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IMPERFECTION OF COMPOSITE LAMINATED PLATES

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ABSTRACT

It is found that the manufacturing processes are responsible of many defects which may arise in fibers, matrix and lamina. These defects, if they exist include misalignment of fibers, cracks in matrix, non – uniform distribution of the fibers in the matrix, voids in fibers and matrix, delaminated regions, and initial stress in the lamina as a result of its manufacture and further treatment.

The above mentioned defects tend to propagate as the lamina is loaded causing an accelerated rate of failure. The experimental and theoretical results in this case tend to differ. Hence, due to the limitations necessary in the idealization of the lamina components, the properties estimated should be proved experimentally.

Keywords: Composite laminates, imperfections, delamination, fiber, matrix.

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1. INTRODUCTION

It is important to recognize that, with the advent of composite media, certain new material imperfections can be found in composite structures in addition to the better – known imperfections that one finds in metallic structures. Thus, broken fibers, delaminated regions, cracks in the matrix material, as well as holes, foreign inclusions and small voids constitute material and structural imperfections that can exist in composite structures. Imperfections have always existed and their effect on the structural response of a system has been very significant in many cases. These imperfections can be classified into two broad categories: initial geometrical imperfections and material or constructional imperfections.

The first category includes geometrical imperfections in the structural configuration (such as a local out of roundness of a circular cylindrical shell, which makes the cylindrical shell non – circular; a small initial curvature in a flat plate or rod, which makes the structure non – flat, etc.), as well as imperfections in the loading mechanisms (such as load eccentricities; an axially loaded column is loaded at one end in such a manner that a bending moment exists at that end). The effect of these imperfections on the response of structural systems has been investigated by many researchers and the result of these efforts can be easily found in published papers [1 – 18].

The second class of imperfections is equally important, but has not received as much attentions as the first class; especially as far as its effect on the buckling response characteristics is concerned. For metallic materials, one can find several studies which deal with the effect of material imperfections on the fatigue life of the structural component. Moreover, there exist a number of investigations that deal with the effect of cut – outs and holes on the stress and deformation response of thin plates. Another material imperfection is the rigid inclusion. The effect of rigid inclusions on the stress field of the medium in the neighborhood of the inclusion has received limited attention. The interested reader is referred to the bibliography of Professor Naruoka[1].

There exists two important classes of material and constructional – type imperfections, which are very important in the safe design, especially of aircraft and spacecraft. These classes consist of fatigue cracks or cracks in general and delamination in systems that employ laminates (fiber – reinforced composites). There is considerable work in the area of stress concentration at crack tips and crack propagation. Very few investigations are cited, herein, for the sake of brevity. These include primarily those dealing with plates and shells and non – isotropic construction. Some deal with cracks in metallic plates and shells [19-22]. Others deal with non – isotropic construction and investigate the effects of non – isotropy [23 – 28]. In all of these studies, there is no mention of the effect of the crack presence on the overall stability or instability of the system.

2. DELAMINATION OF COMPOSITE STRUCTURES

Delaminations are one of the most commonly found defects in laminated structural components. Most of the work found in the literature, deals with flat configurations.. Composite structures often contain delamination. Causes of delamination are many and include tool drops, bird strikes, runway debris hits and manufacturing defects. Moreover, in some cases, especially in the vicinity of holes or close to edges in general, delamination starts because of the development of interlaminar stresses. Several analyses have been reported on the subject of edge delamination and its importance in the design of laminated structures. A few of these works are cited [29–35]. These and their cited references form a good basis for the interested reader. The type of delamination that comprises the basic and primary treatise is the one that is found to be present away from the edges (internal). This delaminating could be present before the laminate is loaded or it could develop after loading because of foreign body (birds, micrometer, and debris) impact. This is an extremely important problem especially for laminated structures that are subject to destabilizing loads (loads that can induce instability in the structure and possibly cause growth of the delamination; both of these phenomena contribute to failure of the laminate). The presence of delamination in these situations may cause local buckling and / or trigger global buckling and therefore induce a reduction in the overall load – bearing capacity of the laminated structure. The problem, because of its importance, has received considerable attention.

3. CONCLUSION

In most of the previous studies, the composite media are assumed free of imperfections i.e. initial geometrical imperfections due to initial distortion of the structure, and material and / or constructional imperfections such as broken fibers, delaminated regions, cracks in the matrix material, foreign inclusions and small voids which are due to inconvenient selection of fibers / matrix materials and manufacturing defects. Therefore, the fibers and matrix are assumed perfectly bonded.

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