The structural typology of origami hyperbolic paraboloids

L.M. Kamp*, T.A. Dudek*, M.K. Adamik*, S. Slezák*, D. Kooter*

*Department of the built environment, Eindhoven University of Technology (TU/e)
De Groene Loper, building 6, Postbus 513, 5600 MB Eindhoven
l.m.kamp@student.tue.nl

Abstract

Over the past decades industries are innovating quickly. The invention of new materials and manufacturing techniques create opportunities for quicker and more efficient production. However the building industry is slow in adapting and still relies on structures based on steel and concrete structure. Therefore, it is needed to investigate new types and structures in order to profit as much as possible from all innovations. The aim of the research is to investigate the structural properties of origami hyperbolic paraboloids in building structures. This will be done by designing a pavilion consisting origami hyperbolic paraboloids, which will be presented at the IASS symposium 2019.

The origami hyperbolic paraboloid, also known as origami hypar, is created by folding one sheet of material in a particular manner obtain the shape of a hyperbolic paraboloid. It is a highly adaptable structure, that due to its properties shows great possibilities for implementation in adaptable and deployable structures. The investigation of the possibilities of using origami hypars as a structural unit is done in two parts. First, different structural typologies and force distributions in the structures are investigated by empirical and literature research about hypars. In addition, the gained knowledge is tested against the physical end result of the built pavilion, taking material properties into account.

The structural particularity of the shape comes from the fact that a continuous surface connects the 2 sets of corners, which are set in an orthogonal orientation to each other. Therefore, forces that act on the corners in the x-direction also influence the movement in the y-direction. This also means that both directions are stabilized if 2 corners are connected by a rod. The foldable nature of the origami unit makes the hypar highly adaptable in size and shape. The adaptability can be used to change the properties of a hyperbolic paraboloid unit according to the desired structure. Furthermore, the adaptable nature creates possibilities to create deployable structures . This creates the possibility of structures that can be erected, disassembled, transported or stored efficiently and quickly [1]. Deployable structures are therefore suitable for temporary spaces, like emergency shelters for disaster management. An example of this is Cardborigami by Tina Hovsepian, which consists of a lightweight waterproofed cardboard structure that can be deployed as a shelter for homeless people or in times of a humanitarian crisis [2].

Moreover, the research will focus on the fabrication of structures made of origami hypars or origami structures in general. The use of foldable polymers, like polypropylene, will be investigated as a suitable material for the construction of the pavilion and efficient ways to fold the shape will be reviewed. Next to that, focus will be laid on the detailing of connections between units to create a pavilion.

References

[1] S.L. van Greevenbroek, “Folding structures: developing a new method using the principles of origami and cnc milling,” [online]. Available:https://repository.tudelft.nl/islandora/object/uuid:430c33c4-b477-49a4-84a4-1d0a98440f72/datastream/OBJ1/download

[2] V.L. Maanasa and S.R. Laxmanna Reddy, “Origami-Innovative Structural Forms & Applications in Disaster Management,” in *International Journal of Current Engineering and Technology*, Vol. 4(5), pp. 3431-3436, Oct. 2014.