The stainless steel structure of a sports stadium in Quart

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The building and its environment

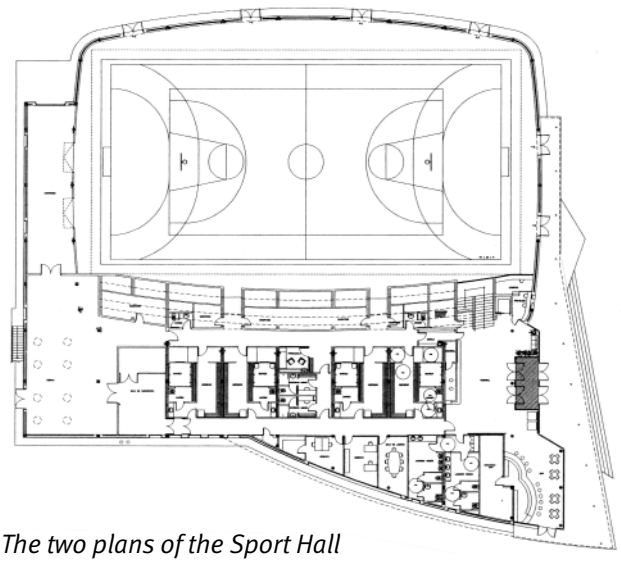
Quart is a small village of 2500 inhabitants, close to the town of Girona in the Northeast of Spain. The Sports Hall is located in the middle of a forest park. It is a multipurpose pavilion that contains 4 changing rooms for sport participants, another 2 for referees, and rows of seats for 250 spectators. It also contains a gymnasium and different service spaces as store rooms, offices, a bar, and toilets. The closed built surface is about 2800 m².

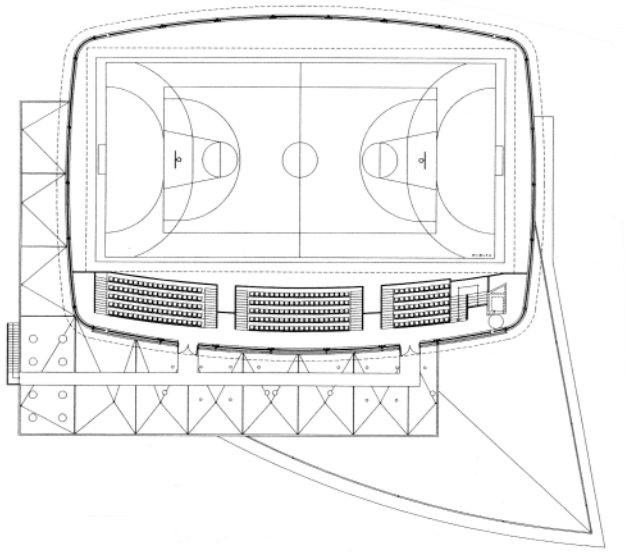
The sports arena and the rows of seats have been covered by a geodesic dome specially designed for this building. It will be described later in detail. In Girona the fire regulations are specially strict, in such a way that they made unfeasible to build an interior spatial truss structure. The solution has been to build the structure outside and hang the roof from it, so that this roof would act as a barrier to protect the structure against the fire.

This roof is composed (from the outside to the inside) of a flexible sheet of FPA, an insulation of 4 cm of rockwool, and a standard galvanised nerved plate supported on beams made of omega shaped galvanised steel 3 mm thick. Below it there is a rockwool false roof 85 mm thick. The conjunct was successfully proved against fire in a homologated official laboratory.

The structure is a double layer spatial grid. Since this structure was to be built outside it was made of grade 1.4301 stainless steel. All the elements of the structure such as bars, screws, nuts, etc., were made with this stainless steel. These bars were preconformated with a hole in each border.

The rest of the building is a standard construction with reinforced concrete in pillars and slabs, and walls made with local brick.





