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SHAPE OPTIMIZATION OF STRAINED GRIDSHELLS

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Abstract: Strained gridshells are reticulated shell structures that are erected from a flat grid of initially straight laths. This construction method allows complex curved shapes to be built without requiring specialized off-site manufacturing techniques. The design of strained gridshells is usually subdivided in different stages. First, the overall shape is chosen by the designer. Next, a geometrical technique is used to map a grid on the target surface. Subsequently, material and section properties are assigned to the members of the grid and the bending of the laths is simulated. Finally, loads are applied to the model and a structural analysis is carried out. These design stages have to be performed iteratively to reach a satisfying design. In this paper, an optimization procedure is proposed that optimizes the shape of a strained gridshell for a given grid of straight laths. The erection forces are chosen as the design variables. These erection forces are optimized to minimize the so-called end-compliance, which is defined as the inner product of the external loads and the resulting displacements. The method of moving asymptotes is adopted and implicit dynamic relaxation [1] is used to solve the nonlinear equilibrium equations, ensuring that the required computation time is acceptable. Nonlinear effects such as buckling are taken into account by using co-rotational beam elements to model the gridshell laths. It is shown that this approach allows the structure to be optimized to satisfy safety and serviceability criteria for different load cases. Moreover, it is possible to account for practical building constraints, such as a limitation of the number of nodes to be pushed or pulled during the erection phase. Finally, also designer's preferences can be taken into account via constraint equations. In conclusion, the proposed optimization approach leads to an optimized design while satisfying the designer's preferences and potential buildability constraints. Moreover, the proposed optimization approach simplifies the design process, as it is not necessary to iterate between different design stages.

References

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