

MEMBRANE CONCEPTS FOR THREE LAST MINUTE EXPO PROJECTS STRUCTURAL MEMBRANES 2015

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Summary. This document describes the membrane concepts with formfinding, detailing and patterning of the membranes for three pavilions on the Expo 2015 in Milan. It describes the development of the membrane shape and details in order to allow a fast fabrication and installation.

1 INTRODUCTION

Expo projects are often made of structural membranes. There are different reasons for this. Certainly the most important reason is that membranes create spectacular eye-catching structures, that attract visitors from a distance. Another reason is cost and timing. Membrane structures have reasonable prices, but they are not the appropriate choice if the only reason is to save money. Due to the prefabrication process in the workshop, membranes come in large panels on site and can be installed quite fast.



Figure 1: Expo site end of March 2015

2 CHINESE PAVILION EXPO15 MILAN

The first time in the history of the Expo, China is present with an own pavilion. The exhibition „Land of Hope, Food for Life“ shows on 4600 square meters the agriculture of China, with traditional techniques and with future innovations. The project was leaded by a consortia of the Tsinghua University and the Beijing Qingshang Environmental & Architectural Design Institute. The shapes of the natural landscape has been combined with those of a City skyline. The flat membrane panels follow the shape of the roof.

The project covers with 2585 m² of the high translucent membrane Hiraoka SA 1800 H membrane an area of 1860 m².

The roof structure consists of 38 curved wood or steel rafters. The roof is covered between the rafters 2 and 35 with membrane panels.

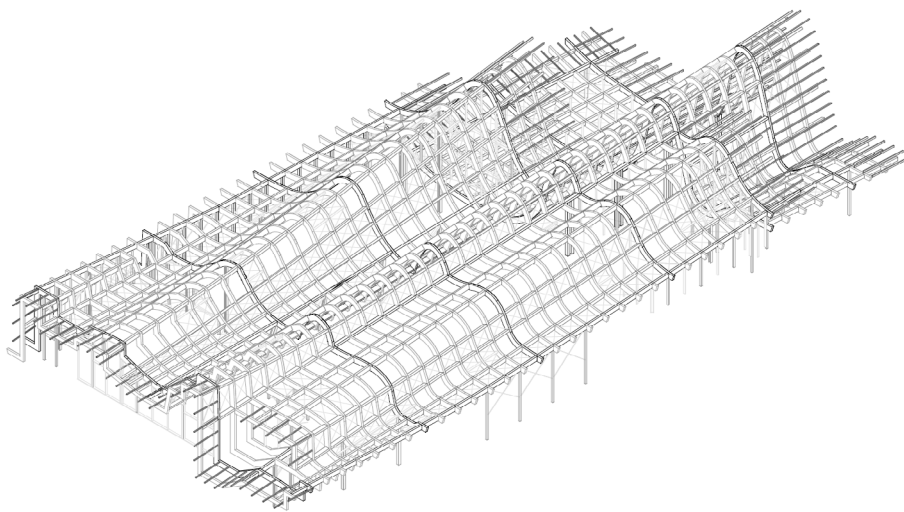


Figure 2: Primary structure

An extruded aluminium profile is fixed on the rafters. The membrane is attached with a keder profile and covered with an aluminium strip. In the middle of the extrusion profile are two rails which allow to attach the bamboo frames sitting over the membrane layer.

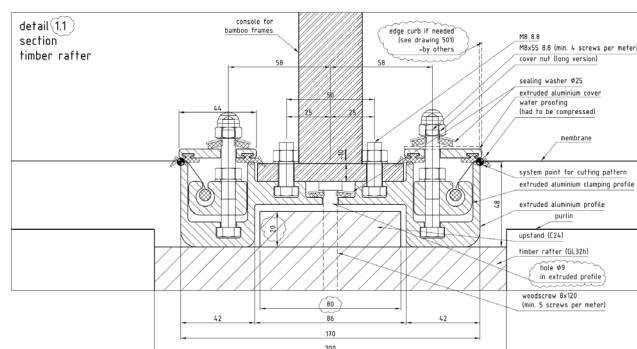


Figure 3: Extrusion profile

The membrane panels are strips spanning between 2 rafters and running from one end to the other end. The form was found from a flat strip, which got then its equilibrium under prestress and self weight which created very low sags. The sharp edges were formed with tubes under the membrane. Edges to the outside are pressing against the membrane, edges towards the inside have a pocket which is tensioning the membrane. In lower areas mesh membrane is inserted in the panels over a gutter to allow the drainage.

