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Flexible production of thin sheet metal panels for the creation of complex free-form structures AiF No.: 19831N

Summary of the research project AiF No.: 19831N

Free-form building envelopes are among the most challenging construction tasks in contemporary architecture. Their difficulty lies in the technically demanding design of the free-form cladding layer, in the material-intensive connection of this cladding to the building via a suitable substructure and the correspondingly relatively high economic cost of such a facade. In this research project, a panel system and the corresponding manufacturing concept were developed based on the forming technologies stretch forming and incremental sheet forming (ISF). The panels consist of two thin sheet layers, which are connected to each other in a shear-resistant manner by conical recesses in the sheets. The panels are self-supporting and have a relatively low weight of around 13 kg/m². Material-intensive substructures can therefore be reduced and resources conserved. The sheets are individually formed, and the geometry spectrum includes almost any shaped, mul-

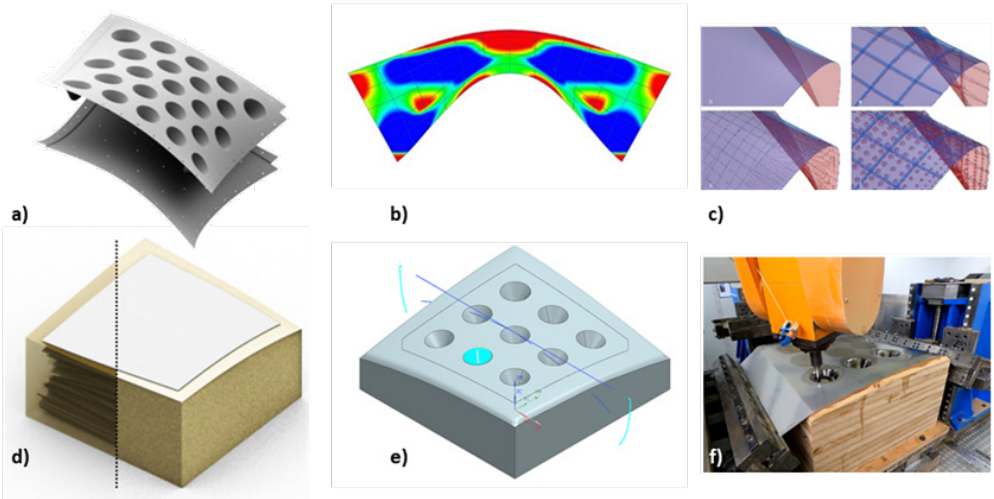

Image 1: From a panel concept for free-form facades covering (a) the analysis of the design geometry (b), the panelization and design of the geometry (c), the most efficient stacking of the geometries in the tool block (d), the production planning in a CAD-CAM environment (d) and the production of the panels (e)

Editor: German Committee for Steel Construction DASt e.V. | Managing Director: Gregor Machura
Sohnstraße 65, D-40237 Düsseldorf | Tel. (0211) 54012-094 or (0211) 54012-080
For further inquiries, please contact: forschungsmanagement@dast.deutscherstahlbau.de

tidimensionally curved surfaces. The conical recesses of the panels can be made in the concave or the convex sheet layers, or in both. The process chain was holistically optimized and an cost-efficient manufacturing concept for individually curved sheet metal components was developed. In addition to the manufacturing technologies themselves, which offer an economic advantage for individual components and small quantities due to their low tool commitment, the developed tool concept also contributes significantly to economic efficiency. By choosing medium-density fiberboard as a cost-effective and efficient material to machine, individual sub-tools can be realized relatively cost-effectively. By using a suitable production sequence (stacking in the tool block) for a large number of individual components, the volume to be machined and thus the costs can be further reduced. An FE-supported analysis and design of the supporting structures was implemented and validated in component tests on a scale of 1:1. Based on a cost-benefit analysis of structural performance and production time, the panel geometry can be tailored to the respective application. As part of the project, a file-to-factory process chain was developed for the realization of the facade system. This includes the structural design of the system, geometric detailing, constructive training, process simulations and production planning. The necessary tools for surface generation and division as well as panel formation were implemented and tools for processoriented alignment in the machine design space were created and take into account important forming technology restrictions with regard to the alignment of the components for production. The process limits determined in the tests are important input parameters for the developed planning chain. Finally, the developed panel system and manufacturing concept as well as corresponding tools for structural design and planning of construction and production were tested on a largescale prototype. The panel concept developed and tested within the framework of this project meets the requirements for the implementation of free-form building envelopes. The manufacturing concept enables suitable and cost-efficient production for the multitude of individual components for such building structures.

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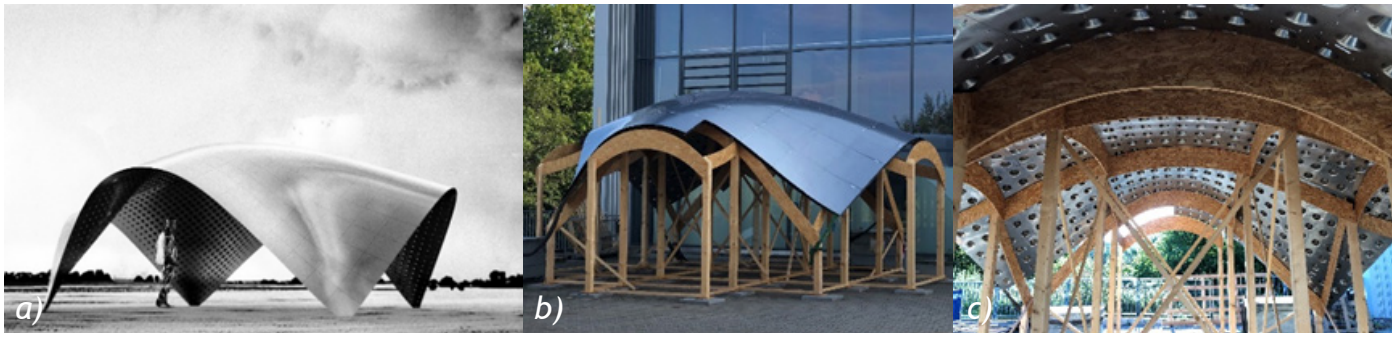

Image 2: Impressions of the prototype construction: Design (a) and during assembly on a false-work (b and c)

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