GEODESIC DOME FREQUENCY 4

- Erasmus Project -

by

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Abstract

The aim of this project is to assess the potential of building an icosahedral geodesic hemispherical structure with frequency 4. The dome is a 4.2 m radius hemisphere and built in wood (weather resistant) with the binding elements in metal. It has a door and 3 windows distributed in the 4 quadrants. The whole structure has good thermal insulation properties and is watertight.

Although this structure has very good characteristics, easy assembly and low price, it is not very common to see due to the poorly leverage both inside the structure and outside, in the plot distribution.

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Introduction

This project has been made in a practical way trying to describe how a dome of frequency four can be built, like a manual.

First of all, it explains the different types of domes with their main characteristics and a brief summary of his evolution along the history. In the ancient times, the dome structure was considered like a mystic built, part of the sacred geometry. Nowadays, there are people who thinks that the dome is a harmonic built which is able to connect with the universal mind.

In practical terms, one of the principal ideas of this project is to compare the geodesic structures against the typical buildings. Because of this, it summarizes the advantages and disadvantages of this kind of structures and talks about the market possibility.

Afterwards, the main part, describes all the components and the way to be assembly in order to build a dome in an easy way, without focus on architectonical or legal points of view.

Finally, there is an indicative budget of the materials and components to get an idea of how much it costs, it does not include the manpower.

State of art

Domes

Definition

Geodesic: relating to or denoting the shortest possible line between two points on a sphere or other curved surface. From geodesy "surveying"; greek geodaisia "division of the earth"; geo "earth, land" + daiein "divide".

Dome: a rounded vault forming the roof of a building or structure, typically with a circular base.

Based on a polyhedron, which is a three dimensional solid that has many flat faces, domes come from geodesic designs [11].

For dome designs, one of the most common polyhedron is the icosahedron. A three dimensional solid composed by twenty faces, which are equilateral triangles. Cutting this polyhedron by a flat ring, an approximation of a geodesic dome is made [11].

Domes enclose the largest volume for the same amount of material, in terms of interior space. As they use little amount material, they are very lightweight [13].

History

People have been building domes for centuries. The Pantheon, one of the most impressive buildings in Rome, was built in A.D. 117-125 it is made from an early type of concrete. However, those domes needed equally large supporting walls keep the entire structure from crashing to the ground. It means that, huge old domes were heavy and bound to fail at some point. [10]

Fig. 1: Construction of a planetarium of Carl Zeiss in Jena (Germany) 1922, planned by Walther Bauersfeld [2].

Referred to the new domes, in 1919 Walter Bauersfeld, a German engineer resolved to build a stationary dome. His first project would be a very large dome, it was more than half of a sphere with 16 metres of diameter. The problem of how to build a very big dome was solved by approximating to an icosahedron. It was built by nearly of 3500 thin iron rods to build the triangles shapes. To cover the dome, he erected a spherical wooden form from inside and then, sprayed a kind of concrete. This shell had the same thickness, proportionality, than an eggshell compared to its diameter. Later, this relation was considered appropriate for geodesic domes. [10]

Thirty years later, R. Buckminster Fuller, an American architect, engineer, poet, and philosopher, who later would be considered like the "father" of new geodesic domes, designed a similar structure. In the World War II, the necessity of build a structure quickly lead Fuller to investigate on this spherical shapes, because they enclose a given space with minimum of surface area. Firstly, he framed spheres approximating great circles, the strips that formed the triangles crossed one another. It was called geodesic dome because this kind of structures was known as geodesics. Sometimes, he built spheres from hexagons and pentagons and dividing them into triangles. [10]

In 1953, to build a structure to cover 28 m diameter, Fuller used his new system. His project was weight 95% less than the others were and he completed the project in only three months. [10]

In 1954, Fuller got the patent on geodesic domes and in the 1960s and 1970s, domes became popular due to this was an inexpensive way for environmental conscious people to build their own homes in an era which unconventionality was prized. [10]

Fuller said that in mid-1980s a million geodesic domes would be built, but in 1990s this estimations over worldwide only reached 300000. Anyway, there is a small but determined group of people of unconventional homebuilders, which continues to build geodesic dome homes. However, nowadays the most of the dome structures are built for greenhouses, storage sheds, defence shelters and tourist attractions. [10]

From then to the present, it there was not important changes on this trend and nowadays is very rare to find a dome as a home where people lives.

Types

Frequency types

To make an icosahedron approximate a sphere more closely, the triangles making up the icosahedron are subdivided by splitting the edges of the triangle and then making the new split edges into more triangles. As in the pictures below, splitting each edge into n new edges yields n^2 new triangles.

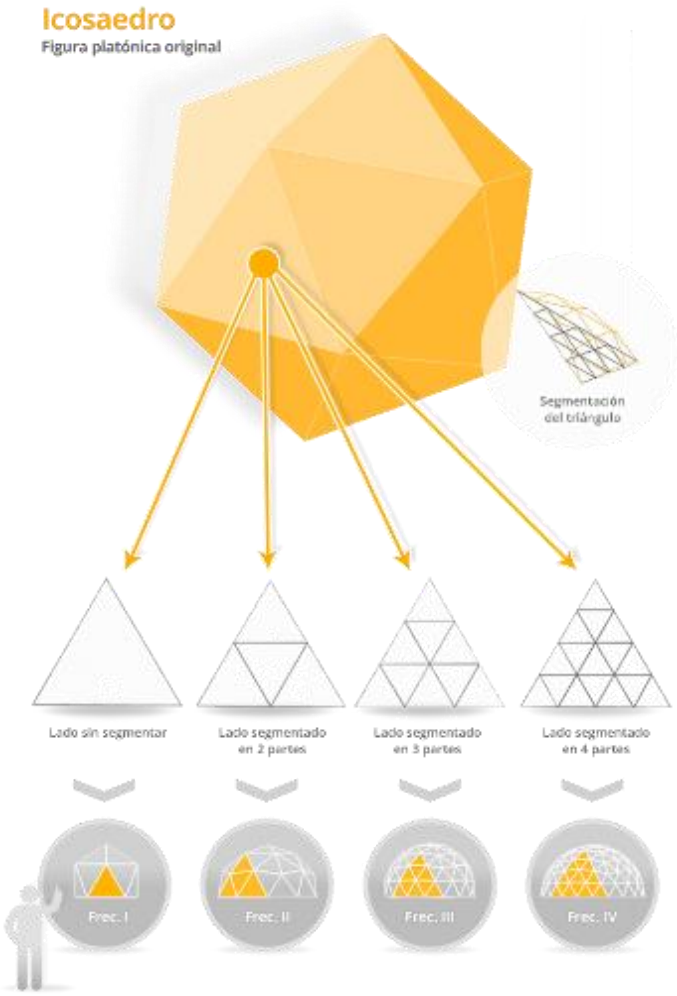


Fig. 2: Different types of subdivision of the main triangle from the icosahedron. [1]

To describe the frequency, it is very common to find the notation: *mV*. Where *m* is the number of new edges made from each original edge, like *2V*, *3V*, *4V*, etc... [12]

More divisions means more resistance and bigger sizes of the domes, it is due to the structure is more similar to the sphere, that is the most stable structure. As it is possible to see in the figure 3.

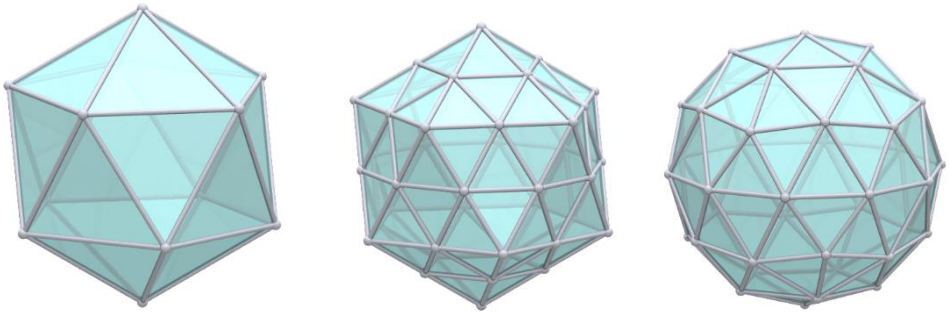


Fig. 3: Development of the triangle subdivision and projection to the sphere. Frequency 2. [2]

Splitting the sphere by the middle, the geodesic dome appears.

Spheres with an odd degree (1V, 3V, 5V, etc...) cannot actually be cut exactly in half. There is a ring of triangles that span the middle of the sphere, so typically it is chosen to split either just above or below that ring. For 3v domes, the popular name on the web for splitting above or below the ring seems to be "4/9" and "5/9", respectively. It is shown in the figures 5 and 6. [12]

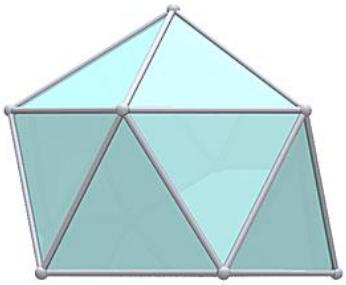


Fig. 4: Dome 1V. [2]

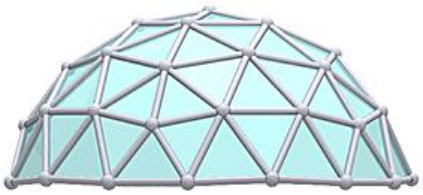


Fig. 5: Dome 3V “4/9”. [2]

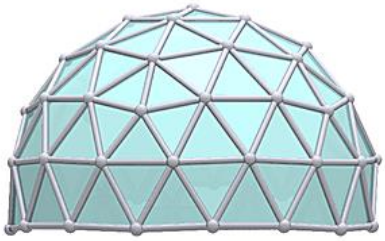


Fig. 6: Dome 3V “5/9”. [2]

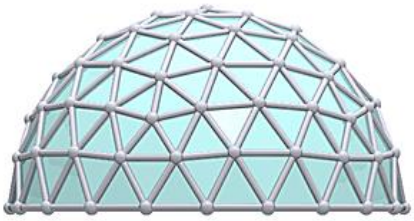


Fig. 7: Dome 4V. [2]

Joint types

Connecting the rods by external joints, using either metallic, plastic or wood materials.The rods have to be placed with a specific angle and distance between them to be correctly assemble by the joint.

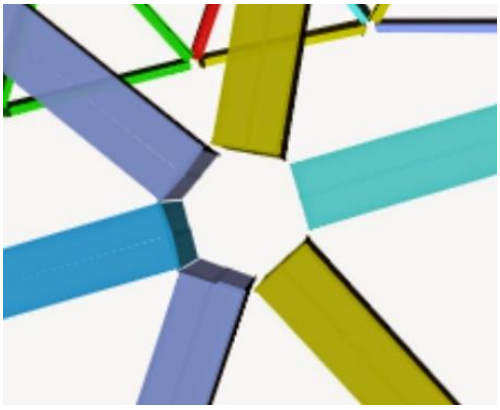


Fig. 8: Rod distribution for joint by connector. [6]

Connecting the rods directly with each other, using special cutting and bolt to fix them. There are many ways to connect the rods to each other depending on the solicitations of the structure and the kind of joint. This is shown in figure 9.

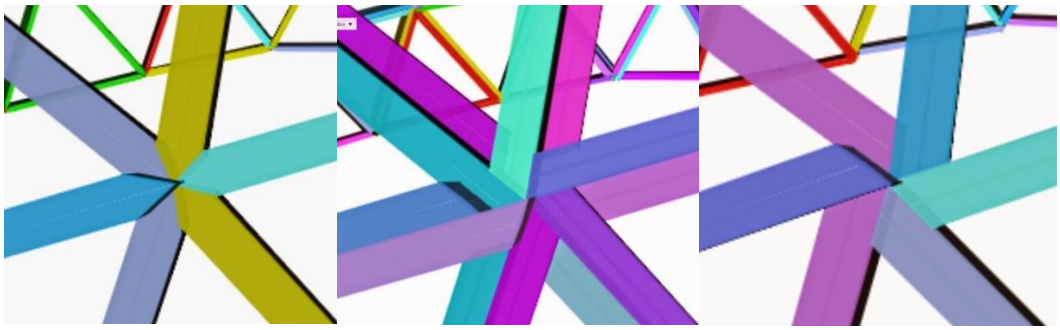


Fig. 9: Rod distribution for joint without connector. [6]

Advantages and disadvantages

Advantages

1. Quickly construction: Geodesic domes can be constructed quickly without heavy equipment. Using prefabricated components, it takes just a few people to erect the dome. [10]

2. Good thermal characteristics: Less volumetric surface exposed to outdoor temperature fluctuations, making the building cheaper to heat and cool than a rectilinear structure with the same materials. [13]

3. Very high resistance: The triangle is a very stable shape, a force applied to the corner of a rectangle can deform it into a parallelogram, but the same force will not deform a triangle. Box style buildings generate huge amounts of turbulence when high winds pass over them, causing massive low pressure, which sucks the roof off. High winds can pass smoothly over a dome because it has no corners and flat surfaces to cause turbulence high pressure air presses the dome down towards the ground. This makes geodesic dome buildings highly resistant to such forces as snow coverings, earthquakes, wind, and even tornadoes. [10].

4. Little material and surface: The surface area of a geodesic dome is only 38% of the surface area of a box-shaped building enclosing the same floor space. [10]

5. Excellent air circulation: The air current flows due to the different density of the heat and cold air, from the bottom to the top, renovating the air ambient. [6]

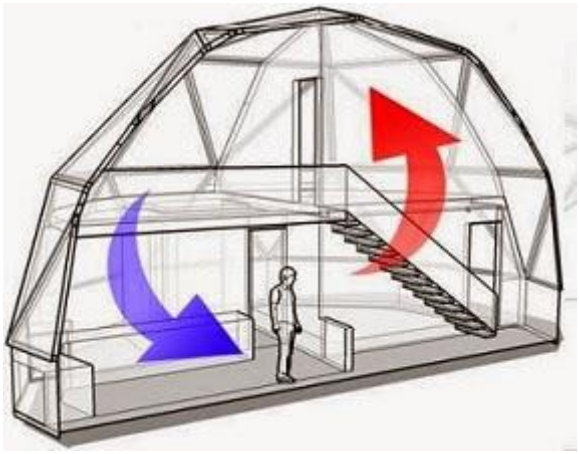


Fig. 10: Air circulation inside the dome. [6]

6. Infinite space felling: Due to there are not columns inside the dome the inside space looks much bigger. [1]

Disadvantages

7. Unusable spaces: The spherical design makes spaces unfit for use near to the bases of the walls due to the most of the furniture has a box appearance and the walls grows up following a curve direction. For this, it is needed to design new furniture specifically for this kind of curve walls. [6]

8. Windows and doors: Complexity to make the windows and doors due to the dome curvature and the triangular shapes, different to the traditional way. Like in the point before, specifically designs are necessaries for windows and doors. [6]

9. Poorly use of the plot space: Technical standard of urban planning distributes the land spaces on square plots, generating dead spaces inside the plots, as it is possible to see on figure 11. It means that domes do not leverage as much as possible in square plots. [6]

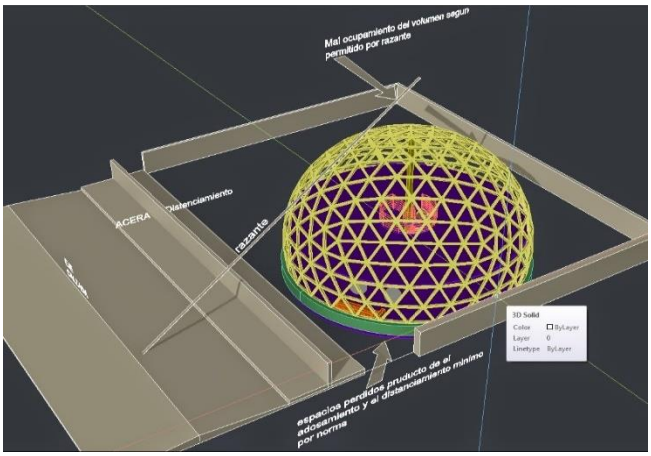


Fig. 11: Use of a square plot space with a dome. [6]

Marketing study

The main advantages that domes have are lightweight, very resistance and quickly and easy assembly.

For that reason, it is a very good building for many applications from common homes until arctic refuge or defence shelter.

Inside the dome, the atmosphere is very good due to the infinite space felling and the good air circulation. There are big spaces inside for conferences or only for a big living room. Anyway, walls to create rooms, even floors, can divide these big zones.

Domes are very good to be developed in the countryside, because of the distribution of the plots is more flexible, in order to arrange the dome with the largest use of the plot. For the cities, it would be very interesting to develop some accessories to arrange around the dome in order to use every space.

