Addressing volumetric locking and near-incompressibility in the material point method

Georgios Moutsanidis*, Yuri Bazilevs

* School of Engineering
Brown University
184 Hope Street, Providence, RI 02912, USA
e-mail: georgios_moutsanidis@brown.edu

ABSTRACT

Nearly incompressible deformations approximated in a pure displacement framework suffer from volumetric locking. To address this issue, reduced/selective quadrature techniques, as well as more advanced B-bar and F-bar type formulations, were developed and popularized in the traditional FEM community. However, the treatment of near-incompressibility is still an open issue in particle-based methods such as the material point method (MPM). In this work, we develop a new formulation to handle near-incompressibility and volumetric locking in the traditional MPM [1] and in immersed-particle methods [2]. Using the B-bar and F-bar techniques [3] as our point of departure, and borrowing from [4], we develop a technique that is based on the projection of the dilatational part of the appropriate measure of deformation onto lower-dimensional approximation spaces. The presented numerical examples exhibit reduced stress oscillations and are free of volumetric locking.

REFERENCES

[1] Sulsky, Deborah, Zhen Chen, and Howard L. Schreyer. *A particle method for history-dependent materials.* Computer methods in applied mechanics and engineering 118.1-2 (1994): 179-196.

[2] Bazilevs, Y., et al. *A new formulation for air-blast fluid-structure interaction using an immersed approach: part II-coupling of IGA and meshfree discretizations.* Computational Mechanics 60.1 (2017): 101-116.

[3] Elguedj, Thomas, et al. *B and F projection methods for nearly incompressible linear and non-linear elasticity and plasticity using higher-order NURBS elements.* Computer methods in applied mechanics and engineering 197.33-40 (2008): 2732-2762.

[4] Moutsanidis, G., et al. *Treatment of near-incompressibility in meshfree and immersed-particle methods.* Computational Particle Mechanics (2019): 2196-4378