SANDER AND NEY

COVER TWO HISTORIC BUILDINGS WITH GLAZED ROOFS

Text **David Keuning**

RENDERING OF THE NETHERLANDS MARITIME MUSEUM BY DOK ARCHITECTEN. THE DESIGN FOR THE COURTYARD ROOF IS BY NEY & PARTNERS.

THE INSPIRATION FOR THE ROOF OF THE NETHERLANDS MARITIME MUSEUM: AN OLD NAVIGATION CHART FROM THE MUSEUM'S COLLECTION.

THE INSPIRATION FOR THE ROOF OF THE MINISTRY OF DEFENCE: BRICK WINDOWS WITH STAINED GLASS ON THE FRONT FAÇADE OF THE MINISTRY BUILDING, A DESIGN BY FORMER GOVERNMENT ARCHITECT GIJSBERT FRIEDHOFF.

'The polyester ribs are extremely accurately detailed, with the same precision as for a car or a plane'

— Ellen Sander —

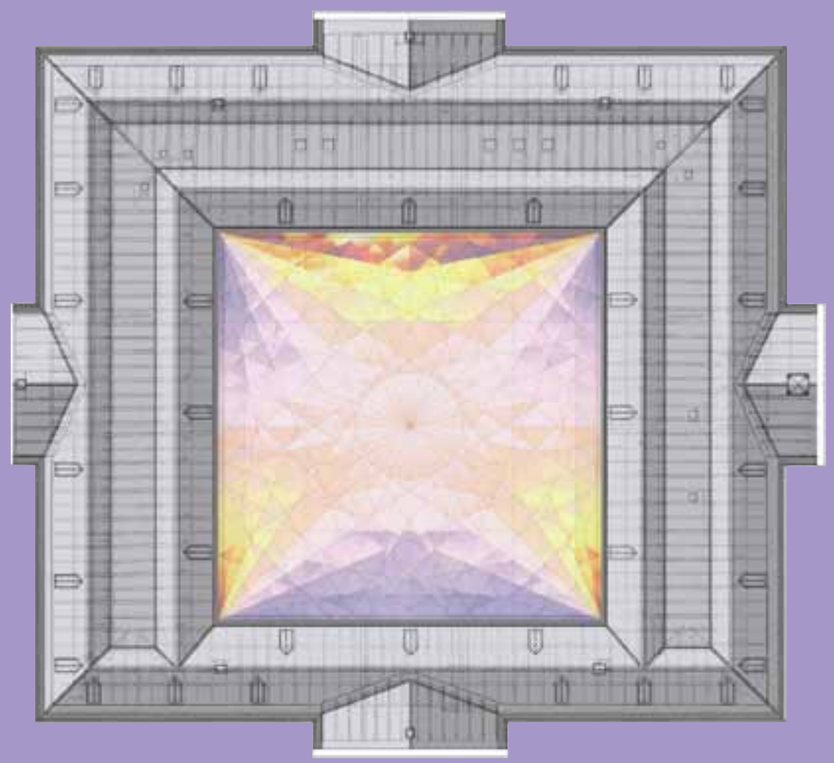
RENDERING OF THE DUTCH MINISTRY OF DEFENCE BY SANDER ARCHITECTEN.

'Curved roof glazing composed of irregularly shaped quadrilaterals, pentagons and hexagons. I think it's the first time a construction like this has ever been built,' says Kenny Verbeeck of the Brussels construction firm Ney & Partners. He is standing on scaffolding in the inner courtyard of the Netherlands Maritime Museum, which is housed in a seventeenth-century warehouse that is currently being renovated by Dok Architecten. The museum is scheduled to reopen next summer, but for now the cold winter wind still blows through the rooms. 'Most curved roof glazing is composed of triangles, because they have the mathematical characteristic that a straight surface can always be found that goes through all three corners. This roof consists of apparently irregular surfaces with as many as six or seven corners, so this is not automatically the case.'

