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In-plane mechanics of a novel cellular structure for multiple morphing applications

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ABSTACT

Cellular structures are potential candidates as underlying supports for flexible skins due to their outstanding characteristics such as light weight, zero Poisson's ratio and low effective moduli. This paper develops a novel zero Poisson's ratio cellular structure composed of semi-periodic sinusoidal beams with light weight, low in-plane moduli and high strain capability. The equivalent in-plane elastic and shear moduli of the structure are studied through a combination of theoretical and finite element analysis. Then the maximum global strains are investigated to show the morphing capability of the structure. Results show that the in-plane moduli of the cellular structures are several orders of magnitude lower than the raw material. The global strains of the cellular structures could be over 10 times greater than the raw material. The results also demonstrate the potential of the proposed structure for uniaxial, shear or hybrid in-plane morphing.

Keywords: Cellular structure, Elastic modulus, Shear modulus, Finite element analysis, Semi-periodic sinusoidal beams

Nomenclature

H = waist length of the isosceles triangle in the x-direction

L = waist length of the isosceles triangle in the y-direction

φ = internal cell angle of the isosceles triangle in the x-direction

θ = internal cell angle of the isosceles triangle in the y-direction

t = thickness of the cell walls

b = gauge thickness of the cell panel

α = H/L, cell wall aspect ratio

β = t/L, thickness ratio

γ = b/L, gauge thickness ratio

I = $bt^3/12$, second moment of area of the cell walls

A = bt, sectional area of the cell walls

ρ_s = density of the raw material

ρ_r = relative density of the structure

E = Young's modulus of the raw material

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