Exact Mixed-Kirchhoff Solutions for the Bending Analysis of Reissner Plates

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Abstract

The plate theory has been and is still a subject which has been very extensively studied for a century. In the theory of plates usually two different limit cases are considered: the Kirchhoff and the shear deformable plate. Of the many shear deformable plate theories proposed over the years, the Reissner plate theory is fundamentally simpler to adopt for modeling the shear deformation behavior of thick plates. This paper presents exact axisymmetric bending solutions of thick plates based on the Reissner plate theory. The solutions are displayed in terms of the corresponding Kirchhoff (or classical thin) plate solutions. These Kirchhoff-Reissner bending relationships are derived using the mathematical similarity of the governing equations of the two plate theories and the basis of load equivalence. The relationships allow one to readily deduce the more accurate Reissner plate solutions that account for the effect of transverse shear deformation, without having to solve the more complicated Reissner plate equations.

Keywords: Kirchhoff plate theory, Reissner plate theory, Axisymmetric bending relationships.

Introduction

Plates are widely used as classical machine elements and structural components in civil, marine, aeronautical and mechanical engineering applications. Owing to their practical importance, much effort has been devoted to the static and dynamics analyses of these plate elements (or structural components). Therefore, the plate theory has been and is still a subject which has been very extensively studied for a century. In the theory of plates usually two different limit cases are considered: the Kirchhoff and the Reissner plate.

In the context of the plate theory, the simplest one is the Kirchhoff (classical thin) plate theory (CPT) which neglects the shear deformation in the plate thickness (Timoshenko and Woinowsky-Krieger, 1959). However, at thick and moderately thick structures are characterized by non-negligible shear deformations in the thickness since the longitudinal elastic modulus is much higher than the shear and the transversal module; hence the use of a shear deformation plate theory is recommended. The Reissner (Reissner, 1944, 1945)