INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title:

ANALYSIS OF THREE PHASE CARBON/(CNT+EPOXY) COMPOSITES WITH FLAWS

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SHORT ABSTRACT

Three phase FRP composites like carbon/(CNT+epoxy) are developed where the matrix dominated properties of FRP composites are enhanced to improve the performance. FRP composites though possess a very high specific strength and stiffness sometimes show poor performance when their interlaminar strengths are challenged. Especially when defects like ply break and embedded delaminations occur due to events like low velocity impact, delaminations usually grows at the interface of the broken and intact plies leading to the final fracture. These defects are sub-surface in nature many a time go unnoticed and results in catastrophic failure. It is therefore extremely important to strengthen the laminates against such failure. Resistance against such failures are decided predominantly by matrix dominated properties like interlaminar strengths. Therefore, three phase composites such as carbon/(CNT+epoxy) with modified matrix properties is expected to provide improved resistance against such failure. The present thesis thus aimed at investigating the performance of three phase carbon/(CNT+epoxy) laminates having internal flaws like ply break and impact induced embedded delamination subjected to loading with the specific objective of understanding qualitatively and quantitatively how adding CNTs to the epoxy enhances the resistance delamination growing from such defects. To study this, full 3D finite element analyses (FEA) have been carried out for carbon/(CNT+epoxy) laminates having two types of flaws viz. ply break and embedded delamination. Delamination at the interface has been modelled using a very thin resin rich layer and the interlaminar stresses around the ply break and embedded delaminations are obtained from the 3D FEA. Using the stresses and displacements from FEA, Virtual Crack Closure Integral (VCCI) has been used to determine strain energy release rate (SERR) components as measures of propensity of delamination. FE results show that delamination from such defects is a mixed mode phenomenon and in the case of embedded delamination the mode mix ratio also varies along the delamination front making the estimation of delamination growth difficult. Delamination at the interface arising from such flaws are observed to be influenced by many factors such as size, shape, relative fiber orientation, loading condition. Critical SERR as a measure of resistance to such delamination has been evaluated in the present work using stress based criteria and virtual crack closure integral from LEFM. From the results, it is clear that in the case of three phase carbon/(CNT+epoxy), addition of CNTs to epoxy leads to significant improvement in resistance to delamination at the interface from ply bear as well as from embedded delamination in all the cases studied. In addition, it was also observed that tendency of two neighbouring delamination to grow as a large delamination is also reduced by adding CNTs to the epoxy. However, results from the FE simulations also show that there is a limit till which CNTs could be added to the epoxy for best performance and beyond this the performance further reduces and it is important to know the limit to the adding CNTs will enhance the resistance to such delamination.