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CONTINUUM COHESIVE FAILURE/INTERFACE FAILURE INTERACTION IN ADHESIVELY BONDED DOUBLE-LAP JOINT SPECIMENS

Jonathan P.-H. Belnoue* and Stephen R. Hallett

Advanced Composites Centre for Innovation and Science, University of Bristol
Queen's Building, University Walk, Bristol, BS8 1TR, UK, jonathan.belnoue@bristol.ac.uk

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Since its development in the late 1950's, the cohesive zone method has shown itself to be of the leading technique for prediction of discrete failure events in engineering applications. The method regards fracture as a gradual phenomenon in which the separation of the surfaces forming the crack takes place across an extended crack tip (i.e. the cohesive zone), that is resisted by cohesive tractions. The method is particularly attractive as it allows the consideration of phenomena such as mixed-mode, rate-dependent effects, environmental effects or fatigue loading using a relatively limited amount of parameters. It has been proved to work especially well in cases such as composites delamination or failure of thin adhesives where the crack-path is known in advance. The inability of the method to describe failure phenomena when the crack path is not known a-priori has however led to the developments of alternative methods, such as continuum damage mechanics (CDM), that are able to overcome this major impediment. CDM considers cracks as bands of damaged material, damage within an element being represented by a number between zero (for virgin, undamaged material) and unity (for material that lost all its bearing capacity). As CDM is prone to give mesh-dependent results and is not very well adapted to the description of very localised fracture mechanisms, the method needs to be handle with care.

Recently, industrial needs for increasingly accurate failure predictions and the tremendous advancement of computational capabilities has led the scientific community to explore increasingly complex models involving multiple material and failure models interacting which is others [1]. This way the real complexity of engineering component failure can be described more realisticaly, opening the way to less conservative design and subsequent cost reductions. Models where interface elements, plasticity and CDM models are used together (each type of model being used for what it is good at) are becoming morecommon place. There is thus a greater need to understand how these models interact with each other. Over the last 10 years, some significant progress have been made towards understanding how cohesive elements interacts with plastic and hardening materials [2-3]. However, the interaction of cohesive elements with a softening material still remains to be adressed.

In the present contribution, the modeling of a metal to composites double-lap joint test presented in [4] is revisited to further study the interaction of cohesive elements with hardening material and CDM models. Debonding of the adhesive and the composite adherend is modelled using the cohesive element formulation proposed in [5] whilst rupture of the adhesive is described using the continuum cohesive failure model proposed in [6]. Model predictions where only adhesive fracture is considered are compared to results obtained when “in the adhesive” damage interacts with interfacial failure and when interfacial failure is coupled to a purely plastic adhesive (no damage capabilities). The best match to experimental tests presented in [4] is obtained when both damage of the interface and of the adhesive bulk material are considered.

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