EFFECT OF CREASE CURVATURE ON BENDING STIFFNESS IN CURVED CREASE ORIGAMI

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Deployable systems play a vital role in design optimisation of spacecrafts. Limited payload capacity in launch vehicles often conflicts with the demand for large-area systems required for better performance in the operational phase. The art of origami enables the storage of a large surface structure in a compact volume by utilising plastically deformed fold lines known as creases. Origami can be categorised into two types as straight crease origami and curved crease origami based on the geometry of the crease. Straight crease origami demonstrates rigid foldability while curved crease origami facilitates smooth and efficient folding by incorporating panel bending.

The use of curved creases in deployable membranes reduces the required number of creases compared to straight creases ultimately leading to less production time and better quality deployed surface. The bending stiffness of the crease and the external force required to fold the membrane are key aspects that influence the packaging efficiency. The main objective of this research is to assess the effect of crease curvature on the bending stiffness of curved creases. The study encompassed quasi-static folding and unfolding experiments of curved-crease specimens with different crease radii made of 80 gsm printer paper to understand crease behaviour. Furthermore, numerical models were developed to simulate the crease behaviour of curved creases and validated against experiments in order to develop prediction tools for future designs.

The resistive force resulting in bending a curved crease specimen was measured experimentally for rectangular specimens with overall dimensions of 60 mm × 100 mm while varying crease radii from 35 mm to 75 mm. Additionally, the force-displacement response was recorded for flat sheets with dimensions of 50 mm × 60 mm and 100 mm × 60 mm to compare the bending stiffness of curved creases to that of a flat sheet having similar overall dimensions. The results demonstrate that the initial bending stiffness of curved-crease specimens with a low crease radius is lower but becomes higher at the maximum folded state compared to specimens with a high crease radius. Additionally, it was observed that the contribution of the unrestrained half of the specimen significantly increases the bending stiffness of a curved crease specimen during the folding motion for lower crease radius, whereas the contribution remains almost constant for higher crease radius. Numerical models of curved creases, developed in the commercial software Abaqus using a segmented curved-crease modelling approach incorporating straight crease characteristics, accurately estimate experimental reaction forces, indicating that the characteristics of straight creases can be used in modelling curved creases.

Keywords: Curved-crease origami, Crease radius, Crease stiffness

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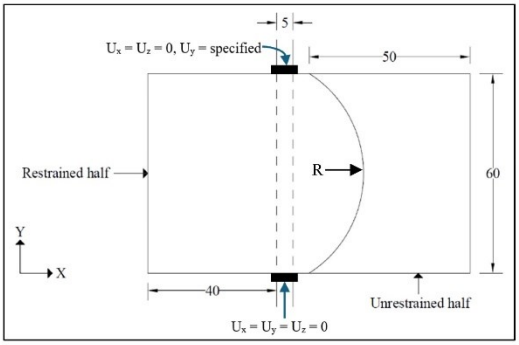
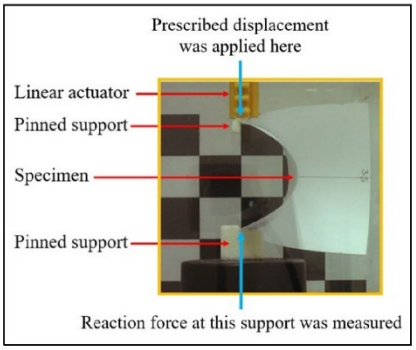
Effect of Crease Curvature on Bending Stiffness in Curved Crease Origami

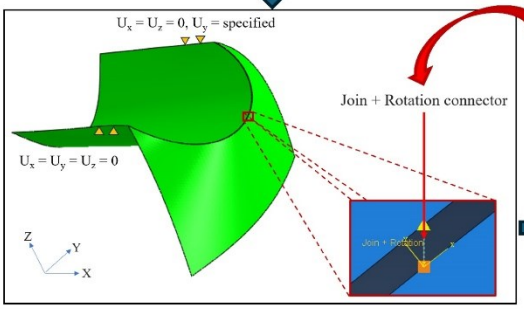
Curved beech leaf pattern inspired membrane antenna prototype



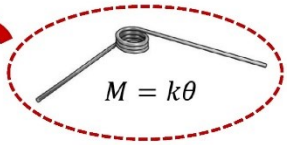
Characterisation of curved creases

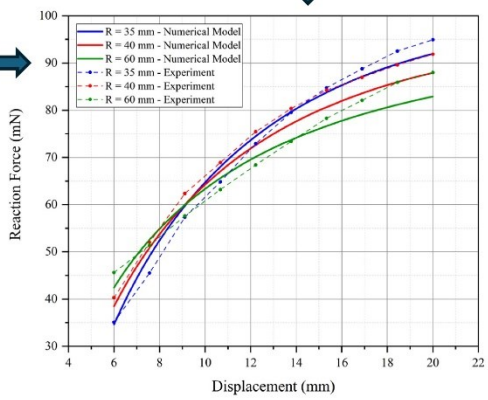


Experimental characterisation



Numerical modelling





Force – displacement comparison