COMPUTER AIDED DESIGN OF SHELL STRUCTURES USING THE FINITE ELEMENT METHOD

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Abstract

The object of the research described in this dissertation is to develop and evaluate computer techniques for the design of shell structures. A computer aided design system for thin elastic shells is described.

Shell surfaces are defined geometrically using an existing surface design program, MULTIPATCH, which is based on the surface patches proposed by S.A. Coons. The structural design system, SHELL, provides facilities for preparing data for a finite element analysis, performing an analysis and examining the result in printed or pictorial form. Interactive computer graphics is used extensively during both input and output.

A new algorithm for automatically triangulating a surface for a finite element analysis is described. The density of triangular elements on any part of the surface depends on an "element density function" whose values are interpolated from values specified by the designer at the corners of the patches which define the surface. The algorithm produces near-equilateral triangles which are well graded in regions of varying density. The designer defines loads and boundary conditions in terms of the patch definition of the surface, and these are automatically mapped on to the finite element idealisation.

An interactive method for obtaining a near-minimum bandwidth for a structural stiffness matrix is described. The method utilises the ability of an engineering designer to appraise the overall structure of a finite element layout and decide on a near-optimum node order. The main disadvantages of previous methods of bandwidth reduction are overcome.

Lengthy finite element analyses may be run as batch-processing jobs and the results may be examined interactively using convenient graphics facilities. The data pertaining to a given structure is stored in a single magnetic disc file to which all phases of the design system have access. Having evaluated the results of analysis, the designer can modify the geometric definition or the structural data and run a further analysis.

The techniques developed, as incorporated into an integrated computer system, accelerate the design process by drastically reducing the amount of input data required for an analysis and by providing convenient output facilities. The evaluation of the system on a number of structures is described and suggestions are given for further work.