Parametric Evaluation of a Deployable Kresling Origami Lattice for Enhanced Automotive Crashworthiness

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In car crashes, the primary cause of fatalities is the sudden forces experienced by the passengers. Considering collision physics, an elongated front bumper would decrease the average force over time. Mechanical, legal, and practical spatial constraints within vehicles necessitate compact, deployable energy absorbers. Studies have proposed inflatable and telescopic crumple zones, although these were never implemented due to cost, complexity, and mass. We investigate a deployable lattice of Kreslings – highly effective energy absorbers with linked rotational-extensional motion. To analyze real-world behavior, a test vehicle impacted a rigid wall at a near-constant velocity across 40 trials. Dual-layer lattices were tested at three extensions: 100%, 62.5%, 25%, and a plastic block as the control. Structural energy absorption (EA) exhibited high linearity, scaled with extension, and attained high r values. Additionally, nominal angular deflection confirmed primarily axial buckling, mitigating off-axis shear risk. The worst case performance lower bounds for EA and r are above 50% of the respective means in EA and r for each kind of trial, except for the 25% extension group, likely due to less frames collected during these trials. Even at an extreme worst-case limit, the hypothetical least stable extension level (100% extension group) retained the majority of the group's mean EA, 90.2%, which confirms deterministic folding geometry strictly constrains impact variance. Ultimately, by maximizing EA in a reliable and stable manner before the forces reach the primary vehicle structure, this predictable collapsing mechanism translates directly into reduced passenger trauma and increased survivability.

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