APPROPRIATENESS AND IMPROVEMENT OF MASTS

The proper design of structural membranes tries to avoid bending. So that the supports would only have to be compressed and tensioned members, either masts and ties. It is illustrated with the examples of figures 1 and 2. On the left the arches that support the membrane are subjected to bending and compression. Although the lengths are considerably reduced thanks to the branching of the masts, the efficiency is much lower than the solution on the right, resolved with masts, flying masts and ties.

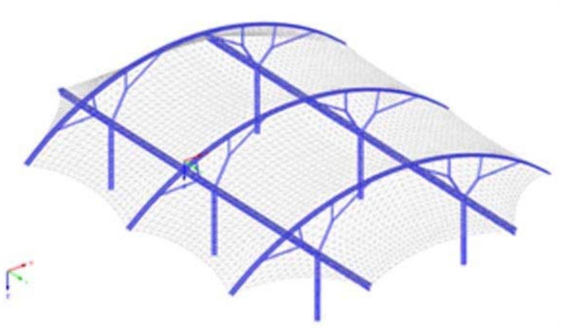

Figure 1: primary structure under bending and compression

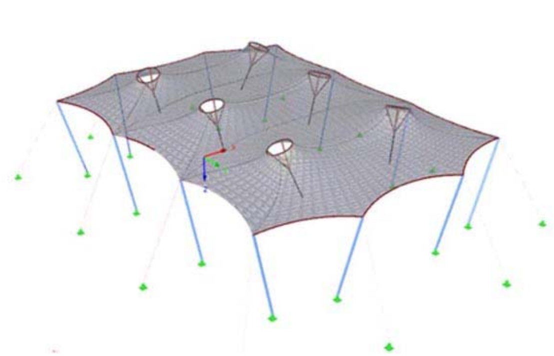

Figure 2: only tension and compression

Figure 3: masts ending up looking oversized

As a result, the masts become the only rigid elements and the most used supporting structural elements. But they have to cope with over-dimensioning imposed by buckling. Many designs do not take it into account to the point that the masts end up looking oversized even though they are not, contradicting the conceptual lightness of the structural membranes they support (figure 3) For this reason, several strategies have been developed (figure 4).

