Analysis of Exterior Acoustics using the Smoothed Finite Element Method (S-FEM)

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Solving acoustic problems governed by Helmholtz equation by standard finite element method (FEM), the numerical dispersion error is not negligible when the wave number increases due to the "overly-stiff" character of FEM. To overcome this numerical dispersion error, this paper uses the edge-based smoothed finite method (ES_FEM) and the face-based smoothed finite method (FS_FEM) to analyze the 2D and 3D exterior scattering problems respectively. Linear triangle elements and tetrahedron elements are employed separately to mesh the 2D and 3D computational domain. Using gradient smoothing technology to build a relatively soft stiffness thus the numerical dispersion error can be significantly decreased. In addition, the gradient smoothing technology transfers domain integrals involving gradient of shape function to simple boundary integrals involving only shape function, which can reduce computing cost. In order to model exterior acoustic problems defined in unbounded domains, the unbounded domain is truncated by an artificial boundary on which the non-reflecting boundary condition is imposed to replace the Somerfield condition at infinite. Examples for exterior scattering problems with known exact solutions are calculated to demonstrate the S-FEM realization, result shows that the S_FEM is also very accurate. Compared to FEM calculation process and results, S-FEM is more effective and could achieve much more accurate result in solving exterior acoustic problems, especially when wave number is large.

Keywords: Smoothed Finite Element Method, Acoustic Scattering, Unbounded Domain, non-reflecting boundary