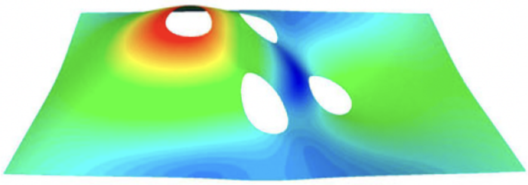
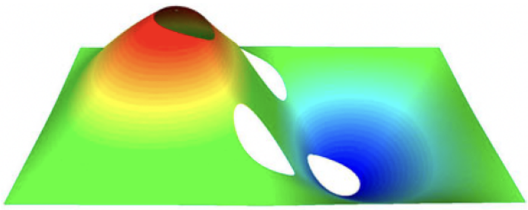
Linear Buckling Analysis of Thin Plates in the Framework of the Finite Cell Method

★★★★★	Programming skills (JAVA)	Start:	immediately
★★★★★	Theory (thin-plates FEM)	Duration:	6 months
★★★☆☆	Development	language:	English
★★★★☆	Research		

Motivation

Thin-walled structures are widely used in civil engineering and the aerospace, automotive, and shipbuilding industries. Their load-carrying capacity is often governed by buckling while the material remains in the linear elastic regime. Although analytical and semi-analytical solutions exist for very simple geometries, the stability analysis of structures with arbitrary domains generally requires numerical methods [1]. In particular, a systematic investigation of complex geometries with openings of arbitrary size and location is computationally expensive and labor-intensive when using classical finite element methods. An effective alternative is the Finite Cell Method (FCM) [2].

The Finite Cell Method is a high-order fictitious domain extension of the Finite Element Method. It embeds the physical domain into a geometrically simple computational domain that can be discretized efficiently using structured quadrilateral, triangular (2D) or hexahedral, tetrahedral (3D) cells, respectively. This avoids complex boundary-fitted meshing and enables the use of high-order polynomial approximations (p-extension) to accurately capture the structural response.

This thesis extends an existing Kirchhoff plate formulation to a fictitious domain framework for linear buckling analysis based on the Finite Cell Method. The Java implementation is enhanced by introducing composed sub-cell integration via recursive element sub-division and by incorporating the geometric stiffness matrix required for buckling analysis. The approach is verified against benchmark problems from the literature and applied to thin plates with complex geometries.

[1] R. Duy (2021). Fictitious Domain Approach for Optimizing Stability Boundaries of Plates with Cutouts, diploma thesis, Faculty of Mechanical and Industrial Engineering, TU Wien

[2] D. Schillinger, M. Ruess (2015). The Finite Cell Method: A review in the context of higher-order structural analysis of CAD and image-based geometric models, Archives of Computational Methods in Engineering 22(3): 391-455.

Scope of Work

- Review and critically assess (i) the current state-of-the-art in high order fictitious domain methods and (ii) the theory and fields of application of linear buckling analyses.
- Become familiar with our in-house finite cell framework implemented in Java.
- Implement a sub-cell integration scheme based in recursive sub-division of triangle elements
- Implement the geometric stiffness contribution according to the linear buckling theory.
- Validate the implementation by solving standard benchmark problems and assessing accuracy and convergence properties.
- Investigate a complex demonstration problem with relevance to real-world engineering.
- Prepare and typeset a scientific thesis or project report using LaTeX.

Our offer

- Regular meetings and continuous scientific supervision throughout the project.
- An introduction to engineering R&D in numerical methods and scientific computing.
- Transparent and clearly defined grading and evaluation criteria.
- A research-oriented project with the potential to result in a scientific publication.

Kontakt

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