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A novel smart hybrid-trefftz finite element for the analysis of smart laminated composite Plates

Manas Chandra Ray
Indian Institute of Technology, Kharagpur, India

The quest for blending the attributes of the Trefftz method with the conventional FE method led to the development of the Hybrid-Trefftz finite element (HTFE) method [1]. The HTFE method generally involves the finding of homogeneous and particular solutions of governing partial differential equations of the domain of the element, a priori. The homogeneous solution is a linear combination of the Trefftz functions. These solutions are not compatible across the interface between two neighboring elements. In order to establish the link between the neighboring elements, auxiliary inter-element fields are considered at the boundaries of the element assuming that each such boundary is a fictitious inter-element. Relating these auxiliary fields with the unknown constants of the homogeneous solutions, the continuity between the elements is enforced. Deriving the Trefftz functions is independent of the geometrical shape of the elemental domain. This enables to derive and optimize the polygonal Trefftz finite element in an easier and straight forward way. Although the HTFE is characterized with some great advantages [2-5], the use of HTFE method for the analysis of smart laminated composite structures is still not available in the open literature probably because of the difficulties in deriving the Trefftz functions in a straight forward manner. In this presentation, an endeavor has been shown to present the derivation of the HTFE for the analysis of smart laminated composite plates based on the exact solutions of the homogenous simultaneous governing partial differential equations of the plates in a straight forward manner. The top surface of the substrate laminated composite plate is integrated with a layer of piezoelectric material acting as the distributed actuator. The smart HTFE model derived here is verified with the exact solution. Figure 1 illustrates a representative result indicating that the present HTFE can be utilized for accurate analysis of smart structures.

Recent Publications:

1. Jirousek, J. and Leon, N., 1977, "A powerful finite element for plate bending", Computer Methods in Applied Mechanics and Engineering, Vol. 12, pp. 77-96.
2. Qin, Q. H., 2005, "Trefftz finite element method and its applications", Applied Mechanics Review, Vol. 58, pp. 316-337.
3. Karkon, M., 2015 "Hybrid-Trefftz formulation for analysis of anisotropic and symmetric laminated plates", Composite Structures, Vol. 134, pp. 460-474.
4. Karkon, M. and Pajand-Rezaiee, M., 2016, "Hybrid-Trefftz formulation for analysis of thick orthotropic plates", Aerospace Science and Technology, Vol. 50, pp. 234-244.
5. Petrolito, J., 2014, "Vibration and stability analysis of thick orthotropic plates using hybrid-Trefftz elements", Applied Mathematical Modeling, Vol. 38, pp. 5858-5869.

Biography

Manas Chandra Ray is one of the pioneering researchers in the area of smart materials and structures. Derivation of the first bench mark exact solutions of smart laminated composite structures is one of his most significant contributions. He developed novel methods for active structural-acoustic control and active constrained layer damping of nonlinear vibrations of smart structures using 1-3 piezoelectric composites. He discovered that the piezoelectric coefficients of the existing 1-3 piezoelectric composite can be significantly improved by growing radially aligned carbon nanotubes (CNTs) on the surface of the piezoelectric fibers. His micromechanics models reveal that the wavy CNTs significantly improve the effective elastic and thermo-elastic properties of the fuzzy fiber-reinforced composite. He explored that the thermal conductivities of carbon fiber heat exchanger can be dramatically enhanced by exploiting wavy CNTs. Most recently, he derived benchmark exact solutions of the flexoelectric nanobeams for developing smart nano sensors and nano actuators.

mcray@mech.iitkgp.ernet.in