Extension of the Line Element-Less Method to Dynamic Problems

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Abstract

The Line Element-Less method (LEM) is an innovative and efficient approach for torsion and bending analysis of beams and plates. The basic idea of the method is an expansion of the unknown displacements into harmonic polynomials and the determination of the expansion coefficients by minimizing a path integral in order to satisfy the boundary conditions. It can thus be considered as a Ritz method, where the approximation functions satisfy the partial differential equation in the interior of the domain. However, in contrast to boundary element methods, it is not necessary to subdivide the boundary into elements. For this reason, the solution can be very efficiently obtained in a semi-analytical procedure.

Until now, the LEM is limited to problems that can be described by a Laplace equation, as the harmonic polynomials are solutions of the Laplace equation. In this contribution, we present a first extension of the LEM to dynamic problems. To this end, we consider the application of the LEM to the Helmholtz equation. We study two scenarios:
i) the eigenvalue problem for the homogeneous Helmholtz equation;
ii) the computation of solutions for the inhomogeneous Helmholtz equation.

In order to apply the LEM to the Helmholtz equation, it is necessary to introduce a new set of approximation functions. These approximation functions are obtained by a transformation that maps solutions of the Laplace equation to those of the Helmholtz equation. The new approximation functions can be best represented in polar coordinates and involve products of harmonic functions and Bessel functions of first kind. With these approximation functions, it is then still possible to solve the Helmholtz equation by a semi-analytical approach, without the necessity to subdivide the boundary into elements.

The new approach is presented and discussed with several examples, which illustrate the efficiency of the method. Moreover, convergence studies are presented.