Finally, in terms of price, it is cheap to build due to the few components involved but also cheap to keep it, because is very resistant, it doesn't need very much maintenance and cheap to heat it so it has the less exterior surface for the volume enclosed, this means less losses to the environment.

Referred specifically to this project, it has the advantage of it is easier to mount than others due to the simplifications introduced by the “universal” joints and the way to fix them.

Structure and coverage

Drawing for building a dome

Plants

The following figures are a representation of the finish structure appearance, made by SchetchUp, a computer program for architectonic designs.

In blue, the three windows distributed on the four quadrants, are made by glass and can be opened using hinges.

In brown, the door, which is divided in two parts for open it independently. Each door part is opened using a pair of hinges held to the structure.

The white cylinders are the foundation pilings, which anchor the structure to the floor by using the piece “FOUNDATION JOINT” shown in the appendix.

All the measures are shown on the appendix plans, “DOME VIEWS”.

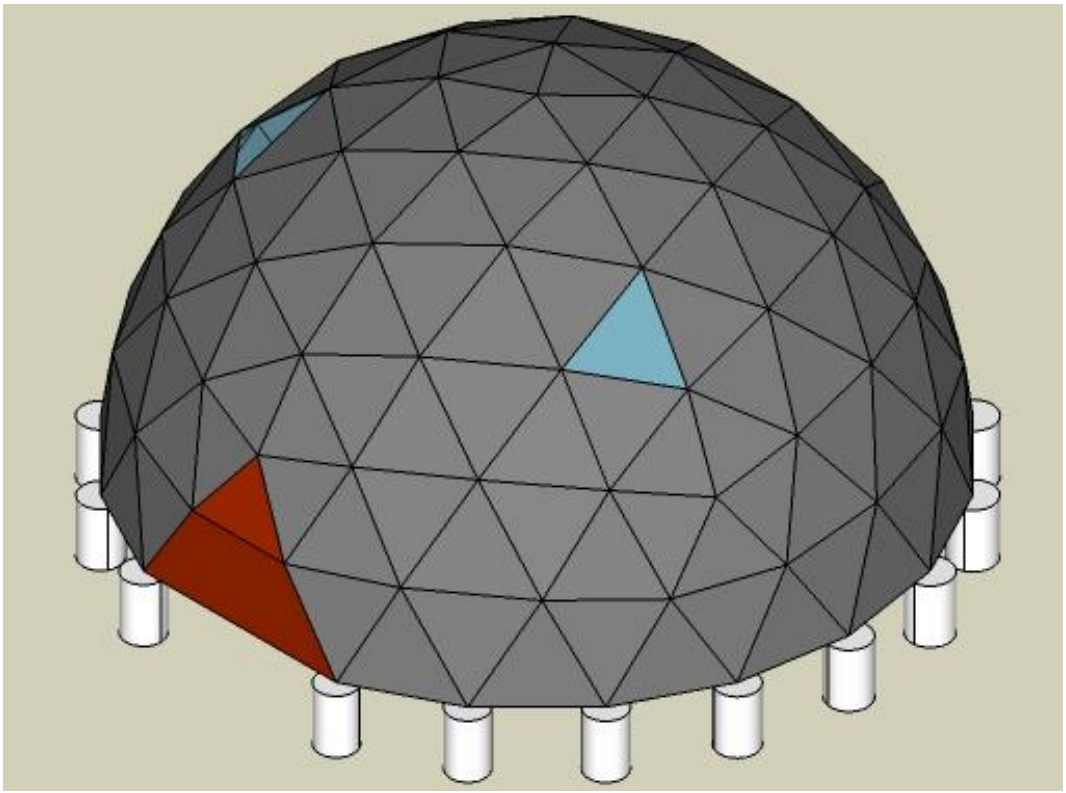


Fig. 12: Isometric view.

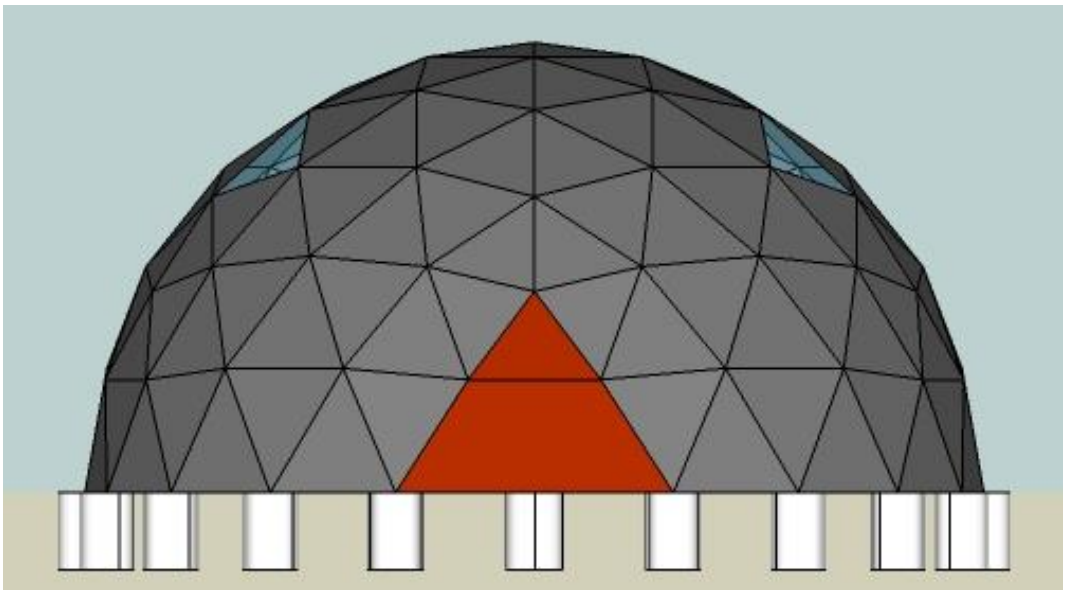


Fig. 13: Front view.

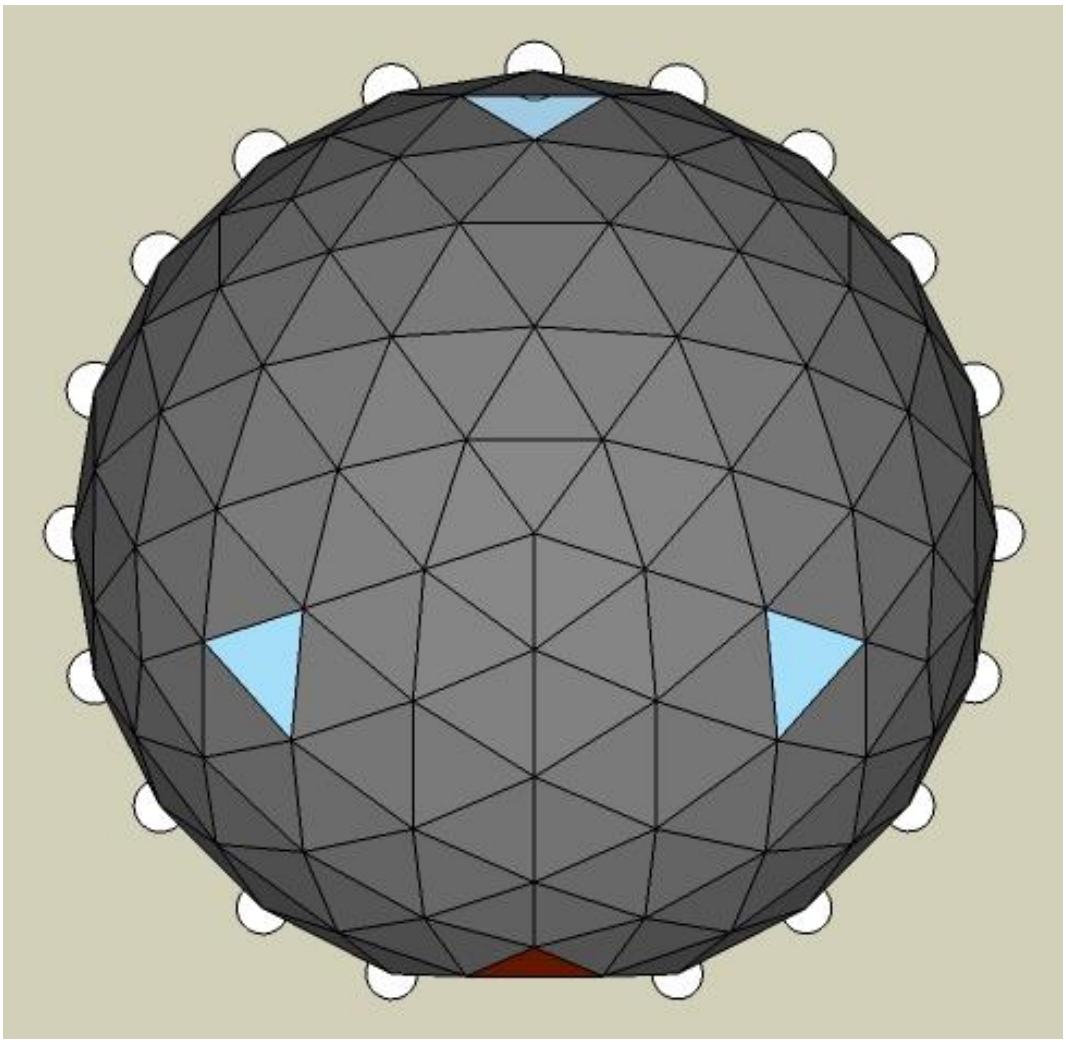


Fig. 14: Top view.

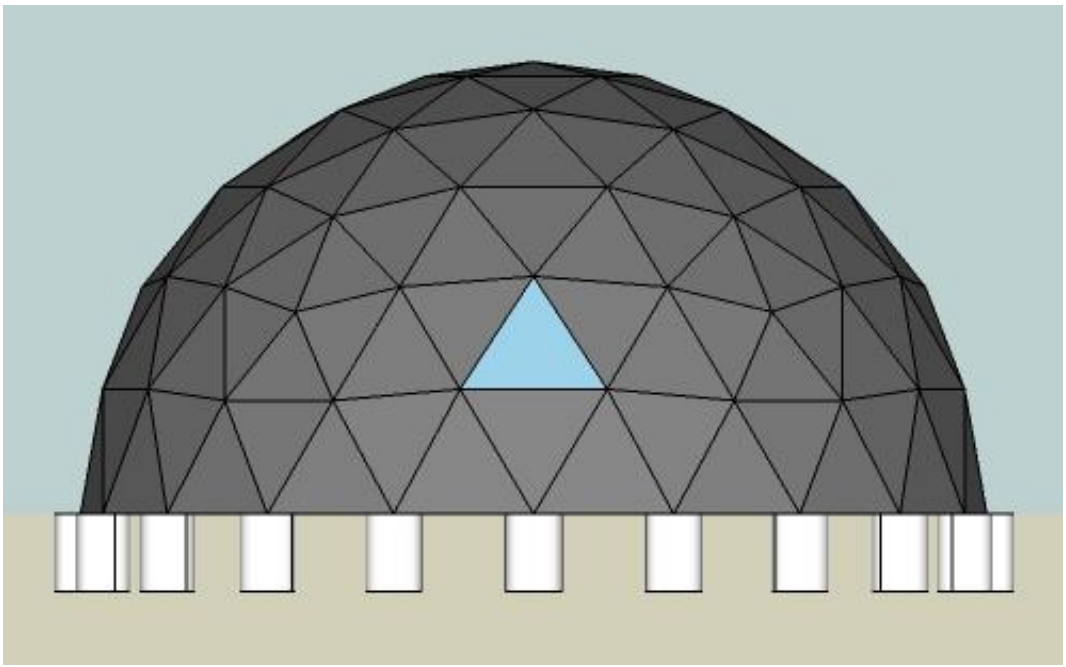


Fig. 15: Back view.

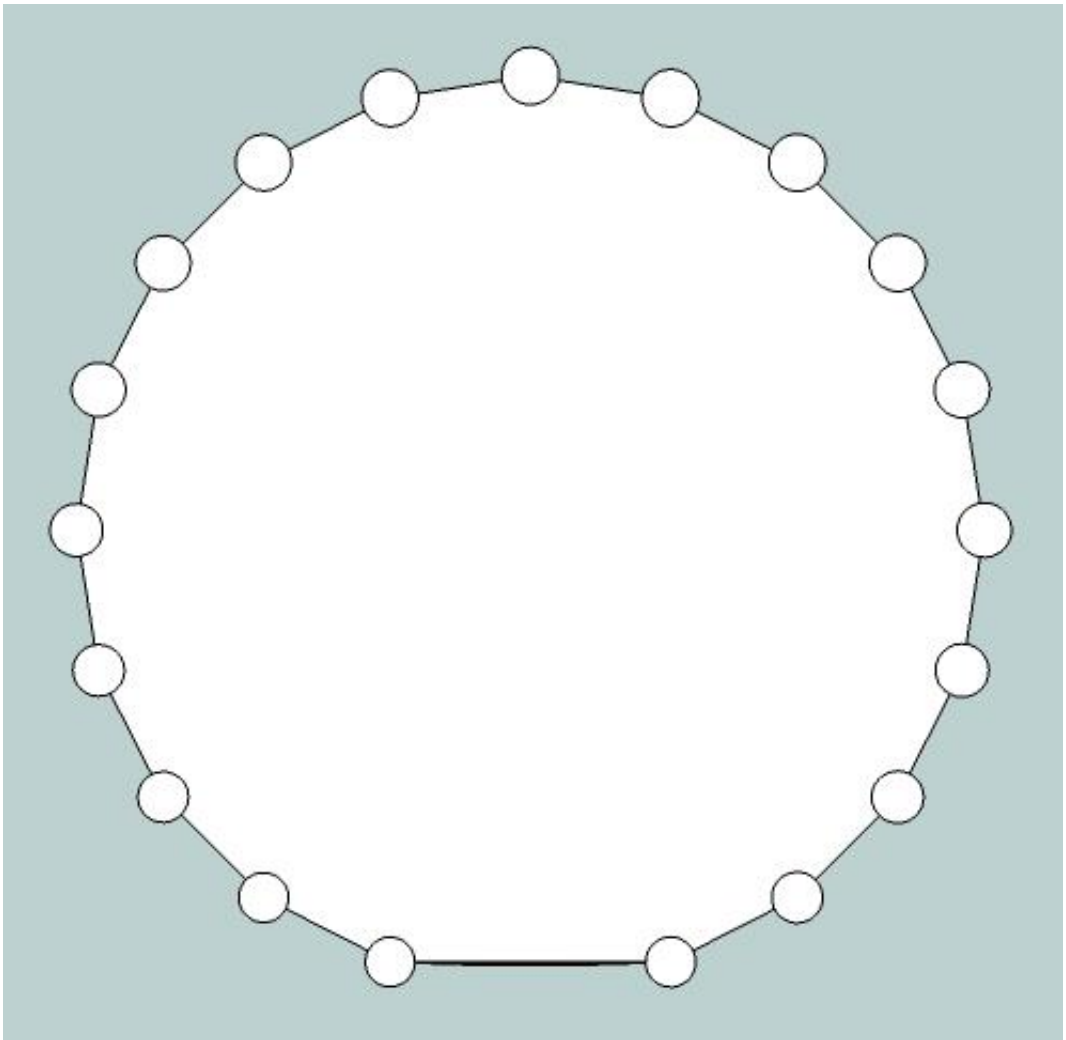


Fig. 16: Bottom view.

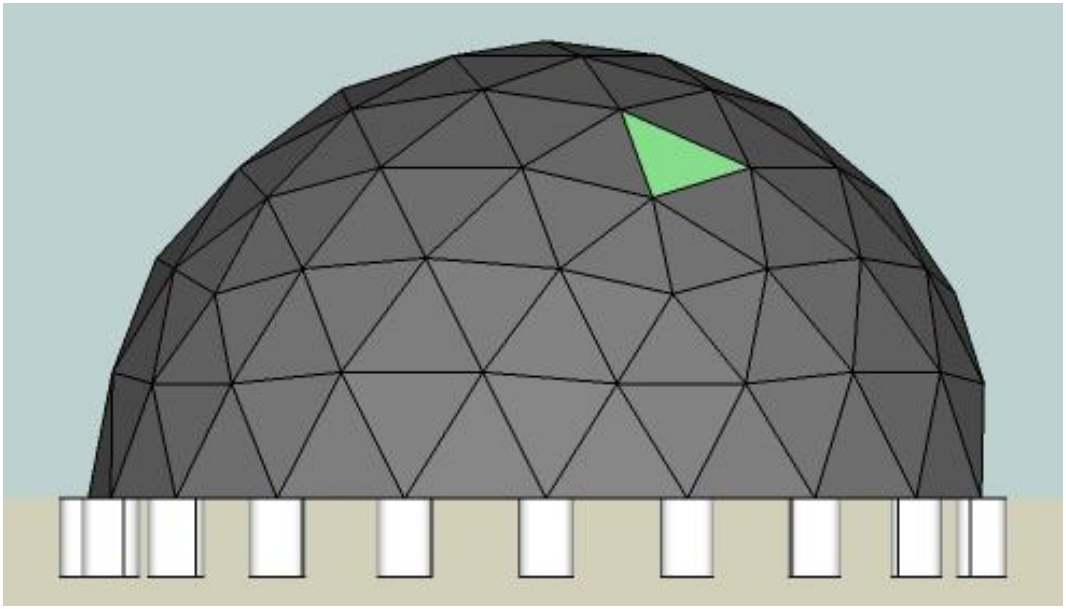


Fig. 17: Left view.