Two reference panels have been used for the analysis under snow and windload. The maximum deflections are around 13 cm.

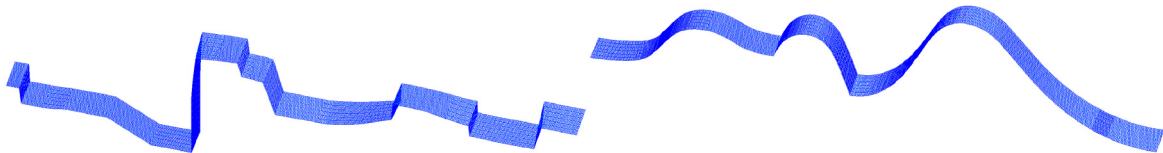


Figure 4: analysed reference panels 02-03 and 23-24 (isometric view)

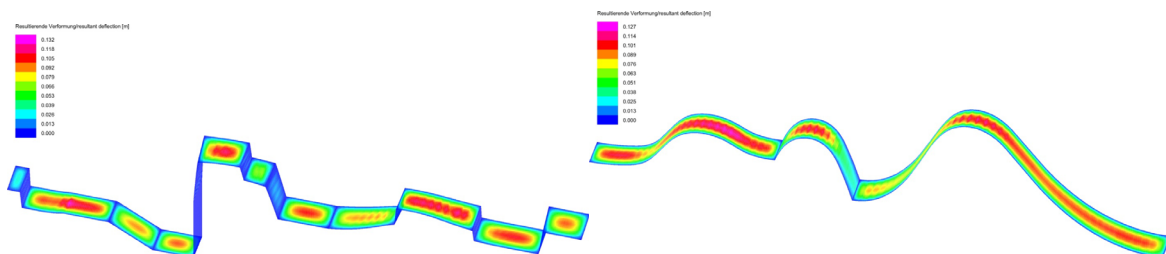


Figure 5: deflections in the reference panels

The bamboo panels sitting on top of the rafters are covering the membrane surface which can hardly be seen. From inside the high translucent membrane plays with the light and the shadow of the bamboo.



Figure 6: Membrane and bamboo installation



Figure 7: Membrane installation



Figure 8: Pavilion with membrane cladding and bamboo panels

3 MALAYSIAN PAVILION EXPO15 MILAN

The Malaysian pavilion with the theme “Towards a Sustainable Food Ecosystem” has the shape of 4 seeds coming from the rain forest. They are closed and open with timber beams, wooden bridges and material made of rice husk. From seed 1 to 4 the visitor travels with regard to a sustainable food eco-system:

- SEED 1 “Our Home – For Now and the Future” (Diversity of Malaysia)
- SEED 2 “Haven of Biodiversity” (Protect and Preserve)
- SEED 3 “Seeds of Change” (Present and Future)
- SEED 4 “Colours of Malaysia” (Music, Arts & Culture)

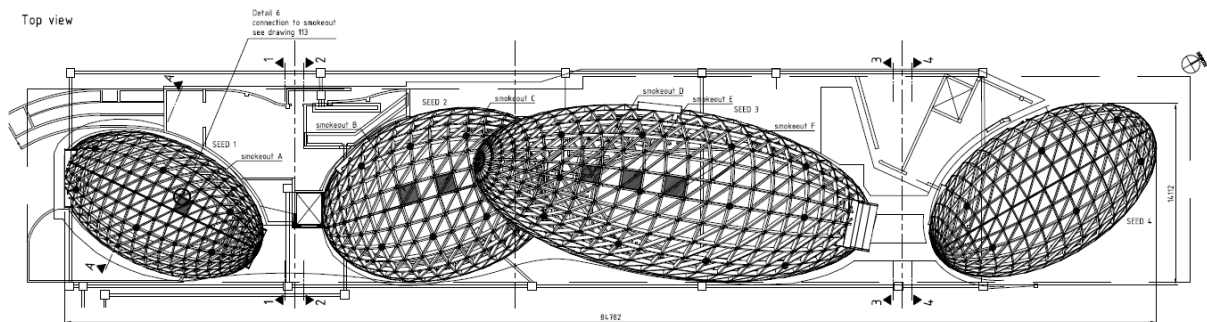


Figure 9: Seed 1 to 4

The membrane is nodal fixed to the timber structure and linear fixed along the lower edge and along openings. The distance between the timber structure and the membrane is 150 mm.