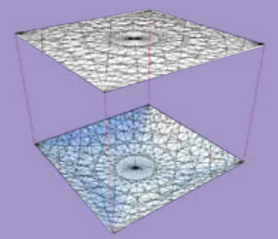
Laurent Ney received the commission for the roof covering after winning a competition, where the entrants included the German roof-glazing designer Jörg Schlaich. The Belgians won with an unusually refined design: they based the supporting structure of the roof on the geometric pattern in one of the historical navigation charts in the museum's collection. On the chart there are 16 points in a circle, some of which indicate important ports. They are all interconnected, which creates a complicated criss-cross pattern of straight lines. Ney cut out a square whose corners converge with four of the 16 points. These four points form the corners of the roof covering.

'We first drew the pattern in a flat surface,' says Verbeeck, 'and afterwards we let the lines drop according to the hanging chain principle, in the same way that Gaudí applied it, for example. This creates curves in which uniaxial tension is present. The cover could not be higher than the roofs of the existing building, so the lowest point was also defined immediately. We then turned the whole thing over and ended up with a construction in which uniaxial compression is present.'

A slender construction was important, because the monuments committee would not allow the existing inner courtyard to be affected. That meant that columns could not be used to support the construction which in turn meant that the roof construction had to be laid on top of the old »



VIEW FROM ABOVE OF THE GLASS ROOF AT THE NETHERLANDS MARITIME MUSEUM.



DRAWING OF THE SUPPORTING STRUCTURE OF THE ROOF AT THE NETHERLANDS MARITIME MUSEUM IN PLAN. BELOW THE CURVED VERSION ACCORDING TO THE HANGING CHAIN PRINCIPLE

walls surrounding the courtyard. That requires the lightest possible method of building.

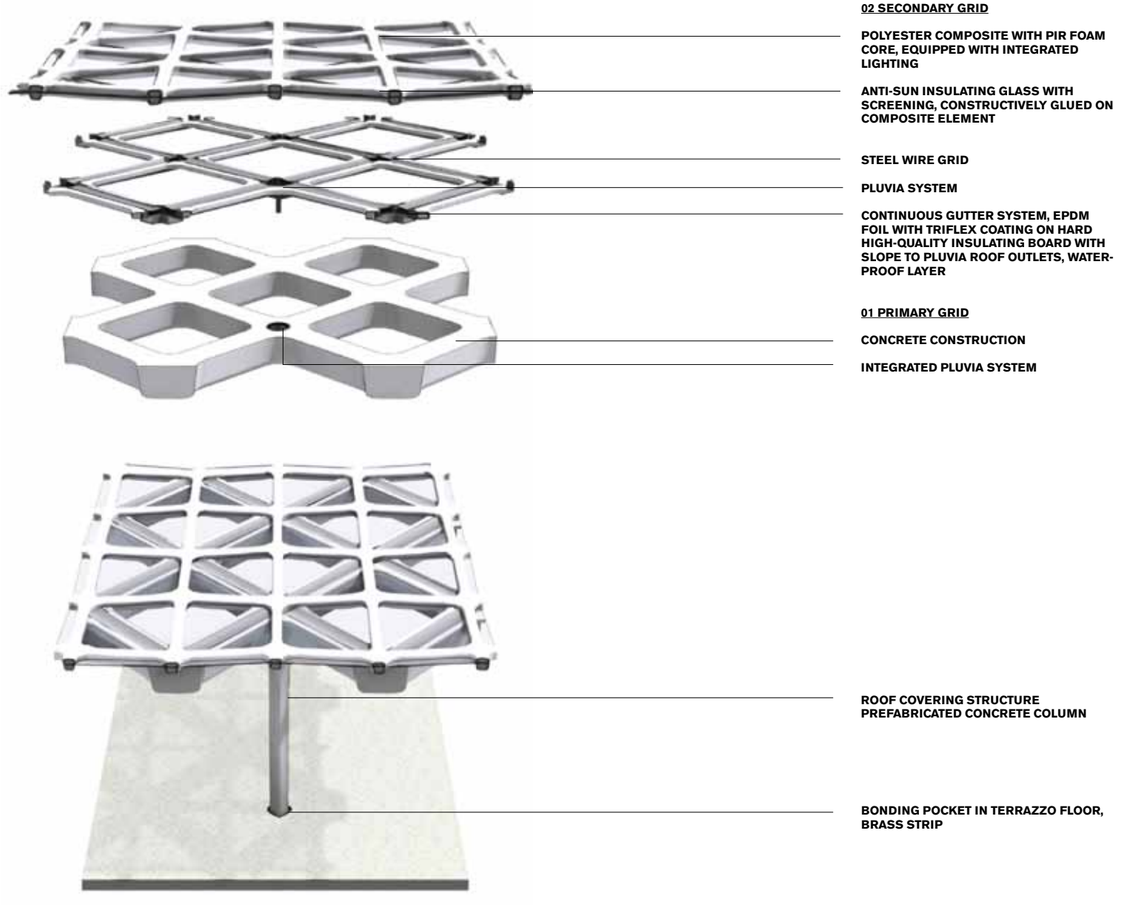
An extra complication was the fact that the museum's inner courtyard, which is built on soft Amsterdam soil and has sunk a little in the course of the centuries, is not a perfect square. 'The plan is actually a very slight trapezium,' says Verbeeck. 'Over 34 m, there is a 30 cm slant. Not enough to see with the naked eye, but too much to ignore.' So the design, which consisted of four identical quarters in an earlier stage, changed into an irregular square where no two lines are precisely the same length. In addition, the walls of the museum are not as straight as a die; they undulate slightly. That problem has been solved with 31 ridges under the edge beams, each of which protrudes slightly differently. In this way the covering rests precisely on the centre of the thick walls at every point.