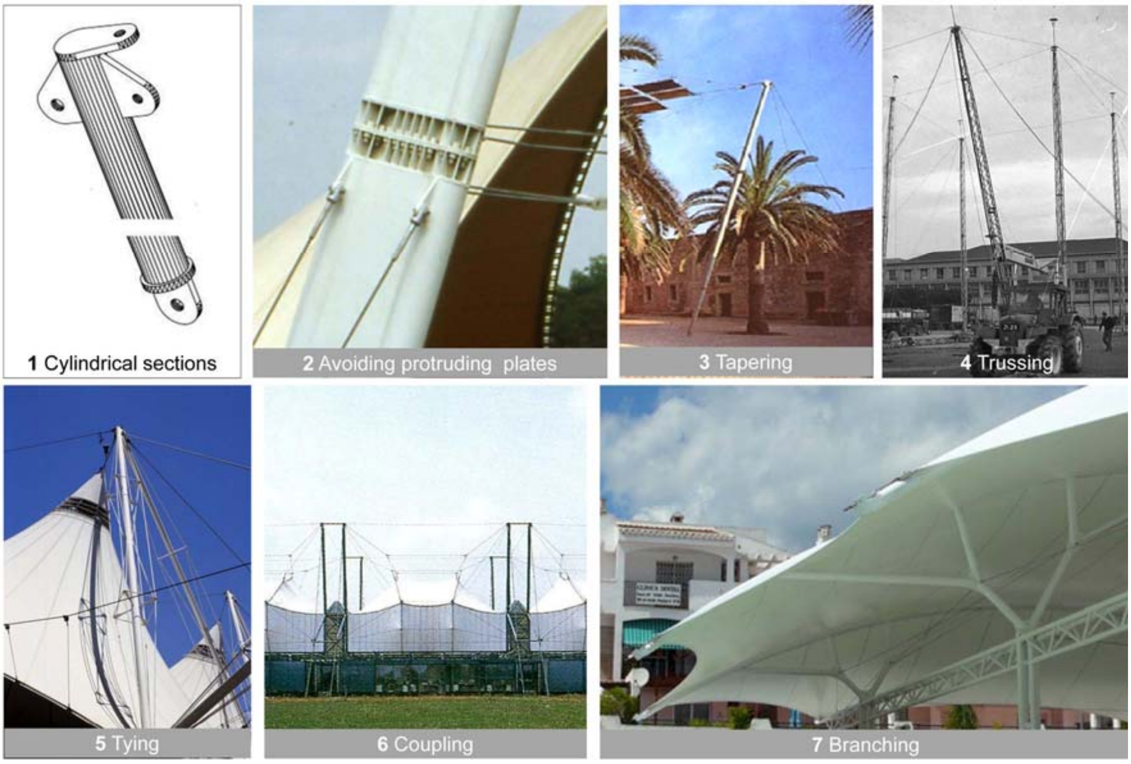

Figure 4: the masts accept different strategies to cope with over-dimensioning imposed by buckling on such long elements.

1 They include the use of circular hollow steel sections because of their efficiency in compression and torsion, minimal surface area to be protected, minimal wind resistance and availability.

2 To simplify the transport, the poles are subdivided and assembled onsite through bolted connections not protruding from the profile of the section.

3 Notice the tapered masts that prevent from looking oversized compared to the whole structure and the site.

4 Trussed masts are common in travelling circuses to reduce weight, facilitate assembly and lifting form the ground.

5 Cross-trees and ties lighten the mast by

reducing the buckling length. It is a way to save steel and to prevent the mast from looking oversized.

6 Coupling or clustering the masts make them thinner. Slim tubes look more elegant than a single bulky cylinder.

7 Branching the masts reduce spans and buckling lengths.

It is worth looking at remarkable cases:

The Shukhov Tower is a spectacular case of lightening, a landmark in the history of structural engineering (figure 5). it was built between 1919 and 1922, rising to the height of 148 m. It was originally designed to be 350 m high but steel shortage made it impossible. It consists of six stacked hyperboloids, which have the property of being constructed out of entirely straight segments. For the construction Shukhov employed his own original method of telescopic assembly.

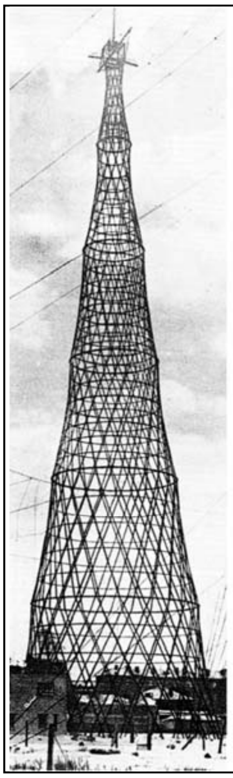

Figure 5: Shukhov tower.

Figure 6: Messetirm, Rostock.

Figure 7: Flying mast, Munich

Tensegrity structures are free-standing pin-jointed networks in which an interconnected system of cables are stressed against a disconnected system of struts. Principles and analysis are documented in papers, articles and bibliography, but few practical applications have been realized and known. K.Snelson first attempts were models and sculptures with such simple detailing that do not apply to building structures. The Messeturm in Rostock increases the rigidity connecting the compression elements and fixing their joints (figure 6). The result can still be considered a tensegrity structure as it keeps being an interconnected system of cables stressed against a system of struts.

Flying masts supported on a cable net push up the membrane. They keep the covered space free of structural supports. The Munich Olympic Stadium is a precursor of the contemporary flying masts (figure 7).