9th International Congress on Civil Engineering, May 8-10, 2012
Isfahan University of Technology (IUT), Isfahan, Iran

The effect of cutoff walls on the seismic behavior of underground structures in liquefiable soil

S. Moshirabadi [1], M. Soltani Mohammadi [2]

1- MSc Student of Earthquake Engineering, Tarbiat Modares University
2- Associate Prof. of Earthquake Engineering, Tarbiat Modares University

s.moshirabadi@modares.ac.ir

Abstract

Underground structures such as subway tunnels, water pipe lines, manholes and etc. are indispensable parts of urban zone used for various applications. Shallow underground structures buried in liquefiable soils may experience extensive damages such as floatation or sinking and extra lateral displacement due to earthquake induced soil liquefaction. Different mitigation strategies have been developed for eliminating or alleviating uplift of underground structures such as densification or replacement of surrounding liquefiable soils, installation of gravel drainages, cutoff walls, grouting and etc. In this paper, at first, the uplift mechanism of underground structures in liquefiable sand soil is explaned; then, the mechanism of cutoff walls in aloviating uplift response and their interaction with subway are studied. The cutoff walls parameters variation effect on interaction behavior of the adjacent subway is numerically investigated. At the end, the effects of dense soil columns installation on the subway reponses are compared with cutoff walls influences.

Keywords: Underground tunnels, Uplift, Cutoff walls, Liquefaction, Earthquake.

1. INTRODUCTION

Soil liquefaction is a phenomenon that happens in loose saturated sand soil. Underground structures such as subway tunnels, water pipe lines and manholes buried in liquefiable soils would be damaged or loss their functions because of liquefaction occurrence in surrounding soil. These underground structures are classified as lifeline facilities which should keep their usage in acceptable region of engineering demand after strong earthquake to reduce number of death toll and save repairing expenditure. Fewer damages were reported to large underground structures in the past, but some damages to manholes and pipelines were observed in 1964 in the Niigata earthquake and the Alaska earthquake [1]. In recent century, sever damages to large underground structures such as subway systems were observed due to the development of urban zones [2]. Some examples of damages observed are the rigid-body motion of subway tunnels like uplift or floating due to liquefaction and structural destruction of subway tunnels like cracking or crushing of concrete with yielding of embedded reinforcing steel which is strongly related to shear deformation.

Various remedial countermeasures have been practically used to maintain underground structures functions. The main objective of these countermeasure procedures is suppression of liquefaction effect by means of prevention of excess pore water generation up to the effective stress; or reduction of liquefied soften soil deformation although pore pressure may rise. Examples of these countermeasure procedures against uplifting are densification or replacement of surrounding liquefiable soils, installation of gravel drainages, grouting and cutoff walls installation. The efficiency of sheet piles application as a countermeasure procedure against uplifting of underground ducts was studied by Kimura et al. in 1995 [3]. On the other hand, the interaction effect of cutoff walls on the structural damages of adjacent structure with increasing the shear deformation has been slightly studied. As a matter of fact, both the positive and negative effects of cutoff walls installation on adjacent subway behavior must be considered from the design point of view. In this paper, at first, the uplift mechanism of underground subway in liquefiable sand soil is accurately explained with numerical simulation. In the second stage, the mechanism of cutoff walls in reducing the uplift of structures is demonstrated and the efficacy of this procedure in seismic behavior of underground subway is numerically investigated. Also, the cutoff walls parameters variation effect on interaction behavior of the adjacent subway are explained by consideration of performance based design schemes, and the effectiveness of cutoff walls is discussed as a whole. At the end, the dense sandy soil columns without liquefaction potential are used next to the underground structure in exchange for cutoff walls and the subway responses are compared in these cases.