



## **Architectural sensation on the summer island**

### **Unique pavilions are a BUGA attraction**

Rethinking architecture – this principle can be drawn from the two fascinating pavilions of the University of Stuttgart, which are unique in the world and can be seen on the summer island of the Bundesgartenschau (BUGA, Federal Horticulture Show). Digitalization, lightweight construction and bionics are the three cornerstones of the two innovative designs and examples of innovative power in Baden-Wuerttemberg. Both pavilions will be used for events during the BUGA.

For Prof. Jan Knippers from the Institute of Building Structures and Structural Design (ITKE) at the University of Stuttgart, and Prof. Achim Menges from the Institute for Computational Design and Construction (ICD) at the University of Stuttgart, the two BUGA pavilions are both the culmination of many years of development and a motivation to rethink architecture and see it from a new perspective: “At the sight of these two buildings, we are proud of our teams, who worked dedicatedly and enthusiastically on the project.”

Learning from biology – that's how Jan Knippers describes his intention to change architecture. The challenge was to model principles and functions of nature in a constructive way and implement them with newly developed materials as well as the tools designed for this purpose. “We have developed a new architectural process that combines design and manufacturing right from the start,” said Prof. Achim Menges. This begins with the preparatory software development for new types of building systems and ranges from robotic manufacturing and simulations to increase material efficiency up to the preparation of new statutory standards and official DIN regulations for stability, for example.

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“There is still a long way to go.” That is, on the other hand, also a conclusion on the progress of their work. For about ten years, the two institutes at the University of Stuttgart have been working in the fields of bionics, lightweight construction and digitalization of manufacturing processes, for the purpose of sustainable and attractive buildings that are fit for the future. The Cluster of Excellence “Integrative Computational Design and Construction for Architecture”, newly established at the University of Stuttgart in 2019, offers the best conditions for this cutting-edge international research. Since building is responsible for more than half of global resource and energy consumption, these efforts are urgently needed. “With the two pavilions we feel certain that BUGA visitors will become aware of this, and that we can enthuse them with a new architecture and its necessity.”

### **The Wooden Pavilion**

In comparison to technical systems, biological structures in architecture generally have a much higher performance and material efficiency. This makes plate structures an especially interesting type of construction. The biological prototype of the Wooden Pavilion is the sand dollar, a subspecies of the sea urchin. Compared to the first design of a wooden pavilion a few years ago, the pavilion is made of a completely new lightweight wood construction and has a span of about 30 meters and a height of seven meters. It is a shell structure made of 376 different, hollow wooden cassettes, which is a particularly efficient use of material. They were manufactured in a robotic prefabrication process especially developed for this purpose, in a fully automated way from two panels and up to seven individual beams. These cassettes were assembled by two cooperating robots in just seven minutes.

At the construction site, the finished wooden cassettes were joined together like a three-dimensional jigsaw puzzle, with tolerances of less than one millimeter, to form a 550 sqm shell construction. It is based on three points and stretches without pillars over a floor area of around 500 sqm. The entire Wooden Pavilion was built by a small team of three construction workers in just twelve days. During the BUGA, it will be used with a stage for the daily program of events.



### The Fiber Pavilion

This pavilion, too, offers a unique visitor experience. With a span of about 23 meters and a height of about seven meters, the Fiber Pavilion has ten support points. This pavilion will be the exhibition space for the digitalization exhibition "Zukunftskarussell" ("Carousel of the Future") by the state of Baden-Wuerttemberg.

The supporting structure of the Fiber Pavilion is made up exclusively of fiber composite components, which are manufactured from glass and carbon fibers in an additive, robotic process. This makes it possible to adapt the 60 components to the respective static requirements, without the need for special shapes or producing waste. This creates a completely new way of building. The resulting constructions are much lighter than all conventional types of buildings. With a floor area of 400 sqm, the 7 m high dome represents the first digitally conceived and developed fiber composite construction system. A particular challenge was that the completely new construction system must meet the strict requirements of the German construction supervision authority.

The surface weight of the fiber composite structure is only 7.6 kg/sqm (about five times less than a comparable steel structure). On average, 1000 m of glass fiber and 1600 m of carbon fiber were used per component, with the total length of the glass fiber for the pavilion being 60 km and that of the carbon fiber 95 km. In particular, the carbon fiber reinforcement, which consists of eight coiled layers with a construction depth of about 20 mm, enabled the components to achieve a load capacity under pressure of 25 tonnes. Another important element of the construction system is the large, transparent ETFE membrane that is mechanically pre-stressed. This demonstrates the compatibility of experimental composite structures with conventional construction systems and serves to protect the exhibition space from the weather.