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MECHANICAL RESPONSE OF HYBRID SHIELDS BASED ON NONWOVEN FABRICS

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Nonwoven fabrics made up of high strength fibres are a lightweight solution for ballistic protection. They are composed by a random fibre network consolidated by means of thermal, chemical or mechanical bonds. They present outstanding deformability and energy absorption capacity, resulting in an efficient ballistic protection against small fragments. Nonwovens can be combined with conventional materials to improve the energy absorption capacity without sacrificing the structural performance of the original components. This study reviews the potential of nonwovens to improve the ballistic performance of conventional protection systems for aerospace, automotive and defence applications.
To this end, a multi-scale virtual testing framework was developed in the finite element code Abaqus/Explicit. A needle-punched Dyneema nonwoven fabric was selected for this study and a multi-scale constitutive model was implemented to predict the impact response [2]. The model provided the constitutive response for a mesodomain of the fabric corresponding to the volume associated to a finite element and was divided in two blocks; network and fibre models. Material parameters were identified by means of a multi-scale experimental campaign [1] and model validation was accomplished for several impact configurations [3].
The model was used to determine the performance of multilayered nonwoven systems, finding high dependency on the energy absorption capacity of the shields with the relative spacing between layers. In particular, a beneficial contribution of air gaps was identified. Afterwards, the performance of hybrid shields was numerically determined and compared. Interaction between projectile, woven/composite/metal and nonwoven was detailed analysed and the complex coupled failure mechanisms were obtained. The numerical results showed that the hybrid shields outperformed the single material configurations in terms of the ballistic limit when placing the nonwoven at the front impact face [4]. Furthermore, hybridisation provided higher energy dissipation than the sum of the energies dissipated individually by the shield components above the ballistic limit, leading to an enhanced energy absorption capacity.

References

[1] F. Martínez-Hergueta et al. (2015) Deformation and energy dissipation mechanisms of needle-punched nonwoven fabrics: A multiscale experimental analysis. *International Journal of Solids and Structures*, **64**, 120-131.

[2] F. Martínez-Hergueta et al. (2016) A multiscale micromechanical model of needlepunched nonwoven fabrics. *International Journal of Solids and Structures*, **96**, 61-91.

[3] F. Martínez-Hergueta et al. (2017) Numerical simulation of the ballistic response of needle-punched nonwoven fabrics. *International Journal of Solids and Structures*, **1066**, 56-67.

[4] F. Martínez-Hergueta et al. (2018) Ballistic performance of hybrid nonwoven/woven polyethylene fabric shields. *International Journal of Impact Engineering*, **111**, 55-65.