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FORMULATION OF A CONSISTENT VIRTUAL POWER PRINCIPLE FOR RVE-BASED MULTISCALE MODELS

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Abstract. In the present work we make use of duality arguments to formulate a variational framework aiming at addressing multiscale modeling based on the concept of Representative Volume Element (RVE). By multiscale modeling we mean the model at the macro scale, the model at the micro scale and their connection. A systematic procedure to define all the necessary ingredients of a multiscale theory will be exposed. The entire multiscale model is fully governed by the kinematics at both scales, and by the relation between these kinematics. We formulate a multiscale virtual power principle which balances virtual power performed at macro scale with virtual power performed at micro scale considering heterogeneous kinematics between the involved scales. The proposed multiscale virtual power principle embodies, and extends, the well-known Hill-Mandel principle of macrohomogeneity. Particularly, we highlight the introduction of a general class of localization operator responsible for the connection between kinematics, as well as for the corresponding homogenization formulae obtained from the virtual power principle. The multiscale virtual power principle delivers, as natural consequences: (i) the homogenization formulae for dual quantities, (ii) the homogenization formulae for body forces, and (iii) the virtual power principle that defines the equilibrium at the micro scale. The so developed multiscale variational theory allows to tackle problems involving macro and micro body forces, different kinematics between macro and micro scales, and failure mechanisms at macro scale generated by failure mechanisms taking place at the micro scale. Examples of these situations will be discussed on the light of a wide range of continuum mechanics applications.