Mounting scheme

Components

Here is the component list. For a better description of everyone, go to the appendix where all the dimensions are described with accuracy.

The rods A, C, D, E+B and F have been designed following the measures and quantity described on [3]. The difference the amount of rods between the web site and here comes from the irregularity which is introduced by the door in the structure symmetry.

The “Door rod” replace two “A rod” joining two “Joint 4”, for this reason this rod is longer than the others. In addition, joining this two “Joint 4” which are not consecutive, the angle that form is different from the others. Due to this, the piece “Door joint” has been designed with a certain angle described on the plan “DOOR JOINT” in the appendix.

The “Cover joint” is a regular flat piece bent according to the angle that two consecutive triangle shapes form.

Shuttering boards are cut from a sheet with the specific measures, for the triangles and for the door. The shuttering board for the door and the triangles just up of it are assembled by hinges to the structure, allowing open and close the door.

The “Joint 4”, “Joint 5” and “Joint 6” are quite similar, all of them have the same angle for the curvature form of the structure, which is said on the reference [3], the only difference between them is the different number of slots.

These pieces have been designed trying to simplify the whole structure both in design and in assembly. After to find many different types of joints this one was selected in order to make the assembly easier, without not very much calculous in the mounting moment, by the user. Using two stamped metallic plates to fix the rods by pressure and bolts, because of the rods work bending, traction and compression. That simplification is to make just one joint type with one angle between slots, being differentiate from the instructions of the reference [3], where there are four joint types with different angles. In addition, the slots width is bigger than the rods width, allowing the mobility and variation of length and angle between the rod and the joint due to the joint simplifications.

For the foundation, concrete type HM 20N/mm^2 has been selected. Building nineteen pilings, one below each “joint 4” of the structure floor, as it is possible to see on the “DOME VIEWS” in the appendix. Anchoring the structure to the foundation by the “foundation joints”. For build the pilings is necessary to do a hole with the piling dimensions and then, introduce the straight part of the foundation joint inside the concrete piling, letting enough space to introduce the rod in the space between the piling and the foundation joint upper part.

The “Foundation joint” has been made with a corrugated steel bar bent to get the form which is shown in the picture.

The window is fixed to the structure by bolts and waterproofing the joints by plastic paint.

Table 1: Component list

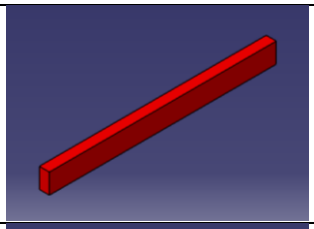
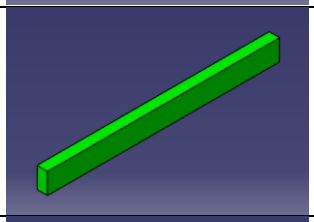
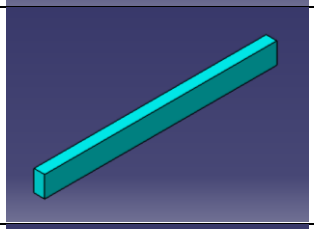
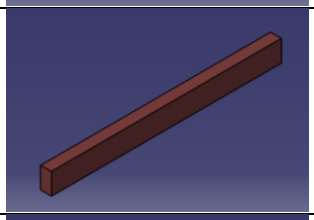
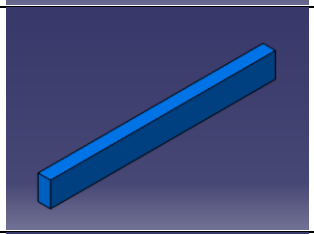
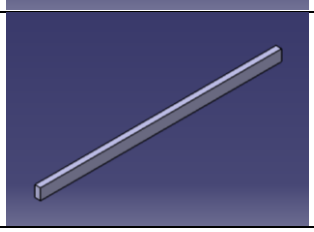
Item	Component	Measures	Quantity
1	A rod		68
2	C rod		30
3	D rod		30
4	E + B rod		87
5	F rod		30
6	Door rod		1

Table 1: Continuation

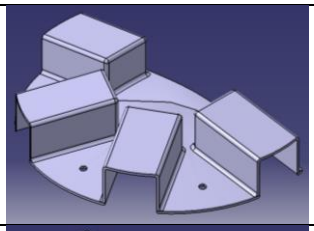
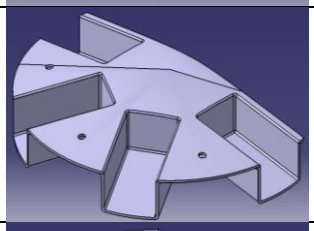
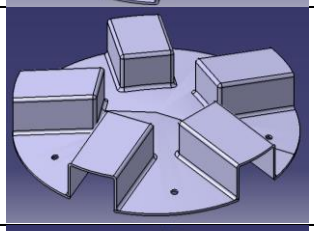
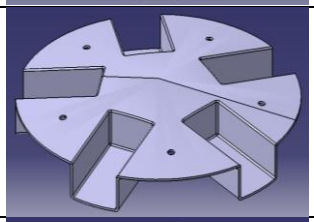
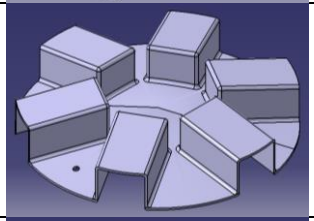
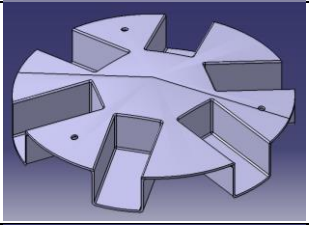
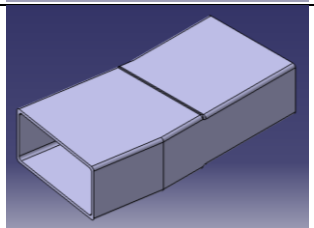
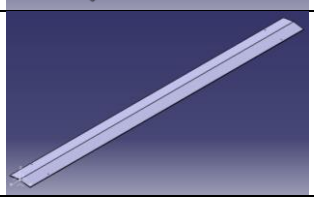
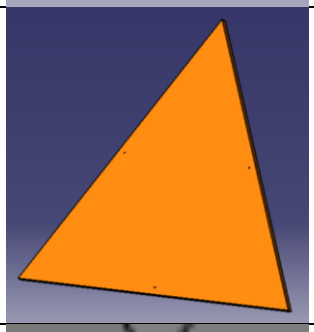
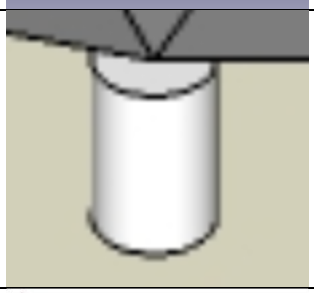
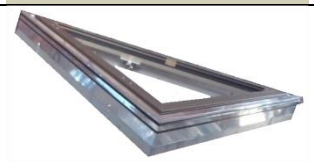
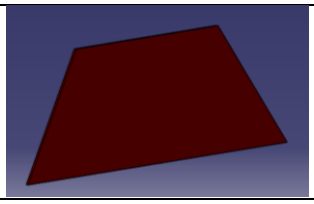
7	Top joint 4 A		21
8	Lower joint 4 B		21
9	Top joint 5 C		6
10	Lower joint 5 D		6
11	Top joint 6 E		63
12	Lower joint 6 F		63
13	Door joint		2
14	Cover joint		165

Table 1: Continuation

15	Foundation joint		38
16	Shuttering board (Triangles)		160
17	Foundation		19
18	Window		3
19	Shuttering board (Door)		1

Assembly

The following figure, made by the program for mechanical design, CATIA V5R20, shows the appearance of one fifth of the total structure and then it repeats following a circular pattern.

Every component that forms the structure is shown below. Each rod colour means different length. The colour pattern shows how the structure must to be built.

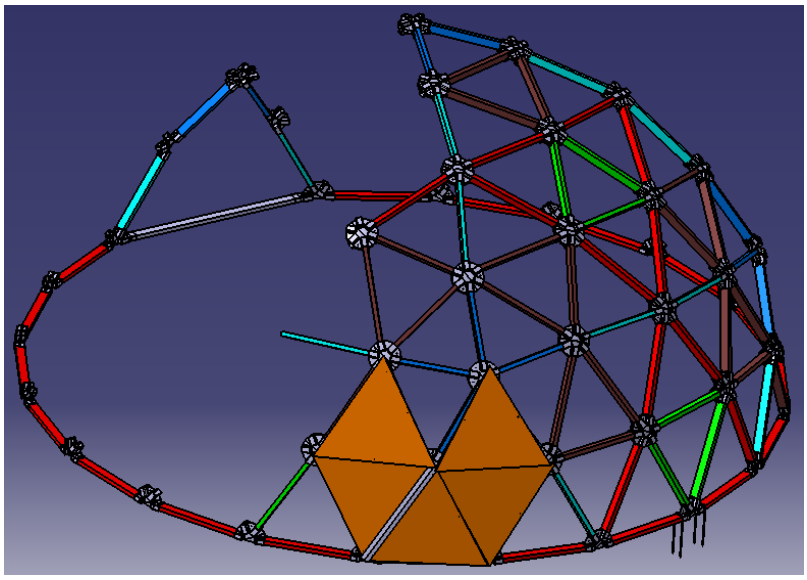


Fig. 18: Structure isometric view in construction phase.

Bolts and nuts of standard metric thin pitch M10x1, fix the two part of the joints 4, 5 and 6 as it is shown below.

The curvature of the pieces gives to the structure the ability to enclose a spherical shape.

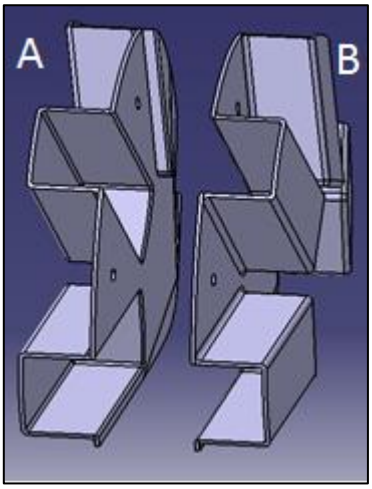


Fig. 19: Joint 4.

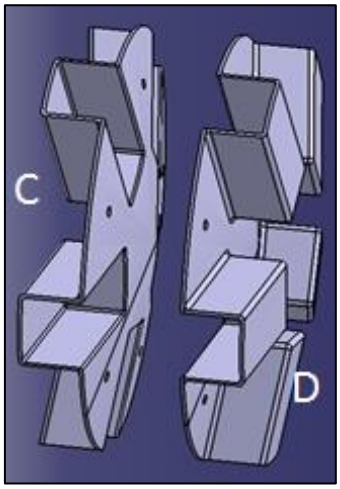


Fig. 20: Joint 5.

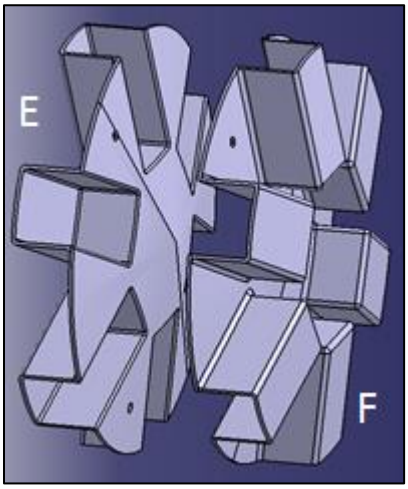


Fig. 21: Joint 6.

Rods are assembled to each other by the different kind of joints, distributing following the Fig. 18. Bolts fix the rods that are inside of the joint slot. The two parts of the joints are not in touch because of it depends on the angle that they form at the assemble moment, as can be seen in figures 23 and 24. In addition, the slot where the rods are placed is a little bit more width than the rod width due to the angle between rods are not exactly the same than the joints form.

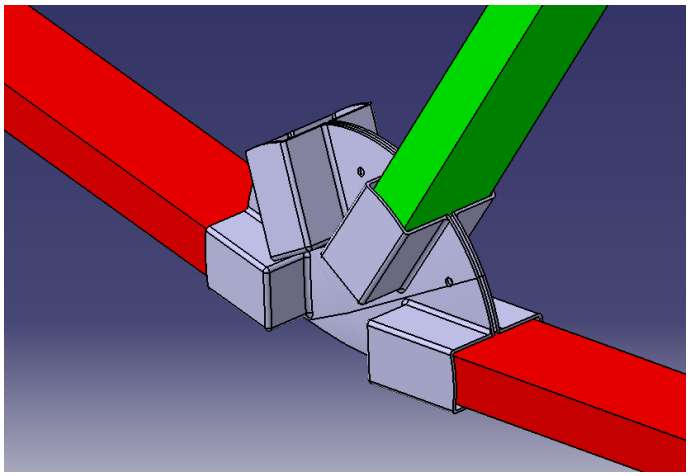


Fig. 22: Mounting scheme for joint 4 with bottom rods.

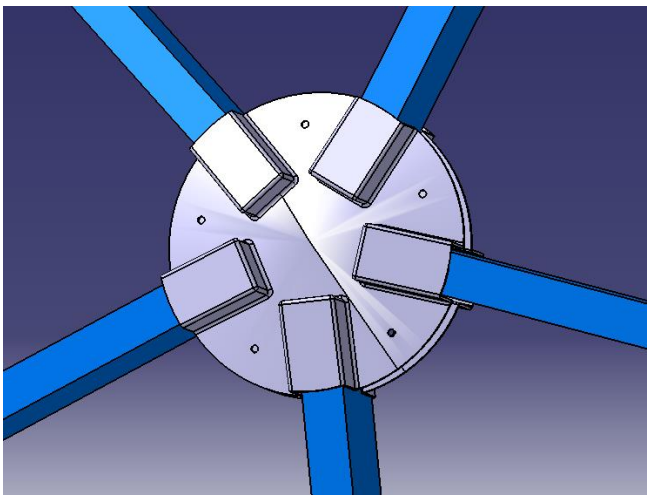


Fig. 23: Mounting scheme for joint 5 with F rods.

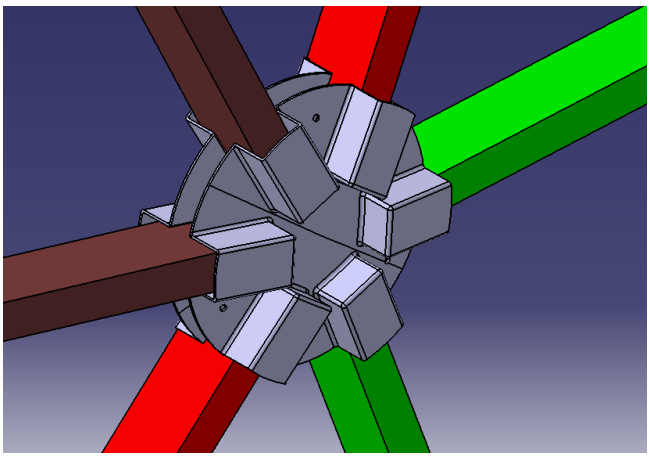


Fig. 24: Mounting scheme for joint 6 with 3 rod types.

It is necessary to plan the structure on the floor and start to assemble the bottom part of the structure (red rods and joints 4). The base, red rods and joints 4, forms a plane where the structure can support itself and it is assembled following the colour pattern and the rods position, as it is possible to see on the picture.

