Transient Response of Elastic Structures Subjected to a Fluid Medium

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Abstract : Presence of fluid medium interacting with a structure can lead to failure of the structure. Since developing efficient computational model for fluid-structure interaction (FSI) problems has broader impact to realistic problems encountered in aerospace industry, ship industry, oil and gas industry, and so on, one can find an increasing need to find a method in order to investigate the effect of fluid domain on structural response. A coupled finite element formulation of problems involving FSI issue is an accurate method to predict the response of structures in contact with a fluid medium. This study proposes a finite element approach in order to study the transient response of the structures interacting with a fluid medium. Since beam and plate are considered to be the fundamental elements of almost any structure, the developed method is applied to beams and plates benchmark problems in order to demonstrate its efficiency. The formulation is a combination of the various structure theories and the solid-fluid interface boundary condition, which is used to represent the interaction between the solid and fluid regimes. Here, three different beam theories as well as three different plate theories are considered to model the solid medium, and the Navier-Stokes equation is used as the theoretical equation governed the fluid domain. For each theory, a coupled set of equations is derived where the element matrices of both regimes are calculated by Gaussian quadrature integration. The main feature of the proposed methodology is to model the fluid domain as an added mass; the external distributed force due to the presence of the fluid. We validate the accuracy of such formulation by means of some numerical examples. Since the formulation presented in this study covers several theories in literature, the applicability of our proposed approach is independent of any structure geometry. The effect of varying parameters such as structure thickness ratio, fluid density and immersion depth, are studied using numerical simulations. The results indicate that maximum vertical deflection of the structure is affected considerably in the presence of a fluid medium.

Keywords : beam and plate, finite element analysis, fluid-structure interaction, transient response