DAMAGE MODELLING IN SUBLAMINATE SCALE WITH HIGHER ORDER ELEMENTS IN EXPLICIT DYNAMICS

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A novel method for modelling damage in laminated composite structures at sublaminate scale is developed for explicit time integration. The physics of the damage mechanisms in composites such as, delamination, transverse matrix cracking and fibre failure, can be described with various methods. Cohesive zone modelling is a prevalent method in modelling delamination. However, the requirement to discretise the numerical cohesive zone with a large number of integration points results in a highly refined mesh when linear elements are used. In the current work, a novel cohesive element formulation with additional rotational degrees of freedom at the corners of the element is used in modelling the numerical cohesive zone. This allows for large mesh sizes in the numerical model, thus alleviating the fine mesh requirement. The cohesive elements are also initiated adaptively. The rotation enabled cohesive elements are used with a compatible continuum element of C^1 continuity. This enables an improved modelling of the stiffness in a sublaminate. For example, bend-twist coupling can be modelled within a sublaminate. Hence, fewer number of global degrees of freedom are required in the through-thickness direction of a laminate. Since the global behaviour of a laminate is described by the sublaminates, a sublaminate scale continuum damage mechanics (CDM) framework is developed to benefit from this improved stiffness modelling. The damage initiation in the plies of a sublaminate can be calculated with any ply-level stress criterion and the damage evolution is calculated with a strain-based energy regularised CDM model. The ply-level stresses are then homogenised to obtain the stress in the sublaminate. This proposed method is demonstrated with example cases where a laminate is subjected to impact loading conditions [1].

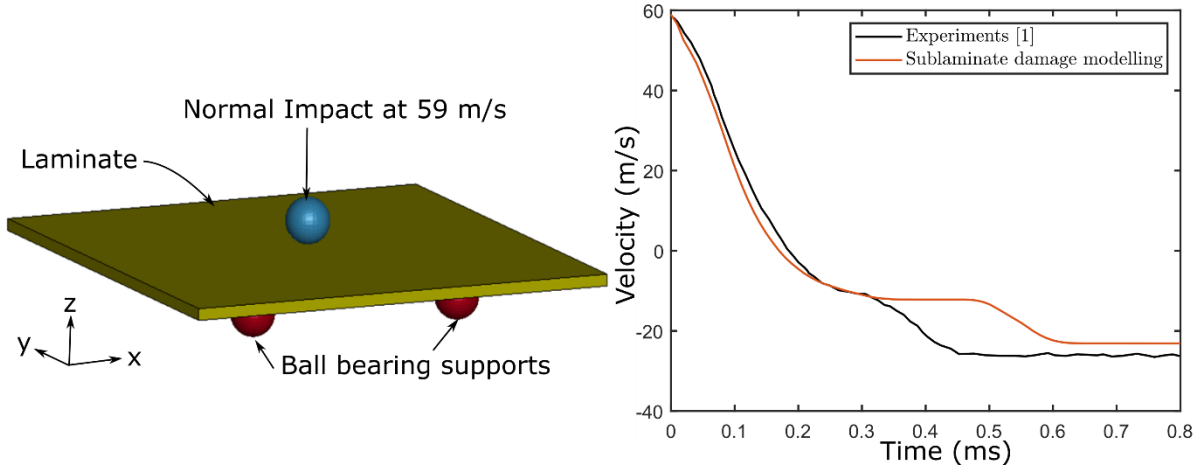

Figure 1. Comparison of velocity-time history obtained with sublaminate damage modelling using higher order elements against experiments [1].

References

[1] Hao Cui, Daniel Thomson, Sina Eskandari, Nik Petrinic, A critical study on impact damage simulation of IM7/8552 composite laminate plate, International Journal of Impact Engineering, Volume 127, 2019, Pages 100-109.