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A boundary element formulation for boundary only analysis of thin shallow shells

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ABSTRACT

The dual reciprocity method (DRM) and the radial integration method (RIM) are techniques used in BEM to transform domain integrals into boundary integrals. They are suitable for boundary element formulations where a complete fundamental solution is either unavailable or very complex, because in these cases one or more terms can remain as domain integrals in order to use a simpler fundamental solution. Thus, a large number of problems can be solved with the knowledge of a few number of fundamental solutions and additional terms as inertia or non-linear effects, can be treated as body forces and taken to the boundary. In both methods, the remaining terms are approximated through a finite series expansion involving proposed approximating functions and coefficients to be determined. This expansion is substituted in the generated domain integrals that are, subsequently, transformed into boundary integrals.

In this paper, a boundary element formulation for thin shallow shells with no domain discretization is presented. The domain integrals due to the curvature of the shells are transformed into boundary integrals using the radial integration method.

Two approximation functions are used in this work. The first is the radial basis function that has been used extensively in the DRM given by:

$$f_{m_1} = 1 + R, \tag{1}$$

and the second is the well known thin plate spline:

$$f_{m_3} = R^2 \log(R), \tag{2}$$

used with the augmentation function. It has been shown in some works from literature that this approximation function can give excellent results for many different formulations (see Partridge [1] and Golberg *et al.* [2]).

Numerical Results: In order to compare the accuracy of the different approximation functions, the method is applied to a shperical shallow shell under an internal pressure. The properties of the shell are as follows: thickness $t = 0.1$ m; radius of the base of the shell $r = 5$ m; $k_{11} = k_{22} = 1/R = 0.01$ m, $E = 210000$ MPa and $\nu = 0.3$. The internal pressure is $q_3 = 1$ MPa. The edge of the shell is clamped, i.e., the boundary conditions are $u_1 = u_2 = u_3 = \partial u_3/\partial n = 0$.

The transversal displacement is computed using the two radial basis functions, given by equations (1) and (2), with a mesh of 20 constant boundary elements and 17 internal points.

Figure 1 shows the transverse displacements of the plate computed using the first and the second approximation functions, given by equations (1) and (2), respectively. Displacements are compared with results presented by Dirgantara and Aliabadi [3] for the the same problem. As it can be seen, there is a good agreement between all results.

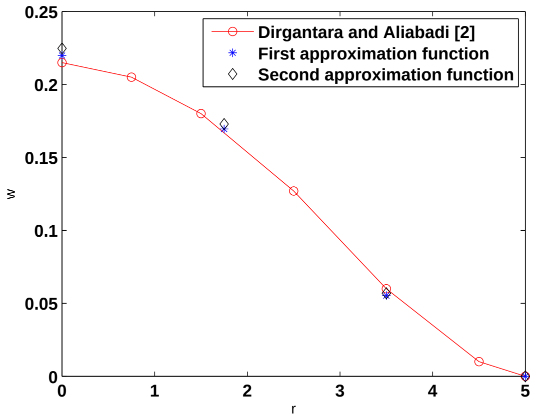

Figure 1: Transversal displacement for the spherical shell with clamped edge.

Conclusions: This paper presented a boundary element formultaion for the analysis of thin shallow shells where domain integrals are transformed into boundary integrals by the radial integration method. As the radial integration method doesn't demand particular solutions, it is easier to implement than the dual reciprocity boundary element method. Two different approximation functions are used in the radial integration method. Results obtained with both approximation functions are in good agreement with results presented in literature.

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