ABSTRACT

The deformation along cylindrical surfaces of holes in tensile-loaded specimens was measured using Moiré interferometry techniques. The techniques were developed and validated using an isotropic, homogeneous aluminum specimen. Two composite tensile specimens, fabricated from IM7/5250-4 pre-preg with ply lay-ups of $[0^\circ, 90^\circ]_n$ and $[+30^\circ, -30^\circ, 90^\circ]_n$, were then examined with Moiré. Circumferential and thickness direction displacement fringe patterns (each 3° wide) were assembled into 90°-wide mosaics around the hole periphery for both composite specimens. Distributions of strain were calculated with high confidence on a sub-ply basis at selected angular locations. The measured strain behavior was complex. Ply-by-ply trends were revealed. Large ply-related variations in the circumferential strain were observed at certain angular locations around the periphery of the holes in both composites. Extremely large ply-by-ply variations of the shear strain were also documented in both composites. Peak values of shear strain approached 30 times the applied far-field axial strain. Residual viscoelastic shearing strains were recorded in regions of large load-induced shearing strains. Large ply-group related variations in the thickness direction strain were observed in the $[+30^\circ, -30^\circ, 90^\circ]_n$ specimen. An important large-scale trend was observed in which the thickness direction strain tended to be more tensile near the outside faces of the laminate than near the mid-ply region. These experimental results were compared with predictions made using a unique spline-based numerical method that has been shown to have great fidelity. Comparisons between the experimental and analytical techniques were extremely close.