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TOPOLOGICAL SENSITIVITY ANALYSIS OF THERMO-ELASTIC CONSTITUTIVE OPERATOR

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Abstract. A simple analytical expression for the sensitivity of the two-dimensional macroscopic thermo-elastic constitutive tensor to topological microstructural changes of the underlying material is proposed. The derivation of the proposed formula relies on the concept of topological derivative, applied within a variational multi-scale constitutive framework based on the Representative Volume Element (RVE) concept. These mathematical concepts allow the closed form calculation of the sensitivity, whose value depends on the solution of a set of equations over the original domain, of a given shape functional with respect to an infinitesimal domain perturbation. Their use in the context of multi-scale material design is reported in a number of recent publications. In the present context, the variational setting in which the underlying multi-scale theory is cast, is found to be particularly well-suited for the application of the topological derivative formalism. The derived sensitivity – a symmetric second order tensor field over the RVE domain – measures how the macroscopic thermo-elastic parameters estimated within the multiscale framework changes when a small circular inclusion is introduced at the micro-scale level. The final format of the proposed analytical formula is strikingly simple and can be potentially used in applications such as the synthesis and optimal design of microstructures to meet a specified macroscopic behavior