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Scattering by a defect in an elastic waveguide: coupling of finite elements and modal representations

Vahan Baronian[a], Anne-Sophie Bonnet- Ben Dhia[a], Colin Chambeyron[a] and Eric Luneville[b]
[a]CNRS, ENSTA - 32 Boulevard Victor, 75 015 Paris, France
[b]ENSTA - CEA, 32 Boulevard Victor, 75 015 Paris, France

The potentiality of guided ultrasonic waves in Non Destructive Testing is currently investigated. Indeed, guided waves can allow a rapid inspection of large areas and of non accessible parts of particular structures like plates or pipes, compared to conventional techniques. This work concerns the numerical finite element computation, in the frequency domain, of the diffracted wave produced by a defect (crack, heterogeneity, discontinuity, local bend etc...) located in an infinite elastic waveguide. The computational domain is chosen as a portion of the waveguide, containing the perturbation, and our purpose is to build transparent conditions on its artificial boundaries by using modal representations. This cannot be achieved in a classical way, due to non standard properties of elastic modes. However, a biorthogonality relation is established which allows to derive a transparent condition relating hybrids displacement/stress vectors. An original mixed formulation is then implemented, whose unknowns are the displacement field in the bounded domain and the normal component of the normal stresses on the artificial boundaries. Numerical validations are presented in the two-dimensional and three-dimensional cases.