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# A Hybrid 1D-3D Computational Framework for Dynamic Analysis of Lattice Structures for Impact Protection

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This study presents a novel computational framework designed to generate and analyse advanced lattice structures for impact protection. The framework offers a dual approach by enabling the creation of both deterministic lattices, through periodic unit cell replication, and stochastic lattices using a Voronoi–Delaunay based procedure. It further integrates a hybrid 1D-3D modelling technique that combines beam element efficiency with localized solid element resolution, allowing for a detailed capture of stress distributions under dynamic loading. Finite element simulations conducted at compression velocities of 3.5 m/s and 35 m/s reveal that the framework reliably reproduces stress–strain behaviours, with the hybrid model effectively identifying local stress concentrations that traditional beam-based methods might overlook. Validation against established experimental benchmarks confirms the accuracy of the approach, which not only advances the understanding of lattice topology in impact scenarios but also lays a robust foundation for the scalable design and optimization of lightweight protective structures.

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