χ-Shell, a new spatial deployable lattice compared to traditional reticulated shells

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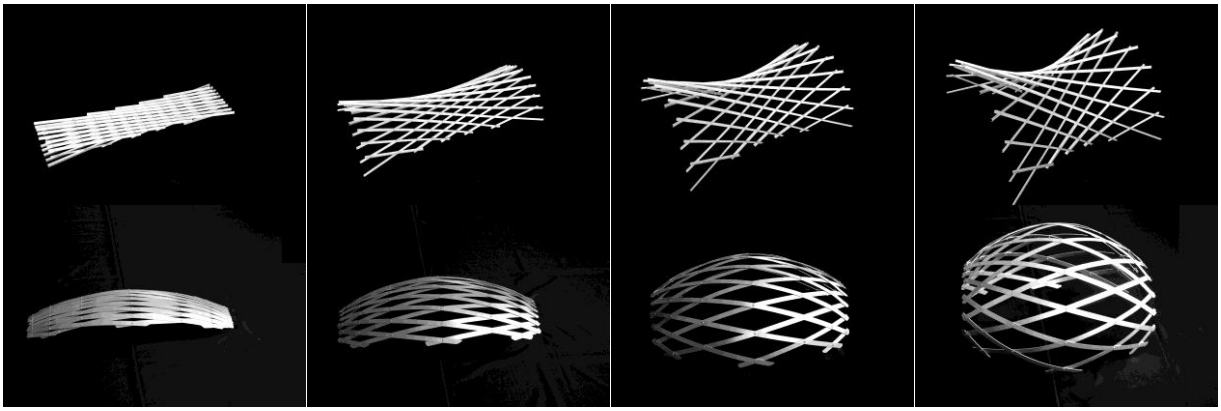
Abstract

From the roof of Vyksa to the Multi Halle in Mannheim and the glass roof of the British Museum, grid shells and lamella roofs have seen their designs and performances follow the technical advances of materials and digital tools. However, the complexity of implementing these structures in situ has always existed and has been the cause of high construction costs despite optimal use of the material.

Not every reticulated shell is the same and its properties differ according to the materials, geometries and techniques used. By comparing about thirty of them chosen over a period of 200 years with neutral criteria, empirical rules appear that reflect the static limits of these structures. Span, thickness, strength, curvature, weight are all parameters that influence the technical choices and the design of reticulated shells.

While maintaining the performance of these structures, we propose a way to facilitate their implementation on site thanks to a combination of grid-shell structure and expandable structure. The frame members are connected flat directly on the ground and form a pattern. This pattern follows a specific rule to generate a mechanism (single DOF) that is transformed into a three-dimensional surface by an actuation induced locally on specific target nodes.

Many surface shapes are possible using this method, two physical models are presented below. The edge conditions are no longer a design constraint and the shell could shape free-form surfaces.



Expansion of an aluminum hyperboloid model (above) and an aluminum spherical model (below).

References

[1] D.T. Wright, "Membrane forces and buckling in reticulated shells", *Journal of Structural Division, ASCE*, vol. 91, n° ST1, Feb 1965.

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