

Novel STRP-SR and Maglev Seismic Isolators †

Arash Akbari Hamed ^{*‡}, Mahsa Saeidzadeh [‡], Hamid Reza Hassani Ghoraba [‡]
and Farid Ostadhasanzadeh Maleky [‡]

Faculty of Civil Engineering, Sahand University of Technology, Tabriz, Iran;
mahsa.saeidzadeh@yahoo.com (M.S.); hamidrezahassanighoraba@gmail.com (H.R.H.G.);
foh.maleky@gmail.com (F.O.M.)

* Correspondence: akbarihamed.a@sut.ac.ir

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‡ These authors contributed equally to this work.

Abstract: This research presents two innovative base isolators known as the Scrap Tire Rubber Pad with Steel Rods (STRP-SR) isolator and the Magnetic Levitated (Maglev) isolator. The STRP-SR isolator offers a cost-effective solution for low-rise buildings, while the Maglev isolator provides an ideal bearing with zero horizontal stiffness. In this study, both the STRP-SR and Maglev isolators were analyzed numerically, and the experimental specimen of the Maglev isolator was tested on a shaking table. It can be concluded numerically that both isolators have the ability to significantly reduce absolute acceleration and displacement values, with average reductions of 53.24% and 100%, respectively.

Keywords: magnetic levitation; scrap tires; seismic base-isolator

1. Introduction

Conventional base isolators are associated with two primary concerns: firstly, a high cost of production, and secondly, the presence of a certain degree of horizontal lateral stiffness. In order to address these issues, this research introduces two innovative base isolators, namely the Scrap Tire Rubber Pad with Steel Rods (STRP-SR) isolator and the Magnetic Levitated (Maglev) isolator. A comprehensive study on the STRP isolator was previously conducted by Mishra [1]; however, it has been observed that the amount of energy dissipation is limited and there is a shortcoming in terms of over-turning. Therefore, it is necessary to address the aforementioned issues by enhancing the seismic performance of STRP isolators. The Maglev isolator is introduced to provide an ideal bearing with zero horizontal lateral stiffness. The concept of the Maglev isolator is inspired by magnetic levitation technology [2].

2. Materials and Methods

As depicted in Figure 1a, the STRP-SR isolator is introduced as a means to reduce production costs. This isolator consists of bonded piled up scrap tire pads accompanied by four steel rods. It is specifically designed for implementation in light buildings of low importance. On the other hand, the Maglev isolator (Figure 1b) utilizes magnetic levitation technology to suspend the building with no physical contact with the ground, thereby eliminating horizontal lateral stiffness. In this research, the STRP-SR bearing was subjected to numerical analysis under compressive and cyclic shear loadings. The effectiveness of the STRP-SR bearing was evaluated for a model of a two-story isolated building using ABAQUS software. Furthermore, the Maglev bearing was examined numerically using COMSOL software, with dynamic sinusoidal loadings at frequencies of 2 Hz and 4

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Hz. Additionally, an experimental specimen of the Maglev bearing was tested on a shaking table.

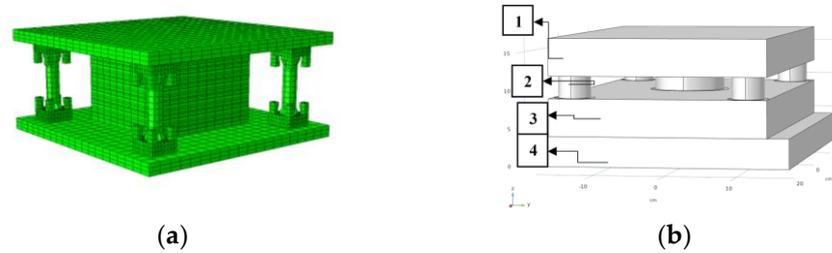


Figure 1. (a) The STRP-SR model; (b) The Maglev model.

