The Summer Undergraduate Research Fellowship (SURF) Symposium
2 August 2018
Purdue University, West Lafayette, Indiana, USA

Mechanical Properties of Interlocking Assemblies on a Rhombille Tiling

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ABSTRACT

The use of glue-less assembly methods has permitted the construction of rigid structures for centuries. Japanese interlocking wood joints and stereotomic structures by repetitious stacking of unit blocks are classical examples. The implementation of interlocking structures occurs when materials such as mortar and nails are unavailable or undesired. There has been a recent revival of interest in these construction methods as modern manufacturing tools enable new form and function. As humanity continues to innovate, materials possessing mechanical properties such as heightened flexibility without compromising strength or increased resistance to fracture will be needed. As one such example, this work examines interlocking assemblies emerging from a rhombille tiling. Rhombille tilings are formed by using three rhombuses to create a regular hexagon, then tessellating those hexagons. The resulting assembly is one of disphenoids and has either triangular or hexagonal symmetry. The elements are arranged such that the assembly forms a hexagonal plate with two thirds the density of a solid plate of equal thickness. Rotation free and restricted states are realized. The mechanical properties of this interlocked assembly are examined in finite element analysis and experiments performed on physical models realized by 3D printing. Initial results suggest a chiral response to loading paths in the hexagonally symmetric arrangement. Triangularly symmetric arrangements suggest load paths based on concentric or patterned hexagons. These load patterns are distinctly different from those in comparable solid plates. All assemblies have shown fracture resistance where damage is localized to few elements, leaving the remainder of the plate intact.

KEYWORDS

Geometry, Topological interlocking, Materials and Structures, Modelling and Simulations, Plane Tessellations