

DEVELOPMENT OF FIBER-REINFORCED COMPOSITE MATERIAL FOR BLAST PROTECTION

G.H.J.J. Roebroeks, J. Hoogland, J. Weerheijm

*TNO Defense, Safety & Security, Lange Kleiweg 137, Rijswijk, Zuid-Holland,
2288GJ, the Netherlands*

Key words : Fiber-reinforced composite – lightweight – blast protection – failure strain – high strain rate

Over the last three years, TNO has explored the performance of fiber-reinforced composite materials to provide vehicle underbelly protection against blast loading. By using the in-house developed scaled test method and by focusing on the failure mechanisms of the tested composite materials, TNO has so far achieved comparable and even better blast performance of selected composite materials in comparison to conventional steel and aluminum blast resistant materials.

This paper shows how standard fiber-reinforced composite materials have limited resistance against blast loading. Their relatively high brittleness in comparison to metals causes them to fail early under out-of-plane blast loading. Their failure appears to be mainly caused by exceedance of strain to failure by local bending, fully absorbing the material straining capability, while the preferred membrane stress in the material hardly develops. Based on this finding, alternative composite material solutions have been manufactured and tested. These tests show that fiber-reinforced composite materials can compete with or even outperform blast resistant aluminum or armor steel solutions on an equal-weight basis. This increased performance is largely based on the significant straining capability of the selected high fiber-to-volume fraction unidirectional glass fiber layers at high strain rates. The strength and strain of the used $0^{\circ}/90^{\circ}$ cross-ply laminates under these conditions were found to be comparable to those of armor steel, at significantly lower density. Test results for aluminum 5083, ARMOX 440 and various composite materials are presented and discussed. An outlook on TNO's continued development work (2018 and onwards) is provided.