The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

Mixed-dimensional coupling between 1D Cosserat continua and 3D solids – From embedded fibers towards contact

Ivo Steinbrecher[*1], **Alexander Popp**[1]

[1] Institute for Mathematics and Computer-Based Simulation (IMCS)
Universität der Bundeswehr München
Werner-Heisenberg-Weg 39, 85577 Neubiberg / Germany
ivo.steinbrecher@unibw.de https://www.unibw.de/imcs

Keywords: *Beam-to-solid interaction, Mixed-dimensional coupling, Finite element method, Non-linear beam theory, Mortar methods*

The interaction of rod- or beam like structures with three-dimensional continua (solids) can be found in a variety of different physical problems ranging from classical engineering problems (e.g. fiber-reinforced composite materials, belt drives) to biomedical applications (e.g. stent grafts for aortic aneurysm repair). From a modeling and computational point of view, it is desirable to employ 1D Cosserat continua, based on non-linear beam theories, to describe the beam like structures. The resulting interaction between the beams and the solids can be classified as mixed-dimensional coupling, e.g. 1D-3D coupling for fibers embedded inside a solid volume or 1D-2D coupling for fibers interacting with the 2D surface of a solid volume.

In the context of the employed finite element method, this mixed-dimensional coupling requires suitable coupling schemes between the inevitably non-matching grids of the beam centerline and the solid volume/surface. Among the main topics addressed in this talk are the different types of coupling discretization schemes (e.g. mortar-type, Gauss-point-to-segment), as well as a discussion of the characteristic traits of mixed-dimensional coupling in solid mechanics (e.g. introduction of singular solutions). Furthermore, a number of different qualitative and quantitative numerical examples are presented in order to underline the usability of the proposed mixed-dimensional coupling schemes for academic and practical applications.

REFERENCES

[1] Meier, C.; Popp, A. and Wall, W. A., Geometrically exact finite element formulations for slender beams: Kirchhoff–Love theory versus Simo–Reissner theory. *Archives of Computational Methods in Engineering*, **26**, 163–243, 2019.

[2] Steinbrecher, I., Mayr, M., Grill, M. J., Kremheller, J., Meier, C. and Popp, A., A mortar-type finite element approach for embedding 1D beams into 3D solid volumes. *Computational Mechanics*, **66**, 1377–1398 , 2020.

[3] Steinbrecher, I., Popp, A. and Meier, C., Consistent coupling of positions and rotations for embedding 1D Cosserat beams into 3D solid volumes, *Computational Mechanics*, 2021, doi:10.1007/s00466-021-02111-4.