

# On Using Tessellation Properties for the Development of Classifying Criteria for Foldable Mechanisms

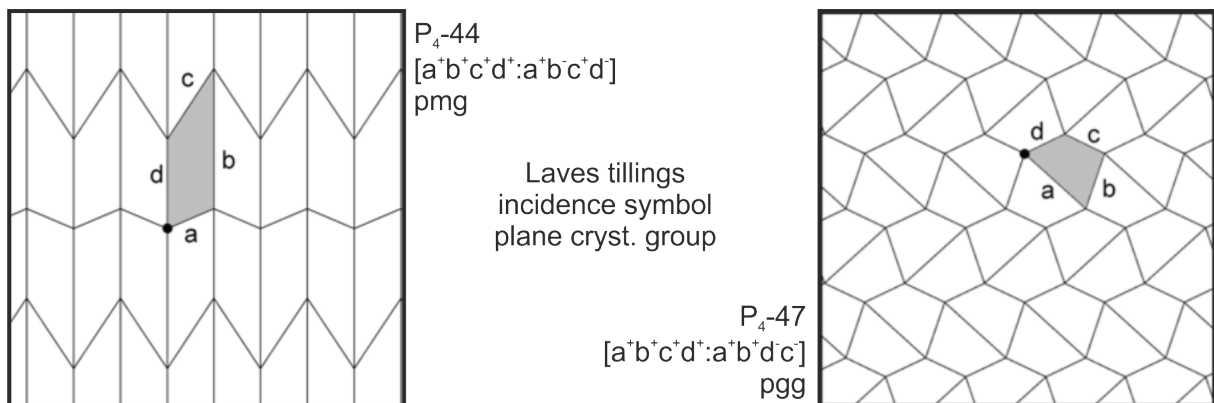
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## Abstract

Folding mechanisms can be technically advantageous in a wide range of applications because they unite transformability and structural integrity. The basic step in the application of foldable mechanisms is the selection of a folding pattern as a function of restrictions and requirements. For this selection a systematic foundation needs to be established. Bringing out the underlying order in folding mechanisms allows the knowledge transfer across traditional disciplinary boundaries. This contribution therefore aims to highlight the distinguishing geometric properties and introduce a classification scheme for thick plate folding mechanisms.

In engineering science the structured accumulation of the examined content is often represented in a classification scheme via classifying criteria. In this contribution, the underlying classifying criteria are synthesised from existing geometric tessellations cross-referenced with restrictions about thick plate folding mechanisms. As a foundation and starting point, tessellations in two dimensional space are used. Furthermore, only isohedral tessellations are considered. Although the presented way is applicable for non-isohedral tessellations, this restriction is based on the goal in engineering design, to mostly use equal parts to reduce development, production and manufacturing costs.



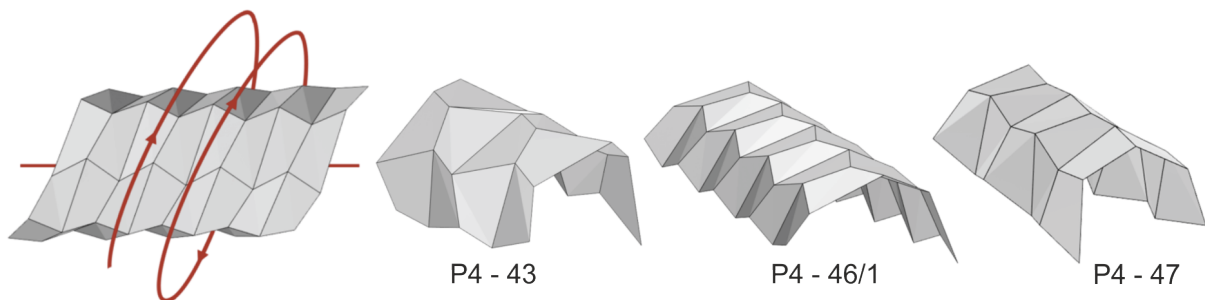
**Figure 1:** Examples for isohedral tessellations with the three different classifications

Regarding the use of isohedral tessellations for the description and specification of foldings,

three different known systems, shown in figure 1, are presented. The plane crystallographic groups are used to describe symmetry, Laves tillings describe the tessellation via the nodes and the incidence symbol allows the descriptions via the edges. Grünbaum and Shephard (1978) used the Laves tillings and incidence symbols to differentiate isohedral tillings and creating 107 distinct convex isohedral groups.

The applicability of those groups in the field of foldings is shown by intersecting them with the definitions for thick plate foldable mechanisms. This generates eleven distinct groups of foldings. The inclusion of mountain and valley folds expands it to 14 distinct groups. This allows the deduction of precise classifying criteria to structure folding mechanisms based on the geometry of the fold faces.

Analysis of the groups shows a single movement pattern for every group. In return it is possible to clearly differentiate foldings with the same movement pattern, as shown in figure 2 via their underlying geometric properties. This contribution in summary shows a possible way to structure folding mechanisms via classifying criteria into distinct groups with respective movements based on the underlying geometric order of the fold faces.



**Figure 2:** Example for the differentiation of three foldings with the same movement pattern

## References

Branko Grünbaum and G. C. Shephard. Isohedral tilings of the plane by polygons. *Commentarii Mathematici Helvetici*, 53(1):542–571, 1978. ISSN 1420-8946. doi: 10.1007/BF02566098. URL <https://doi.org/10.1007/BF02566098>.