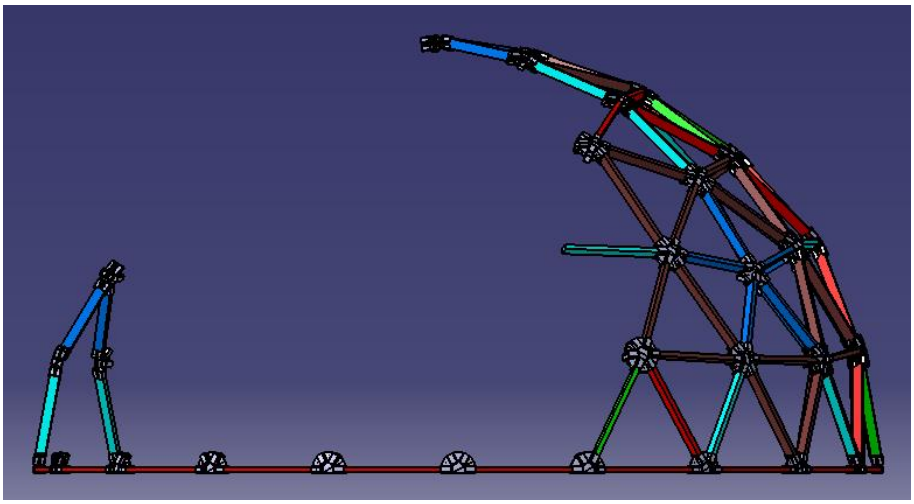


Fig. 25: Structure side view in a construction phase. Flat base.

The door introduce a variation on the symmetry of the structure.

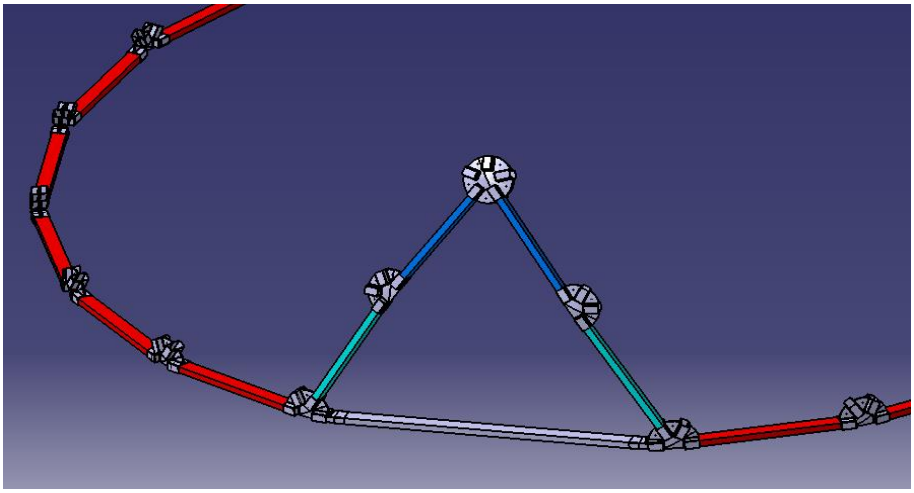


Fig. 26: Door view with variations on the structure rods distribution.

It is solved by changing two joints 6 by two joints 4 and deleting three E+B rods, this can be seen in detail in figure 28. Also, is necessary to introduce a new type of rod, door rod, which is longer than the others are. The involved in this rod is different from the angle pre-establish so, in this case, a new joint is introduced to get it. The mounting scheme is shown in the figure 27.

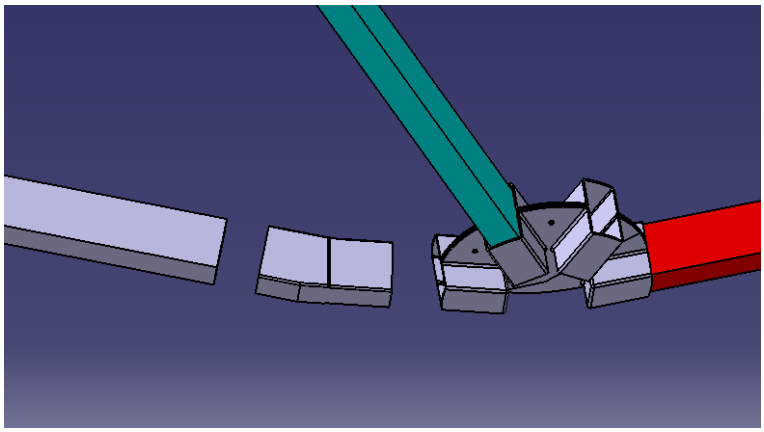


Fig. 27: Mounting scheme for door joint and door rod with the structure.

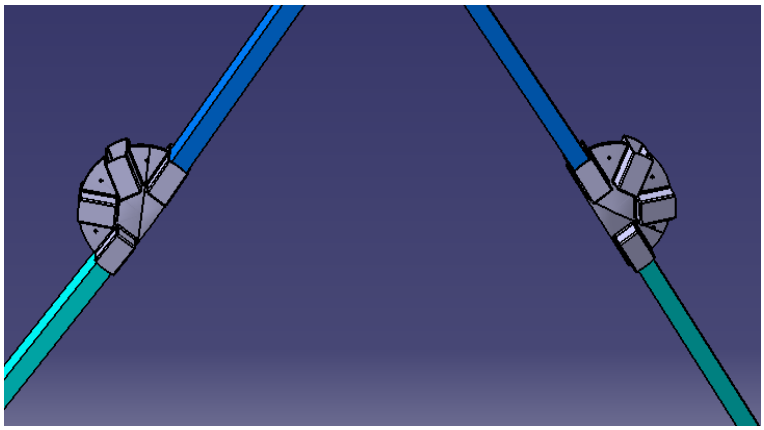


Fig. 28: Changes of joints 6 for joints 4.

To fix the structure to the foundation is necessary a joint that hold the rods which form the base and are introduced into the foundation pilings.

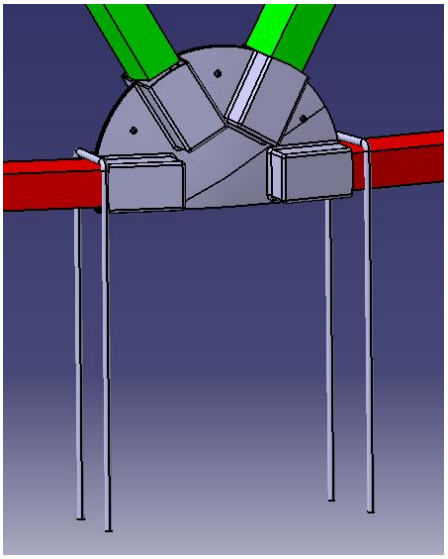


Fig. 29: Mounting scheme for structure anchoring to the foundation.

To assemble the cover, it is mandatory to have finished the rod structure. After, starting from the lower ring, shuttering boards are fixed to the rods by standard thin pitch bolts M10x1. When the lower ring is finished the immediately upper ring of boards is placed, as in figure 30 is shown, putting the lower part of the upper board over the upper part of the lower ring of boards. Then, the same procedure is repeated for the upper ring. To the spaces between each pair of boards, a metallic piece is located covering it, fixed to the boards with bolts too, as it is possible to see in figure 31. To waterproof this area, plastic paint is applied.

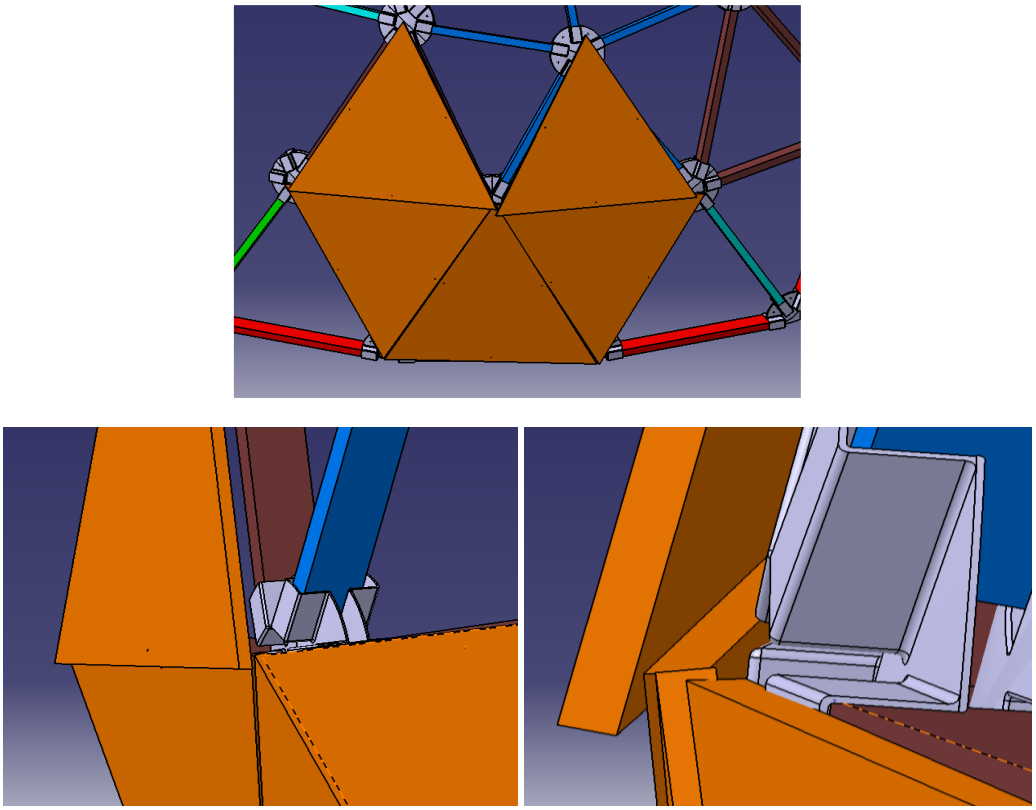


Fig. 30: Different views of the cover and mounting scheme of it.

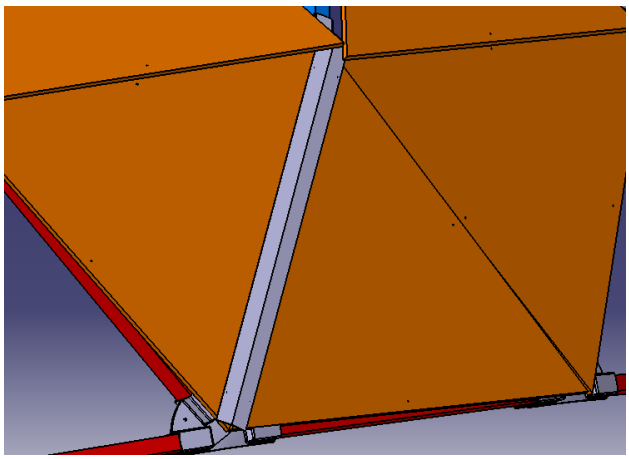


Fig. 31: Metallic piece for cover the space between two boards.

Stability of the dome

The triangle is a polygon that always keep their angles, this means that a structure based on them will be very resistant. The force applied to one triangle side is distributed uniformly to the others and this one successively to the others triangles interconnected. That provide consistency and strength to the whole structure.

Domes have a good weight distribution around the ground plane and a low gravity centre, which is a great advantage against earthquakes.

In addition, the pressure applied to the dome shape is distributed around the entire structure making a stable building, due to its spherical shape.

Negative air pressure on the buildings surface generated by high winds can raise the cover or even the whole building, but the aerodynamic shape of the geodesic dome offer the best protection against them. [13]

In addition, the stability of the dome passes through a good foundation and a good anchoring, because of a high winds could raise the whole dome or move it. Besides, the dome hardness increase when it's anchor to the floor, creating a close shape.

The concrete selection is the lower kind, because of the dome weigh and the forces that winds could practice on the structure are very small.

Budget

This is an estimating budget for every component of the dome; it is not include the work force, the transportation or the design prices. The prices for the pieces that have been designed specifically for this project are illustrative and they could change according with the manufacture process and the amount of pieces.

The price for the plastic paint comes from a paint container so the instructions of it say that is enough for the entire surface.

As it is possible to see, the cover is the most expensive component of the dome. It would be an important point to reduce the price.

All these prices are with IVA tax.

Table 2: Items and price list.

Item	Number of pieces	Price/Unit	Price
Shuttering board (Triangles)	155	6,30 €	1.201,10 €
Shuttering board (Door)	1	8,56 €	10,53 €
Window	3	47,11 €	173,84 €
Top joint 6	63	2 €	154,98 €
Lower joint 6	63	2 €	154,98 €
Top joint 5	6	2 €	14,76 €
Tower joint 5	6	2 €	14,76 €
Top joint 4	21	2 €	51,66 €
Top joint 4	21	2 €	51,66 €
Door joint	2	2 €	4,92 €
Cover joint	165	0,50 €	101,48 €
Wooden rod C	30	4,91 €	181,18 €
Wooden rod A	68	4,71 €	393,94 €
Wooden rod D	30	4,47 €	164,94 €
Wooden rod E+B	87	4,40 €	470,84 €
Wooden rod F	30	3,70 €	136,53 €
Wooden rod door	1	8,82 €	10,85 €
Foundation (HM 20N/mm2)	19	10,56 €	246,79 €
Foundation joint	38	0,20 €	9,35 €
Plastic paint	1	34,95 €	42,99 €
TOTAL			3.592,07 €

Conclusion

Domes come from a polyhedron, in this case, from an icosahedron which triangles are divided to form different frequencies.

Domes have been built from a long time ago but just in middle XX century, they had a big role.

Domes have much more advantages than conventional buildings but the disadvantage of bad use of the plot space makes domes not very common to see.

They have few components and are quite easy to assemble. In addition, domes are very much stronger and stable than others typical structures.

In terms of money, domes are cheap to construct.

Summarizing, there are more advantages than disadvantages but these last make domes not very popular for normal house structures.

For the structure design, there was some problems with the decision of how to simplify both the assembly and the number of pieces, also the complexity of the pieces should be not very high, in order to decrease the final price of the project.

Another important inconvenient to solve was how to make the dome waterproof in an easy way, without very much accuracy in the pieces neither the assembly, for that, the option of overlap the upper cover over the lower one, was selected.

Finally, the inconvenient that introduce the door in the structure assembly and resistance, was solved as most simple as possible, just deleting the rods and the joints that were involved in the door space and substituted by others types, specifically designed for that, trying to not develop additional structures for the door.

As it is possible to see, everything in this project was done in a practical way, without not many structural calculous, based on dome projects already developed because of there are many amateur projects but not too much scientific studies about this theme.

