A Study on the Use of Orthogonal Pairs of Rods on Concave Beds (OPRCB) as a Base Isolation Device for Buildings Systems

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ABSTRACT

A somehow new isolating device consisted of an Orthogonal Pairs of Rods on Concave Beds, which does not need high manufacturing technology, is investigated. Rolling rods installed in two orthogonal directions make possible the movement of the superstructure in all horizontal directions, and the concave beds give the system a hardening stiffness and the re-centering capability. The results of experimental and numerical studies of the device's mechanical features are presented. These include experimental load-displacement relationship of rollers and verification of the finite element models under vertical loads up to 70.0 tonf, almost equivalent to the columns' loads of 5-story buildings.

Keywords: Orthogonal rollers, Base isolation, Rolling resistance, Nonlinear equation of motion

1. Introduction

Seismic isolation gives the structure a fundamental frequency that is much lower than both the frequency of fixed-based structure and the predominant frequencies of ground motions. The first dynamic mode of the isolated structure involves deformation only in the isolation system, and the participation of its higher modes is relatively very low in the motion, so that the high energy in the ground motion at these higher frequencies cannot be transmitted into the structure (Naeim and Kelly, 1999 [1]). During recent decades many seismic isolation devices have been developed to deal with the growing need for practical applications. Among them, lead-rubber bearing (LRB), high-damping rubber bearing (HRB), and friction pendulum system (FPS) are well-developed devices, because these devices meet better the three major criteria of simplicity, reliability, and cost-effectiveness. The FPS adopts a curved sliding surface so that the restoring force can be provided by the weight of its supported structure. However, the curved sliding surface may result in increased horizontal force with larger displacement. One effective approach to further reduce the transmitted forces by the FPS is to adopt a rolling mechanism instead of sliding, since rolling friction is less than sliding friction. In this regard Lin and Hone (1993) [2] studied an isolation system in the form of circular rolling rods. Lin and his colleagues (1995) [3] also conducted shaking table tests to investigate a one-story frame isolated by the free-rolling rod system.

In those works the rolling rods were considered without any restoring force. As a result, there were more peak and residual base displacements. To overcome this difficulty Jangid and Datta (1995) [4] suggested the use of elliptical rods instead of the circular rods. However, the elliptical rolling rods may induce some vertical acceleration into the superstructure. The other alternative is to use some re-centering device along with circular rolling rods to provide the restoring force for controlling the base displacement. Jadgid (2000) [5] investigated the seismic response of flexible multi-storey buildings mounted on rolling rods with a re-centering device to non-stationary earthquake excitation. He has shown the rolling rods are quite effective in reducing the earthquake response of the superstructure, and also that the presence of a re-centering device significantly reduces the relative base displacement without transmitting additional accelerations into the superstructure. A sloped rolling-type bearing (RTB), which utilizes the concept of a steel cylinder rolling on a V-shape surface, has been also proposed to provide the restoring force (Lee et al., 2003 [6]; Wu et al., 2004 [7]). Recently, Tsai and his colleagues (2007) [8] have conducted shaking table tests to investigate the seismic behavior of a 1/7.5 scaled bridge model isolated by the RTBs. The scaled bridge model has been designed to simulate one vibration unit of a multi-span, simply-supported highway bridge. Constant horizontal force is transmitted through the RTB when the sloped rolling mechanism is triggered. Since the