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Seismic Response of Buildings Resting on Soil Isolated With EPS Geofoam Buffer

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ABSTRACT

The present study deals with analyzing the efficacy of EPS (epoxy polystyrene) geofoam buffer as a soil-isolation medium to reduce the seismic energy transferred and thereby to reduce the dynamic response of buildings under earthquake-induced loads. Finite element simulation of the transient response of an integrated soil isolation-building system in which buildings resting on raft foundation in medium dense sand beds with and without soil-isolation mechanism has been carried out using a recorded accelerogram of El Centro earthquake. Four sets of three-dimensional buildings (one, two, three, and four story) of single bay moment resisting concrete frames have been considered for the analysis. The EPS geofoam buffer of various thicknesses was placed at different depths below the raft foundation. The results under field-scale conditions indicate that soil isolation provided by the EPS geofoam buffer substantially reduces the earthquake energy transmission to the superstructure during a strong earthquake.

KEYWORDS

EPS Geofoam, Finite Element Simulation, Raft-Foundation, Soil Isolation-Building System

INTRODUCTION

Earthquakes prove to be the most damaging disasters today, affecting millions of buildings almost every year across the world. Either structures may be built to withstand the disruptive effects of earthquakes in order to provide healthy living environments, or seismic isolators may be provided to reduce these effects. There are different soil reinforcement materials used in the past inn order to increase the bearing capacity of soil and also to reduce the settlement in soil etc. In the last few decades, a significant amount of experimental research has been conducted to investigate the vibration screening problem. For example, Barkan and McNeill et al. were the first to report on actual vibration isolation applications. Here the material, EPS geofoam, its application as a vibration isolator is discussed in this study. EPS geofoam is available in numerous material types that can be chosen by the designer for a specific application. Its service life is comparable to other construction materials and it will retain its physical properties under engineered conditions of use. The lifetime of geofoam is about 70 to 100 years. The use of EPS typically translates into benefits to construction schedules and lowers

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the overall cost of construction because it is easy to handle during construction, often without the need for special equipment, and is unaffected by occurring weather conditions.

The generic term 'Geofoam' was proposed by Horvath (1992) to describe all the rigid plastic foams that are used in geotechnical applications. Later, the definition of geofoam was broadened to include any cellular material or product created by an expansion process. Expanded polystyrene (EPS) geofoam has been used as a geotechnical reinforcement material since 1960s. Because of its excellent mechanical properties such as light-weight fill, pressure reduction, noise and vibration damping, thermal insulation, and compressible inclusions, EPS geofoam has been widely used in geotechnical engineering (Aytekin, 1997; Zou and Leo, 1998; Horvath, 1997; Stark et al., 2004). Geofoam technology has since been used as a super light-weight embankment material for roadway and rail construction in Europe, Asia, and the United States (Frydenlund and Aabe, 1996; Miki, 1996; Bartlett et al., 2000, 2012a; Farnsworth et al., 2008; Riad et al., 2004; Snow et al., 2010).

Light-weight and compressibility are the two primary advantages of EPS geofoam that make it attractive for seismic design. EPS geofoam is approximately 1% weight of soil. As a light-weight fill, it reduces the loads imposed on adjacent and underlying soils and structures. And it is a challenging question that whether the light-weight or compressibility of the EPS Geofoam makes it suitable to give good isolation efficiency under ground motion (Nikolopoulou, 2006). Nikolopoulou (2006) demonstrated that the isolation efficiency of the EPS geofoam under weak and strong ground motions is derived almost entirely from low stiffness of the EPS material rather than its low density. The low weight of EPS geofoam provides a significant reduction in the seismic forces imposed on buried structures, retaining walls, pipelines etc. The range of density of EPS available is in between 10 to 40kg/m^3. But practically EPS with 15 to 30 kg/m^3 density is used (Horvath, 1999). Still many applications of EPS Geofoam have used 20kg/m^3 dense EPS geofoam. Studies show that the isolation efficiency increases with a decrease in the value of density of EPS geofoam. It can deform and act as a buffer to reduce the seismic energy imparted to the soil-structure system due to its moderate to high compressibility. EPS geofoam is available in a wide range of compressive resistances. Compressible applications utilize the compressibility of EPS geofoam to accommodate ground movements. While for many applications, EPS is designed for loading below the compressive resistance of 1%, it is designed for strains beyond 1% for compressive applications (Athanasopoulos, 2011). In civil defence engineering, EPS geofoam as compressible inclusions can be placed in the stress distribution layer to absorb blast-induced stress waves via its damping and diffusing functions. EPS geofoam serves more beneficial when in contact with expansive soils because it deforms and reduces the stresses transmitted to the relatively stiff structures by allowing the soils to expand, compress the EPS geofoam. It is not a general soil fill replacement material but is intended to solve engineering challenges. Geofoams perform functions that are not possible with conventional geosynthetic materials. EPS geofoam can be used to reduce the transmission of vibrations from earthquake motions, for example, under railways or pavements or as a part of the foundation of adjacent structures. Thermal insulation, light-weight fill, compressible inclusion and small-amplitude wave damping (ground vibrations and acoustics) are the main applications of EPS geofoam in the field. It is also expected that EPS geofoam inclusions in a defence layer will better absorb energy from blasting and seismic shocks and reduce the magnitude of stress waves. This technique is simple to implement in a short period of time and has no negative effects on nearby structures (Hazarika et al., 2003; Hazarika and Okuzono, 2004).

In a variety of circumstances, EPS geofoam may undergo cyclic loading. It may include traffic and dynamic loading. The majority of laboratory experiments and field findings indicate that the cyclic load response of block moulded EPS geo-foam is linearly elastic, providing that the strains are not more than approximately 1%. While three cycles are loaded to 10% strain (Eriksson and Trank, 1991), three loading cycle measurements, the initial tangent module in the second and third cycles is less than the initial tangent module in the first cycle. Studies regarding the numerical modelling of these buffer systems suggest that the horizontal seismic forces imparted to retaining walls and other