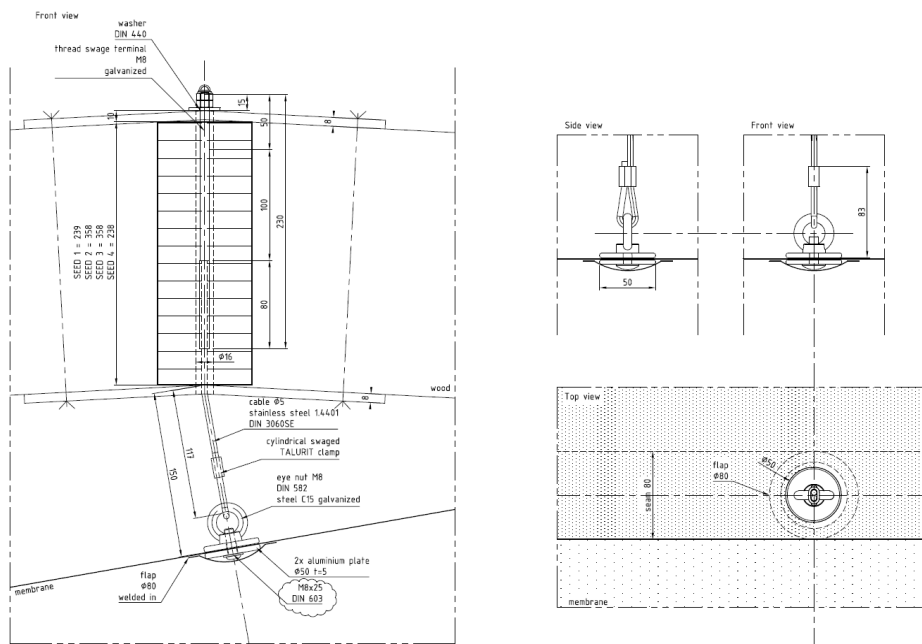


Figure 10: Nodal fixation detail

Seed 1, 2 and 4 have been patterned with longitudinal strips. Seed 3 is elliptical in section. Due to the material width it had to be patterned with single rectangular pattern. Seed 4 has at the lower end catenary cables. Seed 2 and 3 are combined and have an intersection line.

