Seismic Response Prediction of Base Isolated Multi-Span Highway Bridge With Different Modeling Techniques for Lead Rubber Bearings.

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Summary

The effect of modeling of lead rubber bearings (LRBs) on seismic responses of the isolated bridge is evaluated by conducting nonlinear dynamic analyses. The model parameters used in the simulation have been identified from experimental measurements under room (+23^{o}C) and low temperature (-20^{o}C) conditions. Three different analytical models of the isolation bearings (LRBs) are considered in simulation for comparison; the conventional bilinear model as specified by Japan Road Association (JRA) and American Association of State Highways and Transport Officials (AASHTO), a rheology model and a simplified model. The general rheology model considers the observed nonlinear elasto-plastic and viscosity induced rate-dependent behavior into account, while the viscosity effect is eliminated in the simplified version. A tri-linear hysteretic model is employed in the analysis for representing the nonlinear mechanical behavior of the concrete bridge pier. A numerical algorithm for solving the first order governing differential equation of the rheology model has been developed to implement the proposed models into a nonlinear dynamic analysis software. Six different strong ground motions of level-2 earthquake as recommended by JRA, applied in the longitudinal direction, are used in the analysis. The seismic response of an isolated bridge system is studied by comparing the rotation responses of the plastic hinge in concrete piers and shear strain responses at the top of the bearings for different modelling techniques of an isolation system. Finally, a comparative assessment of the bridge responses suggests that a careful selection of isolation bearing's model considering rheology properties is vital for rational prediction of the seismic response of isolated bridge systems, particularly at low temperature condition.

Keywords: Nonlinear dynamic analysis, isolation bearings, bilinear model, rheology model, simplified model, nonlinear elasto-plastic, rate-dependent behaviour, seismic response.

1. Introduction

The use of base isolation is widely increasing in Japan, especially in the aftermath of the Kobe earthquake occurred in 1995. The base-isolation system with laminated rubber bearings is considered to be an efficient technology for providing mitigation for seismic damage for structures and equipments and has proven to be reliable and cost effective [1]. Three types of bearings are commonly adopted for this purpose: natural rubber bearings (RBs), lead rubber bearings (LRBs) and high damping rubber bearings (HDRBs). Of these, HDRBs exhibit nonlinear rate-dependent hysteresis [2]. On the basis of the experimental observations of HDRBs, an elasto-viscoplastic rheology model has been developed by Bhuiyan et al. (2009a) considering the nonlinear rate-dependence and elasto-plastic behavior. This model is capable of reproducing the above-mentioned mechanical behavior of HDRBs. On the other hand, RBs and LRBs acquire nonlinear elasto-plastic behavior along with comparatively

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