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COMPUTATIONAL MODELING OF MICROSCOPIC FRACTURE PROCESS IN COMPRESSIVE FAILURE OF QUASI-ISOTROPIC LAMINATE OF COMPOSITE MATERIALS

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This study investigates computational modeling of microscopic fracture process in compressive failure of quasi-isotropic laminate of composite materials. The purpose of this study is to establish the numerical analysis method to understand the failure mechanism and predict the mechanical response of quasi-isotropic laminate of composite materials through the numerical simulation using the finite element method.

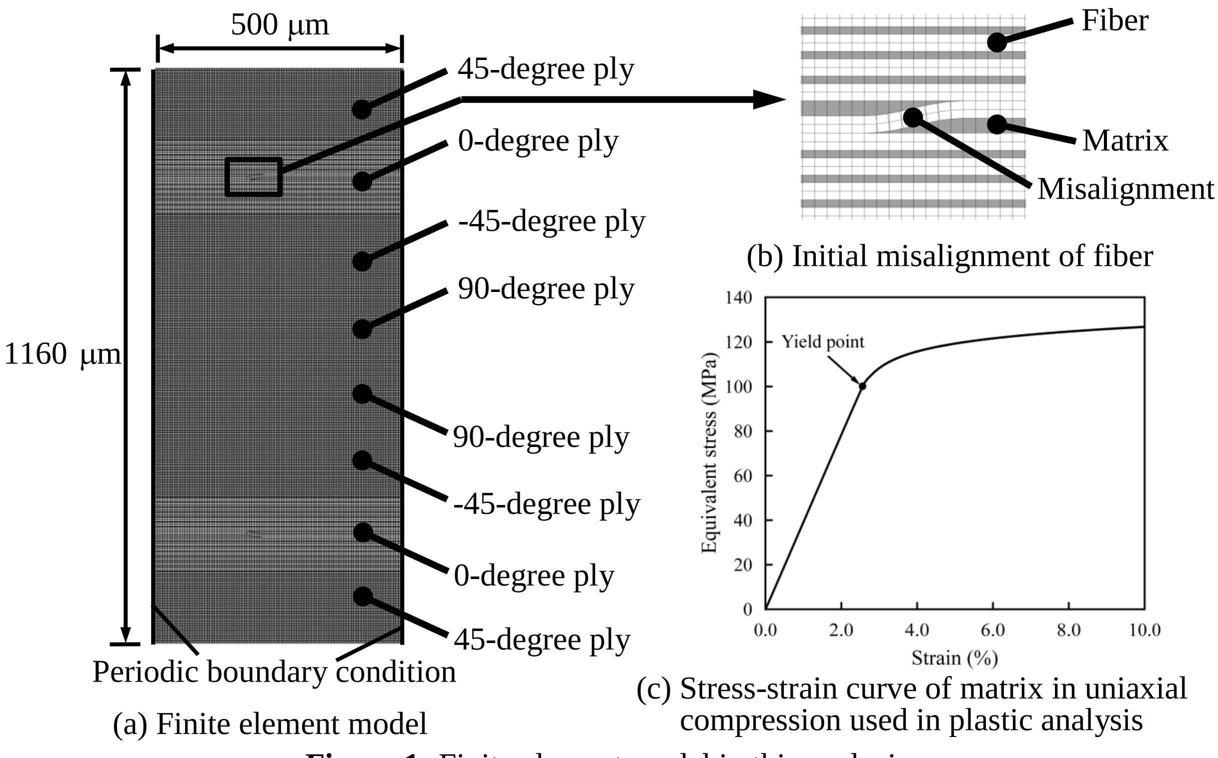
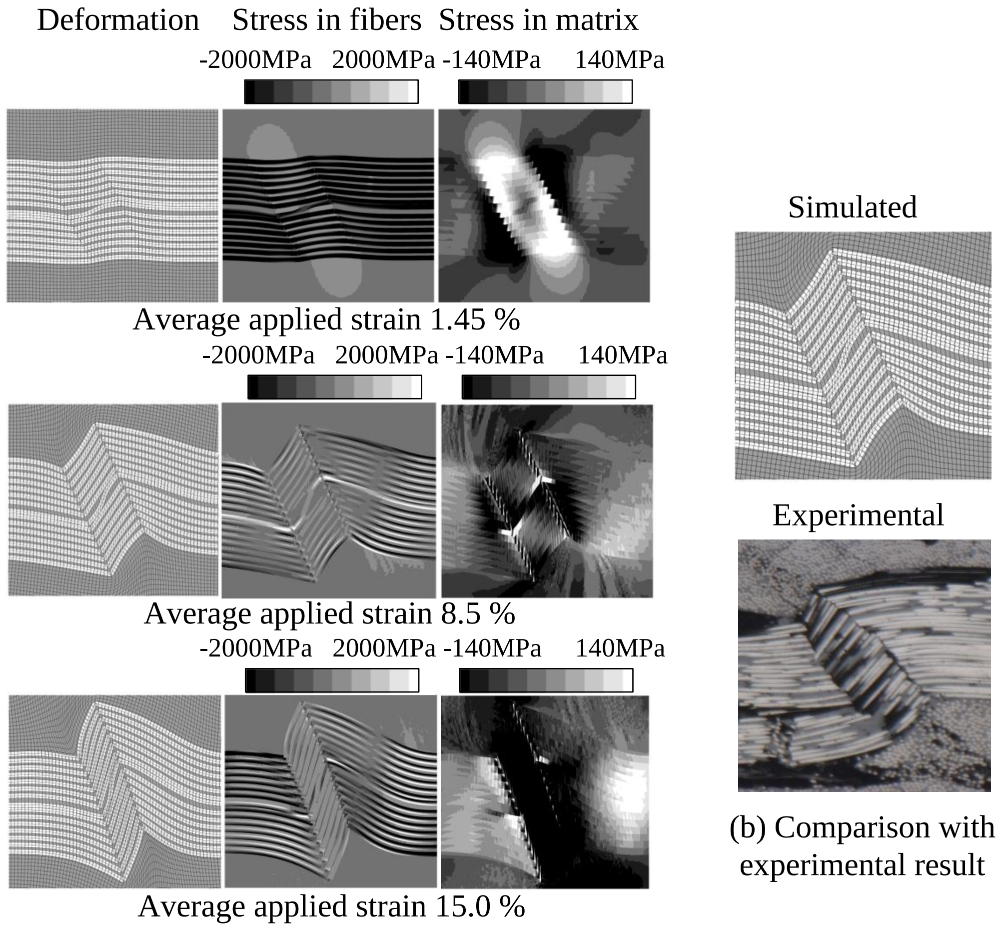


