Abstract

This thesis proposes a method of building-volume optimization (BVO) that is able to assist the design process in early stages of architectural design. With the growing demand to provide sustainable designs, architects require foreseeing a significant reduction and control of initial and operational costs of their projected building designs. Quantifiable design objectives such as the consideration of lifecycle costs (LCCs) can help to improve initial design steps, when implemented early. An evaluation and reduction of LCCs during the early design stage can be seen as a major economic benefit since such decisions are significant, irreversible and can only be changed later with increasing costs. An effective decision-support system like the consideration of quantitative design aspects during the early design phases should therefore enable architects and designers to gain valuable insights and strengthen their ability to make informed decisions during the design process.

Presented in this thesis, the BVO model is understood as such. It allows for finding optimal design solutions in reference to LCC during the early architectural design stage. The model makes use of constraint programming-based optimization techniques, enabling designers to find design solutions that provide optimal cost effectiveness. It combines constraint with performance-based design strategies, minimizing life-cycle costs by determining optimal-volume dimensions, floor number, building orientation and satisfying site, building code regulations as well as individual design constraints.

To ensure possible problem solving of an otherwise extensively complex and immense search space, the BVO model makes use of pre-fixed variables (constants) and decision variables being solved. This makes it flexible enough to allow investigation and impact-analysis of individual design considerations such as building-volume dimensions, material selection of exterior surfaces or window/wall opening ratios. A proposed implementation strategy focuses on separating individual design tasks, leading to a stepwise optimization approach of an architectural design. By adapting existing research in the design methodology field, where man made architectural design is described as a structured process, a piecewise evaluation of individual design alternatives is used to generate design solutions to individual design tasks.
Results indicate solutions can be found within a practical timeframe. The BVO model demonstrates an applicable approach for designers to not only attain a deeper understanding of quantitative design options through constraint definitions of a theoretical building-volume but also the ability to strive for meaningful design solutions in respect to optimized building information such as LCC assessments. The optimization results provide designers with insight into dependencies between building-volume and individual building costs. In particular, the visual display of optimal and feasible solutions employing the demonstrated method allows designers an opportunity to understand design-optimization impact successfully. The documented approach allows for finding meaningful design information in a phase that normally offers a rather vague understanding of the impact of design moves concerning a variety of cost considerations. The methodology to establish cost objectives into building-volume design, therefore, provides designers with an effective method, providing decision-support in a design domain known to be complex owing to several design criteria and constraint influences.

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Decision-Support System
Building-Volume Optimization
Life-Cycle Costs
Constraint-based Design
Performance-based Design