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HIGH ORDER PLATE/SHELL FE FOR PIEZOELECTRIC ANALYSIS: THE BIMORPH CONFIGURATION

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Summary: Research is still active on plate and shell Finite Element (FE) approximations in order to improve performances in terms of convergence rate and accuracy on displacements and stresses and to overcome numerical lacks such as transverse, Poisson and membrane locking, spurious modes, etc. These developments are mainly based on the classical First Order Shear Deformation Theory (FSDT). In this research field, contributions on beam, plate, shell and threedimensional shell FE are too extensive to be reviewed here. Furthermore, research is also active on the development of new theoretical models for heterogeneous structures and multifield problems. In this context, two families can be identified: the Equivalent Single Layer Models (ESLM), where the classical Koïter model (CLT) and Naghdi (FSDT) models can be found for shells, and the Layer-Wise Models (LWM). Another way for obtaining new models is based on the introduction of interface conditions into high-order models pertaining to the ESLM or to the LWM. This permits to reduce the number of unknowns and can be viewed as a ZigZag model. This paper presents a new C0 8-node quadrilateral finite element (FE) for geometrically linear piezo-electric shells. This finite element aims at modeling both thin and thick shells without any pathologies of the classical shell finite elements (shear, membrane and Poisson or thickness lockings, spurious modes, etc). It is based on a high-order kinematics proposed in [1] for the mechanical part and on the piezo-electric approximation introduced in [2]. Furthermore, Murakami's ZigZag functions are introduced for improving the accuracy for multilayered modeling. A plate/shell FE is obtained with nine degrees of freedom (dof) per node for the mechanical part, twelve dof if the ZigZag functions are included. For the piezoelectric approximation, a layer wise description is used with a cubic variation in the thickness of each layer while the potential is assumed to be constant on each elementary domain for the in-plane variation. This FE is evaluated on some standard piezo-electric plate/shell tests including sensor and actuator configurations. Tests concerning bimorph piezoelectric beam/plate/shell are presented in order to evaluate the high-order kinematics and the ZigZag effect. References [1] Polit O., Vidal P. and D'Ottavio M. Robust C0 high-order plate finite element for thin to very thick structures: mechanical and thermo-mechanical analysis. Int. J. Num. Meth. Eng. 2012; 90(4):429–451. [2] Jiang JP. and Li XL. A new finite element model for piezothermoelastic composite beam. J. Sound Vibration 2007; 306:849–864.