SHAPE EFFECTS ON THE SEISMIC RESPONSE OF ON GRADE STEEL WATER TANKS WITH MEDIUM H/D RATIO USING LAGRANGIAN APPROACH

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ABSTRACT

Water Tanks are amongst the most important special structures which are used for storage and providing the needed water on the pick usage time in water supply networks. According to this, investigating the seismic behavior of these structures are of much importance. In current research, the seismic response of circular and square steel water tanks with medium H/D ratio, by the means of Lagrangian approach for considering the fluid-structure interaction, is studied.

Analysis procedure of the whole water-tank system is completed by the means of Time History Analysis method, using 5 pairs of horizontal components of selected accelerograms, recorded on 3 soil categories of Rock, Dense, Loose and Very Loose soils and scaled to spectral acceleration level of S_a=0.35g. The response is computed for the filling strategy of Empty, 50% Full and 100% Full conditions of both shapes and the final results are summarized and discussed.

Keywords: Time History Analysis, Steel Water Tanks, Spectral Acceleration, Soil Category, Lagrangian Approach

1. INTRODUCTION

The on grade cylindrical tanks are the type of lifeline structures which are extensively used in water supply facilities, oil and gas refineries and nuclear power plants for various purposes. Extensive failures and damages observed in the on-grade cylindrical steel tanks have persuaded the researchers to investigate the seismic behaviour of these special structures. Housner (1963) in a pioneering work, divided the hydrodynamic response of a rigid tank into two liquid impulsive and convective masses. The part of the liquid that vibrates with the tank's rigid body, produces the impulsive mode of response, while the rest of the liquid generates the sloshing mode and is identified with a long period of vibration.

2. LAGRANGIAN APPROACH THEORY

Basic formulation for fluid-structure interaction using finite element method with Lagrangian approach is summarized below:

1) Fluid is compressible and linear static. The used finite element is based on a formulation in which the fluid strains are calculated from the linear strain-displacement equations. The only strain energy considered is associated with the compressibility of the fluid (Wilson & Khalvati 1983). The pressure volume relationship for linear fluid is given by equation (1).

$$p=E_v\,\varepsilon_v \tag{1}$$

2) Viscosity effects are negligible. This assumption is not contrary to the fact since the effect of viscosity for the dynamic behavior of fluid storage tanks is negligible and this effect decreases when dimension of tanks increase (Priestley 1986).
3) Displacement field is considered to be irrotational by introduction of a rotational stiffness. If the fluid is assumed to have no shear strength, and the elasticity matrix for the fluid is with the shear modulus set to zero. This results in a singular stress-strain matrix which in turn leads to spurious, zero–energy deformation modes for fluid elements and

fluid meshes. A possible method of overcoming this problem is to assume a small value for shear modulus of the fluid. A second approach is to admit the inviscid behavior and to use the implication that the fluid must be irrotational in