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Controlling errors in the process of automating boundary element method analysis

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Abstract

Automating boundary element method (BEM) analysis will make it possible for a large number of practicing engineers and students to exploit the unique advantages of BEM over other computational techniques for solving several classes of engineering problems. But to successfully automate the BEM analysis requires addressing a host of problems that includes a clear understanding of the various sources of error in the analysis. This paper discusses the various sources of errors in the BEM analysis, how the author of this paper has addressed these errors and the process by which the BEM analysis can be automated. © 2002 Elsevier Science Ltd. All rights reserved.

Keywords: Errors; Adaptive analysis; Mesh generation; Automation

1. Introduction

The proliferation of specialized computational tools for solving engineering problems is imposing a premium on the learning time and effective use of these computational tools. For boundary element method (BEM), this premium on learning time is further exacerbated by the mathematical character of the BEM formulation. The BEM formulations require solutions of integral equations, which most engineers are seldom exposed to in their education or work. By automating the BEM analysis, the intrinsic advantages of BEM are made available to a practicing engineer at minimum cost of learning time.

In this paper, 'automating an analysis' has the following implication. The user would describe the boundary value problem and the acceptable error in the analysis. The process of discretization necessary to achieve the specified accuracy would be done internally in the software and any decision regarding the analysis will also be done internally without any user intervention. At the end of the analysis, the user should have the freedom to display, observe, or further process the output of the analysis.

The current research by the author on automating BEM analysis is restricted to two-dimensional analysis in elastostatics, fracture mechanics, plate bending, and Poisson's equations. Thus, the user description of the boundary value problem implies choosing one of the four applications; entering the values of the material constants; describing the geometry using a graphical user interface; prescribing the boundary conditions. To achieve the user specified accuracy, requires understanding of the various sources of errors in the analysis and then systematically addressing these errors. The author and his students have published several papers in the past on these various sources of error. The results of these past papers are synthesized and presented in this paper. Also presented in the paper is the anticipated path of automating the BEM analysis.

2. Errors in BEM

The various errors in BEM analysis can be classified as: (i) formulation error; (ii) interpolation error; (iii) integration error; (iv) continuity error; (v) collocation error; (vi) matrix conditioning error; (vii) mesh error. The vast literature on BEM is a clear testimony that there are more than one way to address these errors. The solutions to the errors that are presented later should not be viewed as the best solution to the errors but rather a possible solution on the path of automating the BEM analysis. The solution to the errors that are presented later have been incorporated into a computer program BEAMUP, which will be referenced during discussion later.

2.1. Formulation error

The two-dimensional problem in elastostatics is used to

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