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Appendix

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12. Top joint 6
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15. Cover joint
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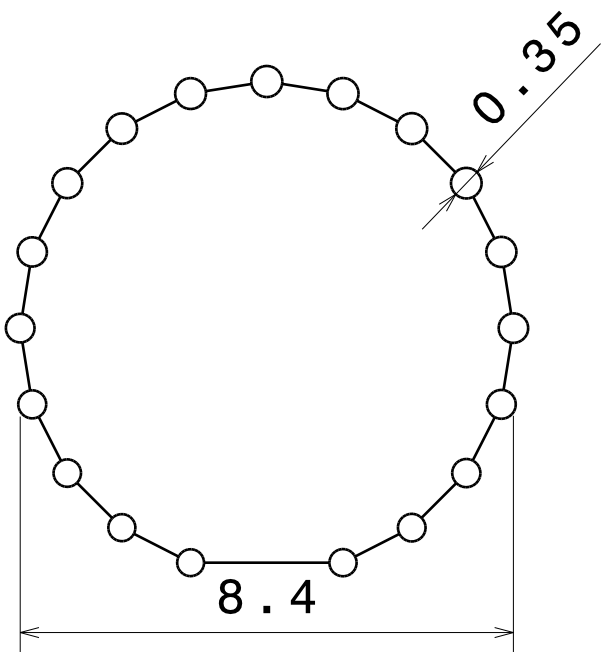

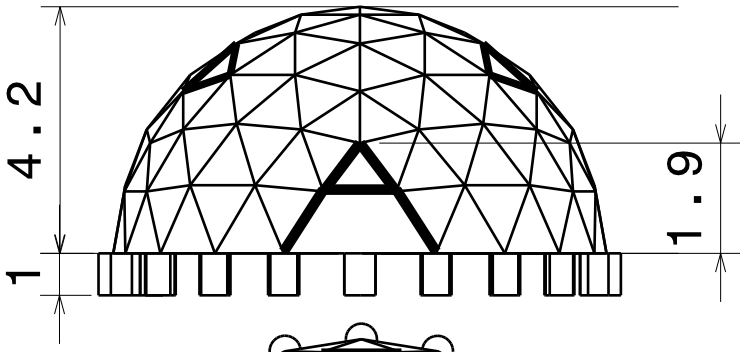

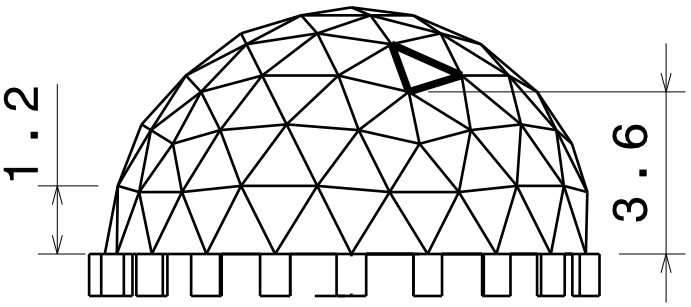

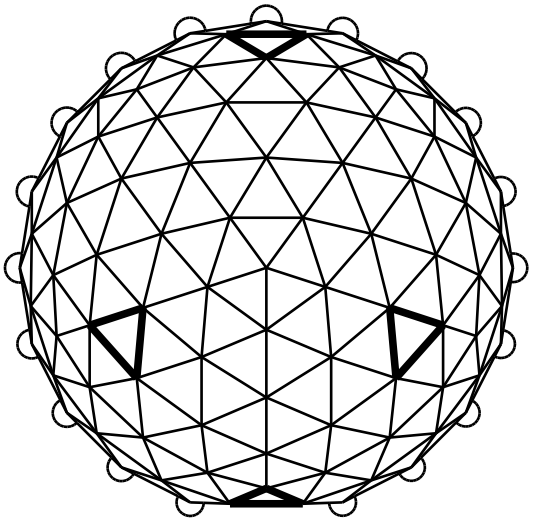

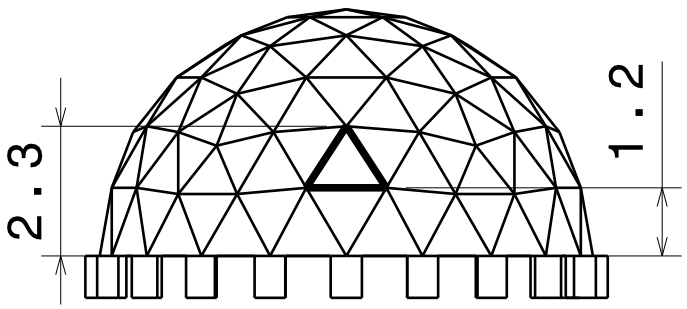

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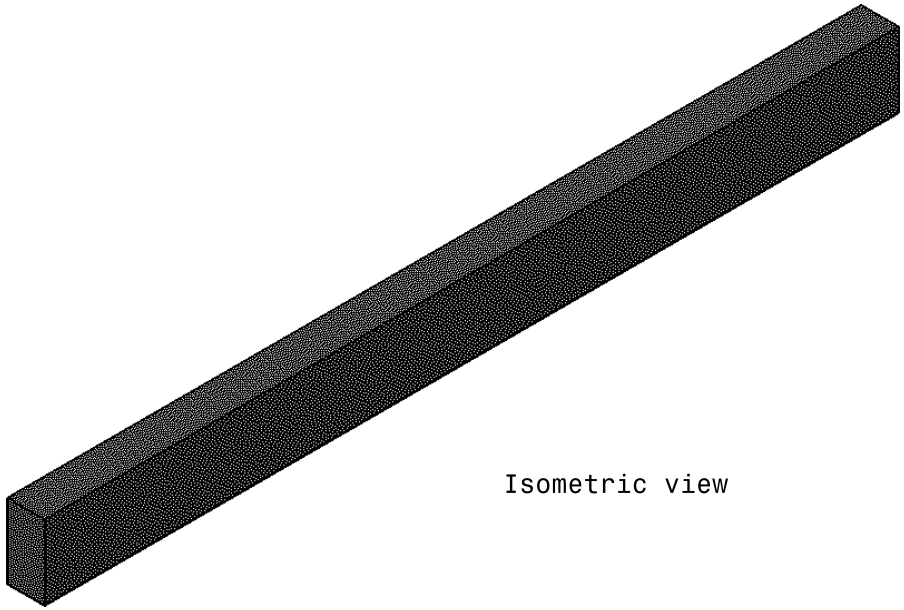

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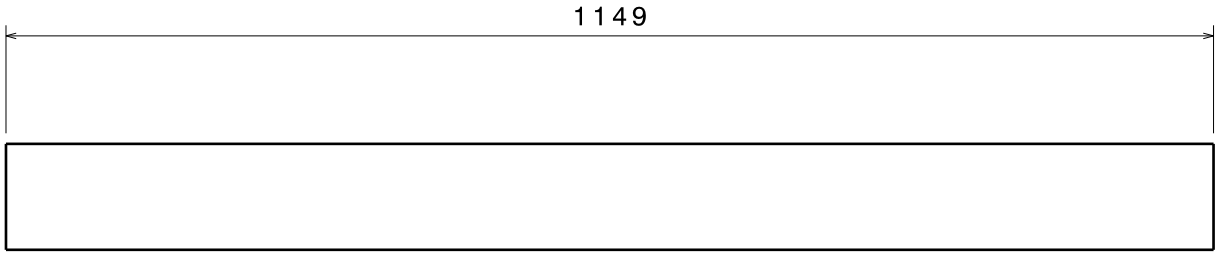

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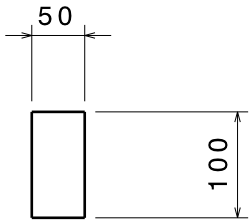

Left view

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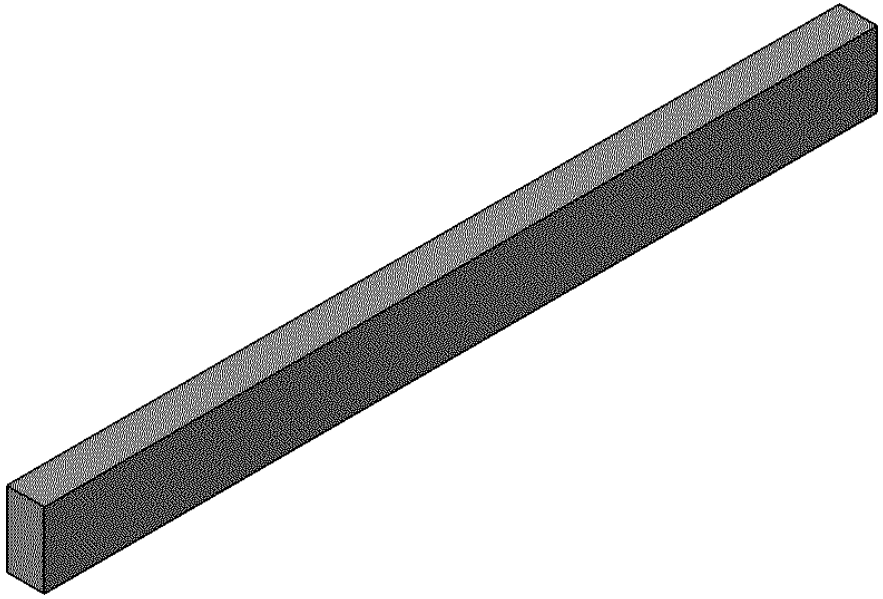

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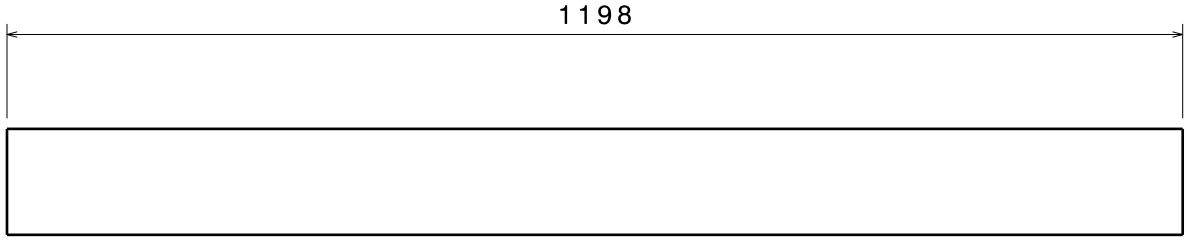

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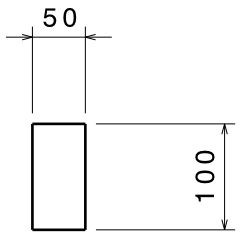

Left view

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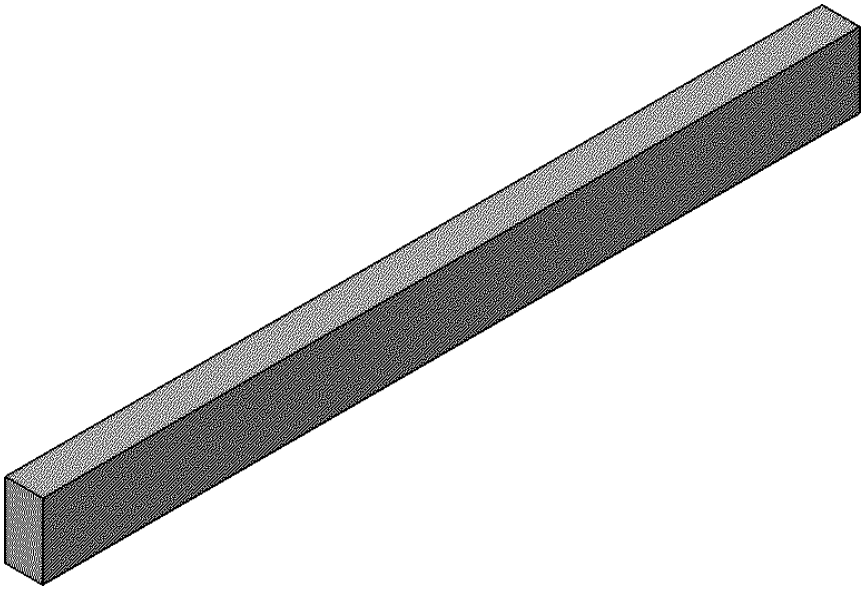

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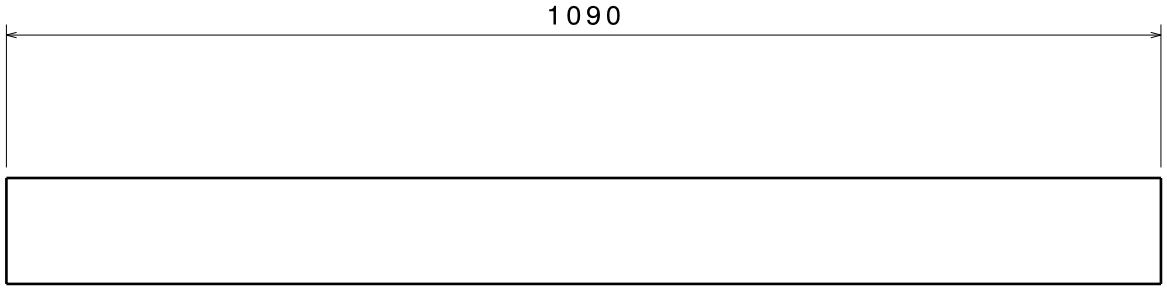

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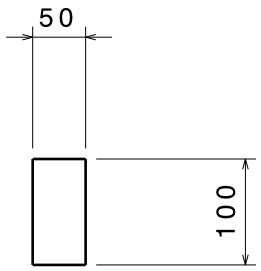

Left view

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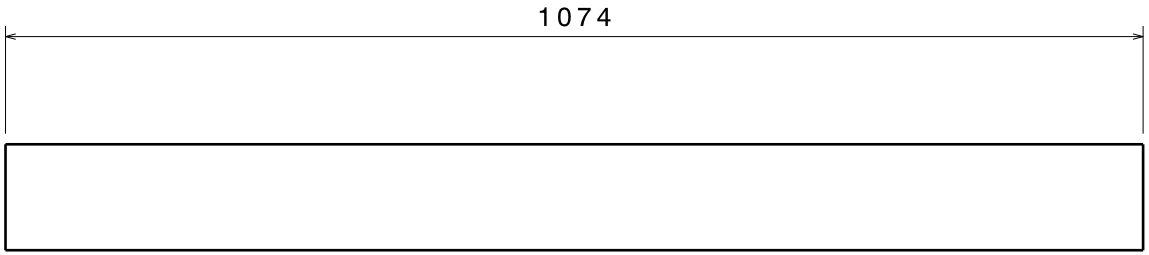
Isometric view



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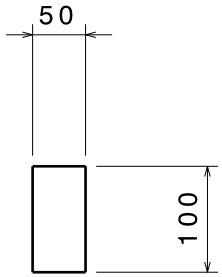

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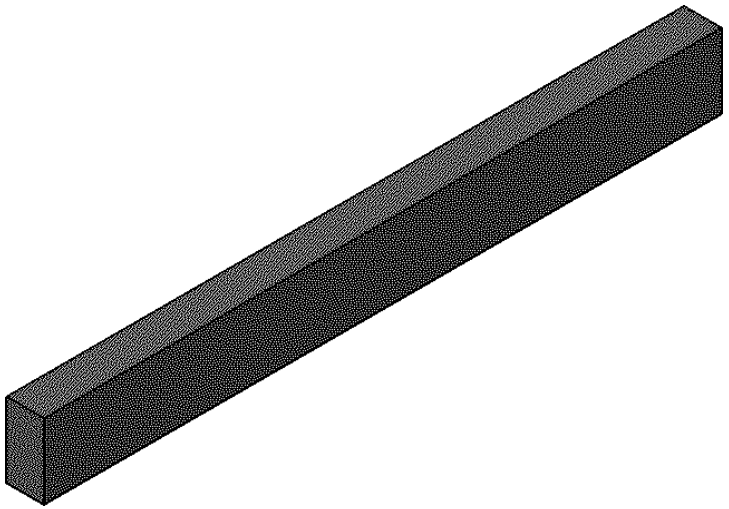

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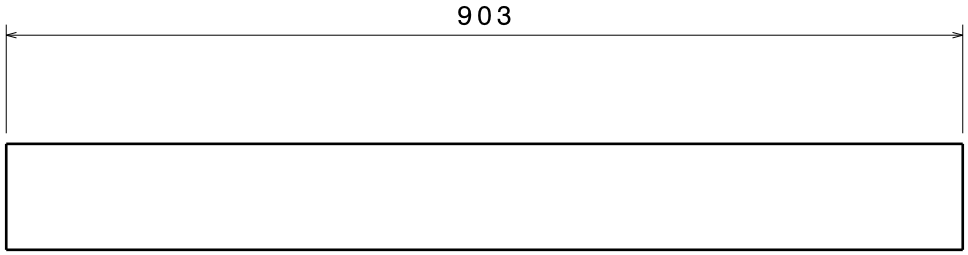

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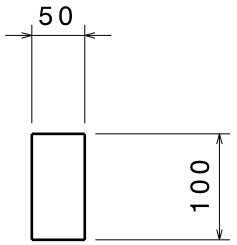

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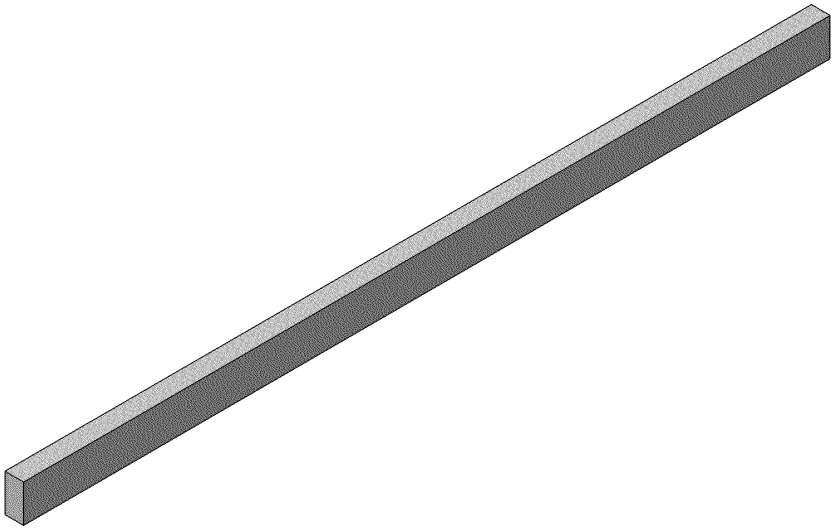

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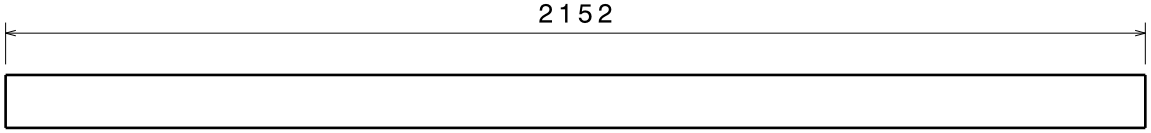

