ABSTRACT

This thesis deals with the finite element analysis of impact behaviour and impact-induced damages in fibre-reinforced polymer matrix laminated composite structures. A three-dimensional finite element and transient dynamic analysis of composite laminates subjected to transverse foreign object impact is performed. Layered version of eight-noded isoparametric brick element with incompatible modes is developed to model the laminate. Non-linear modified Hertzian contact law is used to model the local contact behaviour.

Based on the finite element model, a versatile computer software designated as "FACS" was developed in C++ language using object-oriented approach. The software can be used to provide solutions for a wide range of problems of composite laminates of different geometry and ply orientations subjected to transverse impact with or without any preload. Several results, such as contact force history, displacement, velocity and acceleration histories of the centre point of impactor, and the time-varying displacements, forces, strains and stresses throughout the laminate can be generated. A number of example problems are considered to study the effects of different impactor parameters and laminate characteristics on impact response of composite laminated plates. The analysis is also extended to study the impact response of laminated cylindrical shells and effect of curvature on it. Results are presented for time-varying contact force and laminate central deflection for all the problems considered. Impact-induced dynamic strains, stresses and strain energy density distributions within the laminate are also studied for some selected problems.

Analysis of impact-induced damages is performed using appropriate three-dimensional failure criteria based on major stresses contributing to the initiation of matrix cracking and delamination propagation. Several example problems of graphite/epoxy composite plates with different combinations of impactor mass and velocity are solved, and the initiation of matrix cracking and the location, shape and size of delamination after impact are predicted.

KEYWORDS : composite laminates, plates, shells, impact, dynamic behaviour, damage, matrix cracking, delamination, finite element analysis, object-oriented programming