The two plans of the Sport Hall

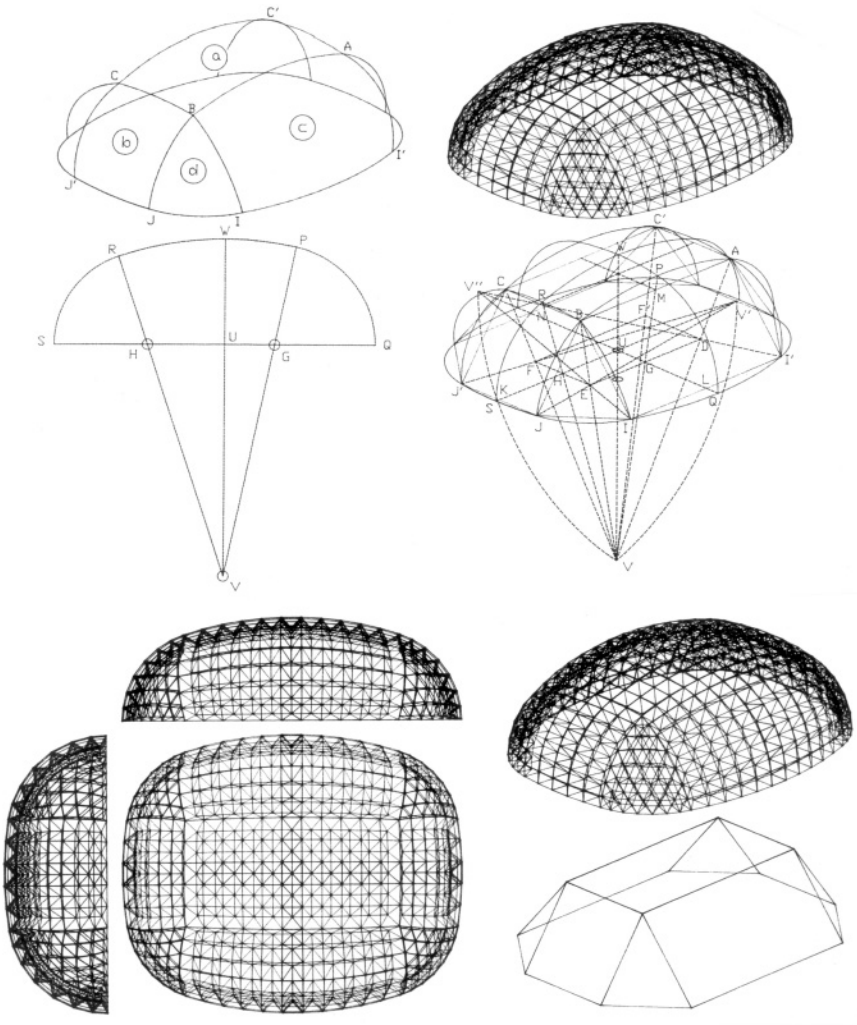
Geometry of the structure

Geodesic domes are, in general, spherical surfaces. As a consequence, their basis are circular or regular polygons such as squares, pentagons, etc., able to be inscribed in a circle. In our case the covered space of the sport hall is a multipurpose arena which shape is not circular, neither a square nor other regular polygon. It is a rectangle, so we wanted to design a geodesic dome on a rectangular basis. At the same time the usual geodesic domes, being spherical, are rather high. Their height usually corresponds to the radius of the sphere. In our case, we also wanted to make a low profile geodesic dome.

To obtain a geodesic dome with these two conditions (a rectangular basis and a low profile) we used a technique that consists in what can be called to make a carpanel dome. In fact it consists on making in 3D the same operation we do in 2D in the carpanel arc. For making a carpanel arc we reduce the height of an arc by curving the borders of the arc with other arcs of smaller radius. In the Quart dome we have reduced the height of a spherical dome by curving their lateral parts, which correspond to the sides of a rectangular basis. Then, the two characteristic cross sections of the dome are two carpanel arcs. The final result is a low profile geodesic dome on a rectangular basis.

It could be interesting to mention that it is possible to use this technique with any polygonal base, of any number of sides, whether they are identical or not. That is to say that any regular or non-regular polygon can be used as the basis for a similar dome to the one we are describing. Moreover, it will be possible to adapt its final height to our needs.

The dome is composed of a central piece, 4 lateral pieces and 4 corners. The central piece and the corners are spherical. The lateral ones are compound surfaces, but made with circle arcs in one of the two grid directions. In all of these pieces the structural grid lines are geodesic lines. That is to say, they are lines of minimal length. This is why they are the optimal lines for distributing the external forces. These geodesic lines have been obtained by projecting the straight lines of a polyedric grid on circle arcs of a sphere. In the central piece and in the corners, all of them spherical, the projection centres are fixed in the centres of those spheres. In the lateral pieces the projection centres are mobile and tour at the same time as those lateral pieces tour. As a result, the obtained grid is a continuous double curvature surface being, at the same time, absolutely geodesic. The curve radii vary between 100 m and 3.20 m in the internal layer. And between 101.20 m and 4.40 m in the external layer. The constant distance between the two layers is 1.20 m.



