KRESLING ORIGAMI CORES FOR HYPERSONIC STRUCTURES

Vincent Csercsevits, Ranajay Ghosh

University of Central Florida - Department of Mechanical and Aerospace Engineering

ABSTRACT

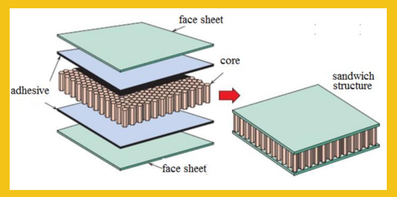
Reducing weight in hypersonic vehicles can be achieved through the utilization of sandwich structures, where origami cores serve as the lightweight core material. This research focuses on the design and fabrication of sandwich structures, incorporating Kresling origami cores. By employing experimental approaches, including fabrication, mechanical testing, and comparative analysis, this study aims to provide valuable insights into the potential advantages and challenges of integrating Kresling origami patterns into hypersonic vehicle design.

BACKGROUND

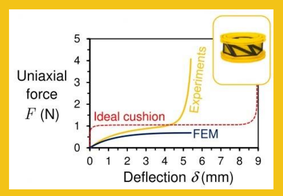
Sandwich structures are composite materials made with a core structure placed between two plates. Plates are made of a strong and stiff core is made with lightweight structures to minimize weight and maximize strength and stiffness.

Aerospace Cores
- Honeycomb
- Foams

Origami Cores
- Miura-ori
- Kresling

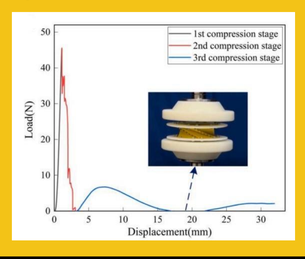


Origami structures are now being researched for use as cores due to their promising geometry.



Benefits of origami cores
- Specific strength
- Adjustable geometries
- Energy absorption
- Deployability

Previous research on the Kresling utilizes compression testing samples to determined mechanical properties.



Kresling research
- Tailorable geometry
- Polymer fabrication
- Bi- and Tri-stability
- Spring behavior

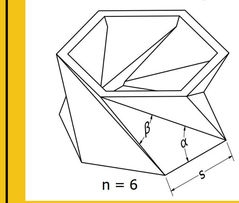
RESEARCH APPROACH

Research approach for this project consists of studying the kinematics of the origami, fabricating foldable samples for experimental testing, and simulating mechanical testing.

KINEMATICS

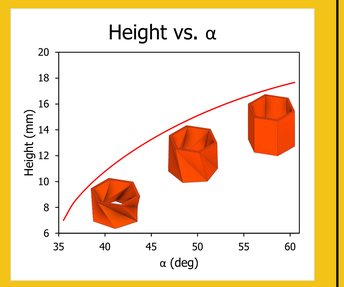
Folded geometry of Kresling is defined by length *s*, angles α and β, and the number of sides *n*.

Geometry Diagram



Computer Aided Design
- Parametric modeling to adjust geometry
- Constraints restrict angle combinations

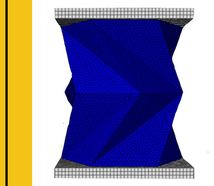
Variables
- *n* = 6, s =10mm, $\beta = 29.5°$, α varied
- Kresling height is dependent on angle combination



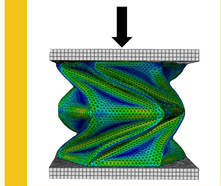
SIMULATION

Program can predict and validate experimental results through the simulation modeling.

No Load



Axially Loaded



Abaqus simulation
- Compression testing simulation on samples of varied geometry
- Load displacement data generation for comparative analysis

FABRICATION AND TESTING

Kresling structures were 3D printed, utilizing Thermoplastic Polyurethane. Samples exhibited desirable flexibility, enabling the origami to fold without fracturing. Cardboard sheets were used for panels in sandwich structure samples and mechanical testing was conducted using an MTS machine.

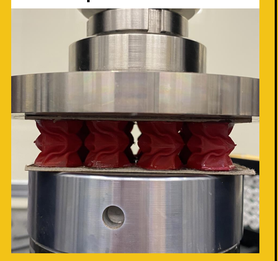
Single Kresling
- Compression testing

Geometry of Samples:
- *n* = 6, s =20mm, $\beta = 29.5°$, $\alpha = 39.5°$, varied in thickness
- No sandwich, testing core structure behavior

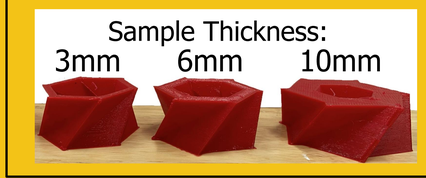
Double Kresling Sandwich Structure
- Compression & 3-Point Bending

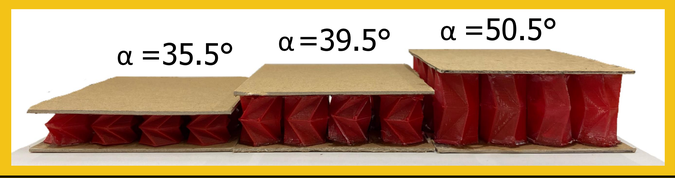
Geometry of Samples:
- *n* = 6, s =10mm, $\beta = 29.5°$, thickness = 1/3 mm, 4x4 Double Kresling configuration, varied α
- 1.5 mm thick cardboard used for sandwich plates

Compression Test



Sample Thickness:

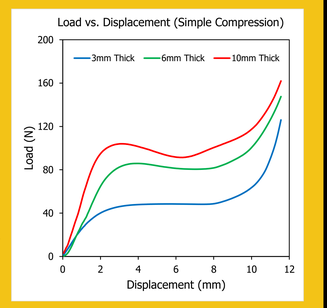




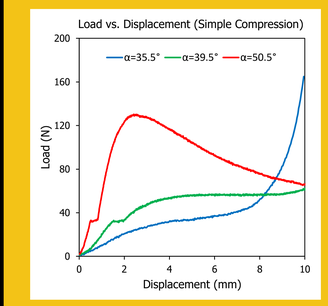
RESULTS

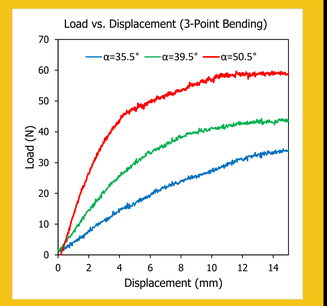
The plots illustrate experimental load displacement data for Kresling structure for different samples.

Single Kresling
- Simple compression shows quasi-zero stiffness (QZS) and non-linear spring (NLS) behavior
- Larger thickness increases the stiffness, and trends towards more NLS behavior



Double Kresling Sandwich Structure
- Simple compression shows increasing angle α increases stiffness, and trends towards more NLS behavior
- Initial 3-point loading shows increasing angle α increases stiffness, and samples show QZS





CONCLUSIONS

Kresling structures demonstrate intriguing mechanical characteristics in compression and 3-point bending tests, showing NLS and QZS behavior. These results provide insights into Kresling core structures, contributing to their potential as lightweight cores with customizable mechanical properties. Future work includes simulating mechanical testing and additional 3-point bending testing of different samples.

REFERENCES

Access the bibliography for this poster by scanning the QR code.

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