Afterwards, the real arithmetic began. The halfway stage was a curved construction, built up from approximately 1016 different polygons, not a single one of which could be described in a flat plane. To prevent the roof covering from becoming exorbitantly expensive, the whole construction had to be translated into straight lines and flat surfaces. But the big question was exactly how to achieve this. To find the answer, Ney called on the assistance of British mathematician Chris Williams from Bath University. 'Together with him, we searched for flat geometric figures that come the closest to the hanging chains.'

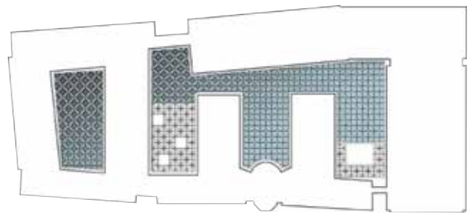
The computer file with the exact geometric pattern then went to the building contractor, who constructed the cupola in two halves in a hall. The ribs are made of solid steel, only 40 mm wide. The height depends on the forces they have to be able to bear. Steel cylinders form the junctions. 'The builder drew out the geometry on the floor,' according to Verbeeck, 'and, together with a surveyor, determined the exact height of each cylinder.' Afterwards he spread out the 868 junctions in the hall and welded the 1772 ribs in between. When he was finished, the builder sawed both halves into eight pieces in order to transport the whole thing to the site. There he hoisted them into position and welded them together again.

Verbeeck walks over to a corner of the scaffolding, where the aluminium glass profiles have already been attached to the ribs. 'Space has been made in the profiles for wiring,' he says, 'because every cylinder has a built-in LED lamp on the underside that can be individually adjusted. So a night sky with stars can be imitated.' Whether the roof glazing will really look like a starry sky in the evenings after delivery remains to be seen. But the steel construction has an impressive gossamer structure, even if you stand right under it.

Something entirely different is the roof covering that Sander Architecten is building at the moment for the inner courtyards at the Dutch Ministry of Defence in The Hague. This is not a light steel construction, but concrete columns and beams. Thick in comparison with the roofing in Amsterdam, but the concrete has been dimensioned ultra-thinly. Round forms give it an organic feel.



EXPLODED VIEW OF THE ROOFING AT THE MINISTRY OF DEFENCE.



VIEW FROM ABOVE OF THE GLASS ROOF AT THE MINISTRY OF DEFENCE.

That is exactly the image Ellen Sander had in mind with the design. 'We started with the image of camouflage netting,' she says. In contrast to the Netherlands Maritime Museum, it was possible to position columns at the ministry to support the roof. Sander: 'We haven't positioned the columns on a grid, they are more or less randomly placed in the space. They look just like trees with branches now.' Furthermore, the roof in The Hague is not located at gutter height on the existing building, but just under the office windows on the first storey.

