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MESH INDEPENDENT MODELLING OF CRACKS AND DELAMINATIONS IN COMPOSITES WITH HOLES

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ABSTRACT

Composite materials and laminated composites in particular exhibit complex cracking and delamination patterns precipitating the final failure. Modeling such damage by using standard finite element techniques presents a formidable challenge even at the current level of computational recourses. Indeed, the meshes required for finite element discretization are dictated by the design features in the pristine state and thus may not accommodate the initially unknown locations of matrix cracking and delamination. In the case of delaminations it is in many cases possible to build in appropriate features, such as decohesive elements to predict their opening and propagation [1]. A more complex situation arises with regard to modeling matrix cracking. Matrix cracking origination and propagation can not be accounted for in the initial model and must be dealt with in the progression of analysis. A mesh independent technique will be utilized for this purpose in the present paper.

Quasi-isotropic $[0/+45/90/-45]_s$ IM7/5250-4 laminate contaning an open hole was consirdered under tensile loading in the 0^0 direction. This laminate developes matrix cracking and delamination pattern observed by X-ray technique and shown on Figure 1. This damage may drastically alter the state of stress in the 0^0 plies responsible for the load carring capacity. Discrete representation of such damage is very difficult if not impossible by

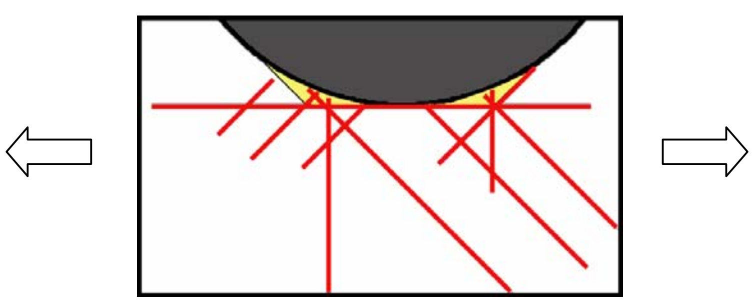

Figure 1. Schematic of an X-ray image of matrix cracking and delamination pattern in quasi-isotropic $[0/+45/90/-45]_s$ IM7/5250-4 laminate at approximately 85% of the average failure load.

using standard FEA software. The mesh independent crack modeling method based on higher order approximation of the step function defining the crack face [3] was used to model both matrix cracking and delamination. Figure 2 illustrates the redistribution of strain in the top load carrying 0^0 ply of the $[0/+45/90/-45]_s$ IM7/5250-4 laminate after development of the damage pattern shown in Figure 1.

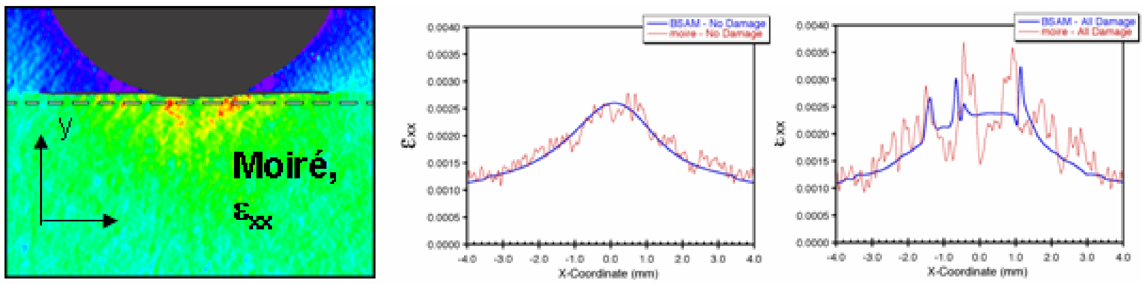

Figure 2. Moire' interferometry map of strain distribution in $[0/+45/90/-45]_s$ IM7/5250-4 laminate with the damage pattern shown in Figure 1 and line plots of BSAM prediction and Moire' experimental strains for undamaged and damaged composite, respectively.

Figure 2a shows the Moire' interferometry map of axial strain with the damage pattern in Figure 1. The line plots of this strain component and along the dashed line are shown on Figures 2b and 2c, where Figure 2b shows the strain distribution before damage occurs and Figure 2c shows the strain in the presence of damage. In both cases, the predictions are in good agreement with the experiment.

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