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Debonding Analysis of Stiffened Composite Panels Using a Two-Way Global-Local Loose Coupling Approach

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Abstract

Fiber-reinforced composites and in particular laminated stiffened composite panels are widely applied in aircraft design. The reason of this large use of composite structures is their remarkable material properties such as high strength and stiffness to weight ratio. Exploiting the advantages of composite panel-type structures results in post-buckled designs in which the load carrying capability after first buckling is used and the occurrence of damage is considered [1]. For this reason, an efficient and reliable progressive failure analysis capability is required. In this work, one of the common failure modes in a composite panel, the debonding between skin and stiffener foot is modelled by means of two-way global-local loose coupling approach.

Global-local coupling approaches have been proposed earlier to simulate the post-buckling progressive failure behavior of panel-type structures in an efficient way [2-4]. In particular, a two-way global-local procedure has been used to predict the behavior of panels with intralaminar damage [2, 4]. In these earlier works, the global-local approach has been verified for typical test cases of panels with one stringer and two stringers. Recently, application of the approach to a larger panel with five stringers demonstrated the applicability of the approach to larger panels [4].

According to a wide range of experimental results, stiffened panels under compression are prone to debonding between the skin and the stiffener foot [5]. The influence of the debonding on the final failure as well as the progressive separation of the skin and stiffener with increasing compressive load is considered in the present work with the help of a two-way global-local finite element approach. First of all, critical areas are defined at the global level and local models with a considerably finer mesh are created by means of a submodeling technique and a local model analysis is conducted. Cohesive elements are applied to model the debonding, while special attention is paid to the exchange of information between the different steps of the coupling analysis. Averaged degraded properties are defined at the local model level and transferred back to the global level. The applied compressive load is increased and can induce a further skin-stringer separation. The global-local coupling loops are repeated until global panel failure occurs. The approach is illustrated for the case of a one-stringer stiffened panel and shows the potential to establish an efficient and fast procedure for the modelling of skin-stiffener debonding in stiffened composite panels.

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