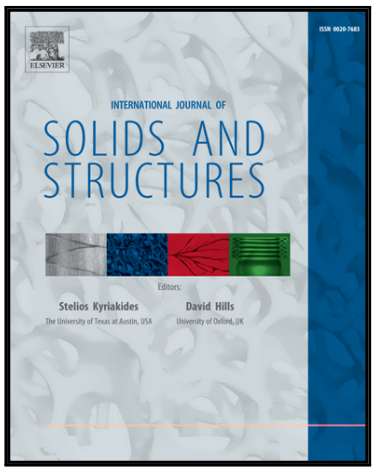

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PII: S0020-7683(17)30533-4
DOI: 10.1016/j.ijsolstr.2017.11.029
Reference: SAS 9818

To appear in: *International Journal of Solids and Structures*

Received date: 9 August 2017
Revised date: 30 November 2017
Accepted date: 30 November 2017

Please cite this article as: Ting-Uei Lee, Zhong You, Joseph M. Gattas, Elastica Surface Generation of Curved-Crease Origami, *International Journal of Solids and Structures* (2017), doi: 10.1016/j.ijsolstr.2017.11.029

Elastica Surface Generation of Curved-Crease Origami

Ting-Uei Lee[a], Zhong You[b], Joseph M. Gattas[a,*]

[a] *School of Civil Engineering, University of Queensland, St. Lucia, Australia*
[b] *Department of Engineering Science, University of Oxford, Oxford, UK*

Abstract

Curved-crease origami are studied for many novel applications across engineering and architecture, as they are developable but possess a non-zero principal curvature and a corresponding energy storage capability when folded. However, geometric modelling techniques are limited, with most methods requiring numerical discretisation of a target curved surface to allow developability constraints to be enforced at vertices. The discretised surface can approximate a physical surface through relaxation for minimum bending energy, however such methods are cumbersome and their accuracy is largely unknown. This paper presents an analytical geometric construction method for curved-crease origami that avoids the need for surface discretisation. The new method combines a 1D elastica solution for large elastic bending deformation with a straight-crease origami projection and reflection process; it can thus concisely and accurately capture the principal surface curvature and developability characteristics of elastically-bent curved-crease origami. A surface error analysis of 3D scanned physical prototypes is used to validate the model, which is shown to be accurate to within ±50% of the sheet thickness for a 2mm thick model for a range of elastica surface profiles. Limitations of the model are also explored including the derivation of a maximum compressibility limit; investigation of accuracy of numerical folding motion simulation; and an investigation of a free edge distortion behaviour which occurs in certain origami forms.

Keywords: curved-crease origami, elastica, developable surface

*Corresponding author.
Email address: j.gattas@uq.edu.au (Joseph M. Gattas)