Interdisciplinary Design Optimization:
A Search Method

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Abstract. The design of architectural structures frequently involves interdisciplinary aspects and aesthetic considerations which, being of subjective nature, are difficult to quantify. The computer-aided design optimization model presented here, therefore, is an attempt to optimize, in an interdisciplinary context, quantifiable parameters only. The objective function is graphically illustrated to give the designer a means to evaluate the impact of esoteric design decisions on performance variables, such as costs. A search method is used, i.e., evaluation of a discrete number of designs and nonlinear interpolation. The model's system of computer programs is demonstrated on the sample of an anticlastic cable roof structure.

Key Words. Anticlastic cable net, architectural structures, interdisciplinary optimization, search methods, structural shapes.

1. Introduction

A model for interdisciplinary optimization of architectural structures is presented. This model consists of a system of computer programs developed by the author for design analysis and optimization of structures such as membranes, trusses, shells, and frames. The aim is to quantify and illustrate optimality as determined by various design variables related to conceptual design configurations. The objective function may be chosen to minimize performance variables such as initial cost, various operating costs, the sum of both, or structural deformation (Ref. 1).

While the model is designed to optimize structural design parameters, it provides the option to include such nonstructural parameters as costs for

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2 This paper contains excerpts from Refs. 1–2.

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architectural finishes, heating systems installation and operation, land, as well as property taxes. All recurrent costs are combined under operating cost and discounted at present value, considering interest rate, inflation rate, and, in the case of property tax, also a rate of depreciation. The model is demonstrated on the example of an anticlastic cable net roof structure supported by an interior mast and with curved cable edges. Design parameters to be optimized are the mast height and edge cable curvature. The results of two objectives are presented, namely, to minimize initial costs and to minimize initial costs plus operating costs.

2. Approach

The wide scope and interdisciplinary approach of this model does not lend itself to formal mathematical optimization. Instead, a search method and nonlinear interpolation is chosen. The search implies design, analysis, and evaluation of a number of design configurations for one or two simultaneous variables. In a typical case, at least four values are evaluated for each design variable. For two simultaneous variables, this implies \(4 \times 4 = 16\) designs. The results may be plotted in a contour map or grid surface. The former is for quantitative interpretation and the latter for visualization of the objective function.

While this method does not guarantee finding the global optimum, it provides a reasonably good approximation; furthermore, it clearly illustrates the impact of design decisions on the selected performance variables. The latter aspect is particularly important in the realm of architectural design, where various unquantifiable parameters have to be considered.

Fig. 1. Surface-boundary relations of quadrilaterally bound minimal surfaces.