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Topological derivative-based topology optimization of incompressible structures using mixed formulations

Inocencio Castañar[1], Joan Baiges[1], Ramon Codina[1,2] and Henning Venghaus[2]

[1] Universitat Politècnica de Catalunya, Jordi Girona 1-3, Edifici C1, 08034, Barcelona, Spain. e-mail: inocencio.castanar@upc.edu, joan.baiges@upc.edu

[2] Centre Internacional de Mètodes Numèrics en Enginyeria, Gran Capità S/N, 08034, Barcelona, Spain. e-mail: ramon.codina@upc.edu

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In the present work [1], we favor using the topological derivative concept in combination with a level-set method to address the topology optimization problem [2]. However, in the context of structural topology design, the topological derivative has been only used as a descent direction utilizing the classical displacement-based formulation. This approach is therefore limited to compressible materials. Considering nearly and fully incompressible material behavior, both the formulation and the topological derivative expression become singular.

In this work a topological optimization algorithm based on the topological derivative concept is proposed for both nearly and fully incompressible materials. So as to deal with such materials, a new decomposition for the Polarization tensor is defined in terms of its deviatoric and volumetric components. Mixed formulations for linear Elasticity are considered to be able to both deal with such materials and obtain a higher accuracy in the computation of stresses [3]. The system is stabilized by means of the Variational Multiscale method based on the decomposition of the unknowns into resolvable and subgrid scales in order to prevent fluctuations. Several numerical examples are presented to assess the robustness of the proposed formulation and its applicability to topology optimization problems for incompressible elastic solids.

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