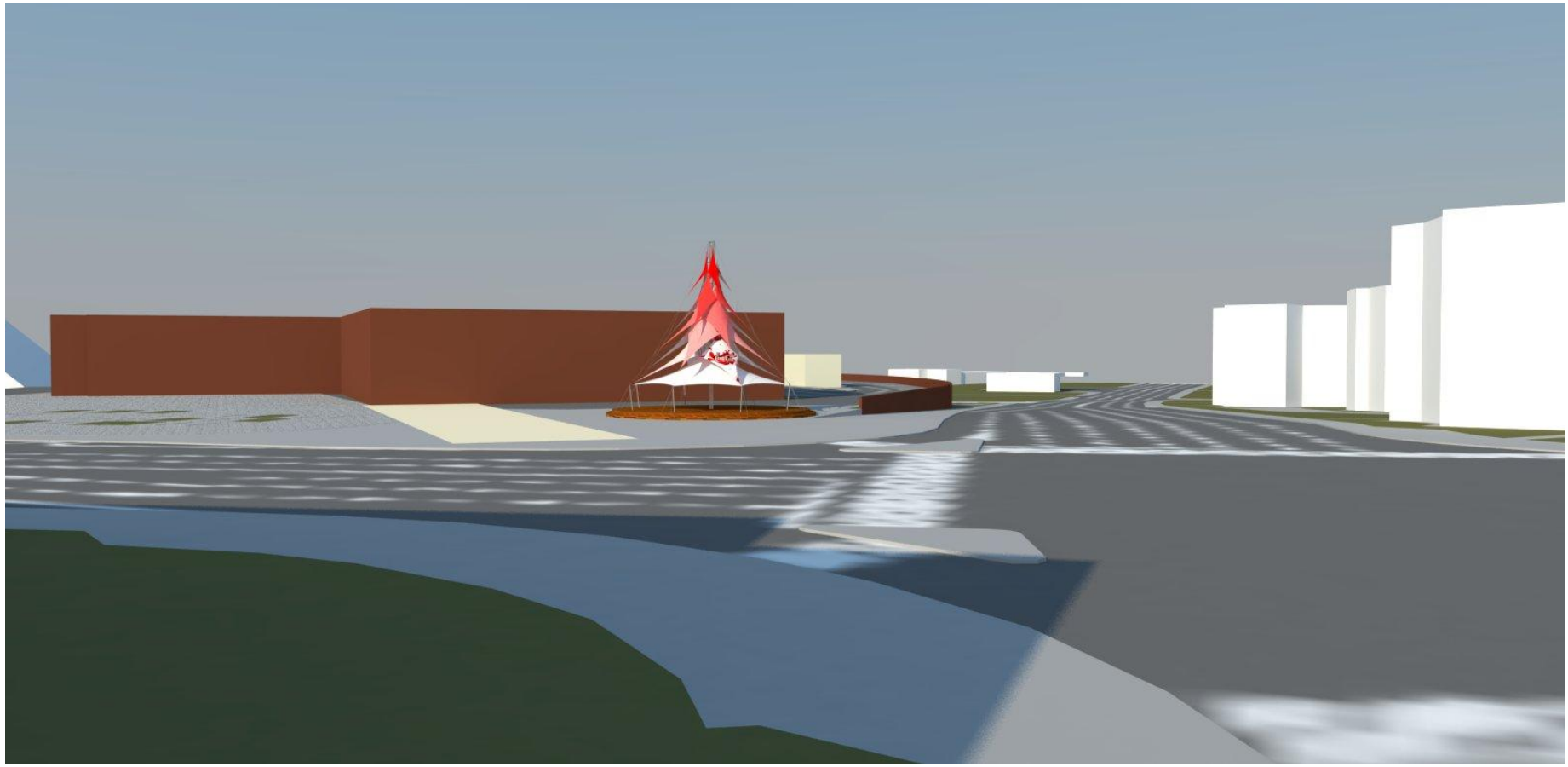

Fig. 83 - Urban billboard tower final form – 3D simulation people height view

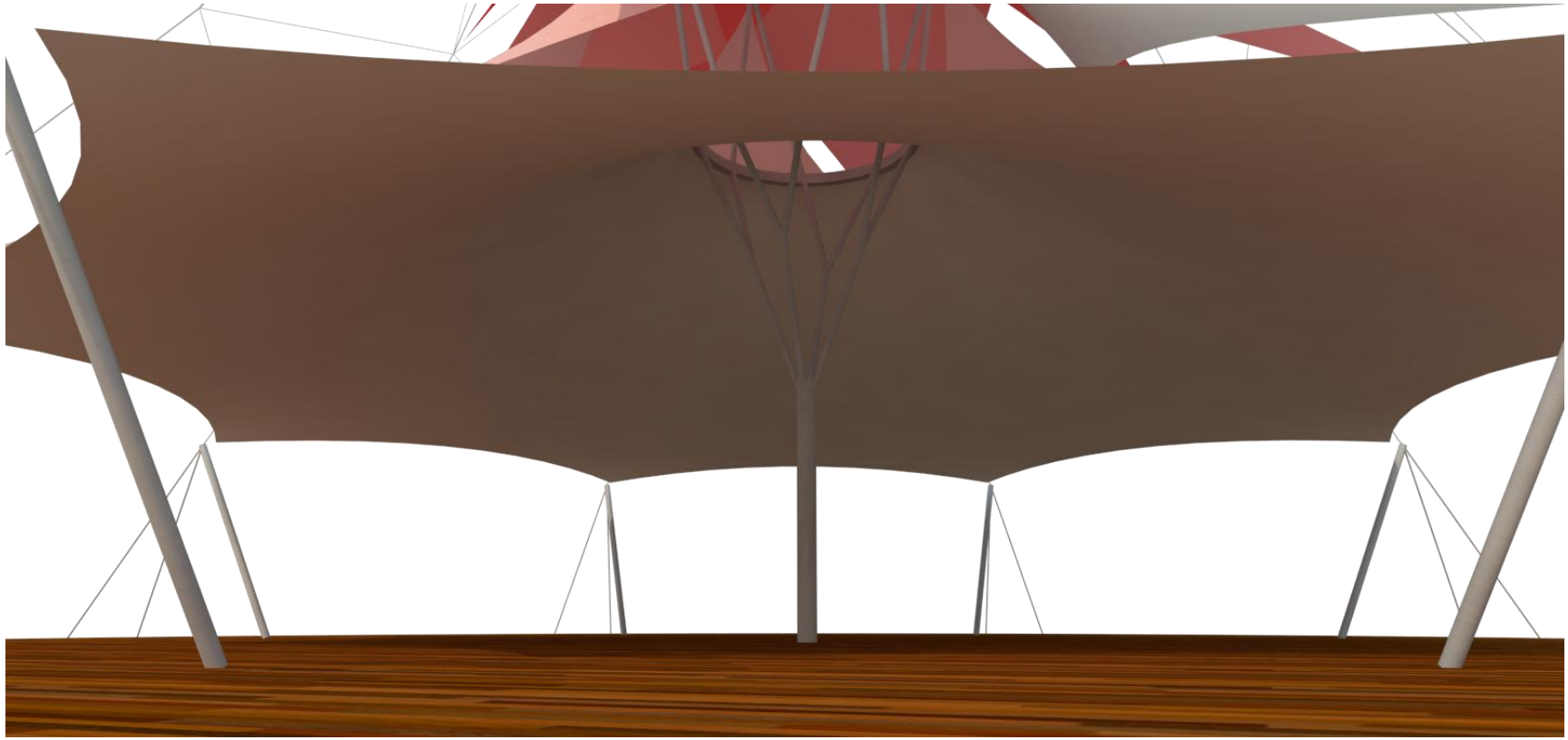

