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DELAMINATION STUDY OF Z-PINNED COMPOSITE LAMINATES VIA TWO-PHASE INTERFACE MODEL

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ABSTRACT

One of the most effective technique, developed over the last decade, to enhance the strength of the composite laminates in the thickness direction (z-direction), is the through-thickness reinforcement in form of stitching [2], [4] or short rods inserting [3]. These reinforcing fibres, providing direct closure tractions to the potential delamination crack faces (bridging effect), increase the interlaminar fracture toughness. The reinforcement system can be applied extensively to the composite laminate or restricted to those critical structural zones that are subjected to high interlaminar stresses. The through-thickness reinforcement is also used in composite-composite assemblages where, coupled with adhesive joints, may replace mechanical fasteners such as rivets and bolts.
The non-linear delamination process in composite materials and in bonded joints can be effectively described making use of the interface concept. The presence of the reinforcement fibres through the adhesive interface thickness provides an anisotropic elastic and post-elastic mechanical response. In order to take into account the presence of the reinforcement fibres in the interface layer, an appropriate two-phases interface model can be formulated. The two phases, namely the adhesive joint (or matrix of the composite) and the reinforcement, are characterized by own constitutive laws and coupled only at the equilibrium level. In this way this complex mechanical problem is treated by simple independent evolutive equations with clear meaning of the material parameters.
In a previous paper [1] the attention was focused on the stitches reinforcements which behave as truss elements, therefore subject only to axial stress; in this paper a similar approach is followed to analyze laminates reinforced by rods in which shear and bending stiffness are not negligible.

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