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A size-dependent composite laminated skew plate model based on a new modified couple stress theory

He Dan * , Yang Wanli, Chen Wanji

(Key Laboratory of Liaoning Province for Composite Structural Analysis of Aerocraft and Simulation, Shenyang Aerospace University, Shenyang 110136, China)

* Correspondence to: He Dan, Email: danhe@sau.edu.cn

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ABSTRACT In this study, a size-dependent composite laminated skew Mindlin plate model is proposed based on a new modified couple stress theory. This plate model can be viewed as a simplified couple stress theory in engineering mechanics. Governing equations and related boundary conditions are derived based on the principle of minimum potential energy. The Rayleigh–Ritz method is employed to obtain the numerical solutions of the center deflections of simply supported plates with different ply orientations. Numerical results show that the normalized center deflections obtained by the proposed model are always smaller than those obtained by the classical one, i.e. the present model can capture the scale effects of microstructures. Moreover, a phenomenon is revealed that the ply orientation would make a significant influence on the magnitude of scale effects of composite laminated plates at micro scale. Additionally, the present model of thick skew plate can be degenerated to the model of Kirchhoff plate based on the modified couple stress theory by adopting the assumptions in Bernoulli-Euler beam and material isotropy.

Keywords Modified couple stress theory; Composite laminated plates; Scale effects; Ply orientation; Rayleigh–Ritz method;

1 Introduction

Recently, micron-sized devices have been increasingly utilized. For instance, the thicknesses of thin films [1] are less than 1 μm and the sizes of micro- and nano- electromechanical systems [2, 3] (MEMS/ NEMS) are often less than 10 μm. It has been reported that when the size of microstructure is down to the micro-level, scale effects are often observed [4-7]. Lam et al. [8] found that the flexural rigidity of epoxy resin beam increased three times with decreasing the thickness from 115 μm to 25 μm. Kouzeli and Mortensen [9] showed that the strength of the composites produced by infiltrating ceramic particles increased with decreasing interparticle distance.

Conventional theories of continuum mechanics could not account for scale effects due to the

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