Seismic Protection of Buildings by Rubber-Soil Mixture as Foundation Isolation

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ABSTRACT

This article proposes a promising seismic isolation method especially suitable for developing countries like India. This scheme includes the use of a rubber soil mixture. Here, the performance of a well-designed layer of sand mixed with shredded rubber as foundation isolation is studied numerically. The computer software ABAQUS CAE has been employed to model the dynamic response of soil structure in this study. On the other hand, the use of scrap tires as the rubber material can provide an alternative way to consume the huge stock of scrap tire all over the world. Moreover, the cost of the proposed seismic scheme can greatly benefit low-cost houses for which resources and technology are not adequate for earthquake mitigation with well-developed yet expensive techniques. The proposed method has been demonstrated through a series of numerical simulation. On an average, the proposed scheme can reduce the horizontal ground acceleration by 50%. A parametric study also has been carried out here.

KEYWORDS

Damping, Peak Horizontal Acceleration, Rubber-Soil Mixture, Seismic Isolation, Tire

INTRODUCTION

For the past several decades an important issue for structural and geotechnical engineers is to find a way to reduce structural response caused by earthquake effects. Many concepts have been evolved regarding this purpose. There are numbers of the mechanism by which the dynamic control action is achieved. To find an economical and feasible way to protect structures from damages due to the earthquake is still an important aspect of civil engineering. One of the approaches used for this objective is seismic isolation system. A seismic isolation system is defined as a flexible or sliding interface positioned between a structure and its foundation for the purpose of decoupling the horizontal motions of the structure, thereby reducing earthquake damage to the structure and its contents. In the conventional approach, this objective is reached by designing a structure with adequate strength and ability to deform in a ductile manner. In this regards the necessary flexibility can be achieved by the use of rubber base isolation technique. Rubber bearing offers the simplest method of base isolation and they are being used for past three decades (Kelly, 1996). There are so many other base isolation

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systems which are already explored and reviewed by various researchers (Jangid & Datta, 1995, Patil & Reddy, 2012, Datta, 2003). But all those conventional systems are not feasible and economic for developing countries like India. United Nations Industrial Development Organization (UNIDO) active in developing low-cost seismic isolation system. The concept of low-cost and effective earthquake protection techniques using natural material like sand was looked at by Qamaruddin and Ahmad (2007), Feng et al. (1993), Nanda et al. (2012), etc.

Soil reinforced with natural rubber demonstrates an increase in energy dissipation capability (Edil & Bosscher, 1994) and can act as a low-cost base isolator. The feasibility of using shredded rubber mixed with sand as a natural base isolator was investigated analytically by Tsang (2008). Neoprene rubber cushions separate the violent shock waves in the ground from the building foundations and used tires have been proven to be a good shock absorber (Edeskä, 2010). Laminated rubber bearing is currently the most commonly adopted system due to the strength required in the vertical direction to support the full weight of the building. At present, owing to the tremendous cost of implementing base isolation technique, applications can only be seen in structures with critical or expensive contents.

There is an increasing interest in developing countries to apply low-cost seismic isolation to public buildings like office buildings, schools, hospitals etc. The significance is that the cost of isolation system used should be economic compared to the cost of replacement due to earthquake damages. In this paper presents results of numerical simulation of a 3D building model resting on a layer of sand and sand mixed with shredded rubber mixture as a low-cost isolation system in ABAQUUS environment. The effectiveness of the aforesaid isolation scheme is studied numerically, as well as parametric studies are also done.

**PROPOSED SCHEME**

The proposed technique is to replace the soil surrounding the foundation by Rubber-Soil Mixture (RSM). The primary mechanism for the reduction of shaking in the proposed isolation method is energy dissipation in a layer below the foundation of the structure. Rubber has excellent energy absorption capability that is why is used extensively for vibration control and dampening. As a source of rubber in the mixture, the scrap tires can be used which on the other hand will result in a beneficial way to reuse and recycle a huge stock-pile of used tires. The use of rubber is the key component in this method. The first use of rubber for earthquake protection of building structure was in Macedonia in 1969. This concept of reinforcing rubber is actually similar to the commonly adopted laminated rubber bearing. Also, the use of pure rubber is not recommended for RSM. Scrap tire is a suitable source of material for the proposed method. Scrap tire stockpile has been a significant disposal problem. It has been a hot topic among engineering community to find new beneficial ways to recycle and reuse the huge stockpile. Hence, the proposed seismic protection method presented in this paper provides a promising way to reduce the huge stockpile, especially that each project could use up a large volume of tires and make the isolator economic with respect to the conventional bearing.

The model consists of one bottom soil strata above which the buildings are modelled. Two three dimensional buildings, 2 and 4 storied two bay moment resisting RC frames are considered for the estimation of seismic response at the roof with and without providing RSM. The span of frames and storey heights are taken as 3.0 m in each case. The cross-section of the beams is taken as 500 × 500mm and for columns, it is 300 × 300. The material properties of frame elements are defined forM20 grade of concrete Here, the foundation of the structure used is a concrete footing of 8m X 8m with a depth of 2m. The frame structure has been embedded in the footing. The properties of embedment interaction are given as input. The model is represented schematically in Figure 1.

The computer programme ABAQUUS CAE has been used to model the dynamic response of soil and structure in this study. It is a finite element programme for different engineering applications in which soil models have been used to simulate the soil behaviour. The model consists of bottom soil strata and a frame structure on it. The frame structure is representing the building. The layer of the
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