URBACH TOWER: SELF-SHAPING PROCESS OF CURVED WOOD COMPONENTS

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The Urbach Tower is a unique wood structure. The design of the tower emerges from a new self-shaping process of the curved wood components. This pioneering development constitutes a paradigm shift in timber manufacturing: from elaborate and energy-intensive mechanical forming processes that require heavy machinery to a process where the material shapes itself. This shape change is driven only by the wood's characteristic shrinking during a decrease of moisture content. Components for the 14-meter-tall tower are designed and manufactured in a flat state and transform autonomously into the final, programmed curved shapes during industry-standard technical drying. This opens up new and unexpected architectural possibilities for high-performance and elegant structures, using a sustainable, renewable and locally sourced building material.

The Urbach Tower constitutes the very first structure worldwide made from self-shaped, building-scale components. It not only showcases this innovative manufacturing approach and resultant novel timber structure; it also intensifies the visitors' spatial involvement and landscape experience by providing a striking landmark building for the city of Urbach's contribution to the Remstal Gartenschau 2019.

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Material Programming and Predictability of Shape Change

In timber construction, moisture typically causes problems with cracking and deformation; hence, moisture changes and stress development must be carefully controlled. In contrast, in this project wood is programmed and arranged specifically to utilize this powerful, naturally occurring deformation to trigger a designed self-shaping behavior. In the same way that machines can be programmed to perform different movements, wood parts can be programmed to transform into predetermined shapes when dried.

While methods of bending wood into different shapes for structure and aesthetics have existed for centuries and have become recognized industrial processes, they still mostly rely on brute mechanical force for the shaping process. Similarly, an understanding of how wood deforms due to changes in moisture content is well known in practice and academic spheres. However, a shift in design thinking, combined with new computational simulations for more accurate prediction, now

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allow us to use this moisture-induced swelling and shrinking to design and program specific self-shaping movements on larger and larger scales.

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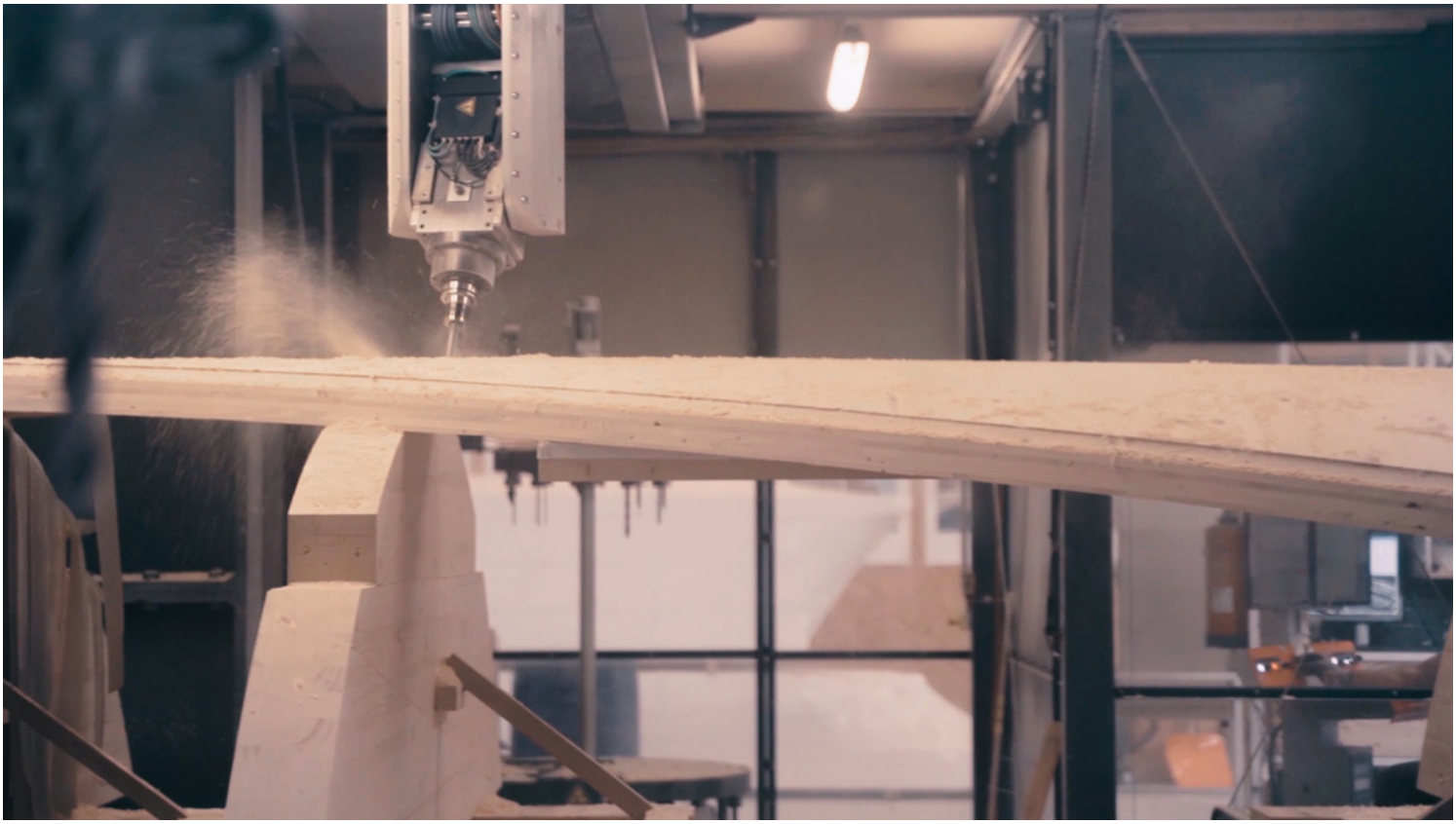

