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3-D free vibration analysis of annular plates on Pasternak elastic foundation via *p*-Ritz method

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Abstract

In this study, a three-dimensional (3-D) free vibration analysis of thick annular plates resting on elastic foundation with different combinations of free, soft simply supported, hard simply supported and clamped boundary conditions at the inner and outer edges of the annular plate is presented on the basis of the polynomials-Ritz method. The elastic foundation is considered as a Pasternak model with adding a shear layer to the Winkler model. The analysis procedure is based on the linear, small strain, and 3-D elasticity theory. In this analysis method, a set of orthogonal polynomial series in cylindrical polar coordinate is used to extract eigenvalue equation yielding the natural frequencies and mode shapes for the annular plates. The accuracy of these results is verified by appropriate convergence studies and checked with the available literature, finite element method (FEM) analysis and the Mindlin theory. Furthermore, the effect of the foundation stiffness parameters, thickness–radius ratio, inner–outer radius ratio and different combinations of boundary conditions on the ill-conditioning of the mass matrix as well as on the vibration behavior of the annular plates is investigated. Finally, the validity and the range of applicability of the results obtained on the basis of the Mindlin and classical plate theories for a thin and moderately thick annular plate with different values of the Winkler foundation stiffness are graphically presented through comparing them with those obtained by the present 3-D *p*-Ritz solution.

1. Introduction

A plentiful number of plates resting on elastic foundations with different shapes, sizes, thickness variations and boundary conditions have been the subject of numerous investigations and those play an important role in aerospace, marine, civil, mechanical, electronic and nuclear engineering problems. For example, these types of plates are used in various kinds of industrial applications such as the analysis of reinforced concrete pavements of roads, airport runways and foundations of buildings.

An excellent survey of the research work on the free vibration of annular plates has been done by Leissa [1]. A vast amount of literature for free vibration studies of circular and annular plates have been performed with two-dimensional (2-D) theories. The natural frequencies of Mindlin annular plates under nine different combinations of free, simply supported and clamped boundary conditions have been reported by Irie et al. [2].

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