10th International Congress on Civil Engineering, 5-7 May 2015
University of Tabriz, Tabriz, Iran

Dynamic analysis of base-isolated flexible rectangular fluid tanks

M. H. Aghashiri[1], S. Hashemi[2]
1-M.A Student, Department of Engineering, Islamic Azad University, Yasooj Branch, Yasooj, Iran
2- Assistant Professor, Department of Engineering, Yasouj University, Yasouj, Iran

mohamadaghashiri@gmail.com

Abstract

As known from some very upsetting experiences, liquid storage tanks collapsed or were heavily damaged during earthquakes all over the world. For this reason, numerous studies have been done on the dynamic analysis of fluid containers; a few of which have been studied on the seismic responses of flexible rectangular tanks with base isolation. This paper focuses on analyzing, the results and arguments about the design of seismic base isolated flexible rectangular tanks. The mechanical model used in this paper contains three masses known as: sloshing mass, rigid mass and flexible mass. Lead rubber bearings (LRB) and friction pendulum systems (FPS) are two types of seismic isolators, used to isolate the storage tank base. Results show that seismic base isolation can be an efficient way to reduce dynamic responses such as base shear and hydrodynamic pressure, but it can adversely affect the sloshing height and the relative displacement of the structure to the ground.

Keywords: flexible rectangular tank, base-isolation, dynamic analysis, mechanical model, Fluid-Structure interaction.

1. INTRODUCTION

The liquid storage tanks are one of the most important elements of the lifeline and industrial facilities in the world. They are used to store a variety of liquids, such as water for drinking and fire fighting, petroleum, chemicals, liquid natural gas and nuclear fuel assemblies. These also play an important role in the rescue work after an earthquake. These tanks are exposed to a wide range of seismic hazards and interaction with other sectors of the built environment. Based on observation from previous earthquakes, it is concluded that liquid storage tanks can be subjected to large hydrodynamic pressures during earthquakes. Consequently, high stresses can cause buckling failure in steel tanks, while in concrete tanks, due to the large inertial mass of concrete, the stresses could be large and result in cracking, leakage or even collapse of the structure. The poor performance of some of these structures in past earthquakes has led engineers and researchers to study this problem, and to improve the behaviors of these structures.

Haskins and Jacobsen published the first report on analytical and experimental observation of rigid rectangular tanks under a simulated horizontal earthquake excitation [1]. Housner developed the most commonly used analytical model for estimating the dynamic response of a rigid rectangular tank [2]. This model, with some modifications, has been adopted in most of the current codes and standards. But several studies were carried out to investigate the dynamic interaction between the deformable wall in the tank and liquid, and showed that the seismic response of a flexible tank may be substantially greater than that of a similar rigid tank. Consequently, the seismic response of liquid storage tanks can be strongly influenced by the interaction between the flexible tank and the fluid within it.

Haroun presented a very detailed method of analysis of the typical system of loadings for rectangular tanks [3]. However, the formula of hydrodynamic pressures only considered the rigid wall condition. This may be due to the fact that rectangular fluid containers are usually made of reinforced or prestressed concrete and may be considered quite rigid dynamically. Subsequently, Kim et al presented an analytical method for calculation of hydrodynamic pressures based on the three-dimensional analysis of tanks [4]. Dogangun et al and Dogangun and Livaoglu investigated the seismic response of liquid-filled rectangular storage tanks using the three-dimensional Lagrangian fluid finite element [5, 6]. Park et al and Koh et al studied the seismic response of rectangular tanks with four flexible walls by using a three-dimensional coupled boundary element-finite element method. Ghaemmaghami and Kianoush (2010) investigated the