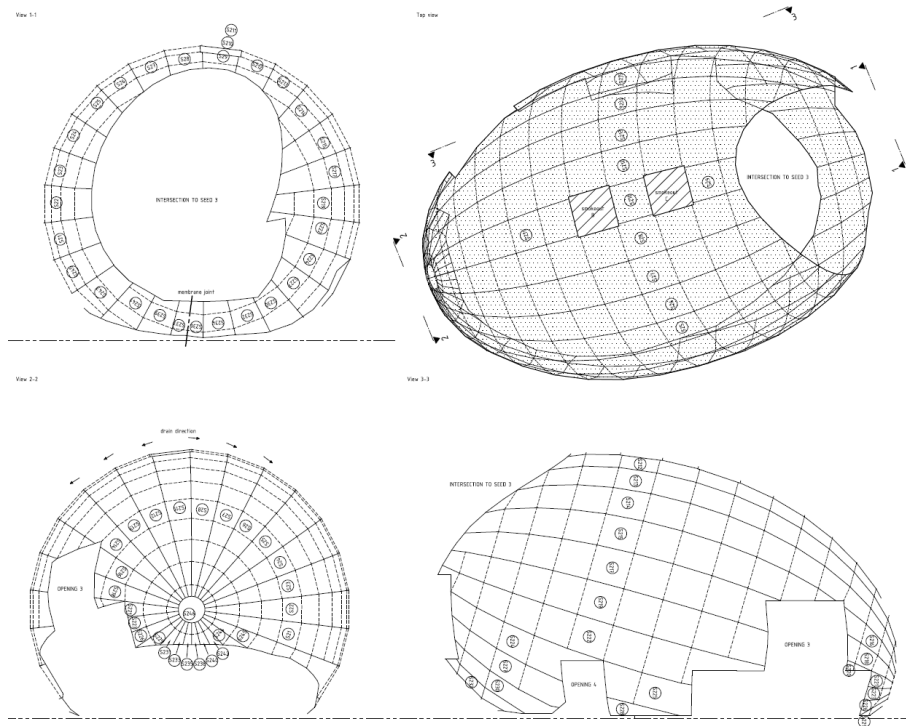


Figure 11: Patterning layout seed 3

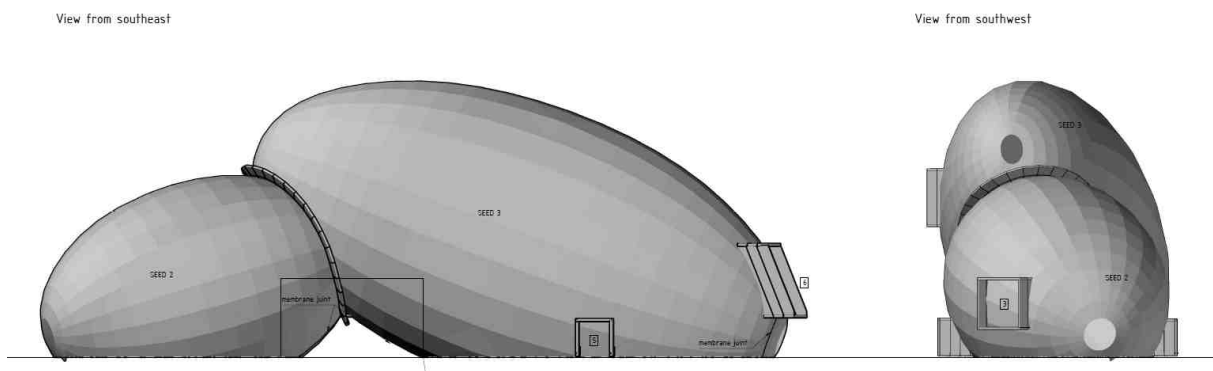


Figure 12: Seed 2 and 3 with the interface

The total surface area is 1730 m² (Seed1: 270m², Seed2: 380m², Seed3: 860m² and Seed4: 220m²). The used material is opaque Serge Ferrari 702 light grey.



Figure 13: View from the outside



Figure 14: View from the inside

4 COPAGRI PAVILION EXPO15 MILAN

COPAGRI, an association of agricultural producers brings Italian farmers together. On the expo they present their approach for the use of natural food, all linked with the Italian tradition, on a marketplace, a hall for cooking presentations, and two rooms for tasting Pizza and Ice-cream to 100% made of organic ingredients.

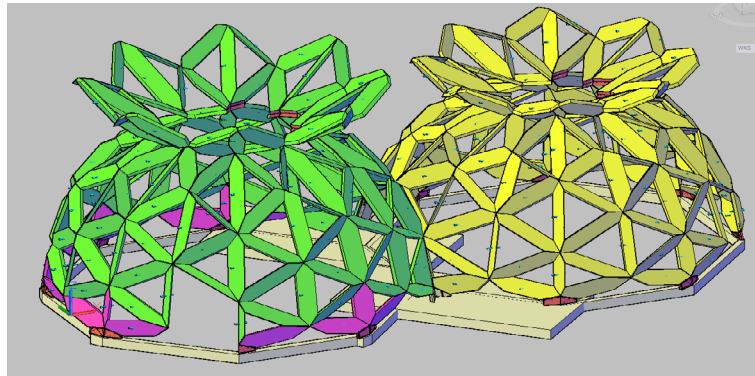


Figure 15: Isometric view timber model

Form the inside a transparent PVC foil is attached to the nodes of the primary structure. The seam layout corresponds to the timber structure.