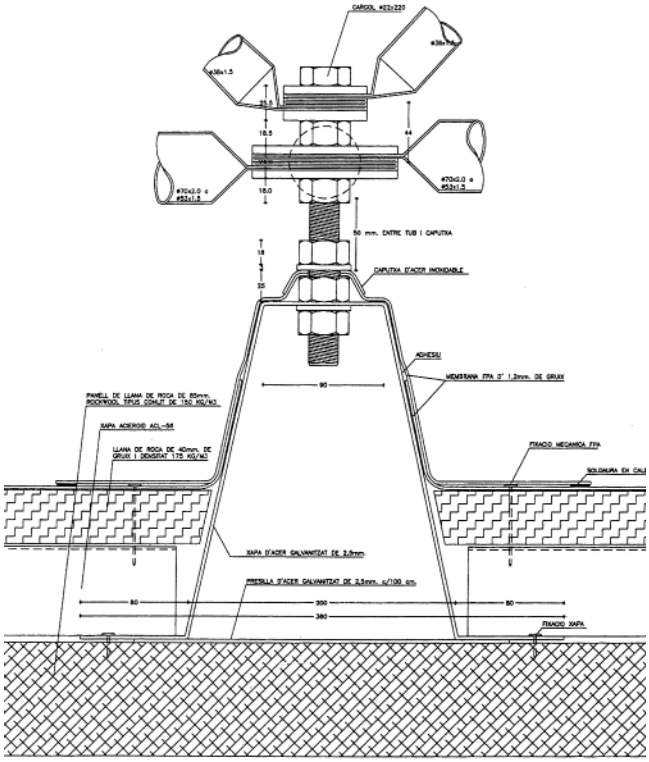
The full geometry of a double layer geodesic dome with low profile and a rectangular basis.

The structure and its construction

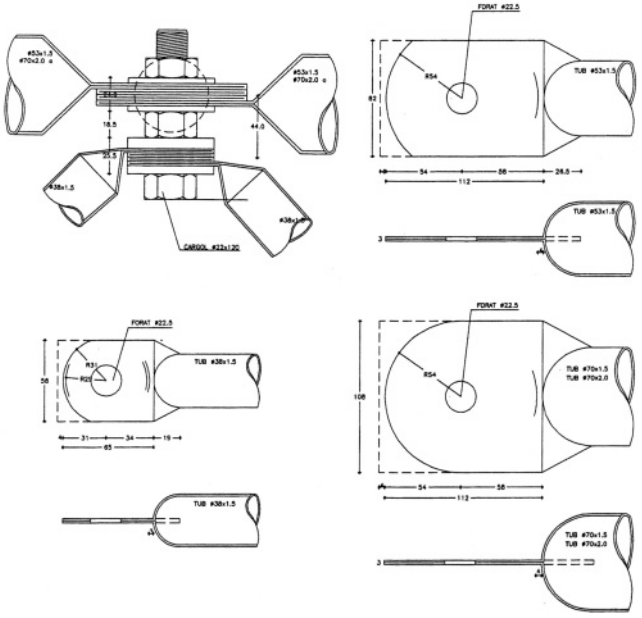
The material for the structure is stainless steel. Fine, but how could we make a stainless steel spatial structure at a reasonable price? The answer is that we have used an extremely simple joint. In fact the bars are jointed together by one single screw in each node. So the stainless steel bars are more expressive than that carbon steel counterparts, but the cost of the node is minimal, and the assembled structure has been made at a cost of about 120 Euro/m².

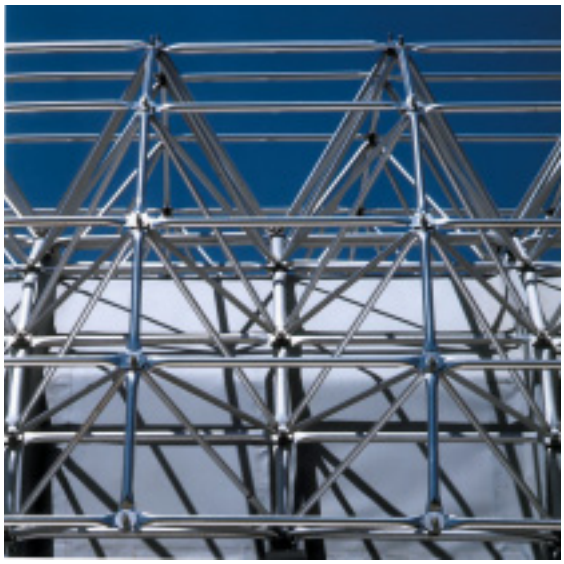
The bars are stainless steel tubes of two basic diameters: one of 53 mm for the two layers, the other of 35 mm for the diagonals. There is a third diameter of 70 mm for the bars that are super stressed in any of the two layers. The bars were prefabricated in the workshop with a 22.5 diameter hole in each border. The screws were of 22 mm diameter. Some special pieces were designed in order to assure the desired properties of the joints.