Fig. 84 – Urban billboard tower – bottom view and central mast detail

Fig. 85 –Urban billboard tower – top view

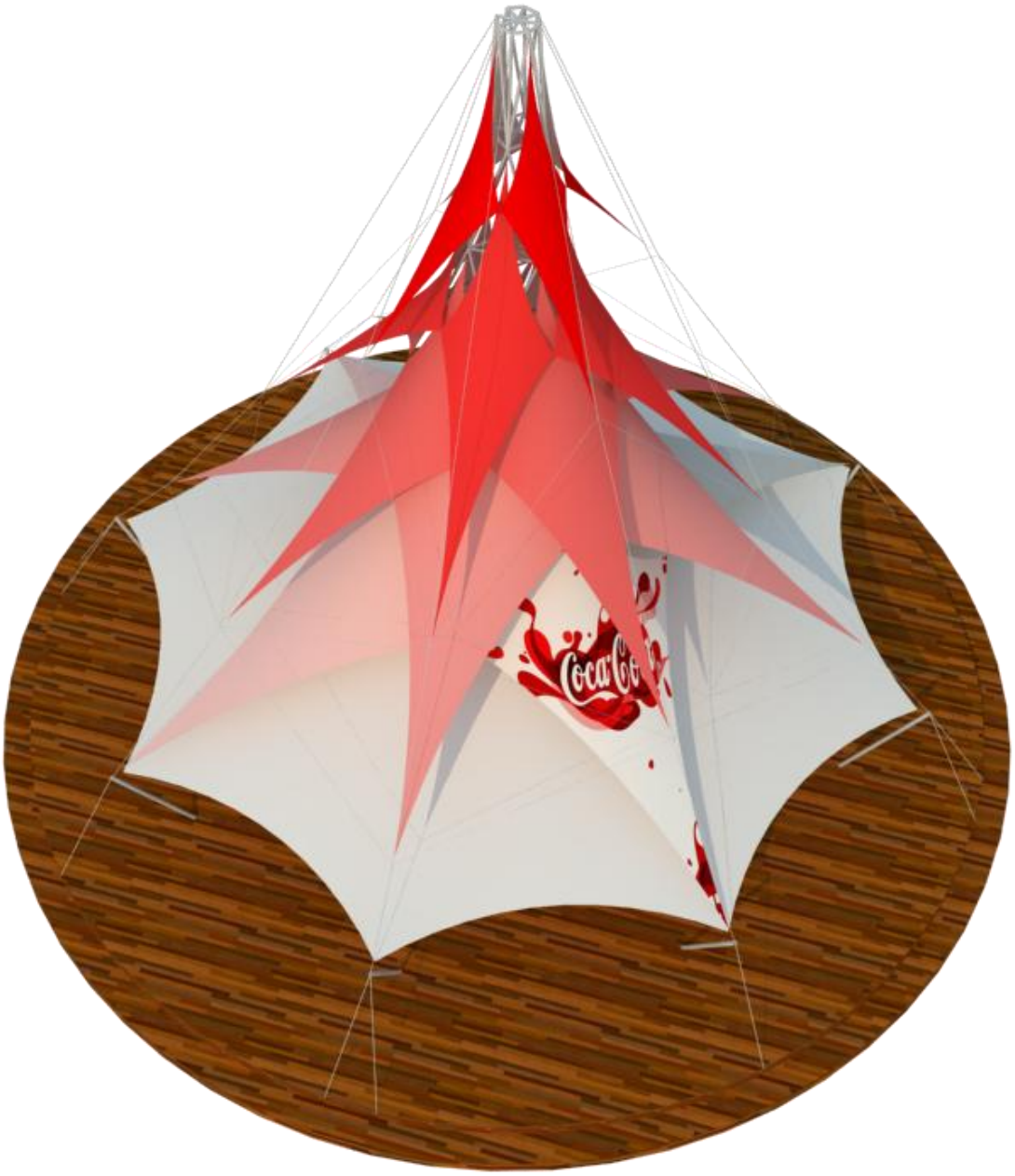

Fig. 86 – Urban billboard tower – optimized guide cable system

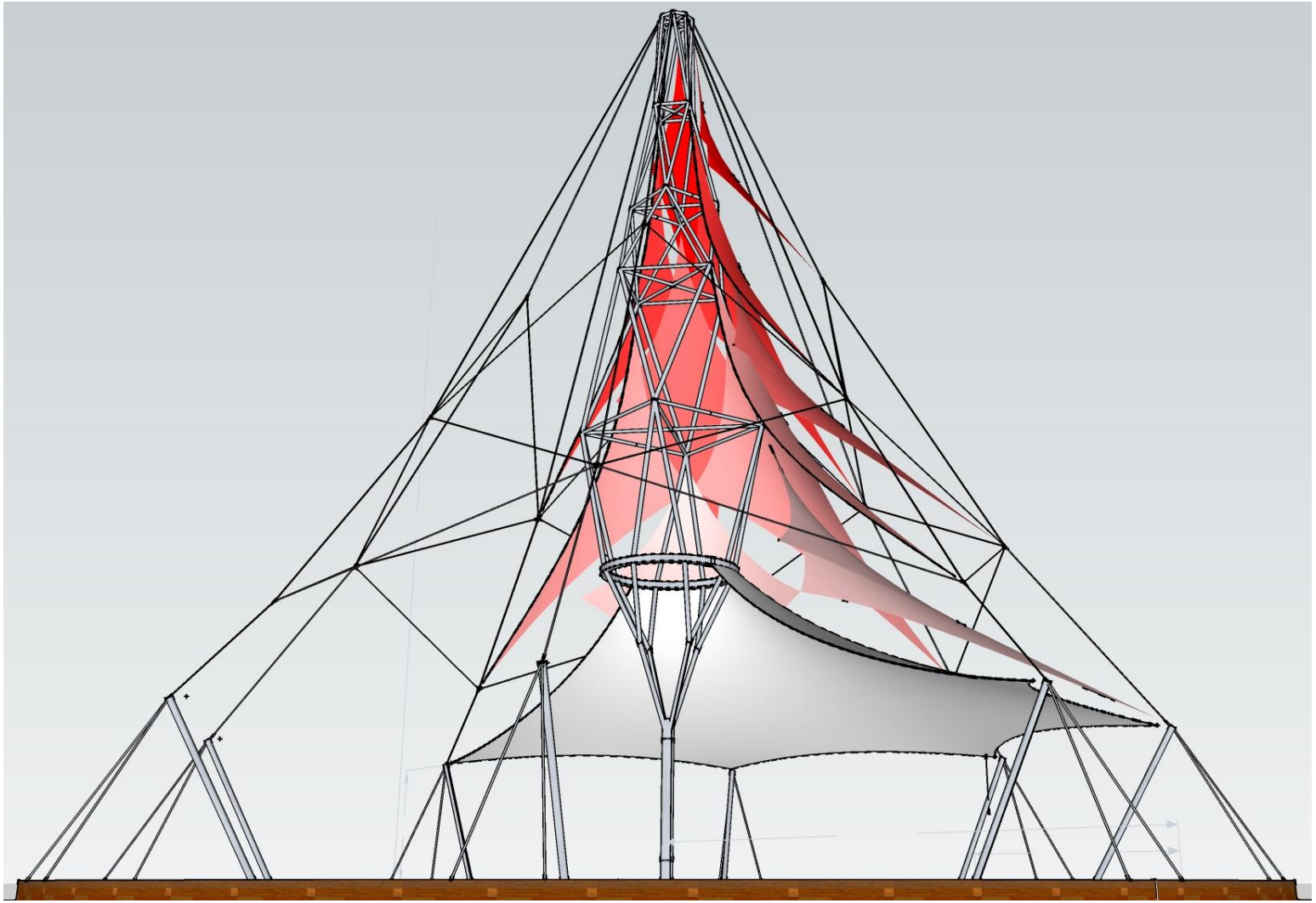