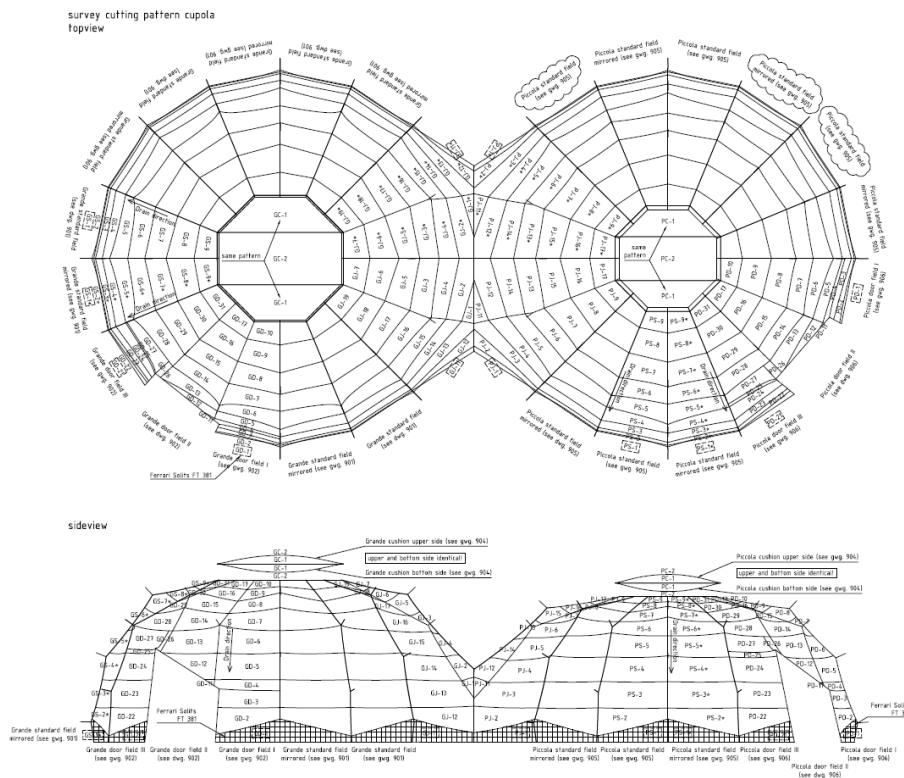


Figure 16: Seam layout

The top is closed with white PVC-polyester cushions. Between these cushions and the foil is a gap that allows for natural ventilation, and along the bottom line is a PVC-polyester mesh that allows for ventilation as well.

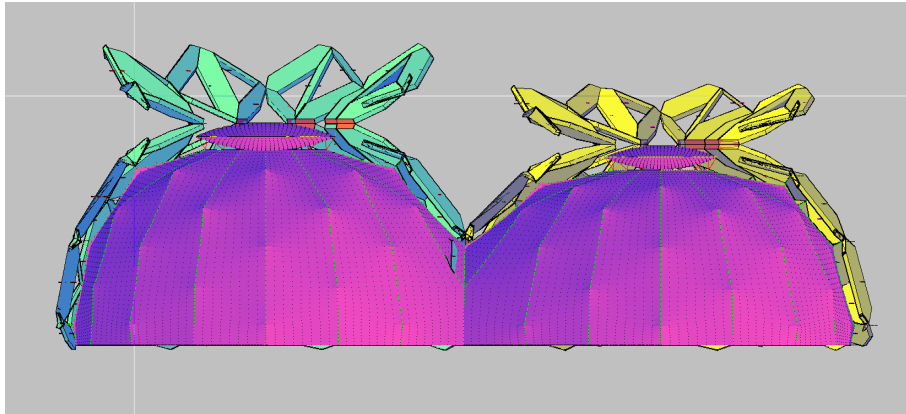


Figure 17: Section with foil and membrane model



Figure 18: Pavilion see from the outside

After the Expo, the pavilion will be dismantled and can be used at another place. It covers an area of 560m². The lower part made of 800 μm Cristal foil and Serge Ferrari mesh FT381 has a surface area of 860 m², the two top cushions made of Serge Ferrari 402 S2 have a surface area of 115 m².

5 CONCLUSION

There seems to be a myth that membranes are fast and can still be realised when there is almost no time left. But as all details need to be finalised prior to fabrication, and site adaption must be avoided, there is still a reasonable amount of time required to realise membranes.

Even though we knew of these projects since a long time, we had been involved in a very late moment, and needed to work out concepts which fit into the tight time schedule. The use of parametric design routines with project specific adaption has played an important role to achieve this goal.

6 PARTICIPANTS

Amongst many others the following people had been involved in the realisation of the membranes for these three expo projects:

Chinese Pavilion:

Architect: Studio Link Arc LLC, New York

General Contractor: Bodino Engineering srl

Membrane contractor: Canobbio Textile Engineering srl

Membrane installation: Montageservice LB

Membrane engineering: formTL:

Malaysian pavilion

Architect: Serina Hijjas

Membrane contractor: Canobbio Textile Engineering srl

Membrane engineering: formTL:

COPAGRI Pavilion:

Architect: EMBT

Membrane contractor: Canobbio Textile Engineering srl

Membrane installation: Montageservice LB

Membrane engineering: formTL: