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# Mechanics of bioinspired flexible composites: experiments, simulations, and analytical solutions

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## ABSTRACT

Motivated by designing bioinspired flexible armor, we study deformable layered materials reminiscent of the structures present on teleost fish species (e.g., zebrafish *Danio rerio* and *Arapaima gigas*) [1]. These materials comprise soft matrix and stiff layers. The overlapping stiff scales are embedded in a soft tissue such that the composite material can provide protection while also undergoing large deformations when subjected to a penetrating loading (such as a bullet, knife, or a powerful animal bite). Moreover, the layered materials hold a great potential for a large variety of applications including noise reduction [2] and actuation [3]. Here, we analyze the influence of microstructure parameters on the performance of the composites. We derive an analytical solution for the multilayered structure accounting for large deformations. The solution predicts the mechanical response of the media as a function of the layer inclination angle, constituent volume fractions and properties [1]. To capture the effects of localized deformation (e.g., in case of penetrating loading), we develop a finite element numerical model of the structure and loading conditions. Physical prototypes of the composites are fabricated by 3D printing. The prototypes are subjected to mechanical loadings and the local deformation mechanics of the layered structure are measured using digital image correlation. The measured mechanical response, macroscopic as well as local, is found to be in good agreement with the simulations as well as with analytical predictions. Moreover, the results provide a detailed picture of the composite deformation mechanisms, which consist of matrix shear, stiff plate rotation and bending, depending on the microstructural parameters and loadings. Understanding the key mechanisms and parameters is an important step towards designing materials with a large variety of functionalities.

## REFERENCES

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