Mechanical properties of origami

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2.671 Measurement and Instrumentation

[1]

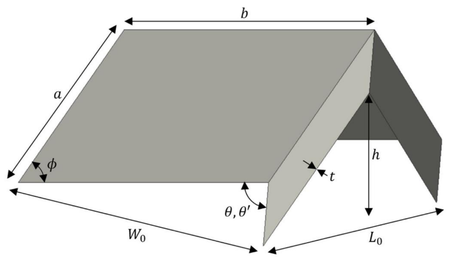
[2]

Abstract

Folded metamaterials offer engineers the potential for lightweight, stiff, impact absorbing, and easily manufacturable materials for applications such as auto or aero industries. To investigate how these materials behave under compressive loads, a texture analyzer was used to perform compression tests on a series of folded samples to find the relationship between folded geometry and the resulting mechanical properties.

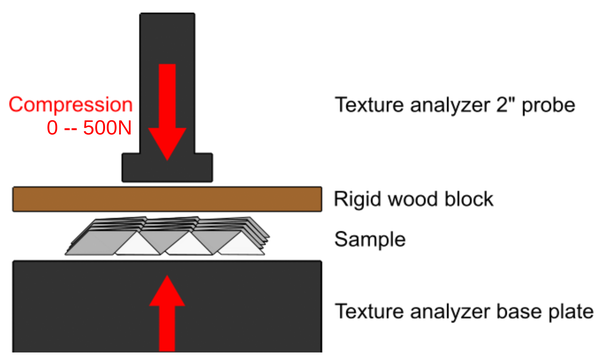
Background

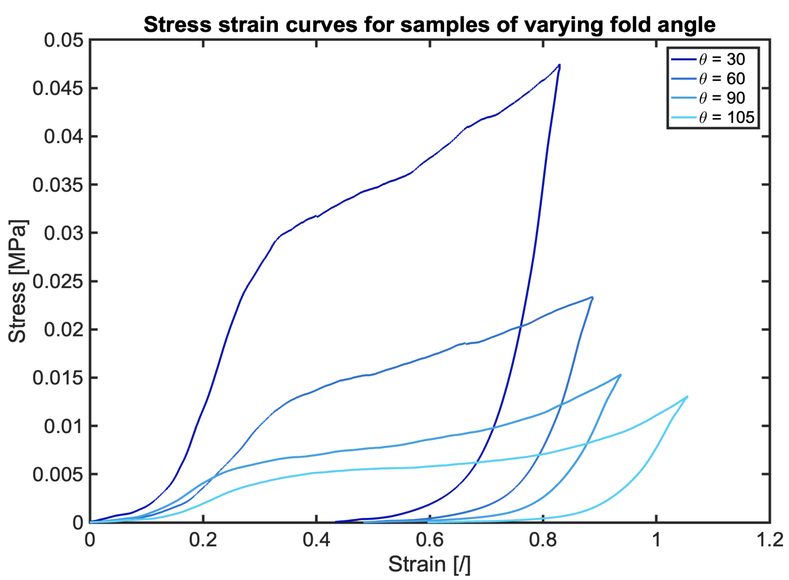
The folding pattern used in these tests is known as the Miura-ori pattern, which is comprised of a repeating cell of 4 parallelograms. A given cell can be fully defined by 5 independent geometric parameters. In the following experiments, we will vary the dihedral "unfoldedness" angle θ and keep other parameters constant.



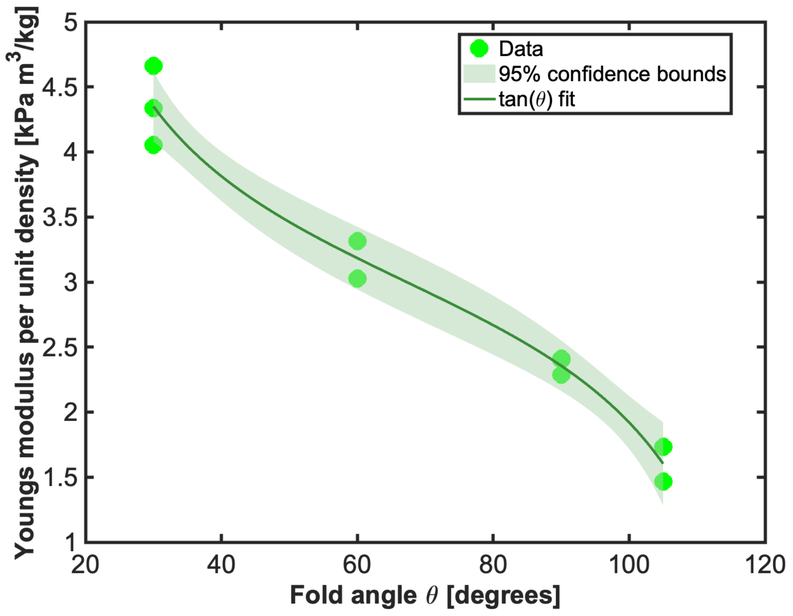
[3]