Since the grid is bi-directional, the nodes are composed by 4 layer bars and 4 diagonal bars. Between them there is a nut. The axis of the 8 bars practically converge in a geometrical point.



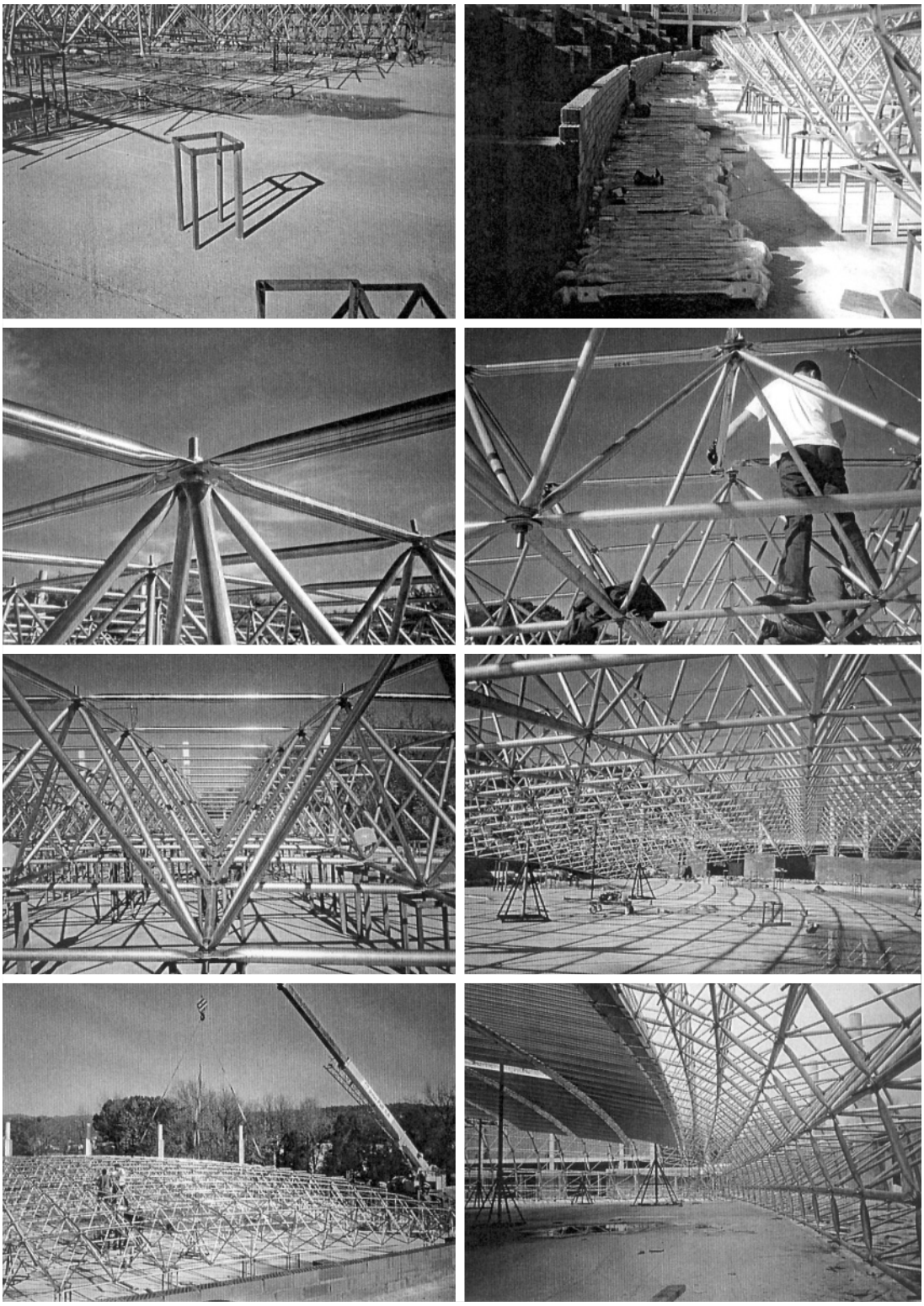
Detail of the connection between the roof and the structure.



