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NODE-DEPENDENT KINEMATIC ELEMENTS FOR THE ANALYSIS OF ENERGY HARVESTER

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The development of advanced materials, such as the piezo-electric material, has lead to the design of small devices able to exploit the electro-mechanical coupling to actuate, monitoring, extract energy or control structures of different nature. These devices can be used to produce small quantities of energy but large enough to supply wireless sensors or monitoring systems. The design of such structures requires to predict complex phenomena such as: electro-mechanical coupling, stress concentrations at the interface between the active material and the substrate layers, complex boundary conditions, etc. The performances of these smart structures may be enhanced by an accurate design of the dynamic response of the structure. A large number of advanced models, able to deal with such complex problems, have been proposed over the last decades. These models, usually based on advanced kinematic descriptions or three-dimensional solutions, requires huge computational costs and can be applied in a portion of the structure.

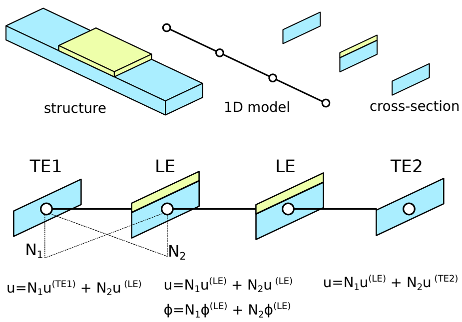

Figure 1: An example of a NDK model for piezo-patched structures.

This work extends the use of one-dimensional elements with node-dependent kinematics (NDK) to the analysis of energy harvester. NDK allows the kinematic assumptions to be defined individually on each finite element (FE) node, leading to FE models with variable nodal kinematics. Derived from Carrera Unified Formulation (CUF), NDK facilitates the mathematical refinement to an arbitrary order at any desirable region on the nodal level while keeping the compactness of the formulation. NDK is applied to increase the numerical accuracy in the areas where the smart material patches lie in through sufficiently refined models, while lower order assumptions are used elsewhere. NDK models capabilities can be exploited in combination with the component-wise approach in order to study complex structures. The results are compared against those from literature. The numerical study shows that the adoption of NDK allows accurate results to be obtained at reduced computational costs.