Fig. 87 – Urban billboard tower – section view

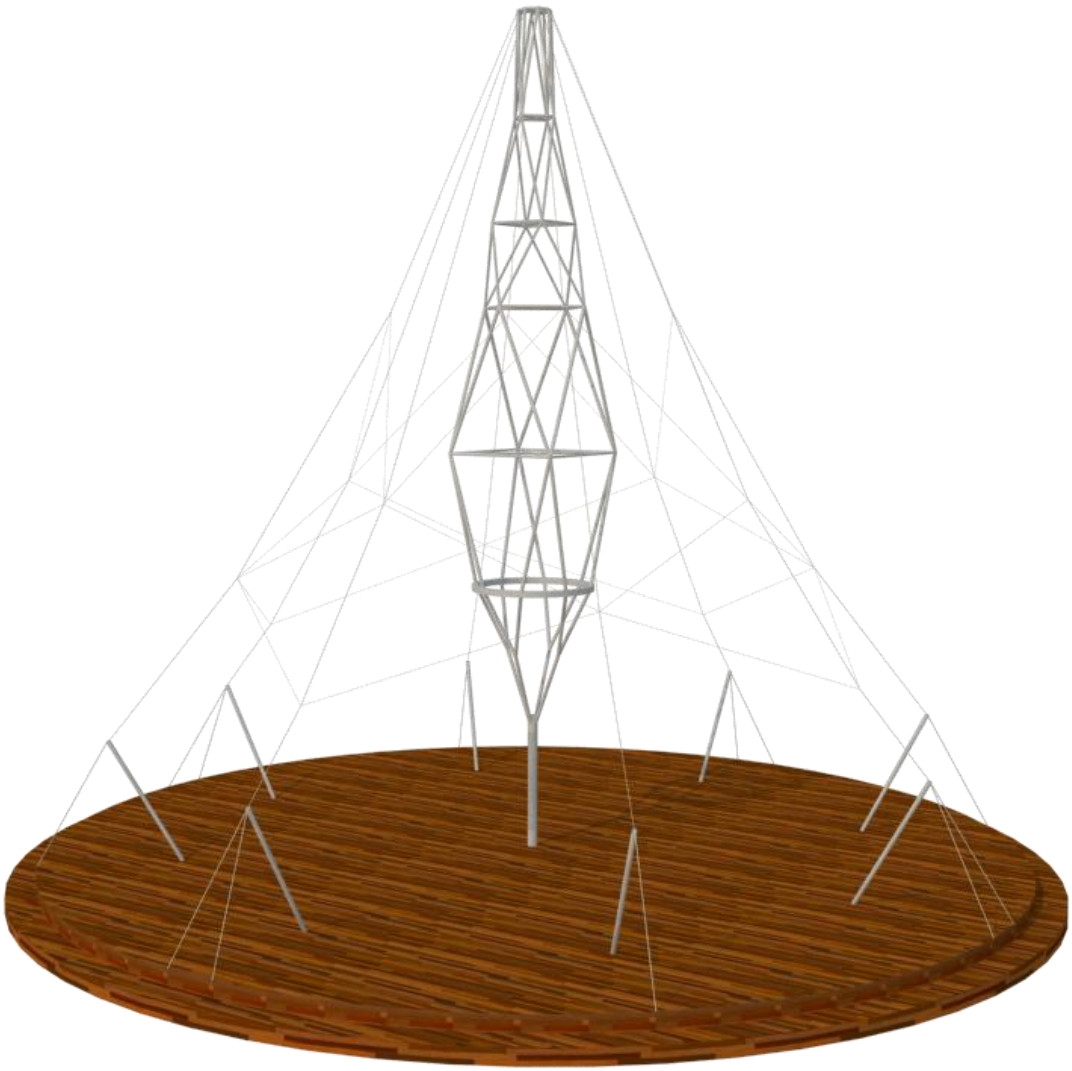

Fig. 88 – Urban billboard tower – steel and cable structure

REPLACING LEAVES

Phase DEMOUNTING

- Release slowly the NODE A tension system.
- Release the NODE B fixing screw.
- Release the NODE C hanging and tensioning system .