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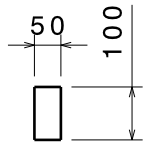

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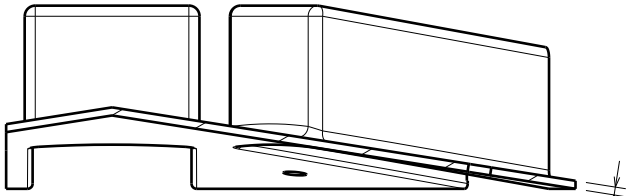
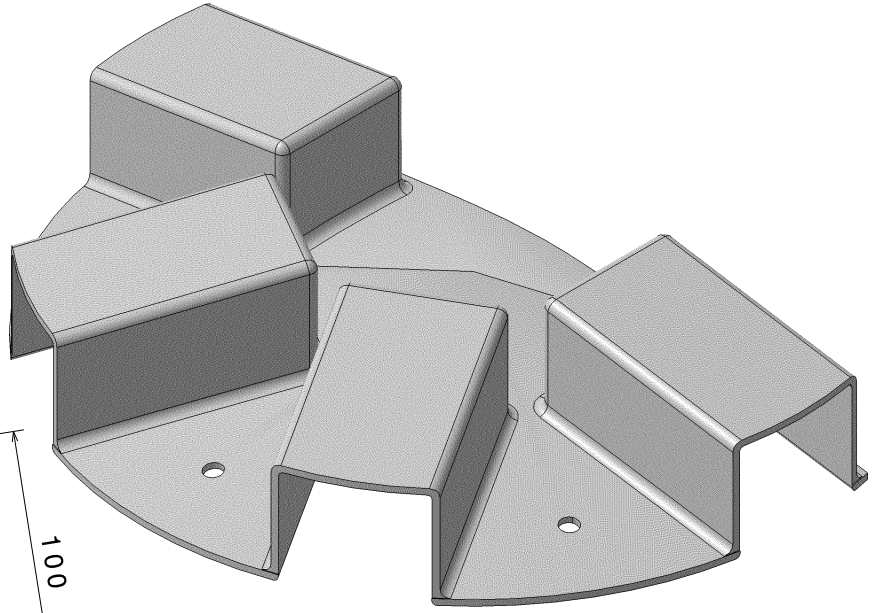
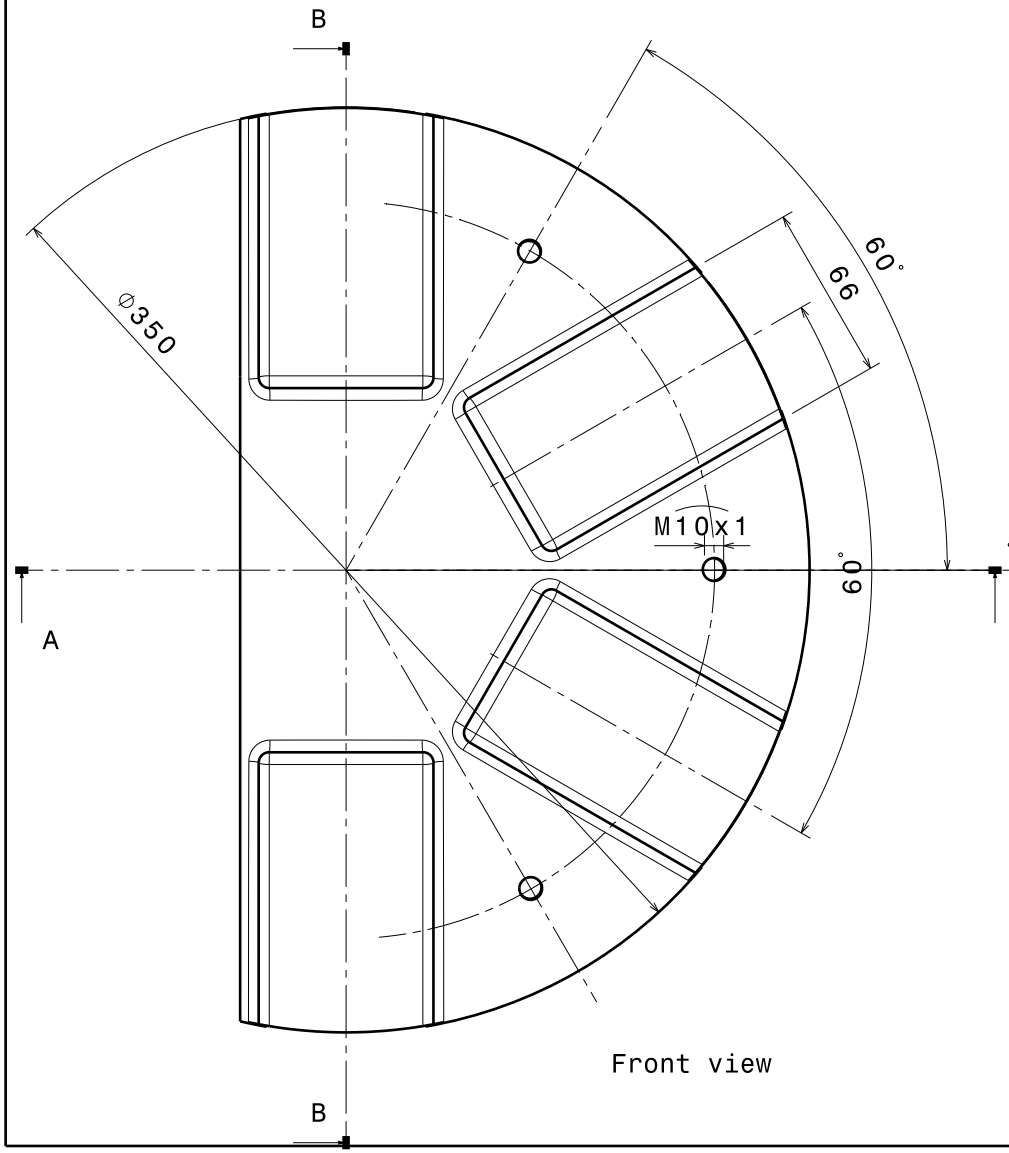
DESIGNED BY: ÁLVARO LUCAS GARCÍA CANDAU		
DATE: 22/06/2016	SCALE: 1:10	7/16



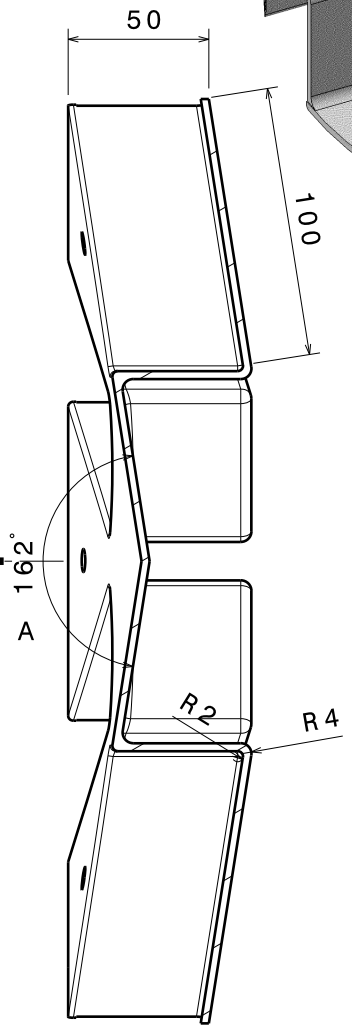
Section view A-A



Isometric view

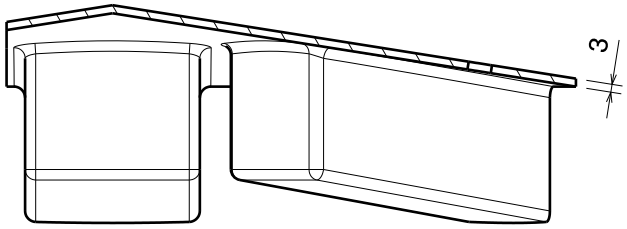


Front view

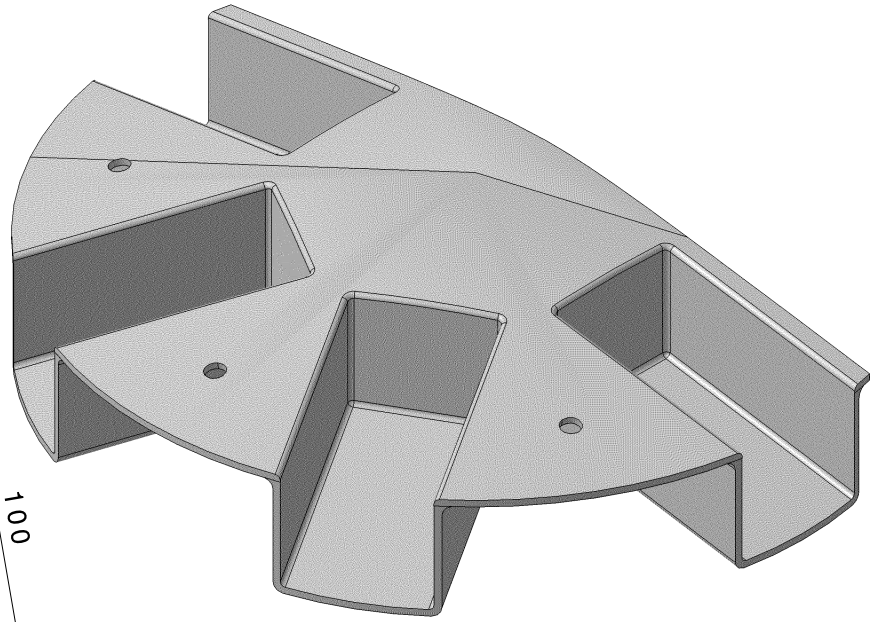


Section view B-B

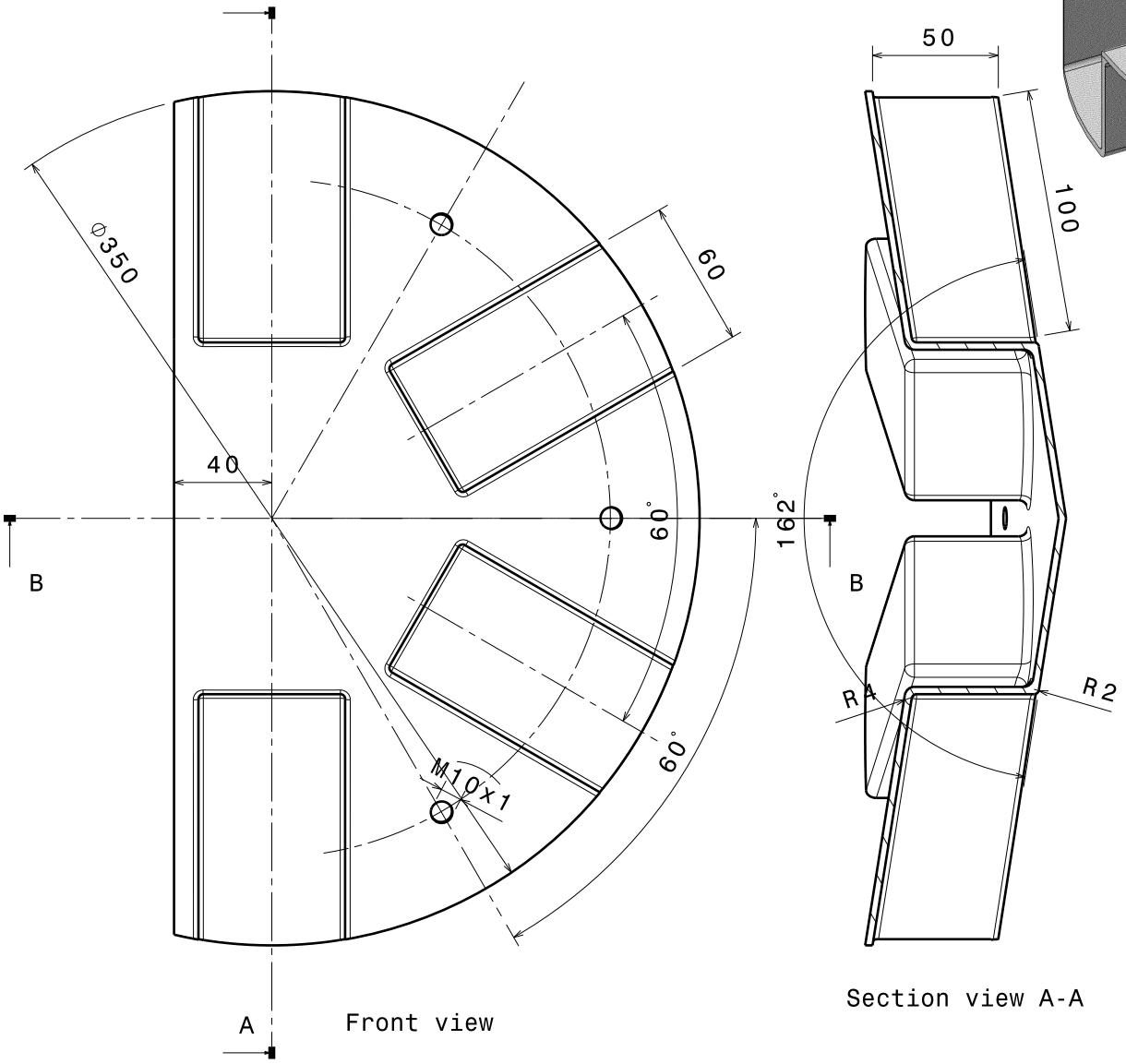
PROJECT: GEODESIC DOME FREQUENCY 4		
PLANE: TOP JOINT 4		
DESIGNED BY: ÁLVARO LUCAS GARCÍA CANDAU		
DATE: 22/06/2016	SCALE: 1:2	8/16



