

## Structural finite-element analysis of steel kirigami space frame to characterize global behavior

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### Abstract

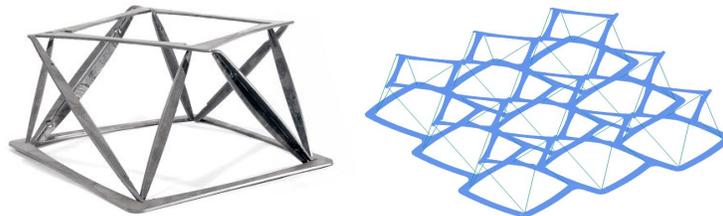
This paper builds on the work done by Baker to develop a structural system using a single sheet of CNC plasma cut steel, folded and reconnected to itself to form a double-layer space frame [1]. The process of creating this system, called Spin Valence, involved the iterative improvement of physical test models. Improvement was characterized through qualitative observation of model characteristics such as internal stability and overall system stiffness. This process was integral to the development of the final form, but also totally separate from any computational analysis. Though the system could have been created in no other way, the lack of analytical modeling makes it more difficult to extend the current system to possible new uses or to rapidly evaluate the effect of changes to material or geometric properties.

The current work aims to address this issue by characterizing the structural behavior of the Spin Valence system via finite element modeling. After a brief outline of the methods of analysis and modeling involved, the behavior of a single module is characterized to identify the flow of forces through the system and isolate the most critical elements. The analytical results of this single-unit model is compared to the results of physical testing being completed in parallel by Sahuc and Herning [2]. The comparison will be used to validate the analytical results.

Then, the model is expanded to a multi-unit system, taking advantage of the inherent stability created by the interconnection of individual units. The multi-unit model is assessed in several different loading and support configurations based on how it may be used in other contexts. The model will be validated against physical testing being completed by Sahuc and Herning [2]. Using this data, the system is compared to an equivalent solid plate, with associated stiffness and strength values in bending and shear.

In both the single- and the multi-unit model, the strength of the system is assessed using codified methods from standard American structural engineering practice, both to assess the strength of the unit for future experimental tests as well as to provide characteristic values, including safety factors, for the potential future application of the system in a building context.

The conclusion of this research brings the Spin Valence system closer to application in a building context or as a piece of structural art. Further, it provides a framework by which future iterations of the system can be tested rapidly and efficiently, and in which entirely new iterations can be created.



### References

- [1] E. Baker, "Spin-Valence: Kirigami Space Frame," in *Proceedings of the International Association for Shell and Spatial Structures (IASS) Symposium*, Cambridge, MA, 2018.
- [2] J. Sahuc, G. Herning and E. Baker, "Experimental and Analytical Investigation of the Spin-Valence Kirigami Space Frame," to be submitted for consideration in *Proceedings of the International Association for Shell and Spatial Structures (IASS) Symposium*, Barcelona, Spain, 2019.