Phase MOUNTING

- Hang the new leaf in NODE C.
- Join the NODE B of new one with neighbouring leaves.
- After all NODE C and NODE B are fixed start attach NODE A to set point.

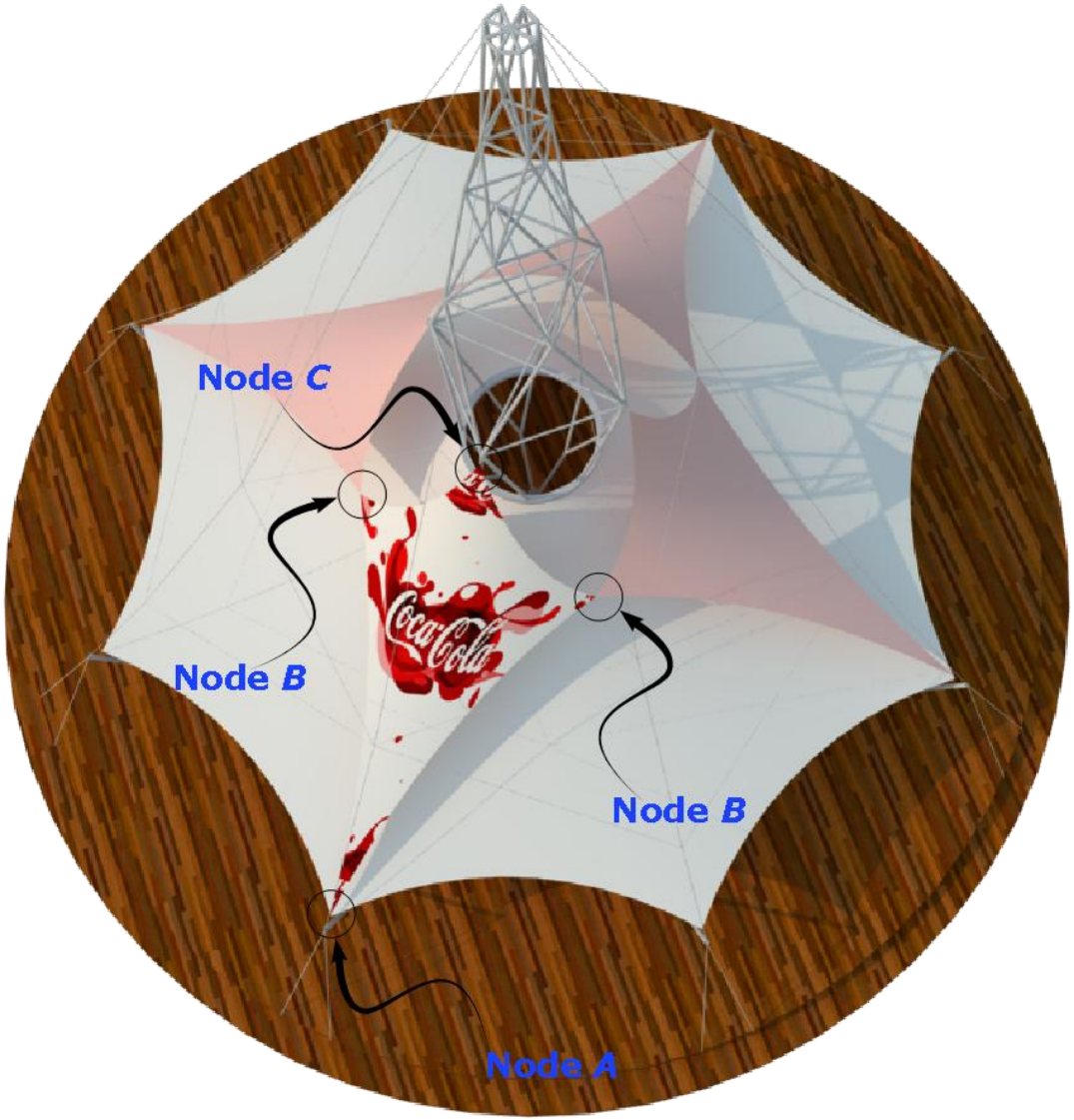

Fig. 89 – Leaf replacement method – upper view

