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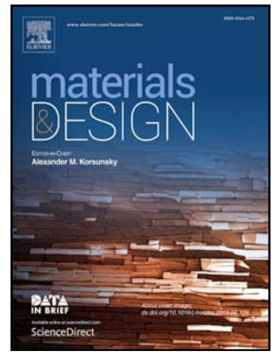

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Material Selection Shape Factors for Compliant Arrays in Bending

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Abstract

Similar to the general class of metamaterials, compliant arrays (CAs) are engineered from an array of subelements that combine to produce a response that is typically not available from a flat panel made of a single material. As such, analysis and design of CA systems requires the integration of both the material and geometrical properties of the array. This paper proposes a convenient and efficient method of combining these essential elements using analytically derived shape factors for bending modes. The approach is validated experimentally, and used to demonstrate large regions of previously inaccessible property combinations in material selection charts that become attainable using carefully design CAs.

Keywords: Shape factor, Bending, Material selection, Compliant, Stiffness, Metamaterials

1. Introduction

Compliant Arrays (CAs) are panels with geometry consisting of a fundamental unit that is patterned in parallel and series to achieve target material properties, particularly out-of-plane bending stiffness. An example of a CA in acrylic is shown in Figure 1. Similar to metamaterials, CAs create responses typically not achievable from a flat panel of a single material. They can be potentially manufactured in micro, meso, or macro scales. Many candidates for the fundamental unit of these arrays come from the field of Lamina Emergent Mechanisms (LEMs). LEMs are mechanical devices fabricated from planar materials (laminae) with motion that emerges out of the fabrication plane [1]. CAs lend themselves towards applications such as deployable or collapsible structures as they enable a larger elastic deformation in out-of-plane bending than is possible with a solid sheet for a given material. Recent developments with the use of patterns similar to those investigated in this paper include an array for solar tracking [2], flexible lithium-ion batteries [3], an optical shutter [4], the creation of super-conformable materials for applications such as flexible circuits [5], and creating materials with extreme Poisson's ratios [6, 7]. CAs can also be modified to create thick-material approximations of curved-crease origami patterns used in origami-inspired

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