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METHODOLOGY FOR PREDICTION OF TRANSVERSE CRACK SATURATION DENSITY AND DIFFUSE DELAMINATION ONSET IN LAMINATES

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When a multidirectional laminate is subjected to unidirectional quasi-static loading, an early stage of damage is dominated by formation of transverse matrix cracks, until eventually, saturation crack density is reached, giving rise to diffuse delamination starting from the crack tips. To evaluate the saturation density, a generalized plane strain model for orthotropic composite lamina is developed. Geometry of the model is taken into account by means of a representative unit cell containing a transverse crack (see Fig. 1). The evaluation is carried out in an iterative manner. After the length of the unit cell, defined as half the distance between two neighbouring cracks, is initialized, a load increment is applied. As a result, either a new transverse crack is created when the longitudinal stress reaches its ultimate value, leading to the update in the length of unit cell, or the delamination is initiated if the delamination onset criterion is met. If both events fail to take place, the load is increased for the next iteration set up.
A bimaterial interface delamination experiences mixed mode conditions near the tip of the matrix crack, creating the necessity to evaluate the mode mixity and adopt the appropriate delamination onset criterion. The strain energy release rate (SERR) for different delamination modes was evaluated using virtual crack closure technique and compared to the SERR obtained using a global strain energy approach.
The predicted delamination onset is in good agreement with the available experimental results for the cross-ply laminates (see Fig. 2). Application of the approach to other layup configurations will also be investigated.

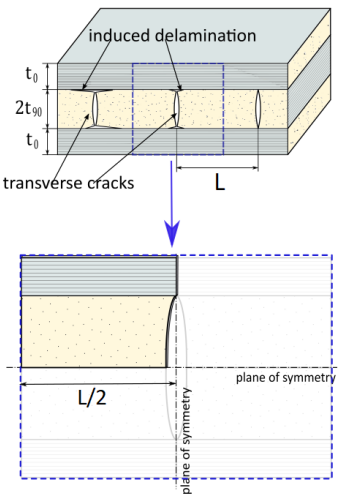

Figure 1: Schematic representation of the unit cell used for the numerical model.

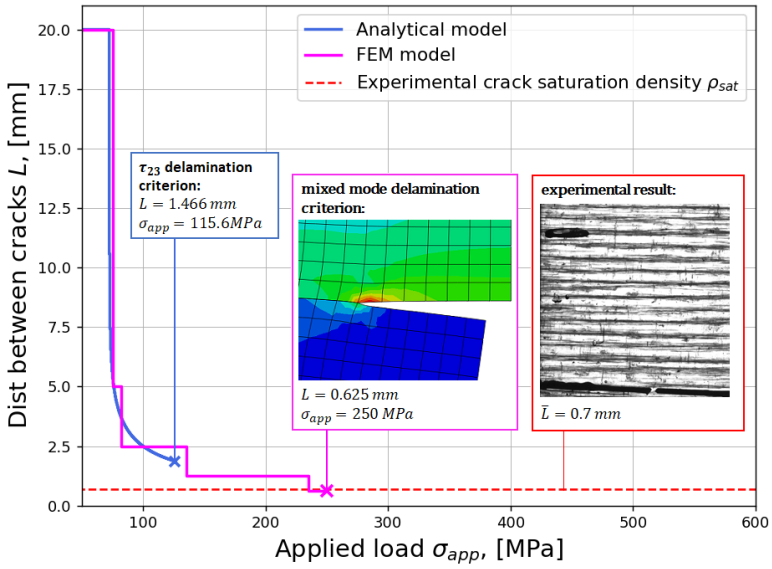

Figure 2: Diffuse delamination onset results using different approaches.