AN ASSESSMENT ON THE FAILURE ANALYSIS OF LAYERED STRUCTURES WITH VARIABLE KINEMATICAL DESCRIPTION

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ABSTRACT

Further advances in the use of laminated composites structures for aerospace applications are subordinate to a better understanding of their failure mechanisms. Proper failure analysis of composite layered structures is currently an unsolved issue. In fact, failure mechanisms are very different from those pertaining traditional metallic structures. The combination of various interfaces (fibers, matrix, layers) at a macro scale level would require a local dedicated analysis in order to establish the initiation of failure mechanisms of a fiber/crack in the matrix or the delamination between two different layers. In order to perform a reasonable failure analysis of composite layered structures by referring to plate modeling, the two following independent requirements should be satisfied:

1. Displacement, strain and stress fields have to be calculated with high precision;
2. An accurate and consistent failure criteria should be applied.

Point 1 can be fulfilled by employing advanced/higher order plate kinematical descriptions, using appropriate constitutive relations and referring to an appropriate variational statement. Extensive literature has been produced in the last decade on this subject. More specifically, the first author assessed the so-called Carrera Unified Formulation (CUF) [1-5]. CUF permits to solve the problem by considering a generic kinematical description, which can be also defined by the user, according to the required accuracy.

Concerning point 2, it should be emphasized that failure of composites is very complicated with respect to metals. Many failure criteria for composites have been proposed in the recent past. First Hashin [6-7] established the need for failure criteria that are based on failure mechanisms. Afterward, Sun et al. [8] proposed an empirical modification to Hashin’s criterion. The World Wide Failure Exercise (WWFE), conceived in 1991 at St Albans (UK) and conducted by Hinton and Soden, clarified that the Puck failure criteria [9-10] is the one which better fits experimental results. As a consequence, referring to Puck’s theory and after some additional enhancements, Dávila and Camanho proposed the LaRC03 failure criteria, which could be considered the best two-dimensional criterion currently available for
composite layered structures.

Several assessments on LaRC03 failure criteria are proposed in this work. Plate finite elements, formulated in the framework of CUF, are employed in order to obtain a set of hierarchical solutions for displacements, strains and stresses. The resultant comparisons will assess the accuracy of LaRC03 failure criteria depending on the kinematical description employed for plate modeling. Both layer-wise and equivalent single layer kinematical description are addressed to. The order of the kinematical expansion is ranged from one to four. The principle of virtual displacement is applied in order to obtain governing equations. When possible, exact and test results are compared with numerical evaluations. All the analysis are performed in MUL2 academic code.

![LaRC03 Failure analysis of a fully clamped two-layered composite plate subjected to a pressure on the top surface. Colors indicate different failure mechanisms. Q4 Layer-wise finite elements with first order thickness-expansion are applied.](image.png)

**Fig. 1** LaRC03 Failure analysis of a fully clamped two-layered composite plate subjected to a pressure on the top surface. Colors indicate different failure mechanisms. Q4 Layer-wise finite elements with first order thickness-expansion are applied.

**REFERENCES**


