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Static analysis of non-uniform 2D functionally graded auxetic-porous circular plates interacting with the gradient elastic foundations involving friction force

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Abstract

Solids that exhibit negative Poisson's ratio are called auxetic materials. Static behavior of the auxetic-porous structures has not been investigated so far, especially for structures composed of multi directional heterogeneous materials. The two parameter elastic foundation (Pasternak type) is developed by taking into account the torsional interaction and horizontal friction force. The material properties of the plate except the Poisson's ratio are assumed to be graded in the thickness and radial directions according to exponential functions. The governing state equations are derived in terms of displacements based on 3D poroelasticity theory. These equations are semi-analytically solved using state-space based differential quadrature method. A detailed parametric study is carried out to highlight the influences of key parameters on the static response of non-uniform bi-directional functionally graded auxetic-porous material (FGAPM) circular plates to compound mechanical tractions. Finally, the static response of circular plates composed of various functionally graded materials to compound mechanical loads is compared. Results reveal that the auxeticity of the material, torsional couples on the plate and rotary interaction of the elastic foundation play important roles on the static behavior of the plate.

Key words: Heterogeneous, Auxetic-porous material, Circular plate, Gradient elastic foundation, Torsional interaction, Elasticity, Porosity, Compressibility, Auxeticity.

1. Introduction

In recent years, new kinds of materials known as two-directional functionally graded materials [1], porous heterogeneous [2], auxetic composite materials [3] and auxetic- porous materials [4], have been introduced in the literature. Fascinating properties of auxetic-porous composite materials have led scientists to find remarkable applications in engineering and scientific disciplines, such as optics, aerospace, biomedical, civil, mechanical and vehicle engineering.

On the other hand, with growing the applications of novel materials in engineering structures and foundations, developing new models for design and modeling of structure-foundation interactions and optimizing the behavior of structures under various loads is a necessity in engineering design. As basic structural elements, functionally graded circular plates made up of auxetic-porous materials interacting with the elastic foundations often find a wide range of applications in engineering fields. Typical examples may be found in the power transmission systems, machining devises, support tables, driven plates of a friction clutch, disk of vehicle

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