Sander is responsible for a renovation of the ministry, which consists of an amalgam of buildings dating from different periods. By making different use of the basement and attic floors and covering over the courtyards, an efficiently operating complex should be created that functions as a single building. Of all the interventions, the roofing is the most striking part. For the materialization of the supporting structure, she initially investigated polyester composite, but that cannot yet be applied as load-bearing under Dutch law. In the end a choice was made for concrete. Because none of the four inner courtyards are exactly rectangular, Sander positioned the grid, with a gauge of 2.40 x 2.40 m, at an angle of 45 degrees. That makes it easier to realize the connections with the existing walls. Because computer renderings didn't give a good impression of the exact seizes and shapes, Sander started experimenting with life-seize models: 'A carpenter first made one in MDF, covered with polystyrene. We had it hung up in a hall at the correct height, to see what the »

THE ENTIRE STEEL CONSTRUCTION IS IN POSITION AND THE GLAZING BEADS HAVE BEEN FITTED. STEEL GRIDS COVER THE NEW GUTTER.

POSITIONING OF ONE OF THE 16 WELDED STEEL CONSTRUCTIONS. ON THE RIGHT CAN BE SEEN HOW THE NEW GUTTER DOES NOT AFFECT THE EXISTING GUTTER, AND HOW THE EDGE BEAM OF THE ROOF CONSTRUCTION IS LAID ON THE CENTRAL LINE OF THE EXISTING WALL. BROAD OPENINGS ABOVE THE NEW GUTTER MAKE NATURAL VENTILATION OF THE COURTYARD POSSIBLE.

impact would be. In turned out that we had dimensioned the rods too heavily. We optimized the structure in close consultation with Jan Versteegen of engineering firm Pieters. We then made a more serious full-size model, which we had hung up at the intended height in the courtyard.'

Once the definite form had been determined, the builder made cross-shaped formwork templates, which were positioned at height on location and then filled slowly, drop by drop, with self-compacting liquid concrete. Only the columns, including the four curved rib springs, were prefabricated. The result is an exceptionally smooth construction, which feels light and heavy at the same time. In the middle of each beam a narrow seam betrays where the two formwork templates were attached to each other, but these seams will be finished invisibly at a later stage.

Square cupolas will be built on top of the concrete construction. Smit Plastics in Alkmaar has manufactured cross-shaped ribs made of polyester composite with a foam core. Four triangular glass panels rest in them. 'The polyester ribs are extremely accurately detailed,' says Sander, 'with the same precision as for a car or a plane. First we CNC-milled the components in the required form. These moulds were sent to Smit, who made plastic master templates from them. Reinforcement and wiring for built-in LED lighting have also been added to the masters.' Because the roof covering lies horizontally, rainwater drainage also had to be included in the polyester profiles. 'There is 1.7 km of guttering in the roof,' according to Sander.

Two cupolas are already in place at the building site: a low one for the edges and a higher one for in the middle. 'These have been used to carry out drop testing,' says Jeroen Steenvoorden, who previously worked at Sander Architecten, during a site visit. 'They have let sandbags fall onto the cupolas from a height of a metre. The testing showed that they can withstand 4000 kilos. A single cupola can support around four cars.' The round organic forms and the large amount of concrete should evoke a feeling of shelter and security. That seems to be working extremely well, while at the same time the construction is very refined. It's a fitting language of form at a Ministry of Defence. But anyone attracted by the endless lightness of the starry sky will have to go to Amsterdam. «

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NARROW SEAMS IN THE CONCRETE BETRAY WHERE THE FORMWORK ELEMENTS WERE ATTACHED TO EACH OTHER. THEY WILL BE FINISHED INVISIBLY AT A LATER STAGE.

DURING THE DESIGN PHASE, A POLYSTYRENE MOCK-UP WAS HUNG UP AT THE INTENDED HEIGHT TO STUDY THE EFFECT.

THE COLUMNS, INCLUDING THE RIB SPRINGS, WERE PREFABRICATED. THE REST OF THE CONCRETE GRID WAS CAST IN SITU. SMIT PLASTICS MANUFACTURED THE PRECISELY DIMENSIONED FORMWORK ELEMENTS.

'We started with the image of camouflage netting'

— Ellen Sander —

SMIT PLASTICS IN ALKMAAR HAS MANUFACTURED CROSS-SHAPED RIBS MADE OF POLYESTER COMPOSITE WITH A FOAM CORE.

THE CUPOLAS ARE GLAZED WITH TRIANGULAR GLASS PANELS MADE BY SCHEUTEN GLAS IN HOORN.