

EVALUATION OF MODIFIED MIXED-MODE FRACTURE TEST APPARATUS

K. N. Shivakumar, M. Naiva, N. Adeyemi, and V. S. Avva

ONR Grant N00014-95-1-0649; Technical Monitor: Dr. Yapa Rajapakshe, ONR
Center for Composite Materials Research, Department of Mechanical Engineering
North Carolina A&T State University
Greensboro, NC 27411

Research Objective:

Overall objective of this research is to characterize mode I, II, and mixed-mode delamination fracture toughness of fabric composites manufactured through compression, autoclave, and resin transfer molding processes under pure mode and mixed mode loading conditions. The specific objective of this task is to develop a modified mixed-mode fracture testing apparatus.

Approach:

Split beam test specimen is used to measure mode I and II fracture toughness of composite laminates. Crews and Reeder proposed a mixed-mode bending test apparatus for measuring mixed-mode delamination fracture toughness. Their concept used the combination of mode I and II loading through a lever mechanism. Although their test apparatus is unique, it has a number of limitations, namely, heavy loading lever, complex attachments, ball bearings, and geometric nonlinearity. After evaluating this apparatus, a modified test apparatus was developed (see Fig. 1). The lever and attachments are replaced by a single light weight (0.75 lb) lever with an embedded roller bearing. The lever is graduated to directly read the load position. The load is applied through a yoke and saddle. This test apparatus was used for mode I, II and mixed-mode tests. Linear G equations were verified by a geometric nonlinear analysis.

Accomplishments:

Figure 2 demonstrates that the error in the linear G and G_I/G_{II} equations is small (less than 2%) for $V = 0.4$ - in (distance between the load point and specimen mid-plane). Load and displacement response of a typical mixed-mode fracture test is shown in figure 3. Fracture was brittle for mode II and $G_I/G_{II} = 1/4$ tests and it was stable for mode I and $G_I/G_{II} = 4/1$ and $1/1$. Delamination fracture toughness diagram for IM7/5260 graphite Bismaleimide composite laminates is shown in figure 4.

Significance:

Developed a modified mixed-mode delamination fracture test apparatus. The test apparatus is compact, light weight, and suitable for both fracture and fatigue tests.

MODIFIED MIXED-MODE FRACTURE TEST APPARATUS

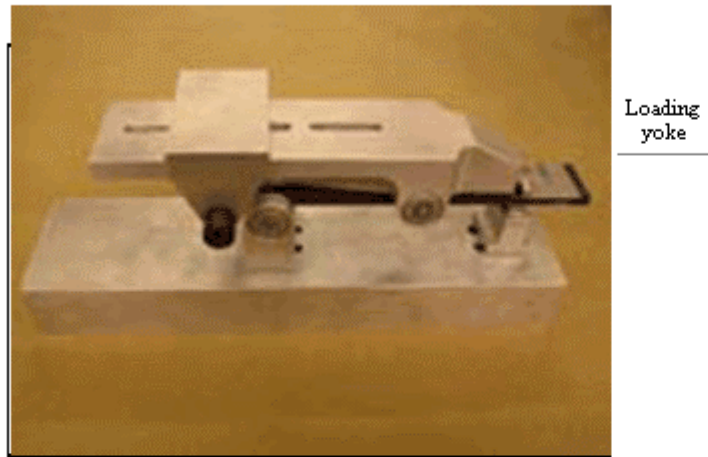


Figure 1.- Modified MMB Test Apparatus

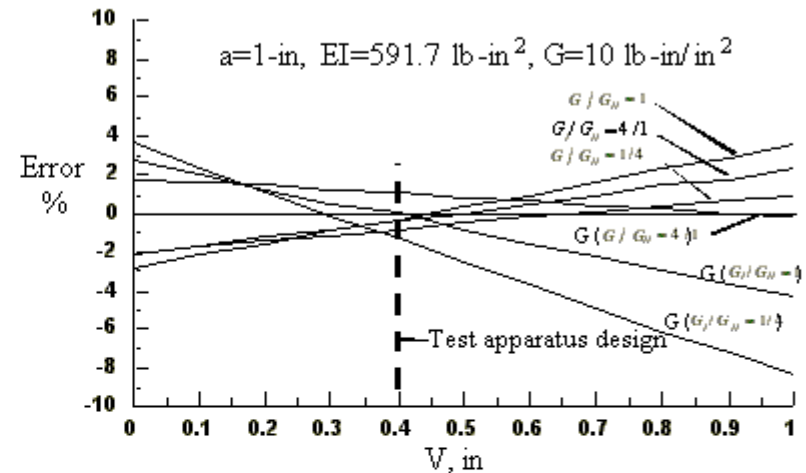


Figure 2.- Error in linear G equations.

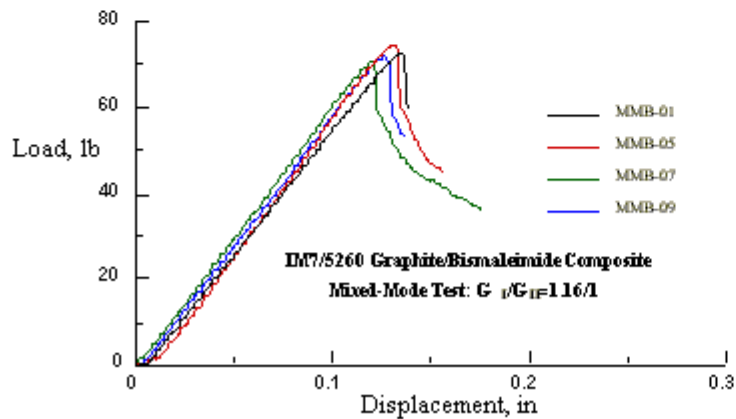


Figure 3.- Typical load-displacement response.

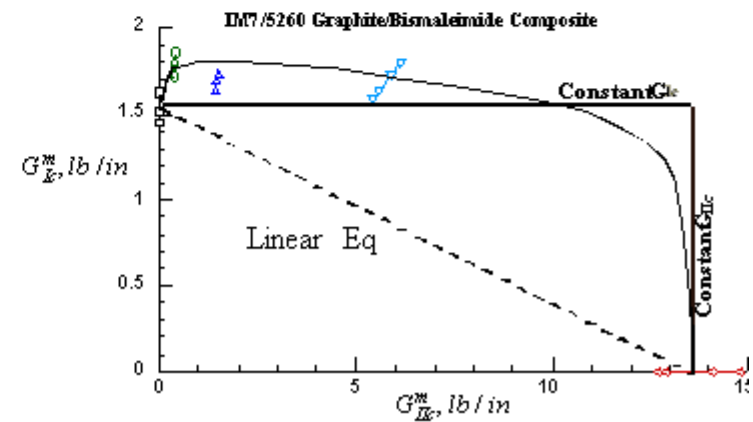


Figure 4.- Delamination fracture toughness diagram.