Section view B-B



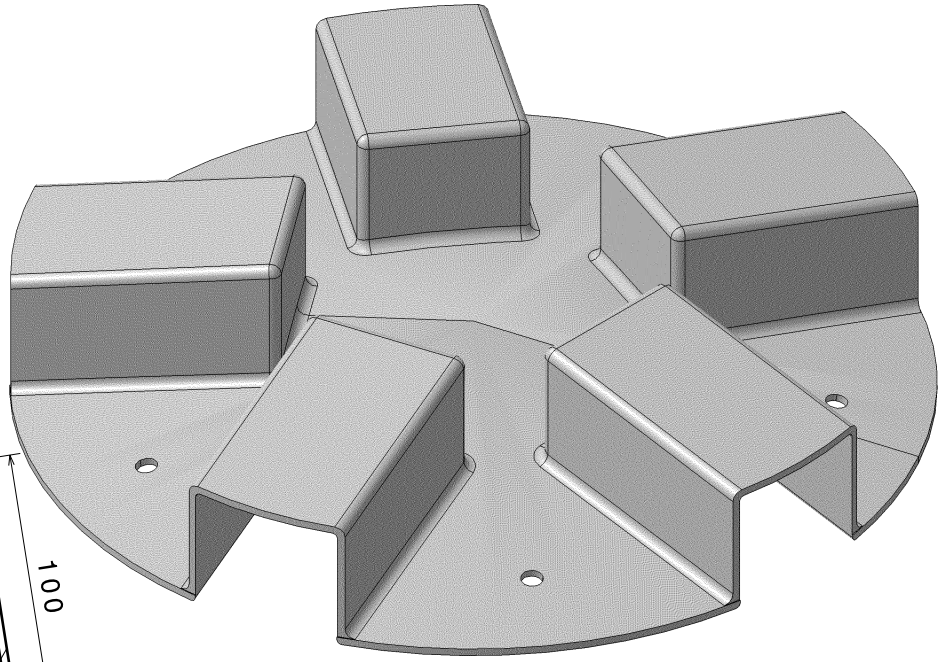
Isometric view



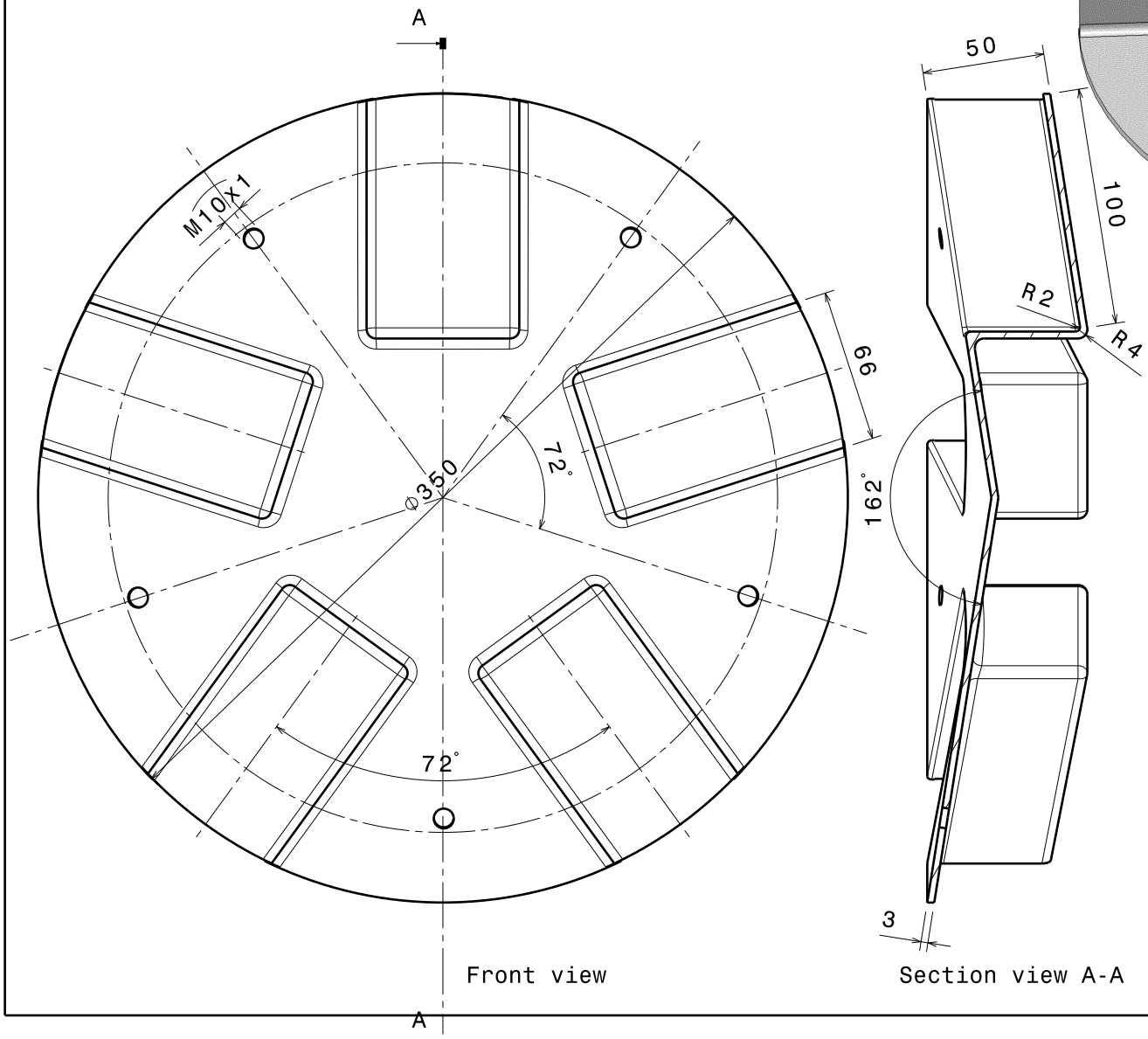
Front view

Section view A-A

PROJECT: GEODESIC DOME FREQUENCY 4		
PLANE: LOWER JOINT 4		
DESIGNED BY: ÁLVARO LUCAS GARCÍA CANDAU		
DATE: 22/06/2016	SCALE: 1:2	9/16



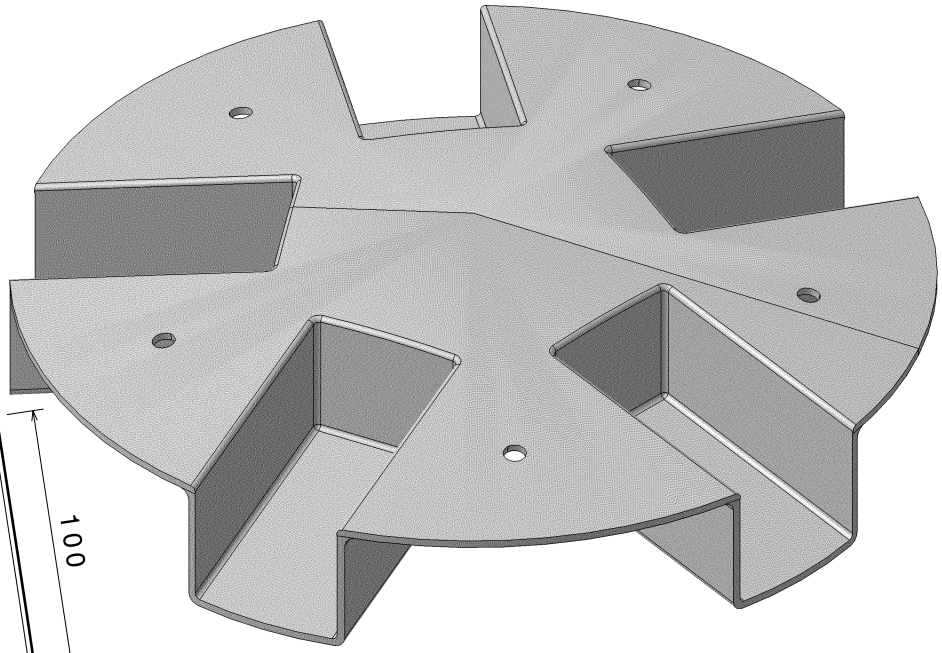
Isometric view



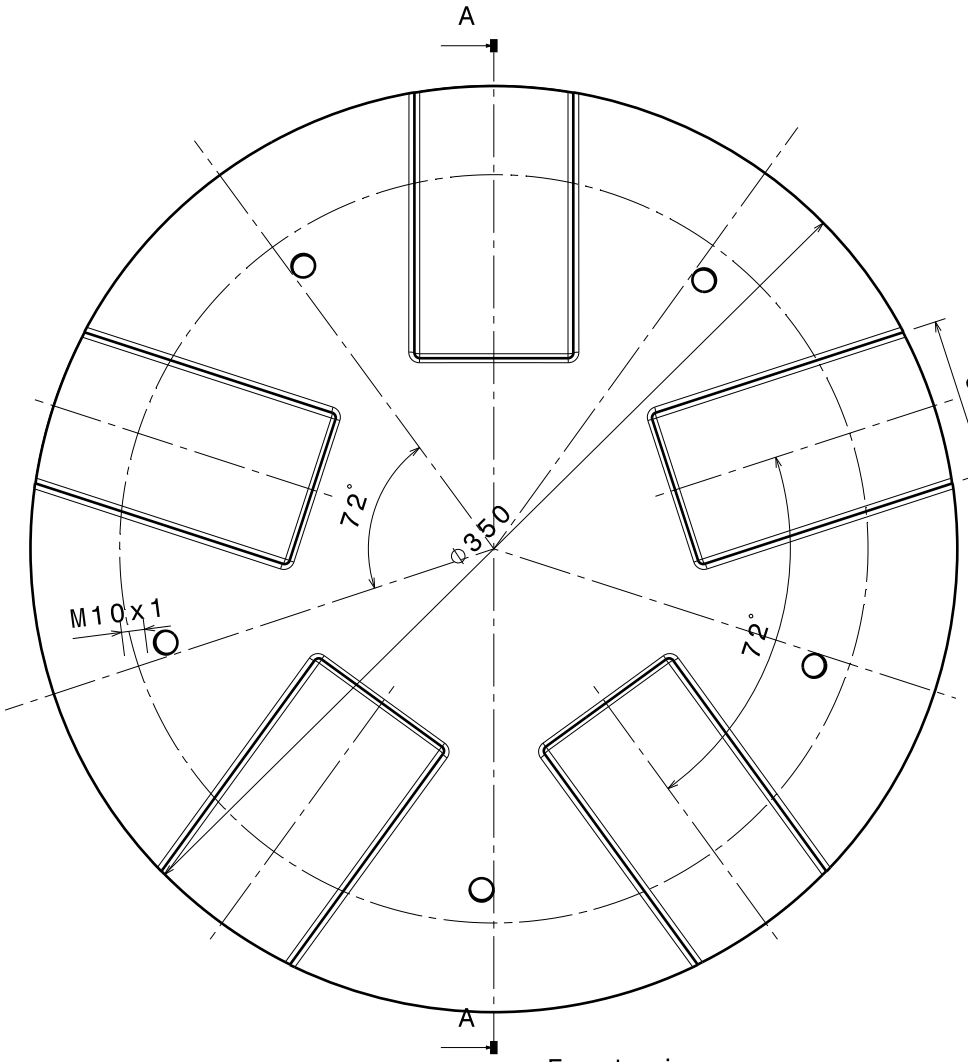
Front view

Section view A-A

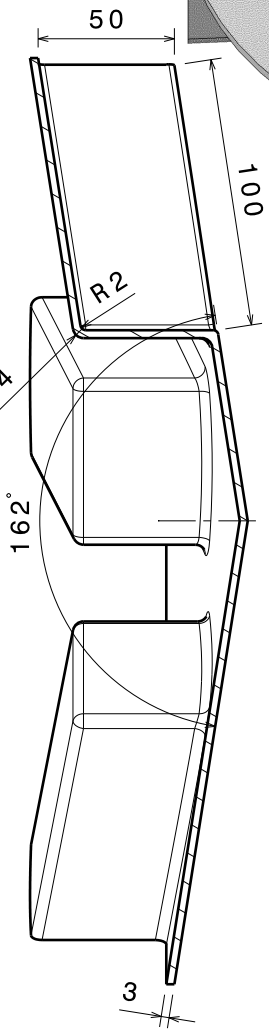
PROJECT: GEODESIC DOME FREQUENCY 4		
PLANE: TOP JOINT 5		
DESIGNED BY: ÁLVARO LUCAS GARCÍA CANDAU		
DATE: 22/06/2016	SCALE: 1:2	10/16



Isometric view

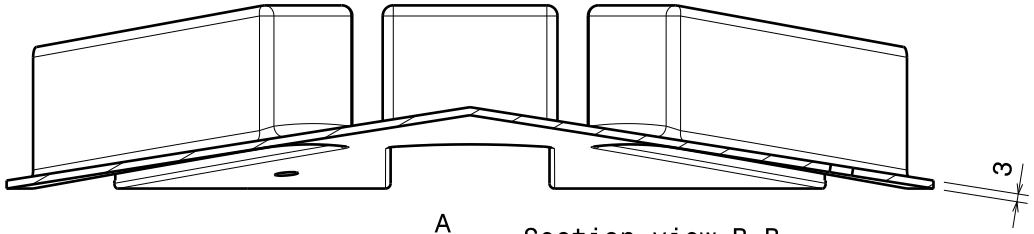


Front view

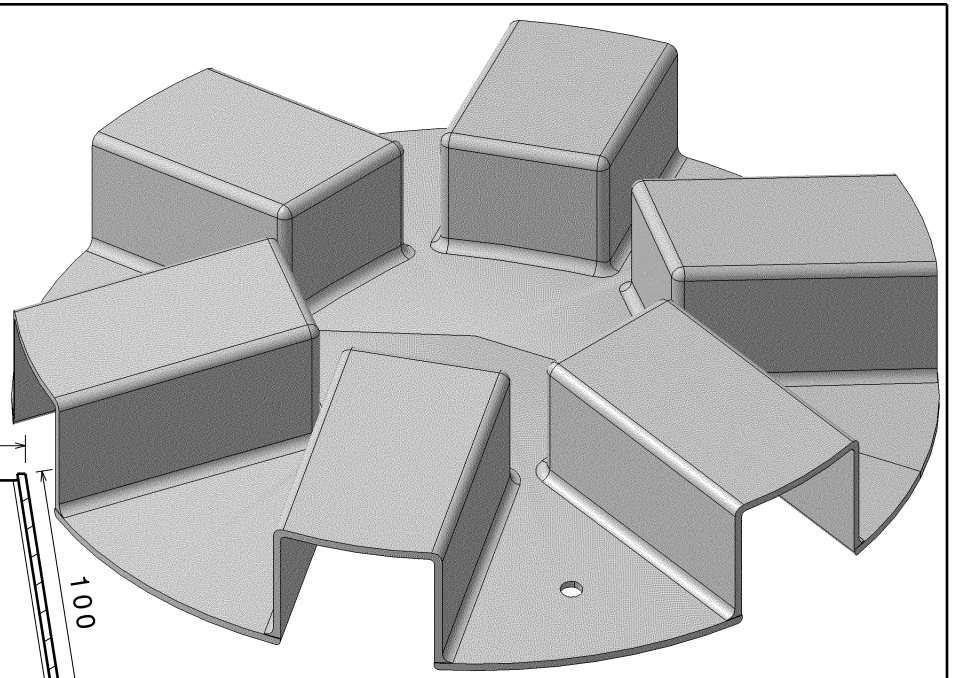


Section view A-A

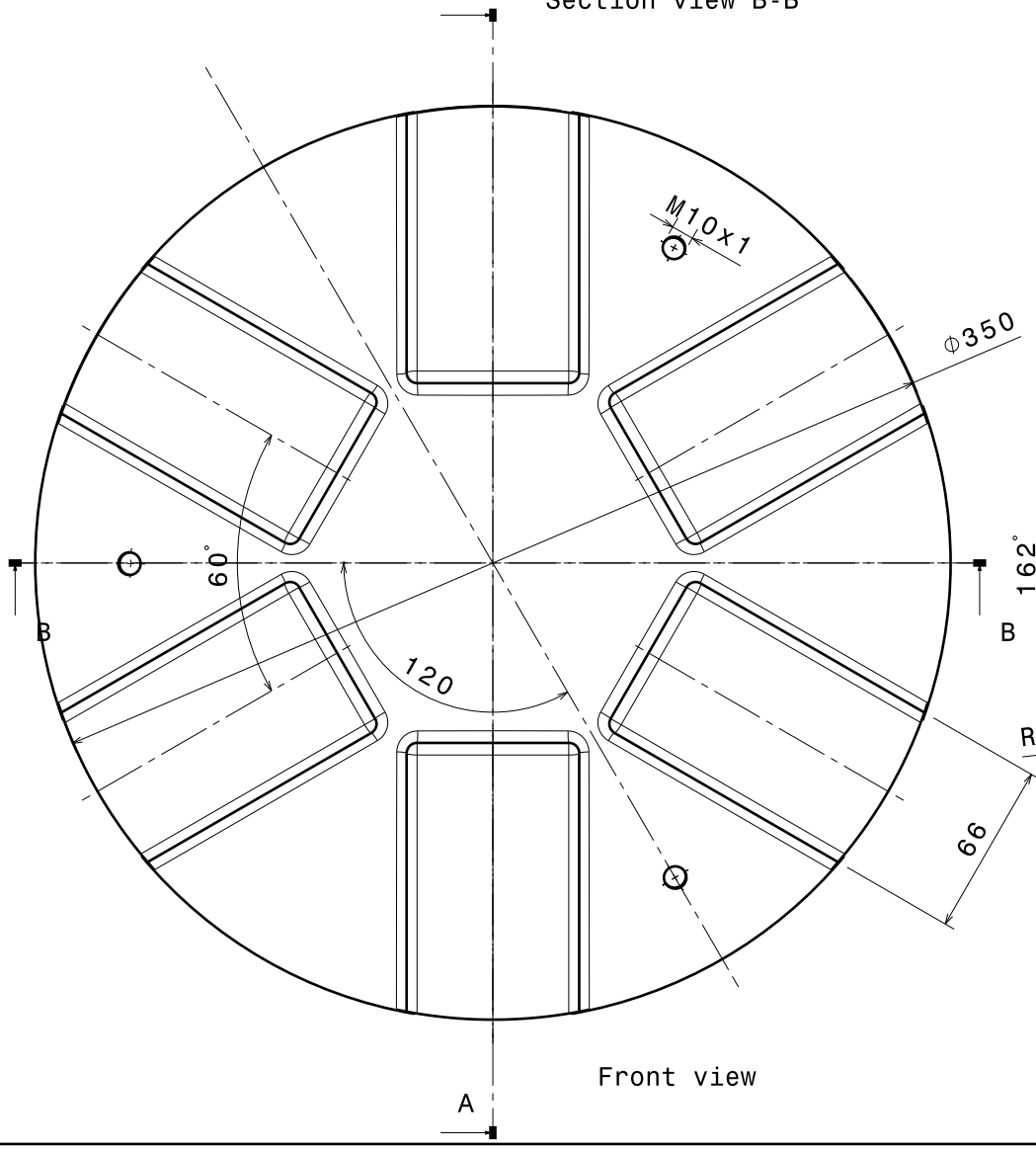
PROJECT: GEODESIC DOME FREQUENCY 4		
PLANE: LOWER JOINT 5		
DESIGNED BY: ÁLVARO LUCAS GARCÍA CANDAU		
DATE: 22/06/2016	SCALE: 1:2	11/16



