Mitigation of Surface Impact Loading Effects on the Underground Structures with Geofoam Barrier: Centrifuge Modeling

https://www.sciencedirect.com/science/article/abs/pii/S0886779817308398

Tunnelling and Underground Space Technology

Abstract

Studying the effect of dynamic loads on the underground structures and applying mitigation strategies to reduce these effects are important for the safe design of these structures. In this paper, the effect of dynamic loading on an underground structure and the performance of geofoam as a barrier were investigated using the centrifuge tests. Impact loading created by blast was used as an example of dynamic loads. Two sets of centrifuge experiments were performed to study different mitigation systems. The first set of the experiments included the a test without barrier, and the another test with a vertical geofoam barrier installed between the impact source and the underground structure. The second set of the experiments included the following three tests: the a test with no barrier between the impact source and the underground structure; the a test where a horizontal geofoam barrier existed near the source of the impact source,; and another test where a horizontal geofoam barrier existed near the underground structure. The results of the tests confirmed the effectiveness of the geofoam barrier against dynamic loading effects and indicated that the barrier effect was more prominent when it was installed near the structure. This study also provided better understanding of about the effect of impact loading effect on the underground structures and mitigation effects.

Keywords: Centrifuge, Physical modeling, Impact loading, Geofoam barrier, Underground structure

1. Introduction

Underground structures and utilities, including underground tunnels, subways, shelters, fuel supplysupplies, silos and water supply and sanitation systems constitute the infrastructure and essential parts of the modern cities. Operation of these structures and utilities during their service life and during emergency conditions is very important. It has been understood that underground structures are less vulnerable during natural disasters like earthquakes with respect to surface structures and are considered as the low risk structures against seismic loads (Kusakabe et al., 2008). However, these structures may be vulnerable against dynamic loads such as traffic load (car, high speed train), machine foundations load, pile driving and blast loading. The effects of such loads, applied exerted to underground structures, are in the form of vibration. The Ccharacteristics of various vibration sources are illustrated in Fig. 1 (Itoh, 2003). Pile driven and especially blast loading have more influence on deep soil layer than the loads of traffic and machine foundations loads.