

## A Selection of Benchmarks in Third Medium Contact

Jože Korelc<sup>1</sup>

<sup>1</sup>University of Ljubljana, Faculty of Civil and Geodetic Engineering, Slovenia  
E-mail: joze.korelc@fgg.uni-lj.si

**KEYWORDS:** *Frictionless contact, Finite deformations, Third medium, Benchmarks*

A very simple scheme that avoids the complicated treatment of contact inequality constraints is provided by third medium contact, which was first introduced in [1] using anisotropic modelling near the contact area. Since then, the methodology has been improved and mainly applied in areas such as optimisation, soft robotics, and the development of metamaterials (see Fig. 1). Recently, however, the third medium approach has been (re)discovered for its potential to include contact in topology optimisation, where boundaries are a priori unknown. In this class of problem, voids are part of the modelling and make the contact problem differentiable. This has led to very recent rapid developments of the approach [2], [3], and the present paper contributes to this.

The third medium contact formulation is characterised by its simplicity of implementation, resulting in an abundance of proposed formulations in recent years that mainly differ in the regularisation term. The regularisation term is needed to control severely deformed elements that appear in finite strain contact problems. Despite the overall success of the formulation, several serious deficiencies have been recognised, including: the need for higher order elements in most formulations, lack of scale invariance, parameter dependency, ill-conditioning of the resulting system of linear equations, high spurious stresses in the case of separation, significant error in the deformation field of contact bodies just before first contact is made, inability to release contact when contact is lost due to sliding among the bodies, and the description of frictional contact is also not straightforward. In this contribution, we provide a series of benchmark problems in the field of third medium contact, where the above-mentioned issues will be discussed and compared for different recently proposed formulations.

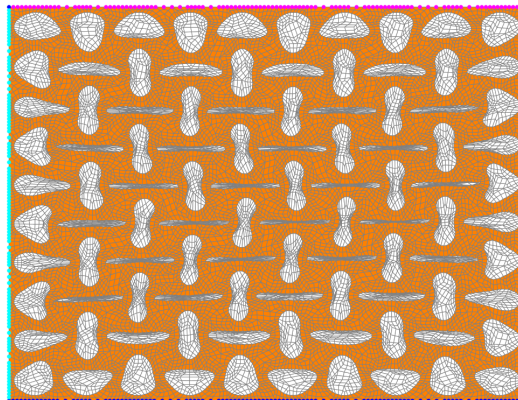


Figure 1. Third medium contact based simulation of evolving micro-structure.

- [1] Wriggers, P., Schröder, J. and Schwarz, A., “A finite element method for contact using a third medium”, *Comput. Mech.*, **52**, 837–847, (2013).
- [2] Bluhm, G.L., Sigmund, O. and Poulis, K., “Internal contact modeling for finite strain topology optimization”, *Comput. Mech.*, **67**, 1099–1114, (2021).
- [3] Wriggers, P., Korelc, J. and Junker, Ph., “A third medium approach for contact using first and second order finite elements,” *Comput. Methods Appl. Mech. Engrg.*, **436**, (2025) 117740.