



**INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI  
SHORT ABSTRACT OF THESIS**

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Finite Element Analysis of Carbon Nanotube(CNT)-Reinforced Composites having a Broken CNT

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**SHORT ABSTRACT**

The present thesis deals with three dimensional (3D) finite element (FE) analysis of carbon nanotube (CNT)-reinforced composites starting with determination of thermoelastic properties to failure analysis of such composites having a defect in the form of broken CNT fiber. Owing to the fact that experimental determination of thermoelastic properties of CNT composites are difficult, FE analysis has been performed on a representative volume element (RVE) of the CNT-reinforced composites to determine thermoelastic properties and to understand not only the effect of important parameters on the properties but also the effect of types of modeling on the estimated properties. Eight noded solid elements have been used to develop the FE model and appropriate properties of matrix and the CNT are input. Different types of matrix materials viz. polymer, metal and ceramic; and nonlinear stress strain relation of the CNT has been considered in the analysis. Considering the fact that CNTs are the main load bearing member and volume fraction of CNTs in CNT-reinforced composites are much lower compared to that in conventional fiber (like glass or carbon) reinforced composites, it is important to understand the consequence of having one or more CNTs defective which may break during loading. Therefore, FE analysis of CNT-reinforced composite having one CNT broken has been performed, first to study the stress redistribution near the vicinity of such break especially the induction of

interfacial stresses at the interface of the broken CNT and the matrix which might lead to debonding of the fiber from the matrix and to determine the ineffective length of the broken CNT. Secondly, strain energy release rate (SERR) components near the vicinity of the broken CNT have been determined to understand the propensity of fiber matrix debonding from such break using linear elastic fracture mechanics (LEFM). At the end an attempt has been made to numerically determine the critical SERR of a broken CNT composite using LEFM and stress based failure criterion.

Based on the results of FE analysis, some important conclusions have been drawn. It has been observed that even a very small volume fraction (~3%) of CNT increases the elastic modulus of matrix substantially, and leads to a very low coefficient of thermal expansion of the resulting composite thus improving the thermal stability of the composite. Ineffective length of a broken CNT in a CNT-reinforced composite is also observed to be dependent on the matrix material and for stiffer matrix material it is low thus enabling a major length of the broken CNT to actively participate in the load bearing. Mode-II SERR component is observed to be also dependent on the matrix materials and volume fraction. Mode-II SERR of CNT/epoxy composite is approximately three times more compared to that in conventional carbon fiber/epoxy composites. Critical SERR determined using the FE analysis and LEFM shows qualitative agreement with available results and could be used to decide the growth of debonding from a fiber break in a CNT-reinforced composite.