Figure 1: Finite element model in this analysis.

Figure 1(a) shows the finite element model in this analysis. The stacking sequence of the laminate is [45/0/-45/90]s. The reinforcement fibers in 0-degree plies are modeled by circle cross-section beam element to represent the three-dimensional effect in bending of fibers, and initial misalignment is introduced in center fiber in each 0-degree ply as Fig. 1(b). Cohesive elements are inserted in the connection of beam elements to simulate the bending breaking of fibers. Since material and geometrical nonlinearity commonly affect the buckling phenomena of the materials, the material nonlinearity due to the nonlinear stress-strain relation of matrix as Fig. 1(c) and geometrical nonlinearity of material deformation are incorporated. Periodic boundary condition is introduced to avoid the edge fracture of the material.

After starting the loading, the stress concentration occurs around the initial misalignment of fiber in 0-degree plies. When the applied load is increased, local areas of matrix around the stress concentration start to yield, and deformation is locally increased. At one moment of the loading, the load is catastrophically decreasing in load-displacement curve, and at this moment the localized deformation initiates in 0-degree plies, and the damage is formed in those plies. Figure 2 shows the simulated results of deformation and stress distribution during the damage evolution. The maximum supported load of the material is associated with the initiation of localized deformation in 0-degree plies, and it is indicated that the material strength is closely related with the internal stress distribution and deformation of the material.



(a) Deformation and stress during damage evolution

(b) Comparison with experimental result

Figure 2: Simulated results.