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ASYMPTOTIC MODELING OF A THIN PIEZOELECTRIC INTERPHASE

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In the last decades the use of intelligent materials, like piezoelectric materials, has deeply increased in several domains of aeronautical, mechanical and civil engineering. For instance, piezoelectric transducers, in the form of piezo-patches, are commonly employed in structural monitoring, in the active/passive dumping of high frequency vibrations and in the eliminations of undesired vibrations. An important example is given by the actuated rotating blades of the helicopters. The present work is aimed at deriving a mathematical model of the mechanical behavior of a piezo-patch, which is constituted by a thin piezoelectric plate between to conductor films, glued to a structural member, as a helicopter blade, or surrounded by the structure that needs to be monitored. This particular structural assembly gives rise to a complex multi-material characterized by a high contrast between the thickness of the piezo-plate and the actual dimensions of the structure and, also, among the mechanical properties and physical behaviors of its constituents. This important difference in the geometrical and electromechanical properties creates remarkable numerical instabilities in a FEM analysis and justifies the need of looking for a simplified model. The successful application of the asymptotic methods to obtain a mathematical justification of the most used models of elastic and piezoelectric plates (see [1, 2]) has stimulated the research toward a rational simplification of the modeling of complex structures obtained by joining elements of different dimensions and/or materials of highly contrasted properties. For example, Bessoud et al. in [3] have studied the behavior of elastic shell-like inclusions with high rigidity immersed in a three-dimensional body; concerning with piezoelectric multimaterials, Geis et al. in [4] derive an asymptotic model of a piezoelectric stack actuator with metal inclusions. In this case we consider a simplified situation in which the assembly is made by an anisotropic linearly piezoelectric plate included in two three-dimensional linearly elastic and conductor bodies. By defining a small real parameter ε, which represents the thickness of the plate-like domain, we perform an asymptotic analysis, following the approach of [1]. Then we derive a limit model in which the piezoelectric plate between the two bodies in some way "disappears": its contribution in the limit model is given by a specific surface energy defined over the middle plane of the plate, which generates some ad hoc electromechanical transmission conditions at the interface of the two bodies. The obtained model is then mathematically justified by a variational convergence argument.

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