840. Investigation of eigenvalue problem of water tower construction interacting with fluid

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Abstract. The paper concerns problems, in which both the structural and fluid responses of a complex construction to mechanical actions are strongly coupled. Particularly, there are treated problems, in which the structural dynamic response to actions is significantly affected by the presence of the fluid in the structure. The work presents the evolution of the way of solving that problem of the complex solution of the generalized problem of the structure using multiphysical ANSYS program package. The formulation of fluid finite elements is discussed, considering both pressure (Euler) with/without sloshing and displacement (Lagrange) approaches. The solution is demonstrated on thin-walled steel water tower structure.

Keywords: fluid structure interaction, eigenmode, sloshing, free surface, Euler fluid, Lagrange fluid.

Introduction

A steel water tower structure alters its dynamic characteristics considerably, primarily because of the difference in mass distribution with a full or empty upper tank. This happens during a common operation cycle. A water tower is a slender structure sensitive to dynamic loading effects. When designing a thin-walled steel structure, it is necessary to take into account stability effects as well. Furthermore, this structure is of circle section and inclined to transverse wind resonance vibration caused by vortex shedding in a wake. For this reason, a correct determination of eigen frequencies is necessary [15].

For a static analysis, a completely full upper tank represents the most unfavorable case; fluid can be substituted by hydrostatic pressure on the bottom and walls. For a dynamic computation, the fluid substitute is further more complicated. In this case, an appropriate description of moving fluid effects plays a decisive role. This problem is shown on a water tower structure detail described below, water retained weight being 531 Mg and structure weight more than 93 Mg. The structure with more than 80% of its weight concentrated in the upper part can be also described using a top mass concentration model. Since the hypothesis of simultaneously moving fluid is very conservative, an eigen value structure frequency is lower than it would correspond to a real situation. For very simple shapes, algorithms to determine added mass vibrating with the structure are available, although, in general, this represents a complicated task. A basic idea about the entire structure behavior can be obtained from the model of concentrated fluid mass connected to the proper water tower model (usually beam with very few degrees of freedom) using a spring-damper element. The fluid effect considered in this way can also describe the interaction of fluid volume and water tower structure vibration [13].

Present day possibilities of computational models allow a very detail description of the entire structure. For models with structure – fluid interaction, fluid influence is considered as an added value. Here, the problem of determining a moving fluid mass value must be dealt with. A fluid area model must be created and much more accurate results must be obtained. At present, Lagrange and Euler methods with two different boundary conditions are used [2].