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RESEARCH PAPER

Bending of orthotropic plates resting on Pasternak's foundations using mixed shear deformation theory

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Abstract The mixed first-order shear deformation plate theory (MFPT) is employed to study the bending response of simply-supported orthotropic plates. The present plate is subjected to a mechanical load and resting on Pasternak's model or Winkler's model of elastic foundation or without any elastic foundation. Several examples are presented to verify the accuracy of the present theory. Numerical results for deflection and stresses are presented. The proposed MFPT is shown simplely to implement and capable of giving satisfactory results for shear deformable plates under static loads and resting on two-parameter elastic foundation. The results presented here show that the characteristics of deflection and stresses are significantly influenced by the elastic foundation stiffness, plate aspect ratio and side-to-thickness ratio.

Keywords Mixed theory · Bending · Rectangular plates · Pasternak's model

1 Introduction

The studies on bending of plate structures are one of the most important research areas in applied mechanics and have attracted attentions of many researchers. The problem of rectangular plates resting on elastic foundation finds wide applications in foundation engineering such as foundation of deep walls, storage tanks and slabs of buildings. The bending of plates resting on elastic foundations, which has practical applications in civil, mechanical, marine and aerospace engineering, has been investigated extensively and various analytical and numerical methods have been employed to study this problem.

To simplify the solution procedure, the elastic foundation is usually represented by a uniformly distributed layer of Winkler's springs resulting in a foundation reaction pressure $\Re(x, y) = k_1 w(x, y)$ which depends only on the local displacement w and the Winkler's foundation modulus, k_1. The Pasternak's foundation model $\Re(x, y) = k_1 w(x, y) - k_2 \nabla^2 w$, which allows more realistic modeling of foundations by taking account of curvature $\nabla^2 w$ as well as displacement w of the foundation layer, introduces a second parameter, k_2, usually referred to as the shear modulus of the foundation. Plates on elastic foundations have been widely adopted by many researchers to model interaction between elastic media and plates for various engineering problems involving plates. For the static problem, Yu [1] has derived an analytical solution for a circular thin plate resting on both Winkler's and Pasternak's foundations. Balas et al. [2] have derived the fundamental solutions for a thin plate on a Pasternak's foundation. Fundamental solutions for a thick plate on a two-parameter foundation were derived by Wang et al. [3], Fadhil and El-Zafrany [4] and Rashed et al. [5]. Kobayashi and Sonoda [6] have presented a Levy-type solution for the rectangular plates on Winkler's foundation with two opposite simply supported edges, and two other edges being arbitrarily restrained. Svec [7] has studied a similar problem by the finite element method. Liew et al. [8] have presented a differential quadrature solution to the rectangular Mindlin's plates on Winkler's foundation with arbitrary combinations of boundary conditions. Liu [9] has developed a differential quadrature method to solve the bending problems of thick rectangular plates resting on Winkler's foundation. Ozgan and Daloglu [10] have adopted the Mindlin's plate elements

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