Hybrid Plane, Axisymmetric and Three-Dimensional Finite Element Models for Helmholtz Problem

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In this presentation, the previous work on formulating hybrid finite element models for plane, axisymmetric and three-dimensional bounded Helmholtz problems will be reviewed. These models share the same formulation framework in which boundary (inter-elemental) and domain (intra-elemental) modes are defined for each element. The domain modes satisfy the Helmholtz equation and the boundary modes are constructed by nodal interpolation. Compared with many other advanced elements for Helmholtz problems, “small” elements which means the number of elemental dofs entering the system equation is small are concerned due to their high application value. In “large” elements, these dofs are plenty and the elements are less sensitive to the choice and the number of domain modes. Moreover, accuracy of “small” elements can vary significantly with respect to the domain modes and their number. Poorly chosen domain modes can lead to not only poor accuracy but also rank deficiency and variance of the element matrix with respect to element translation, rotation and connectivity [12-14]. Different bases for the domain modes have been attempted for linear and quadratic plane, axisymmetric and three-dimensional elements. These include plane waves propagating at different directions, cylindrical and spherical waves with distributed origins as well as wave solutions involving various Bessel functions. In absolute majority of our computational benchmark tests, the proposed hybrid elements are considerably more accurate than their conventional single-field counterparts.

Keywords: Helmholtz, hybrid, finite element, plane wave, spherical wave, cylindrical wave