Lehrstuhl für Tragwerksplanung
Fakultät für Architektur
Technische Universität München

Asymptotic Pavilion

Designing doubly curved structures with asymptotic curve networks

Experimental Structures is a research project held annually at the Chair of Structural Design. We are searching for methods to simplify the construction of double curved surfaces. Through physical and computational experiments we demonstrate new possibilities for an intelligent symbiosis of form, structure and fabrication.
Our latest research investigates three specific types of curve networks. Each of them has the property of omitting a certain curvature type. This has great potential for fabrication and construction.

- **Geodesics** have no geodesic curvature. They can be constructed from straight strips tangential to the surface.

- **Principal Curvature Lines** have no geodesic torsion. All joints are orthogonal. Both orthogonal and tangential surface-strips are developable.

- **Asymptotic Curves** have no normal curvature. They can be constructed from straight strips orthogonal to the surface.

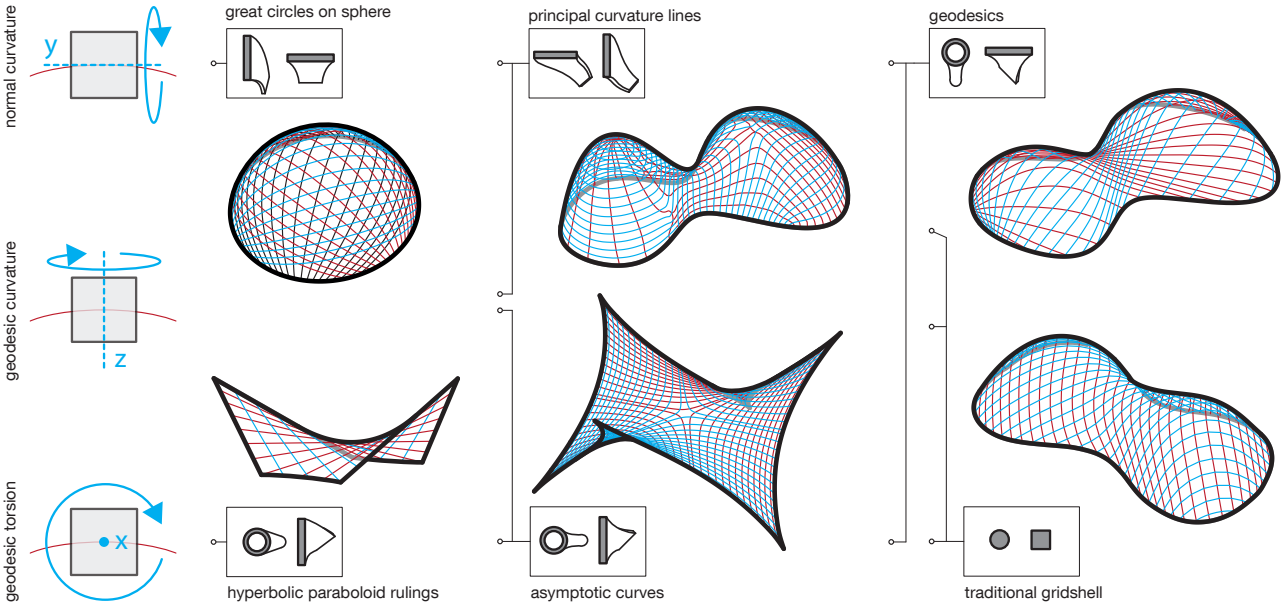
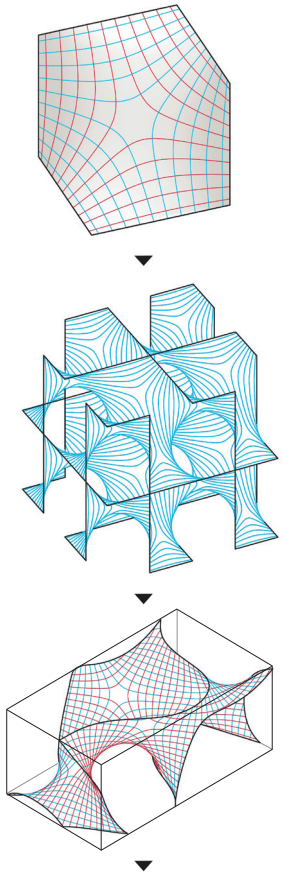


Fig. 1: Shown above are specific line networks, which are based on a constant value k=0 of either their normal curvature, geodesic curvature or geodesic torsion. This has an influence on the constructability, as indicated by the bending or twisting of the respective profiles.

Current and future research. During the summer semester 2016 we have investigated the use of these specific curve networks to design gridshells. We have found the most potential in the use of asymptotic curve networks in combination with minimal surfaces. This construction method allows for both straight strips and orthogonal nodes.

In the coming year, it is our aim to focus our investigations on the aspects of shape, structure and statics of these networks.
After a morphological analysis of minimal surface, we will investigate alternative computational techniques of generating asymptotic line networks. A separate study will look at possible cladding options, with transparent elastic sheet material. To analyse the load bearing behaviour of such curve networks, a digital model will be constructed and simulated in FEM.
Finally we will verify the use of metal sheets for the construction in real scale, by conducting prototypical tests.

