ANALYSIS OF POLYMERIC COMPONENTS UNDER IMPACT LOADING

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The increasing use of polymeric structures has attracted the attention of researchers and practitioners seeking a fundamental understanding of their mechanical characteristics under different service situations, including impact loading. This paper presents both experimental and analytical investigations to characterize different polymers under varying strain rates up to impact levels. A rate-dependent constitutive model based on tests of polymer specimens is established and applied to predict dynamic behavior and failure of polymeric specimens using the finite element analysis.

A split Hopkinson pressure bar (SHPB) is employed in the tests to measure the material behavior of polymers at high strain rates. In addition, the effects of specimen thickness, low mechanical impedance, and low compressive strength on the measured material properties are examined. Mechanical characterization of the polymers at strain rates up to the order of $10^2 \sim 10^3$/s has been achieved using SHPB. Behavior at lower rates ($10^{-5} \sim 10^{-3}$/s) has been determined using an MTS machine. The measured data confirm high strain rate sensitivity of the materials, even within the range of quasi-static loading. The test data enables the development of a rate-dependent constitutive model to accurately characterize the material behaviors of the polymers.

Upon external loading, the mechanical behavior of a polymer changes due to initiation, growth and coalescence of its internal micro-defects. The phenomenon of progressive micro-structural changes of a material is generally referred to as material degradation or damage. The material damage will eventually lead to macro-crack initiation and rupture of a component. In this work, a failure criterion is developed based on the theory of damage mechanics and used to predict crack initiation, propagation and eventual rupture.

Finally, a material model for the polymers taking into account strain rate effects and progressive material degradation is established and applied via finite element analysis to analyze the mechanical behavior and failure of polymeric specimens under impact loading. The load-displacement curves are predicted and compared with test data from three-point bending tests. The potential hotspots in the specimens are identified from the damage distribution of the FEA results and the predicted critical locations of failure are compared with those observed experimentally.