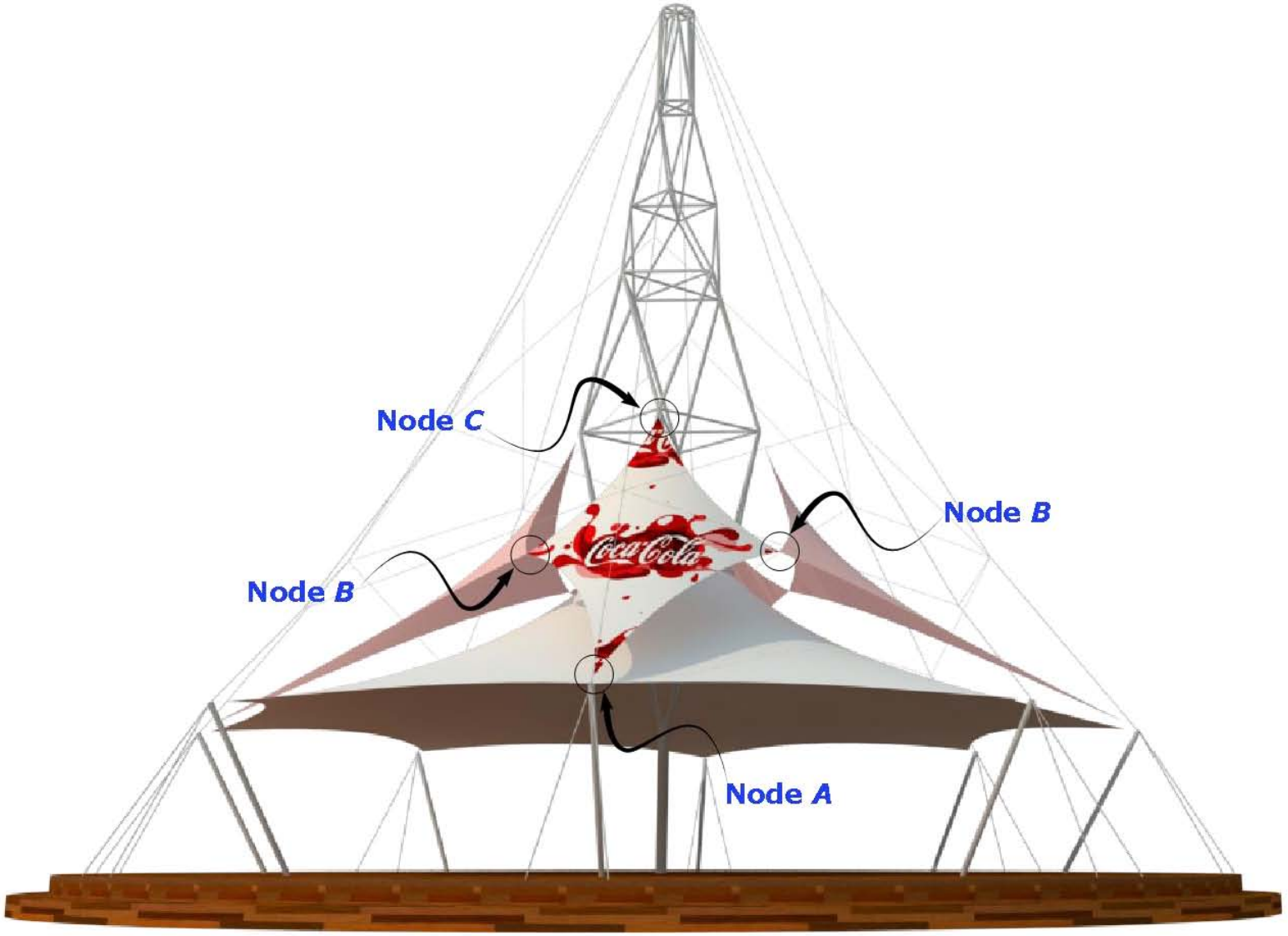

Fig. 90 - Leaf replacement method – side view

7. Conclusions

This research has set out from a powerful desire to mitigate the negative effects of the existing outdoor advertising means on the urban aesthetics.

