

Shape and Thickness Optimization Performance of a Beam Structure by Sequential Quadratic Programming Method

A. Jarraya · F. Dammak · S. Abid · M. Haddar

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Abstract Successful performance of beam structures is critical to failure prevention, and beam performance can be optimized by careful consideration of beam shape and thickness. Shape and thickness optimization of beam structures having linear behaviour is treated. The first problem considered is the thickness distribution of the beam where the optimization variable is the thickness of the control points. The second problem is the shape optimization where the optimization variables are the ordinates of the control points. The optimization criterion (function objective to be minimized) is defined starting with the Von Mises criterion expressed in plane constraints. The resolution of the mechanical problem is made by the finite element method, and the optimization algorithm is the sequential quadratic programming (SQP) method.

Keywords Finite elements · Beams element · Parameterization · Optimization · Sequential quadratic programming method

Introduction

The optimization of structures with linear mechanical behaviour (small displacement) was widely treated over the last two decades. Powerful methods were developed to treat a large variety of problems. Gill [1] and various

commercial software (such as *ANSYS*, *NASTRAN*, *IDEAS*, and *SAPCEF*) contain structural optimization modules. Dimensioning problems (in particular the optimization of thickness or shape) have been treated by several investigators, for example the works of Boisserie, Glowinski [2], Fleury [3], Abid [4] and Vanderplaats and Moses [5]. The variables treated were the nodes and sections of bars. Zienkiewicz and Campbell [6], K Choi and Duan [7], and Vinot et al. [8] generalized the concept by systematically using the finite element method. The approach described in this work is based on a discrete finite-element analysis considering the effect of membrane, bending, and transverse shear in isotropic materials. Parameterization is achieved by B-Spline of orders three and four and by the points of Bezier. A formulation of the optimization problem is made using an objective function, which considers both the mechanical constraints and the volume of the structure. The constraints are represented by the Von Mises criteria for isotropic material. For all examples treated, the selected objective function allowed the simultaneous reduction in the total state of the structural constraints and an estimate of the gradients of the objective function. The numerical technique used is based on the finite differences method. The steps followed in this article are: (1) formulation of the beam element, (2) choice of the objective function, (3) implementation of parameterization techniques, (4) resolution of the optimization problem, and finally some examples and applications.

Formulation of the Beam Element

The relations presented characterize the theory of the beams in bending by taking into account the influence of

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