# Partially closed BCCZ lattice structure infused with Polyurethane foam for high Energy Absorption

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## Abstract

University of North Texas, Denton Building lightweighting is essential for fuel economy in transportation applications including aircraft, cars, and other vehicles as well as in the transportation of goods from one place to another. Higher strength-to-weight and modulus-to-weight ratios have been reached by intentionally introducing porosity. It has been demonstrated that hybrid lattice-cored sandwiches may be created to suit the ever-increasing demands of engineering applications, including blast and ballistic resistance, simultaneous weight carrying and energy absorption, thermal insulation, and sound absorption.

Researchers have previously studied the effects of injecting foam into strut-based lattices, which led to higher energy absorption due to delayed buckling failure of the struts, which is covered in more depth later. [1] [2] [3] Theoretically, plate-based lattice structures alone have been demonstrated to have higher strength to weight ratios; however, they are not applicable for practical applications since they result in air trappings when employed in sequence or tessellation, resulting in unpredictable behavior under loads, which is never acceptable for real world applications. [4]

In our research we attempt to find the optimum ratio in which the struts and plates can be used to create a novel partially closed lattice which will maximize the foam and lattice interaction to achieve high energy absorption, load bearing capacity and manufacturability as well.

In our previous work we started by using the BCCZ struct based lattice structure and iteratively started to close out faces in between the struts to form hybrid strut plus plate based lattices, PLA(Polylactic ACID) was used to make and test the samples using FDM(Fused deposition method).[5] The lattices were designed to have a strut and plate diameter and thickness of 1.5mm respectively. The unit cell was kept to have a dimension of 10x10x10 mm and to examine the scale up effects the lattice was made to form a grid like pattern to form a cube of 40x40x40 mm, i.e., the cube had 4x4x4 cells to form the overall cube. To increase the repeatability of the experiments we switched to SLM(stereolithography method) using Tough Resin from form labs

as the material, which gave us much better finish. The structures were subjected to compressive loads to complete densification to extract the modulus, strength, and energy absorption(SEA). Then to examine the lightweighting properties of the resultant lattices we normalized the values with the density of the material used which gave us the values of specific modulus, specific strength and specific energy absorbed. Then the best performing lattice types were infused in PU foam to study the effects of the interaction between the modified surfaces of the BCCZ structures and the foam. An increase of up to 181.84% in SEA was registered for the hybrid or partially closed, strut+plate based lattice structure.


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