Several possible designs have been studied, of utmost importance in the selection of the final study design was the feasibility aspect.

The urban billboard tower resulted from the design process fulfills to a large extent the objectives considered.

From an architectural point of view, it is a multipurpose lightweight structure which integrates into the urban architecture; it creates a landmark into an area which was previously devoid of identity and by its multi-functionality, it becomes a part of the social life of the community.

From an economic point of view, a versatile reliable product has resulted, with reduced costs and several profit-generating sources (both the advertising area and the renting area of about 110 m^2).

The study remains open for further research of the aspects which have not been discussed in this paper. For example, chosing the foundation method and the foundations calculation, how to provide a foundation system which must not affect or affect as less as possible the base surface, how to provide a mobile and reusable foundation solution. On the other hand, the possibility of advertisement projections on the leaves instead of the classical print is still subject to further study, as are the possibilities of decorating the billboard tower according to each event.

Bibliography

Baker, M. J. (1998), *Macmillan Dictionary of Marketing & Advertising* , London: Macmillan Business

Eggen, A.P., and Sandaker, N.B., (1995) *Steel, Structure and Architecture*, Whitney Library of Design

Otto Frei, Burkhardt Berthold (1983), *Natural Building*, Institute for Lightweight Structures, University of Stuttgart

Schlaich, J. and Bergermann, R. (2004), *Leicht Weit/Light Structures*. DAM

Schultz, H.C. et al., (2000). *Steel Construction Manual*. Birkhäuser Edition Detail

Nerdringer, W. (2005), *Frei Otto Complete Works Lightweight Construction Natural Design*

Lightweight Structure in Architecture and Nature – a publication for the exhibition "Natural Structures" in the Shussev Museum of Architecture in Moscow, 1983

http://povestisasesti.com/2013/03/27/romania-neasemuita-in-ilustratele-unui-soldat-german-din-primul-razboi-mondial/

http://povestisasesti.com/2013/03/27/romania-neasemuita-in-ilustratele-unui-soldat-german-din-primul-razboi-mondial/

http://www.gandul.info/stiri/cum-aratau-alegerile-in-perioada-interbelica-de-la-mogulul-malaxa-la-nae-cap-de-fier-si-staff-ul-sau-de-campanie-5152221

http://www.ziarulring.ro/stiri/45277/hai-sa-ti-arat-bucurestiul-noaptea

http://chirac.wordpress.com/tag/str-victoriei/

http://www.uni-stuttgart.de/impulse/imp/start.php?id=6&lang=en

http://www.mentondailyphoto.com/2012/12/christmas-in-menton-lotus-flower.html

http://www.architen.com/projects/london-festival-of-architecture

http://www.l-a-v-a.net/projects/uae-geometrical-forest/

http://www.tensilefabric.co.uk/fabric-structures/tensile-fabric-portfolio/project.aspx?type=interior&ref=1729

http://www.tensilefabric.co.uk/fabric-structures/tensile-fabric-portfolio/project.aspx?type=interior&ref=1892

http://www.tensilefabric.co.uk/fabric-structures/tensile-fabric-portfolio/project.aspx?type=exhibition&ref=1085

http://www.tensilefabric.co.uk/fabric-structures/tensile-fabric-portfolio/project.aspx?type=exhibition&ref=1566

http://www.tensilefabric.co.uk/fabric-structures/tensile-fabric-portfolio/project.aspx?type=exhibition&ref=1122

http://www.architen.com/projects/broadmead-fabric-sail

http://www.pinterest.com/pin/326018460496380651/

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