Boolean extension of the finite cell method for elasto-plasticity problems

A. Abedian and A. Düster

Numerical Structural Analysis with Application in Ship Technology (M-10),
Hamburg University of Technology,
Am Schwarzenberg-Campus 4 (C), 21073 Hamburg, Germany.

ABSTRACT

The finite cell method (FCM) [1] can be considered as an embedding or fictitious domain method combined with high-order finite elements. The key advantage of the method is that it converges to results with acceptable accuracy when using an accurate integration scheme, even though the mesh does not conform to the boundaries. For elasto-plasticity problems, the method results in efficient approximations [2]. In this embedding method, the mesh is not necessarily conforming to the boundaries and the boundary is extended to a simple domain which can be discretized using a Cartesian grid. Thus, the problem of meshing is replaced by a problem of numerical integration of cells that are cut by the boundary. Recently an extension of the FCM using Boolean operations (B-FCM) has been introduced [3]. In this method, the contribution of the stiffness matrix over the fictitious domain is subtracted from the cell, resulting in the desired stiffness matrix which reflects the contribution of the physical domain only. This method yields an exponential rate of convergence for elastic problems with a smooth solution provided that the numerical integration is carried out accurately enough. In addition, it reduces the computational cost, especially when applying adaptive integration schemes based on the quadtree/octree. The B-FCM, as a high-order finite element method is extended in this paper to elasto-plastic problems. The Newton-Raphson iterative algorithm has been adapted by a scalar integration parameter suitable for the integration scheme. Moreover, for the first time integration points inside the fictitious domain are used for the numerical integration of the weak form. The potential of the B-FCM to solve elasto-plastic problems is demonstrated in 2D and 3D examples.

ACKNOWLEDGEMENT

This work has been supported by the Alexander von Humboldt Foundation. This support is gratefully acknowledged.

REFERENCES

[1] J. Parvizian, A. Düster, and E. Rank.Finite cell method h- and p-extension for embedded domain problems in solid mechanics, *Computational Mechanics*, 41:121-133, 2007.

[2] A. Abedian, J. Parvizian, A. Düster, and E. Rank. The finite cell method for the J_2 flow theory of plasticity, *Finite Elements in Analysis and Design*, 69:37–47, 2013.

[3] A. Abedian and A. Düster. An extension of the Finite Cell Method using Boolean operations, *Computational Mechanics*, DOI: 10.1007/s00466-017-1378-3, 2017.