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Effects of Ply Orientation and Material on the Ballistic Impact Behavior of Multilayer Plain-Weave Aramid Fabric Targets

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ABSTRACT

Virtual testing of fabric armor provides an efficient and inexpensive means of systematically studying the influence of various architectural and material parameters on the ballistic impact behavior of woven fabrics, before actual laboratory prototypes are woven and destructively tested. In this finite element study, the combined effects of individual ply orientations and material properties on the impact performance of multi-layered, non-stitched woven aramid fabrics are studied using 2- and 4- sided clamping configurations. Individual ply orientations of 0°, ±15°, ±30°, and ±45° are considered along with three levels of inter-yarn friction coefficient. Functionally graded fabric targets are also considered wherein the yarn stiffness progressively increases or decreases through the target thickness while keeping the yarn strain energy density constant and with all other material and architectural parameters unchanged for consistency. For each target configuration, one non-penetrating and one penetrating impact velocity is chosen. The impact performance is evaluated by the time taken to arrest the projectile and the backface deformation for the non-penetrating impacts, and by the residual velocity for the penetrating impact tests. All deterministic impact simulations are performed using LS-DYNA. 2-sided clamped targets and lower inter-yarn frictional levels generally resulted in better impact performance. The functionally graded targets generally showed either similar or inferior impact performance than the baseline fabric target configurations for the non-penetrating shots. Some performance improvements were observed for the penetrating shots when the yarn stiffness was progressively decreased through the layers in a direction away from the strike face, with additional performance enhancements achieved by simultaneously reducing the inter-yarn friction.

Keywords: *Aramid fiber, Kevlar Fabric, Ballistic Impact, Finite element analysis, Impact performance, Ply Orientation, Functional grading*

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