NUMERICAL SIMULATION OF THIN MEMBRANES WITH CURVED CREASES

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Master of Science (Major Component Research)

Department of Civil Engineering
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Thesis submitted in partial fulfillment of the requirements for the degree

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DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other University or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature: *UOM Verified Signature* Date: 2025-03-02

K.A.L.H. Kuruppu

The above candidate has carried out research for the Masters thesis under my supervision. I confirm that the declaration made above by the student is true and correct.

Name of Supervisor: Prof. H.M.Y.C. Mallikarachchi

Dr. H.M.S.T. Herath

Signature of the Supervisor: Date: 2025-03-03

……………………………………….. ………………………………

Prof. H.M.Y.C. Mallikarachchi Dr. H.M.S.T. Herath

DEDICATION

I hereby dedicate this to my family and all the teachers who have been the backbone of my life.

ACKNOWLEDGMENT

I would like to extend my gratitude to all the personnel who have given their immense support throughout completing this thesis.

I would like to first and foremost thank my supervisors Prof Chinthaka Mallikarachchi and Dr Sumudu Herath for giving me unwavering support and dedication towards me and my work. Your support has been a great motivation for me, and I am thankful for the knowledge I gained under you.

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Sincerely,

K.A.L.H. Kuruppu

ABSTRACT

Deployable membranes are commonly used in the construction of solar sails, solar arrays, and sun shields. These structures are fabricated on the ground and then deployed to their operational configuration in space. These structures are very large in dimensions but need to be compacted into a very small package that can be stowed inside a launch vehicle. Membrane structures are often folded using different crease patterns and wrapped around a central hub to achieve the compacted state. The thickness of the membranes place and important role in selecting a folding pattern as one length of the membrane increases with layers overlapping around the hub. To get a smooth wrap, a viable option is to change the crease pattern geometry to a curved crease with changing curvature to accommodate increased thickness. Changing the geometry into a curved crease pattern needs to be analyzed properly to understand its suitability for use in deployable membrane structures. This study analyzes the effectiveness of curved and straight crease wrapping structures. Two numerical models are used for the analysis of each crease pattern to understand behavior. The curved crease wrapping pattern shows good overall wrapping motion with less stresses in the initial stages when compared to the straight crease wrapping pattern. The stress is reduced up to 26% in the initial stages. Also, a crease idealization technique is introduced in this study to incorporate the self-opening behavior of the membrane creases into the numerical model. This idealization technique is further evaluated for a multiple crease geometry with a Miura-Ori model. The crease modeling technique shows a good overall fit with the experimental results validating the numerical simulations.

Keywords: Deployable structures, membrane, wrapping structures, curved crease

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