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Modeling and evaluation of rectangular hole effect on nonlinear behavior of imperfect composite plates by an effective simulation technique

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Abstract. In the present study, geometrically nonlinear behavior of relatively thick composite laminates containing square and rectangular cutouts with or without initial geometric imperfection has been investigated. The effects of cutout size, shape and presence of initial geometric imperfection for plates under uniaxial in-plane compressive load are studied. The structural model is based on the first-order shear deformation theory and Von-Karman's assumptions are used to incorporate geometric nonlinearity. The perforated plate is modeled by assembling eight plate-elements and the connection between these elements is provided by the Penalty method, which is called plate assembly technique. The fundamental equations for perforated plates are obtained by the principle of minimum of total potential energy and the response is found by solving the obtained nonlinear set of equations using the quadratic extrapolation technique. The approximation of the displacement fields in this study has been based on the Ritz method and by Chebyshev polynomials. The load-displacement responses for plates with various cutouts and with different boundary conditions are extensively provided. The accuracy of the present work is examined by comparing the results with the finite element analyses by ABAQUS program wherever possible.

Keywords: geometrically nonlinear behavior; square/rectangular cutouts; composite laminates; plate assembly technique; penalty method

1. Introduction

Composite structures are subject of many studies and used as structural components in many industries especially aerospace industries due to their light weight and durability. By piling layers with different material properties and various fiber orientation, the composite laminates are fabricated. Composite laminate's planer dimensions are one or two orders of magnitude larger than the laminate thickness. For moderately thick plates, the transversal shear effect should be taken into account, as a result, the first-order shear deformation theory (FSDT) is used in this paper. Reddy (2004) described the laminated plates mechanics and theories in details in his book. These composite components are often in situations where they are subjected to in-plane compressive loading. Consequently, it is a necessity to precisely foresee the buckling of such elements and many studies have been done in this field for instance, Ghannadpour and Ovesy (2009) used the exact finite strip

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