Plate/shell finite element for piezoelectric patch modelling

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ABSTRACT

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. 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 C^0 8-node quadrilateral finite element (FE) for geometrically linear piezoelectric shells. It is based on a high-order kinematics proposed in [1] for the mechanical part. The approximation of the electric potential must be able to model piezoelectric patches, and a constant value is considered on each elementary domain while a cubic variation in each layer is used, based on the polynomial expansion given in [2]. Furthermore, Murakami's ZigZag functions [3] is superimposed for the three displacement components 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 dofs if the ZigZag functions are included, [4].

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 assess the high-order kinematics and the ZigZag effect. The role of electrode segmentation, i.e. the size of equipotential surfaces, on the electro-mechanical response has been also considered.

REFERENCES

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