# Abstract

The requirements for higher strength-to-weight ratios, better corrosion resistance, longer fatigue life, greater stealth characteristics over metals as well as the directional properties, have resulted in increasing demand for laminated composite structures in many challenging applications. Various forms of defects are introduced in laminated composite structures during the manufacturing and operational processes. The reduction in strength is due to different kinds of defects that occur in the material. These kinds of deterioration in material properties may be termed as damage. Damage assessment of composite structures is an important design criterion, which plays a major role in the integrity of composite structures.

In the present investigation a finite element procedure is developed to analyse damaged laminated composite plates. Two isoparametric quadratic plate bending elements, namely, six-noded triangular and nine-noded rectangular elements are developed based on Mindlin plate theory and the corresponding computer codes are written in FORTRAN90 for the present finite element analysis. A uniformly reduced integration scheme is adopted to calculate the element stiffness matrix. A phenomenological damage model based on the effective stress concept is used to model the damage of a lamina. To represent the damage status of a lamina, a second order tensor, aligned on-axis, is introduced. An initiation of a lamina damage is represented through the satisfaction of the Tsai-Wu criterion and the damage-status of a lamina is determined using a strain dependent damage progression law. The present investigation is carried out using graphite/epoxy composite plates of different stacking sequences: cross-ply, angle-ply, bending stiff, quasi-isotropic and torsion stiff. The displacement behaviour of composite plates is studied for symmetric location of damage patches. The stresses due to the individual variation of the damage variables are computed. The changes

of fundamental frequencies due to the variation of damage variables are also studied. The study also includes the initiation and progress of damage in laminae under three different loading conditions: uniformly distributed transverse loading in the case of static bending, uniformly distributed pulse loading in the case of dynamic forced vibration and impact loading in the case of low velocity impact.