Experiment and raw data

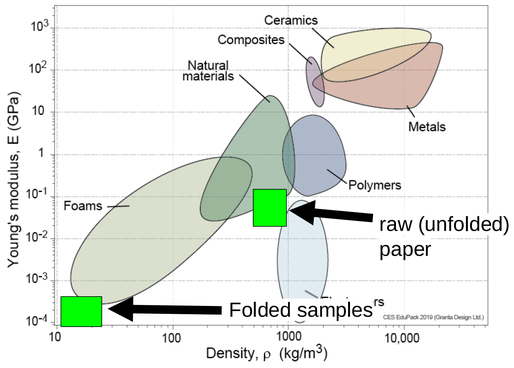


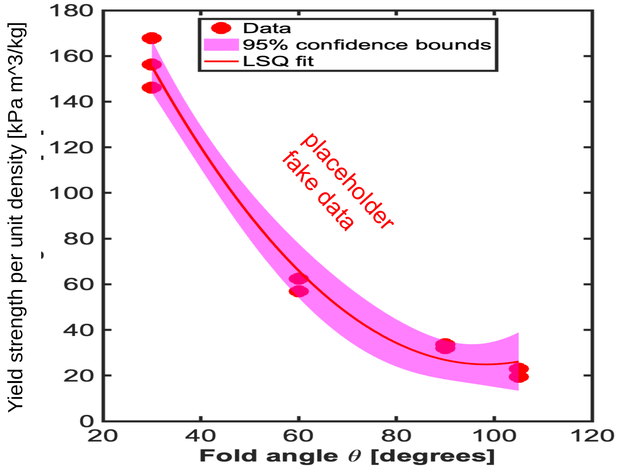


Mechanical properties

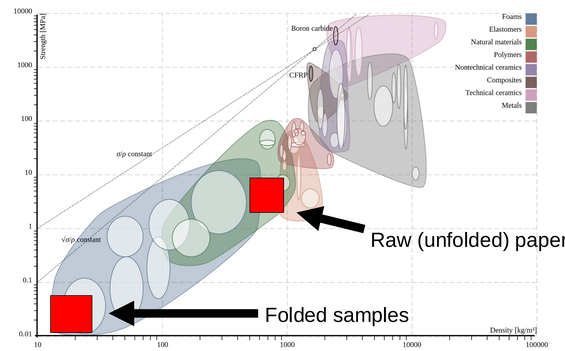


Ashby plot comparison of Young's modulus vs density for other known materials [4]





Ashby plot comparison of yield strength vs density for other known materials [5]



Conclusions

- The Young's modulus per unit density varies as a function of tan(θ). This implies that samples with lower fold angles will have higher stiffness. There is no "sweet spot" angle.
- The yield stress per unit density varies as a function of [TBD]. This implies that samples with lower fold angles will also have a higher yield strength.

Acknowledgements

Thank you to Dr. Ragallar, Dr. Hughey, and Annemarie Dapoz for their support and guidance during this project.

References

[1] https://www.svgrepo.com/svg/24274/weight

[2] https://thenounproject.com/icon/origami-crane-77260/

[3] Kankkunen, Tomi, Jarkko Niiranen, Jarmo Kouko, Miia Palmu, and Kirsi Peltonen. 2022. "Parametric Linear Finite Element Stress and Stability Analysis of Isotropic and Orthotropic Self-Supporting Miura-Ori Structures." Mechanics of Advanced Materials and Structures 29 (27): 5808–22. https://doi.org/10.1080/15376494.2021.1965679.

[4]https://www.grantadesign.com/education/students/charts/

[5]https://en.wikipedia.org/wiki/Material_selection#/media/File:Material-comparison--strength-vs-density_plain.svg

April 5, 2024