Lightweight segmented timber shell for the Bundesgartenschau 2019 in Heilbronn

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Abstract

Segmented timber shells offer the possibility of constructing long span, double curved shell structures efficiently and economically. This was demonstrated with the Landesgartenschau Exhibition Hall 2014 in Schwäbisch Gmünd [1], a prefabricated segmented timber shell made of planar beech plywood plates. However, the application of this construction method for larger spans and more general shell geometries requires further technical development of the construction system, of its associated fabrication methods, and of the methods for form finding and optimisation. This paper presents the development and construction of the wood pavilion for the Bundesgartenschau (Federal garden exhibition, BUGA) 2019 in Heilbronn , which translates these technical developments into practice.

The architectural requirements and the site specifics led to a significantly increased span compared to the Landesgartenschau Exhibition Hall. In order to maintain a lightweight construction system, solid timber panels were replaced by a recently developed multi-layer cassette system. Each cassette consists of a top and bottom plate and edge beams that border them. The panelisation of the underlying double curved shell surface into planar segments leads to 376 geometrically unique cassette elements, rendering manual fabrication techniques infeasible and thus requiring a maximally automated fabrication process. The customized cassettes of the multi-layer segmented shell are produced of spruce laminated veneer lumber plates, which are assembled, glued, and milled in a fully automated process by two collaborative industrial robots.

The application of a multi-layer construction system also required the development of an adapted connection strategy, which mainly consists of a combination of previously established CNC-milled finger-joints [1] as well as regularly spaced steel bolts. Due to this connection system, the shell can easily be disassembled and rebuild at a different location. Material thicknesses of edge beams, spacing of fasteners and geometric details of the connections between adjacent cassettes vary throughout the entire shell. Thus custom design and analysis tools were developed in order handle the amount of data as well as the increased geometric complexity. This pavilion illustrates the potential of bridging spans of over 25m by means of a lightweight, material efficient timber shell, completely robotically prefabricated and without the necessity of formwork.

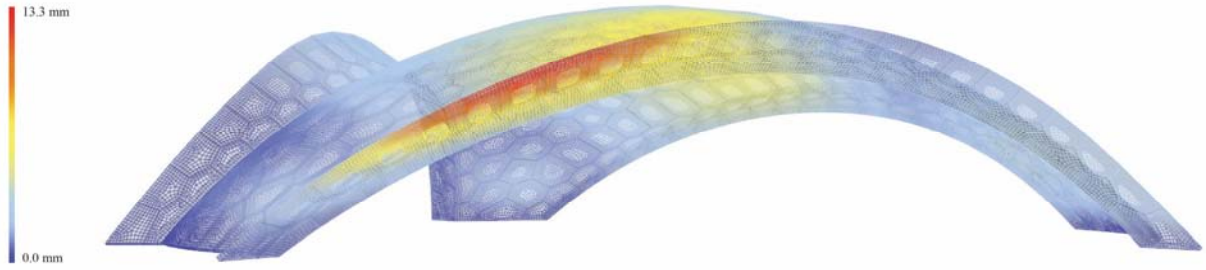

Figure 1: Expected deformations under full loading of the shell simulated using the finite element method

References

[1] J. Li and J. Knippers, “Segmental Timber Plate Shell for the Landesgartenschau Exhibition Hall in Schwäbisch Gmünd—the Application of Finger Joints in Plate Structures”, *International Journal of Space Structures,* vol. 30 no. 2, pp. 123-139, 2015.