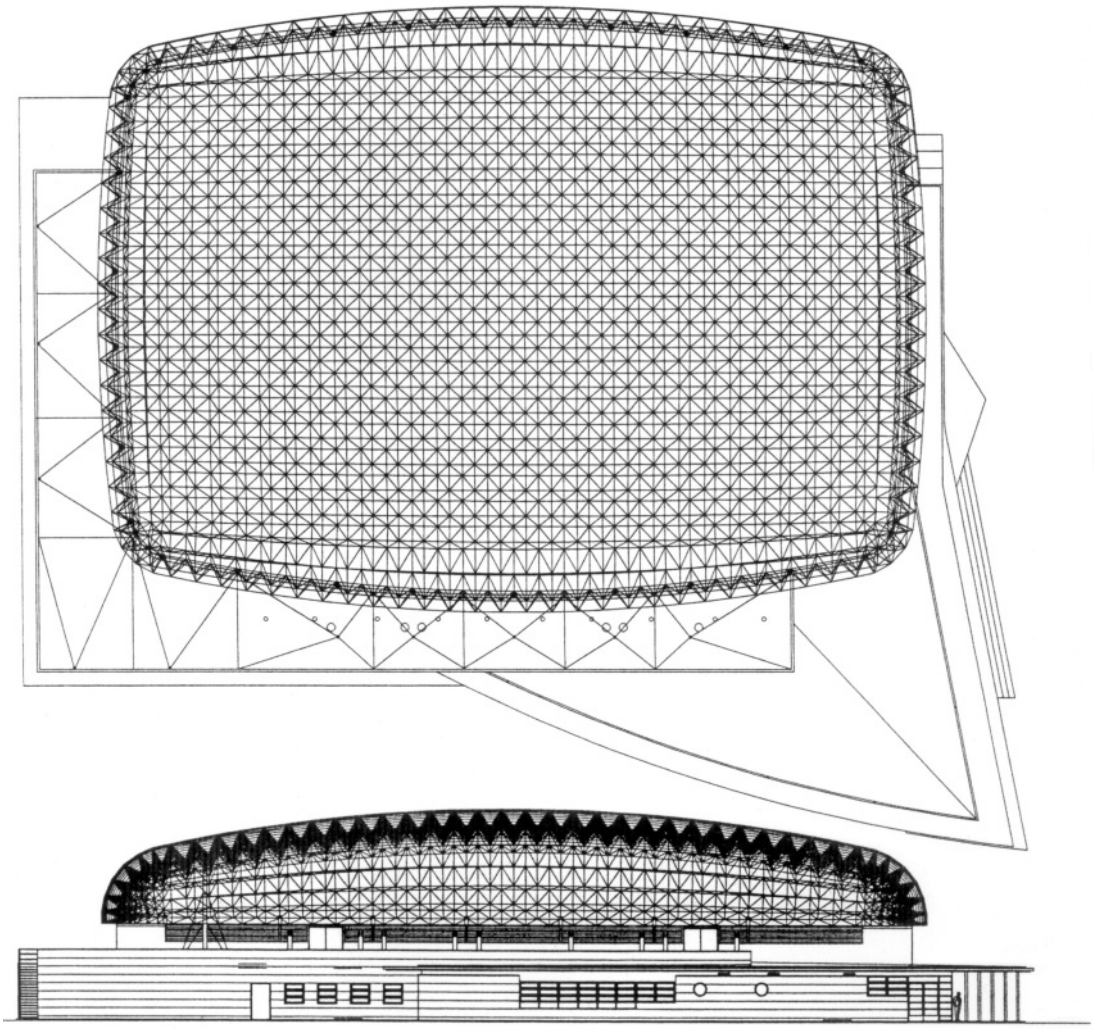


Constructive details of the bars of the stainless steel structure.

Due to the fact that the length of every bar was fixed by the two holes in their borders, the construction of the structure had to begin by the highest node, going down toward the lower nodes. The assembly was made on the ground by only three workers, and without any special equipment. The full structure was built in two identical half parts. Once erected, the two half parts were sewed to complete the dome.



Some aspects of the structure as it was erected on the ground in two halves.



The geodesic dome in its final position.

Summary of the principal characteristics

- Full geodesic dome on a rectangular basis
- Double layer 1.20 m thick
- Fully made with AISI 304 inox steel
- Diameters of bars:
  35x1.5 mm, 53x1.5 mm, 70x2 mm
- Joints with 22 mm diameter screws
- Developed surface: 2000 m²
- Covered surface: 1550 m²
- Main transversal spans: 48 m and 34.5 m
- Number of bars: 10,456
- Number of different length bars: 625
- Medium length bar: 1,450 mm
- Number of joints: 2,565
- Total weight of the structure: 30,000 kg

The construction team

General contractor: AGT
Inox bars: TROCOMPSA
Structure: CASANOVAS
Roof: ACIEROID

The technical team

Luis Sánchez-Cuenca, Dr. Architect
Miquel Llorens, Arch. structural consultant
Eduard Bonmatí, Technical Architect
Francesc Rodriguez, Technical Architect