Self-Shaping Manufacturing at the Building-Scale

The pioneering development of large-scale self-shaping constitutes a paradigm shift in timber manufacturing. The curved cross-laminated timber (CLT) components for the tower's structure are designed and produced as flat panels that deform autonomously into predicted curved shapes when dried. The 5.0 m x 1.2 m spruce wood bilayers parts are manufactured with a high wood moisture content and specific layups and dried in an industry standard technical drying process. When removed from the drying chamber, the parts are precisely curved. The parts are overlapped and laminated together to lock the geometry in place, forming larger curved CLT components with a stable form.

Material-specific computational mechanics models have been developed to both design, predict and optimize the material arrangement required to produce different curvature types and radii. The technology of self-shaping manufacturing for solid timber boards and the rapid adaptability of the

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process to different curvatures open up new and unexpected architectural possibilities for thin-shell wood structures, using a sustainable, renewable and locally sourced building material. The Urbach Tower is the very first implementation of this technology on the building scale, using load-bearing timber parts.

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Sustainable Wood Construction and Functional Timber Cladding

The self-shaping components are made entirely of spruce wood boards sourced regionally from Switzerland. Individual components span up to 15 m, with a radius of 2.40 m and a structural thickness of only 90 mm. The components are 5-Axis CNC cut and detailed from half cylinder blanks and pre-assembled into building groups of three components for transport, including water barrier and external wood cladding. With a precise curvature and optimal fiber alignment from the manufacturing process, each component is cut and detailed in just 90 minutes of machine time. A custom-made protective cladding layer consisting of glued laminated larch wood is added on the outside. This also includes the application of a transparent and durable inorganic coating, which protects the wood from UV radiation and fungi attack. Instead of ripping and turning silver-grey when exposed to outdoor weathering, the larch wood will take on an even white color over time.

The entire process chain, from cutting regional logs in the sawmill to the production of the self-

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shaping panels, the drying process and final machining and pre-assembly takes place within the same group of companies and at the same location. This not only allows for sustainable and innovative production but also shows how self-shaping manufacturing can seamlessly integrate into established industrial wood processing and manufacturing workflows.

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Thin-Shell High-Performance Timber Structure

The Urbach Tower consists of 12 curved components made from cross-laminated timber. The tower's load-bearing structure exhibits a thickness of 90mm while cantilevering over 14 meters, resulting in a span-to-thickness ratio of approximately 160/1. The inherent curvature enables a highly slender and lightweight tower structure of only 38 kg per square meter surface area. In the assembled state, the tower acts as a surface-active structure through its expressive curved geometry. The lightweight building elements are connected by crossing screws, the arrangement and specific angle of which is optimized throughout the structure in relation to their utilization while preserving a continuous connection along the seam for homogeneous load transfers.

The prefabricated assembly groups of the tower, each consisting of three curved components, were assembled in a single working day by a team of four craftsmen without the need for extensive scaffolding or formwork, and topped off by a transparent roof. The structure showcases the

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possibilities for efficient, economical, ecological and expressive wood architecture which sits at the intersection of master craft, digital innovation and scientific research.

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A Unique Architectural Landmark for the Rems Valley

The Urbach Tower is one of 16 stations designed by some of the most renowned German architects for the Remstal Gartenschau 2019. The stations are small, permanent buildings that evoke the traditional white chapels distributed in the fields and vineyards along the scenic Rems Valley. Located on a prominent hillside in the center of the valley, the 14-meter-tall tower is a striking landmark that visually connects several stations. It provides a place of shelter, internal reflection and outward perspective by revealing stunning vistas and framing the landscape. The distinctive form of the tower constitutes a truly contemporary architectural expression of a traditional construction material: wood. It celebrates the innate and natural characteristics of self-shaped wood in its upward-spiraling shape.

The concave curvature of the structure on the outside results in sharp lines and crisp surfaces, which are further accentuated by direct daylight and the whitening of the larch cladding over time.

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In contrast, in the interior the convex curvature creates an unexpected visual and tactile material experience, with the timber structure appearing to be almost soft and textile-like, highlighted by the light that washes over the gently undulating surfaces. Opposite the entrance, the thin wood envelope opens like curtain, putting the Rems Valley on center stage.

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