Our goal is to publish this research in journals and proceedings and construct a 1:1 **research pavilion** by October 2017 to be exhibited at the Structural Membranes Conference 2017.



ASYMPTOTIC PAVILION is the design proposal of a gridshell developed for the Structural Membranes Conference 2017 in Munich.

The design is based on a repetitive modular shape, called Schwarz D minimal surface. We can generate asymptotic lines on one cubic cell, and multiply them to form a continuous curve network. The design shape is a rectangular clipping of this surface.This generates an expressive sculptural space.

Fig. 2: Design Process: *Top:* A minimal Surface inscribed in 6 edges of a cubic cell. An asymptotic curve network is generated on this surface. *Middle:* The Schwarz D surface is assembled from multiple cubic cells. *Bottom:* The design surface is a rectangular clipping of this Schwarz D surface.

In a prototypic 1:5 model we were able to test the fabricational benefits for this type of gridshell construction. All elements can be formed out of straight wooden strips. All strips intersect at 90 degrees, allowing for simple slot joints.

The model has been exhibited at at the TUM during the Architectural „Jahresschau 2016“, and at the AAG2016 (Advances in Architectural Geometry) conference in Zurich.

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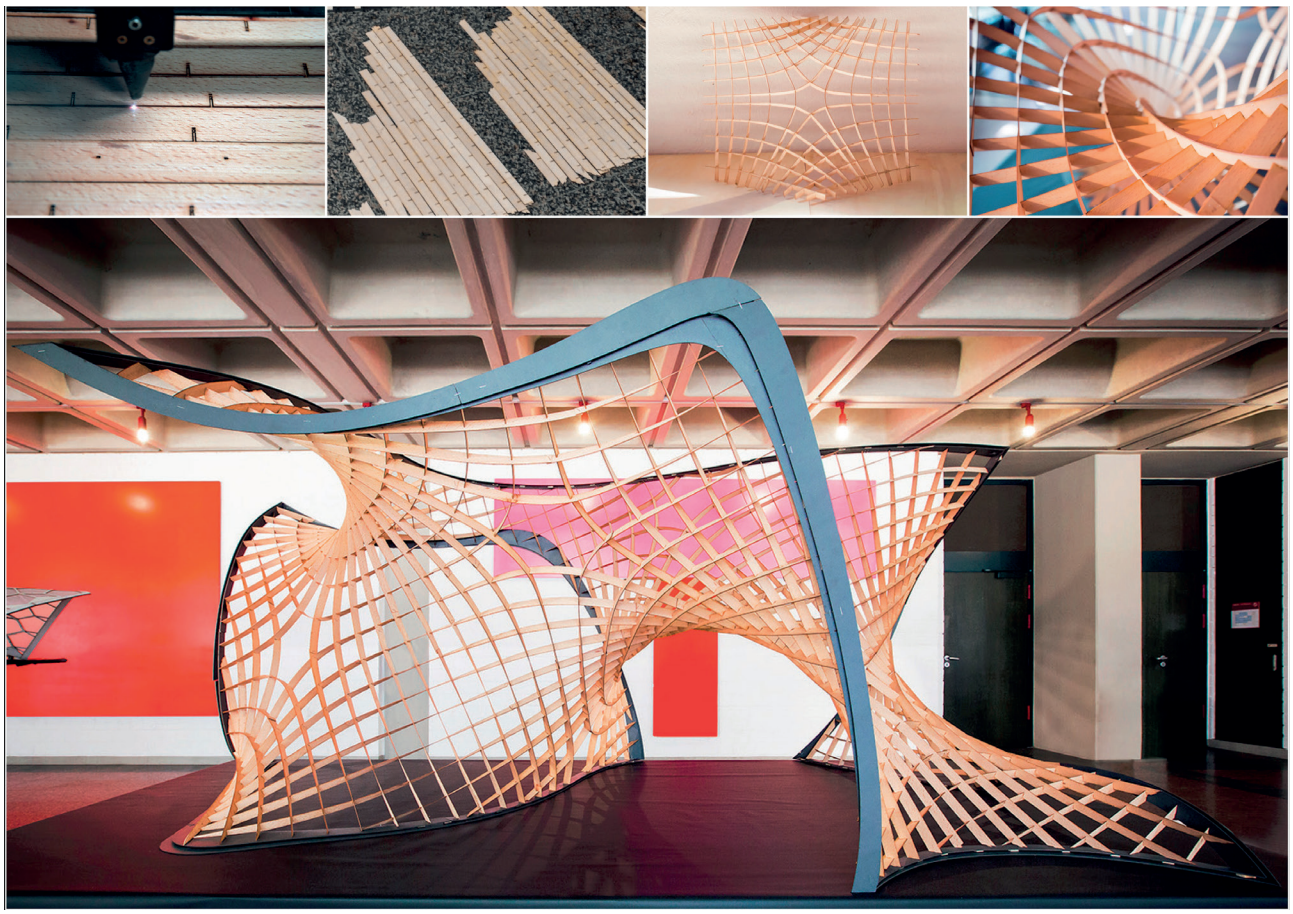

Fig. 3: Prototype model at scale 1:5. A network of asymptotic curves on a clipping of a minimal Schwarz D surface. The support structure was constructed from straight strips of beech veneer. All joints are identical and orthogonal. Model: Denis Hitrec; Foto: Magdalena Jooß