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A COMPUTATIONAL MICROMECHANICS-BASED MODEL FOR ENERGY RELEASE RATE OF CRACKED CROSS-PLY LAMINATES UNDER BENDING LOADS

Néstor D. Barulich[a,b], Luis A. Godoy[a] and Patricia M. Dardati[b]

[a]*Instituto de Estudios Avanzados en Ingeniería y Tecnología, IDIT, CONICET-Universidad Nacional de Córdoba, Av. Vélez Sársfield 1611, Córdoba, Argentina, nbarulich@frc.utn.edu.ar, luis.godoy@unc.edu.ar, http://www.inv.idit.efn.uncor.edu*

[b]*Grupo de Investigación y Desarrollo en Mecánica Aplicada, GIDMA, Facultad Regional Córdoba, Universidad Tecnológica Nacional. Maestro M. Lopez esq. Cruz Roja Argentina, Córdoba, Argentina, pdardati@frc.utn.edu.ar, http://www.frc.utn.edu.ar*

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Abstract. Transverse cracks (TC) and delamination induced by transverse cracks (TCID) in laminated composites are damage modes that can trigger final failure. Predicting TC and TCID, among other damage modes, is primordial to structural design and analysis and it has been the subject of numerous research campaigns during the last decades. However, little attention has been paid to TC or TCID generated by bending loads, mainly due to the difficulty in representing the deformation and load transfer mechanisms during bending. This work presents a two-scale numerical model based on computational micromechanics to predict the mechanical behavior of cross-ply laminates with TC and TCID under bending loads. The model allows the evaluation of the Energy Release Rate (ERR) of symmetrical and non-symmetrical cross-ply laminates using a two-dimensional mesoscale Representative Volume Element (RVE) connected with a macro-scale thin-plate model through the Hill/Mandel principle. The RVE is subdivided into Finite Elements and displacement periodic boundary conditions are used to represent the interaction with neighbor RVE's. The ERR is obtained using the strain energy change and also using the Virtual Crack Closure Technique (VCCT). Comparisons of ERR for membrane loads show that the model here presented is in agreement with existing models for the whole crack density spectrum. New results for the ERR for bending loads are obtained for several cross/ply laminates as functions of the transverse crack density and delamination percentage. This model allows identifying a characteristic damage state for which TCID start prevailing over TC.

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