3. Results and Discussion

With regards to the results obtained, it is evident that the conventional unbonded STRP isolator (Figure 2a) experienced over-turning, resulting in an unstable hysteretic curve with a degradation in strength and stiffness (Figure 2c). Conversely, the use of bonded scrap tire layers in the novel STRP-SR isolator produced a stable hysteretic curve with a doubled strength value and eliminated the detachment of rubber corners (Figure 2c). The STRP-SR isolator, which was subjected to a constant compressive axial pressure of 6 MPa, dissipated the induced energy through the built-in steel rods, which generated friction between the spherical part of the rods and the inner surface of the bowl-shaped parts located above and below them (Figure 2b). Consequently, the energy dissipation capacity of the STRP-SR was significantly increased. Upon comparing the displacement variation obtained from fixed-base and isolated finite element models in the frequency domain, it can be concluded that the introduced Maglev isolator achieved the primary objective of zero lateral stiffness and complete separation of the building from the ground, thereby ensuring the safety of the building during severe earthquakes. However, upon testing an experimental specimen of the Maglev isolator, it was observed that while the amount of acceleration was significantly reduced, it was not completely eliminated.

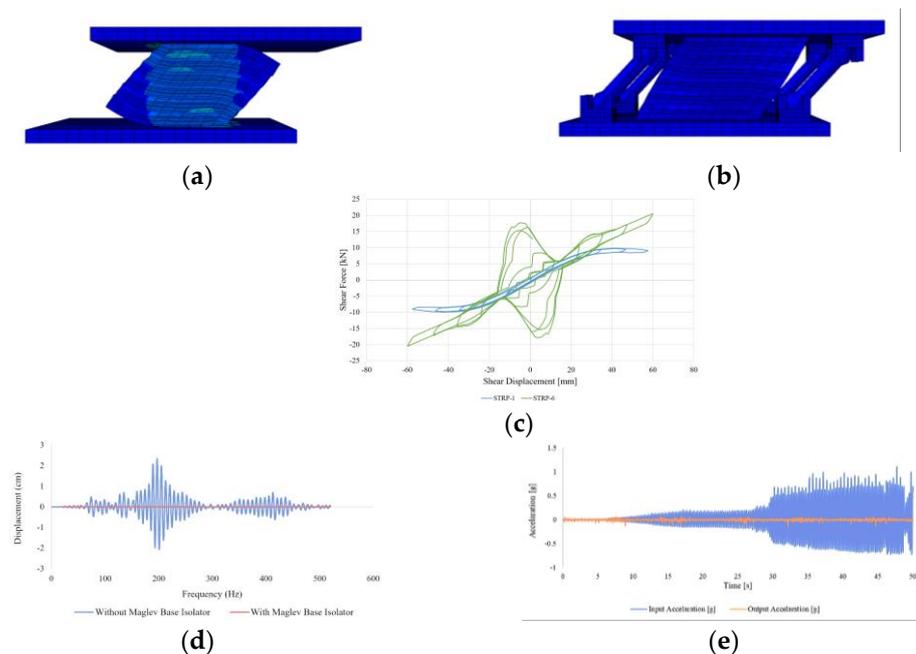


Figure 2. (a) The deformation status of an unbonded STRP; (b) The deformation status of the STRP-SR; (c) Comparison of the hysteretic curves obtained for unbonded STRP (STRP 1) and STRP-SR

(STRP6) isolators; (d) The numerical variation of displacement for the Maglev isolator in the frequency domain; (e) The acceleration time-history for the experimental specimen of Maglev isolator.

4. Conclusions

Based on the acquired numerical findings, it has been deduced that the STRP-SR and Maglev bearings possess the ability to diminish the absolute acceleration and displacement values by mean percentages of 53.24% and 100% correspondingly. This underscores their efficacy in ensuring the safety of isolated structures. The experimental outcomes for the Maglev isolator indicated that the aforementioned reduction percentage was lowered to an average of 74.67%, which remains an acceptable value in terms of the practical bearing's efficiency.

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