A STUDY OF IMPACT RESPONSE OF LAMINATED COMPOSITE SHELLS INCLUDING IMPACT INDUCED DAMAGE

by

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Submitted
in fulfilment of the requirements of the degree of Doctor of Philosophy
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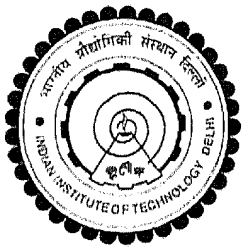

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Shells-stresses

Shells structures

Certificate

This is to certify that the thesis entitled "**A study of impact response of laminated composite shells including impact induced damage**" being submitted by Mr. K.S.Krishnamurthy to the Indian Institute of Technology, Delhi for the award of the degree of Doctor of Philosophy is a record of bonafide research work carried out by him under our supervision and guidance. The thesis work, in our opinion, has reached the standard fulfilling the requirements for the award of the degree of Doctor of philosophy.

The research report and the results presented in this thesis have not been submitted in part or full to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

The vulnerability of structural components such as beams, plates and shells made of laminated composite materials to damage in the form of cracking of fibers and matrix material, and delaminations under low velocity impact loads such as projectile hits or dropping of heavy objects on their surface is well known. Low velocity impact, e.g., due to a blunt-nosed object, causes a region of high stress concentration in the vicinity of contact area leading generally to a localized damage and adversely affecting the integrity of the structural member. While considerable work has been carried out especially in understanding the impact response and damage in the case of laminated composite plates, that concerning laminated composite shells, however, is relatively small. In the present work impact response of cylindrical laminated composite shells including the prediction of impact induced damage has been studied. Impact response is represented by the variation of the contact force and the deflection of the shell (under the point of impact) with time and the impact-induced damage. Two approaches to solving the impact problem have been followed. First, the impact response is determined by the analytical method, viz., by the classical Fourier series procedure for a cylindrical shell. After the mathematical formulation of the problem, the solution is obtained by means of an alternative numerical procedure instead of the Laplace Transforms technique used in an earlier work. The present procedure incorporates the non-linear Hertz's contact law which enables consideration of local indentation produced by the indentor on the impacted surface. The above procedure is also extended to the problem of impact on a cylindrical shell panel. Secondly, impact response is determined by the finite element method for the problem of impact on a cylindrical shell and on a cylindrical shell panel.

The finite element method includes a prediction of the impact-induced damage using the semi-empirical damage prediction model of Choi-Chang developed for impact on composite plates. Further, a number of parametric studies have been made to determine the effect of varying various parameters of the impact problem, both on the impact response and on the impact-induced damage. Some of the important parameters are: viz., impactor mass, approach velocity, elastic properties as well as the geometric characteristics of the laminate. The impact responses obtained from the Fourier series method and the finite element method have been compared. The Series method, which provided information regarding natural frequencies of vibration of the impacted structure, helped in selecting the size of the time step. The Series solution also lent confidence in accepting the accuracy of finite element solutions which are known to be significantly affected by the choice of mesh used, element type, grading, etc. The finite element method, however, proved to be a powerful numerical tool as it enabled us to incorporate the effect of damage produced in the shell on its impact response, simultaneously as the solution progressed. This helped us in obtaining a quantitative measure of the extent to which the structural member has been weakened due to a given impact situation. Computation of the coefficient of restitution, the energy absorbed by the impacted structure and that required for forming the indentation has also been made to understand the manner in which the energy imparted by the impactor gets apportioned during impact.

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