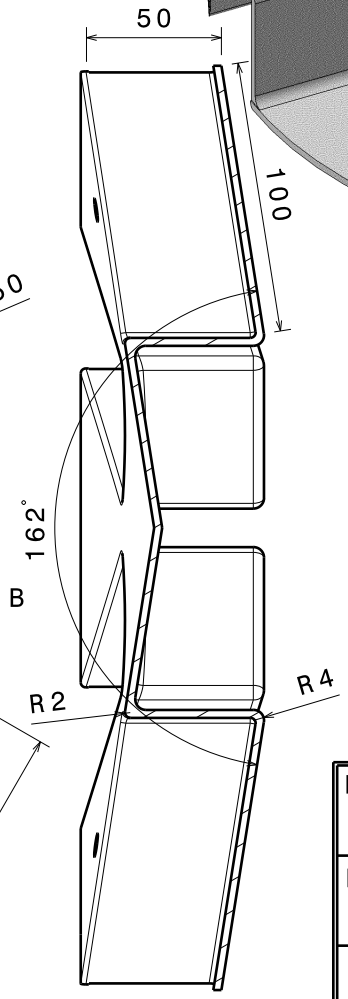
Section view B-B



Isometric view

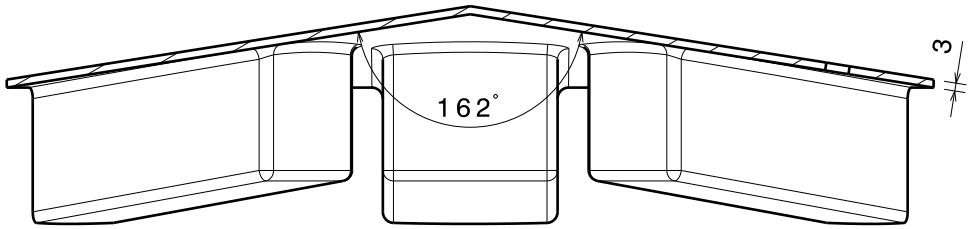


Front view

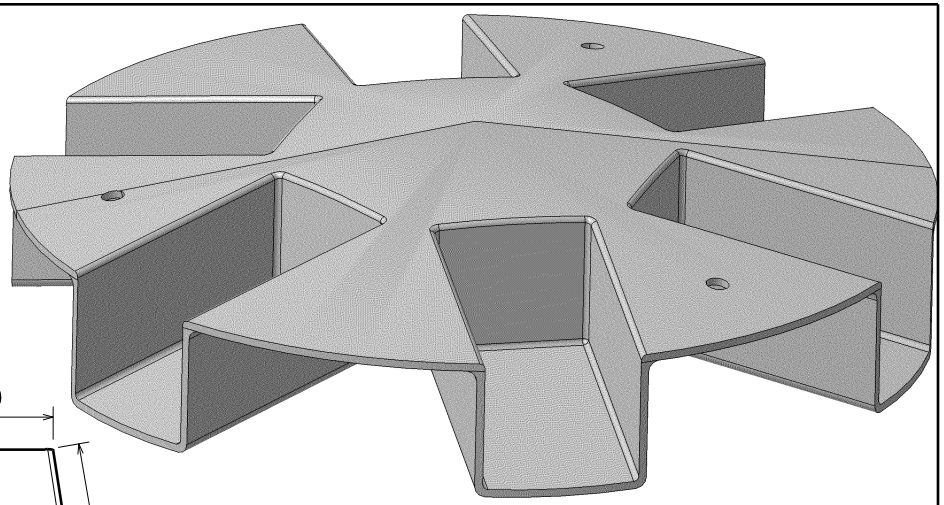


Section view A-A

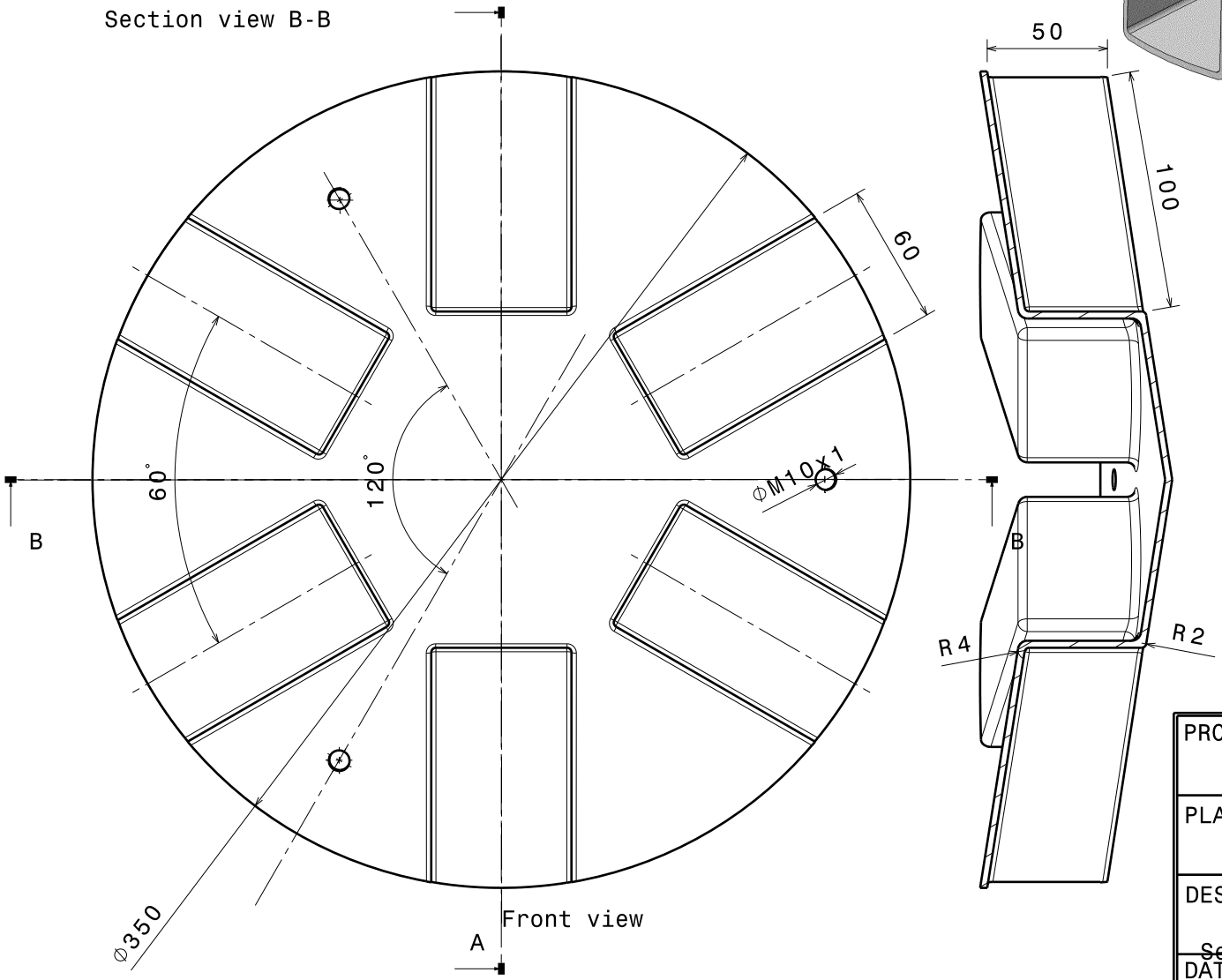
PROJECT: GEODESIC DOME FREQUENCY 4		
PLANE: TOP JOINT 6		
DESIGNED BY: ÁLVARO LUCAS GARCÍA CANDAU		
DATE: 22/06/2016	SCALE: 1:2	12/16



Section view B-B

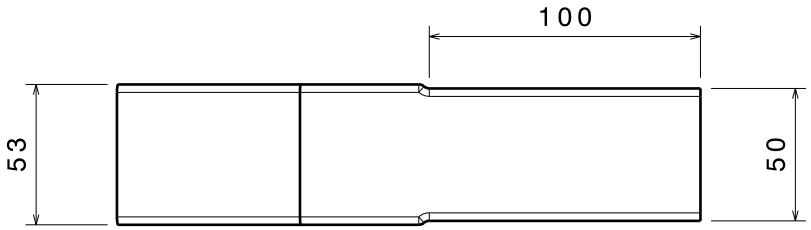


Isometric view

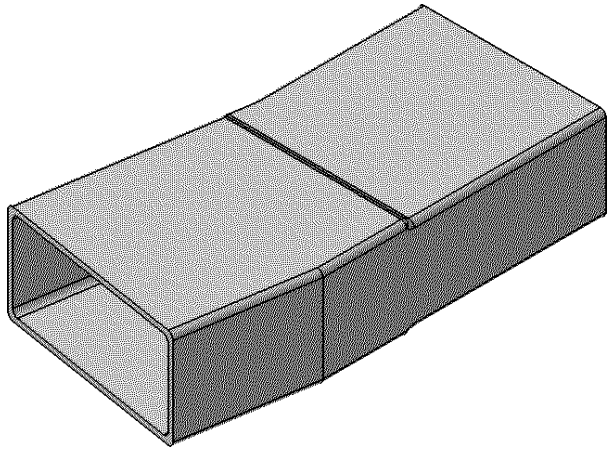


Section view A-A

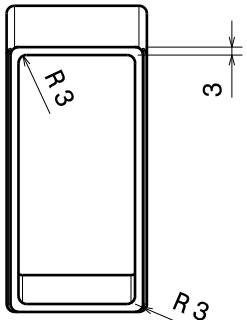
PROJECT: GEODESIC DOME FREQUENCY 4		
PLANE: LOWER JOINT 6		
DESIGNED BY: ÁLVARO LUCAS GARCÍA CANDAU		
DATE: 22/06/2016	SCALE: 1:2	13/16



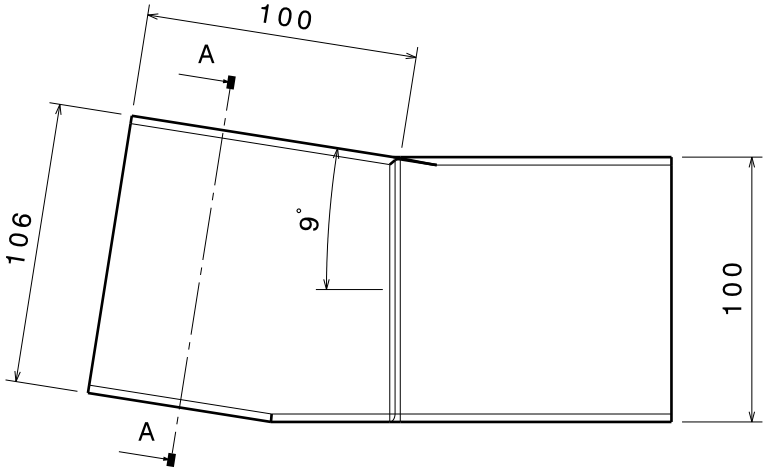
Bottom view



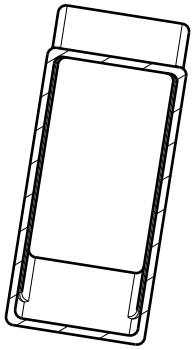
Isometric view



Right view

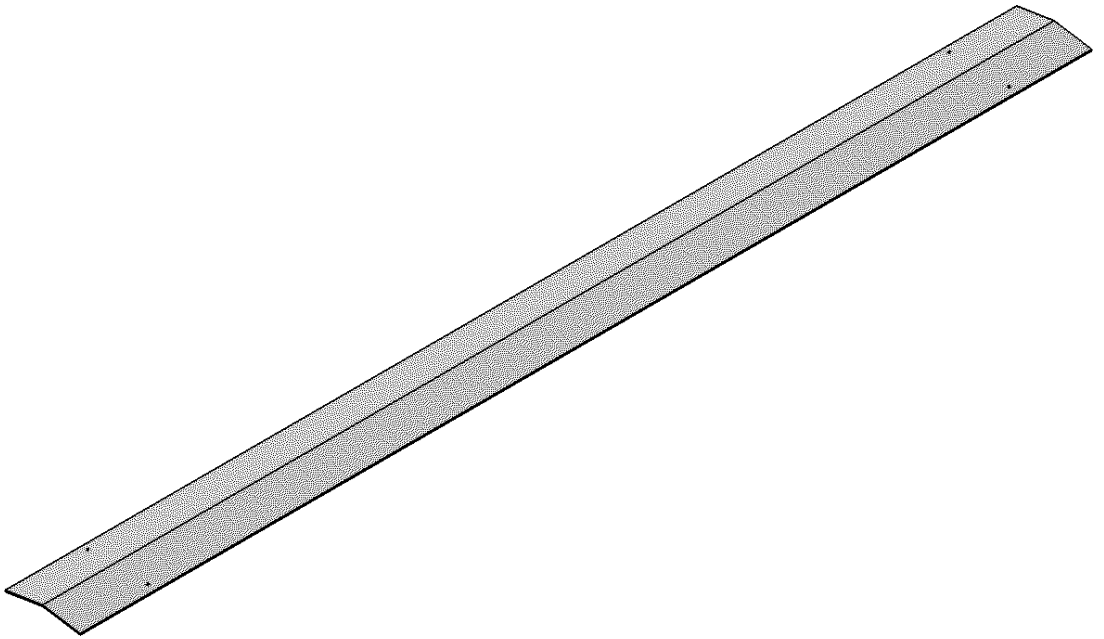


Front view

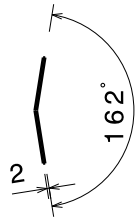


Section view A-A

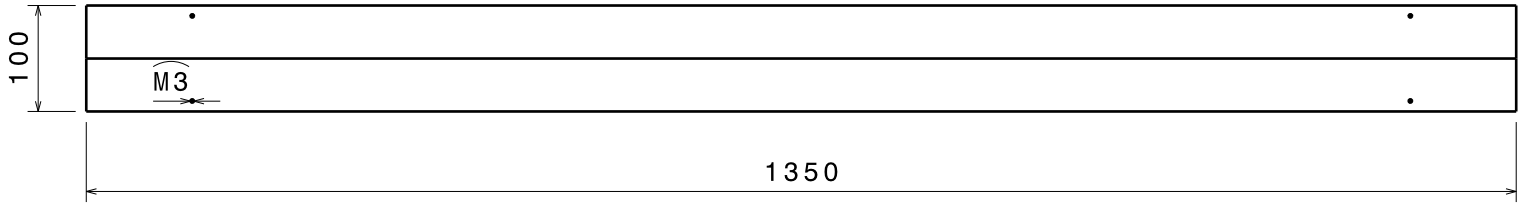
PROJECT: GEODESIC DOME FREQUENCY 4		
PLANE: DOOR JOINT		
DESIGNED BY: ÁLVARO LUCAS GARCÍA CANDAU		
DATE: 22/06/2016	SCALE: 1:2	14/16



Isometric view

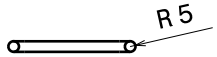


Right view

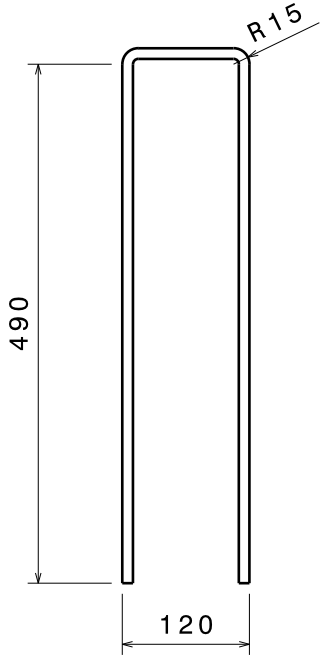


Front view

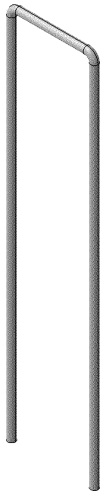
PROJECT: GEODESIC DOME FREQUENCY 4		
PLANE: COVER JOINT		
DESIGNED BY: ÁLVARO LUCAS GARCÍA CANDAU		
DATE: 22/06/2016	SCALE: 1:5	15/16



Bottom view



Front view



Isometric view

PROJECT: GEODESIC DOME FREQUENCY 4		
PLANE: FUNDATION JOINT		
DESIGNED BY: ÁLVARO LUCAS GARCÍA CANDAU		
DATE: 22/06/2016	SCALE: 1:5	16/16