12051

Non-Orthogonal Kevlar® Fabric Architectures for Body Armor Applications

Ronald G. Egres[1], Leopoldo A. Carbajal[2]

1. DuPont Protection Technologies, DuPont Spruance Plant, 5401 Jefferson Davis Highway, Richmond, VA 23234
2. DuPont Engineering Research and Technology, Chestnut Run Plaza, 4417 Lancaster Pike Wilmington DE 19805

Abstract

Fabric architectures having inherent multi-threat ballistic and blunt trauma resistance can be used to produce monolithic soft body armor systems having reduced areal density and lower materials cost. In this paper, we report non-orthogonal biaxial and triaxial Kevlar® fabric architectures that demonstrate improved bullet and fragmentation threat resistance over typical woven Kevlar® fabrics used in soft body armor applications. Against deformable handgun bullet threats, non-orthogonal biaxial and triaxial braided Kevlar® fabrics demonstrate both improved ballistic V50 and backface deformation resistance over orthogonal woven Kevlar® fabrics of comparable basis weight. The observed performance improvements would indicate that these fabrics could be used to develop body armors meeting NIJ Standard 101.06, level IIIA ballistic requirements at areal densities lower than 1.0 lb/ft^2. Additionally, these woven fabric architecture exhibit improvements in fragmentation threat protection over typical woven Kevlar® fabric constructions. Mechanical investigations, including quasi static fiber pull-out testing and high speed biaxially constrained puncture experiments, as well as computer simulations of ballistic impact on non-orthogonal biaxial and triaxial braided Kevlar® fabrics help elucidate the mechanisms associated with the observed improvements in ballistic response over conventional woven constructions.

12051

Non-Orthogonal Kevlar® Fabric Architectures for Body Armor Applications

(R. G. Egres, L. A. Carbajal, Supporting Documentation, Terminal Ballistics and Impact Physics Session)

The development of flexible body armor systems with multi-threat ballistic resistance and blunt trauma protection often require hybrid constructions of two or more high strength fiber ply structures; each type of ply structure being specifically suited for the defeat of a particular class of threat or impeding backface deformation. This "division of labor" approach to soft body armor development can become an inefficient development strategy as body armor requirements drive toward increased protection against a diverse and growing variety of threats, while simultaneously trying to reduce the overall areal density of the body armor. We report non-orthogonal biaxial and triaxial fabric architectures having inherent multi-threat ballistic and blunt trauma resistance that can potentially be used to produce monolithic soft body armor systems with lower areal density and lower materials cost.

Figure 1 presents pictures of the experimental non-orthogonal (trellised) biaxial fabric (37° trellis angle, generated through stretching bias-oriented 17x17 epi plain weave fabric), and a standard braid triaxial fabric used in this investigation. Figure 2 presents the .44 magnum V50 and backface deformation (NIJ Standard 101.06, plastilina clay witness, 1430 ± 30 ft/s test velocity) experimental results for 1 lb/ft^2 monolithic test panels made with 600d Kevlar® KM2 fabrics. For typical (orthogonal) biaxial plain and twill weave Kevlar® fabrics, increased V50 penetration resistance can be achieved through reducing fabric cover % (reducing the number of yarns per inch or increasing float length), but this approach has the undesirable effect of increasing backface deformation. Monolithic ballistic test panels of non-orthogonal biaxial and standard braid triaxial constructions at the equivalent areal density demonstrate high V50 performance with backface deformation measurements successfully below the NIJ Standard 101.06 maximum requirement of 44 mm. Ballistic test panels fabricated with non-orthogonal biaxial and standard braid triaxials also demonstrate improved resistance to fragmentation threats (17gr. FSP) over typical (orthogonal) woven Kevlar® fabrics.

In addition to reporting the ballistic impact testing results of these non-orthogonal fabrics against various threats, we will explore their mechanical properties through quasi-static and high speed testing. Computer simulations of impact on these fabric architectures will help elucidate mechanisms responsible for the observed improvements in ballistic performance.

Figure 1. from left to right: a) plain weave, b) trellised biaxial and c) standard braid triaxial fabrics

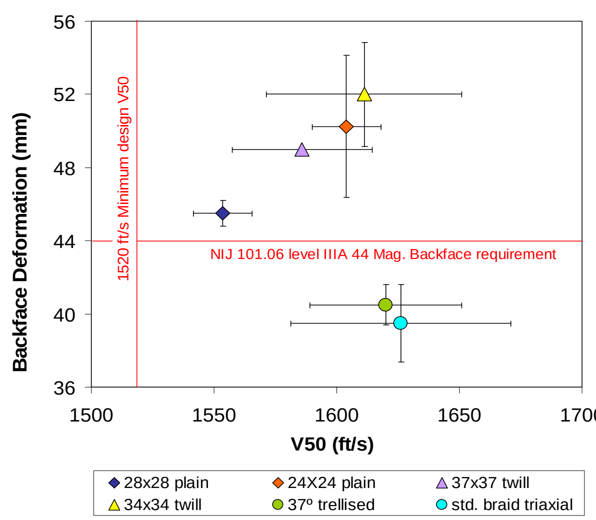

Figure 2. .44 magnum V50 and backface deformation performance of monolithic 1 lb/ft^2 test panels

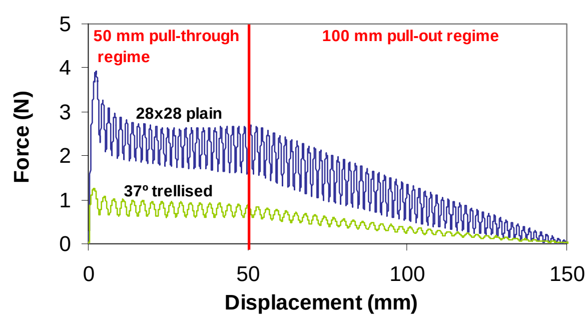

Figure 3. Non-orthogonal (trellised) fabrics exhibit lower pull-out resistance when compared with plain weave fabrics of identical basis weight.