Computational modeling of the probabilistic impact response of flexible fabrics

Gaurav Nilakantan [a], Michael Keefe [a,d], Eric D. Wetzel [e], Travis A. Bogetti [e], John W. Gillespie Jr. [a,b,c,⇑]

[a] Center for Composite Materials, University of Delaware, DE 19716, USA
[b] Department of Materials Science and Engineering, University of Delaware, DE 19716, USA
[c] Department of Civil and Environmental Engineering, University of Delaware, DE 19716, USA
[d] Department of Mechanical Engineering, University of Delaware, DE 19716, USA
[e] US Army Research Laboratory, Aberdeen Proving Ground, MD 21005, USA

a b s t r a c t

The impact response of flexible woven fabrics is probabilistic in nature and described through a probabilistic velocity response curve or **V**0–**V**100 curve. Computational impact analyses based on deterministic methods are incapable of predicting the experimentally observed probabilistic fabric impact response. To overcome this limitation we have developed a probabilistic computational framework within a finite element analysis to predict the **V**0–**V**100 response. The finite element model is a yarn-based representation of the fabric architecture, with a principal stress based failure criterion implemented uniformly within each yarn, but varying for each yarn within the fabric. For each impact simulation, individual yarn strengths are mapped from experimentally obtained yarn strength distributions, resulting in fabric models with spatially non-uniform failure conditions. Impact simulations are run for the case of a spherical projectile of diameter 5.556 mm impacting a single layer of 50.8 _ 50.8 mm, edge-clamped, unbacked, aramid fabric. Three different yarn strength models are implemented, representing spool yarns, and yarns extracted from greige and scoured woven fabrics. Decreases in yarn strength are found to correlate to decreases in the **V**1, **V**50, and **V**99 velocities predicted by the simulations. The relationships between yarn strength distribution and probabilistic fabric impact response are discussed.