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ScienceDirect
Engineering Structures 30 (2008) 2360–2369
ENGINEERING STRUCTURES
www.elsevier.com/locate/engstruct

Sizing, geometry and topology optimization of trusses via force method and genetic algorithm

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Received 25 April 2007; received in revised form 1 January 2008; accepted 15 January 2008
Available online 10 March 2008

Abstract

In this article, a combination of energy and force method is used for minimizing the weight of the truss structures. Genetic algorithm is employed as an optimization tool for this purpose. The main idea proposed in here is the manner in which the input variables are reduced. Using the force method is of a considerable help in handling GA for the structural optimization. In the present method, there is no need to find the inverse of matrices, and only a limited number of variables are added to GA, which is equal to the degree of static indeterminacy of the structure. The efficiency of the present approach is illustrated through several examples for different types of optimization, and the results are compared to those of different optimization techniques.

Keywords: Force method; Genetic algorithm; Topology optimization; Strain energy; Complementary strain energy; Trusses

1. Introduction

For size/geometry optimization of structures with fixed topology, it becomes necessary to optimize structural cross-sections and geometry simultaneously. For such optimization, usually large numbers of design variables will be encountered consisting of cross-sectional areas and nodal coordinates, thus resulting in design spaces with large dimensions. Selecting the cross-sectional areas from a list of profiles leads to a discrete design space, and due to the constraints on member stresses, buckling stresses, and nodal displacements, the possibility of being trapped in a local optimum increases.

Goldberg is one of the pioneers in developing the Genetic algorithm [1]. Early papers on structural optimization using GA are due to Goldberg and Samtani [2], Jenkins [3], Adeli and Cheng [4] and Rajeev and Krishnamoorthy [5]. Many others have published papers improving the results and increasing the speed of GA in the last decade.

In the process of optimizing the geometry (shape) of a structure by the Genetic Algorithm (GA), if minimizing the structural weight is taken as the objective, by altering the geometry of the primary structure and increasing the dimension of the design space, the optimization may lead to local optima.

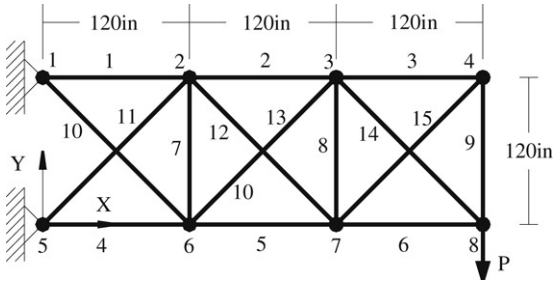

Fig. 1. The geometry of a fifteen-bar truss.

Analysis of structures by the force method is well established by Argyris and Kelsey [6]. Further developments are due to Herderson [7], Cassell et al. [8], Denke [9], Felippa [10], and Kaveh [11] among many others. A comprehensive list of references can be found in the review paper of Kaveh [12].

Energy methods are the most important approaches for the linear and nonlinear analyses of structures. In this article, an energy method and the force method are used for minimizing

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doi:10.1016/j.engstruct.2008.01.012