

SEISMIC RESPONSE OF ELEVATED WATER TANKS: AN OVERVIEW

¹Ankesh Birtharia and ²Sarvesh K Jain

¹ M. E., Civil Engineering Department, MITS Gwalior, Madhya Pradesh, India

² Professor, Civil Engineering Department, MITS Gwalior, Madhya Pradesh, India

Abstract- Elevated storage reservoirs are the structures which need to remain functional after major seismic events and therefore should be designed accordingly to resist expected seismic vibrations. Depending upon the storage capacity and other considerations, these reinforced concrete tanks can be of different shapes. Failure of these structures adds to the misery of the affected population and adversely affects the post-earthquake relief operations. Extensive research on dynamic response of liquid filled tank traces its origin back to the middle of the last century. This paper summarizes the studies of seismic response for elevated water tanks.

Key Words: : Elevated Water tanks, Finite Element method, Dynamic Parameters, Degree of freedom, Seismic Response.

1. INTRODUCTION

Elevated reservoirs are considered as important structures and need to remain functional immediately after a major earthquake event for relief operations and to control fire break outs etc. [8]. Elevation of the reservoirs is provided through staging. Staging generally has structural system comprising of columns and horizontal braces which transmits the load to the foundation. The poor seismic performance of reinforced concrete elevated water tanks under earthquake ground motions has been observed in past earthquake. Supports of number of elevated water tanks got damaged during past earthquakes in spite of moderate magnitude and large epicentral distances [22]. Therefore the columns and braces are critical parts of such structures and are also designed to resist wind and earthquake loads. Expected seismic load depends upon several aspects like seismicity of the area, soil type, dynamic characteristics of the structure etc. The dynamic characteristics of the structure - the natural time period and damping largely influence the expected seismic load [17]. According to seismic code IS: 1893(Part I): 2000, more than 60% of India is prone to earthquakes [12]. Seismic analysis of elevated water tanks differ from other structures in two ways: (i) at the time of seismic excitation, the fluid inside the tank exerts hydrodynamic force on tank walls and base and (ii) in comparison of other structures liquid containing elevated water tanks have low ductility and redundancy leading to necessity of increased design seismic forces [19]. Thus these

structures required precise estimation of design earthquake load and careful seismic analysis.

2. SEISMIC RESPONSE OF ELEVATED WATER TANKS

Large number of papers has been published till date related to seismic response of elevated water tanks. Researchers used different types of model and analytical and experimental techniques to find out the seismic response of these structures. Such studies are being used to provide guidelines and appropriate methods to ensure safety of elevated water tanks as far as possible in the event of earthquake.

Chandrasekaran and Krishna [1965] proposed a single-DOF model for obtaining a satisfactory estimation of dynamic response of elevated water tanks. They found that during severe earthquake, provisions should be made in the design for energy absorption. Measurements of time period of concrete water towers indicate that the effective flexural rigidity changes considerably with the vertical load. For full tank, the nominal values suggested for L E and L give time periods which were a very good approximation to the measured values. They observed that tank full is the most critical condition for the design of water tanks against earthquake forces. Ramiah and Gupta [30] also used single-DOF model to estimate dynamic response of elevated water tanks for different types of foundation soils.

Housner [1957, 1963] developed a model by using an approximate analysis of the hydrodynamic pressures exerted on the walls of rigid tanks subject to unidirectional horizontal seismic ground motion. He assumed the liquid, divided into two-mass systems: a part of the liquid at the bottom of the container, known as the impulsive component behaves the same way as solid material while the liquid above it, known as the convective component participates in sloshing with a different dynamics having long period of vibration. The liquid was assumed to be incompressible and undergo small displacement. Due to its implementation simplicity, the model has been adopted in many codes and standards with certain modifications.

Sonebi [1969] further reported application of Housner's model in seismic analysis of elevated water tank. Both free vibration and stationary vibration tests were performed on 1/10- 1/20 scale models of two elevated water tanks in this study. The first model was a cylindrical tank model having 60cm diameter supported by a frame which had

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