Nonlinear Behavior Identification of HDR-S Bearing Using Neural Network for Seismic Structural Design

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Abstract

The initial parameter selection is the bottleneck of optimization method in determining the nonlinear parameter of seismic isolators during seismic isolation design. Bilinear model is easy to understand physically but more complicated nonlinear models are hard to explain due to hidden characteristics. Therefore, this study used a machine learning based approach which aims to classify the suitable nonlinear model and predict the nonlinear parameters of an HDR-S experiment data at both low and room temperature. The trained neural network model A shows that at low amplitude, Bilinear Model was classified, however at higher amplitude, Modified Park-Wen model governs. On the other hand, neural network model B successfully predicted the five parameters of Modified Park-Wen model and solve the initial parameter assumption problem of KH Method. The proposed inverse approach can be used to train an ANN model using more complicated nonlinear models.

Keywords: neural networks, rubber bearing, nonlinear numerical simulation, HDR-S bearing

1 Introduction

This study proposed two AI based design approach to solve the problem of model selection and initial parameter identification in determining the nonlinear parameter of seismic isolators prior to seismic isolation design. Deploying isolation devices like elastomeric bearings in bridges is an effective method to increase the damping and reduce the seismic forces effect on the structure. Among the seismic elastomeric bearings, Super High Damping Rubber (HDR-S) bearing increase the damping by 20% compared to High damping rubber (HDR) bearing and is currently widely use on bridges in Japan [1]. However, after the 2011 Tohoku earthquake, there were several recorded damages of elastomeric bearings [2]. This serves as a wake-up call that the design of these seismic isolators should be investigated further. Relative to the seismic isolation design of bridges, the main focus is to increase the damping characteristics which improves the energy dissipation and decreases the seismic forces transmitted to the structure, this leads to continuous development of new types of seismic isolators [3].

In current design, nonlinear time history simulation is the most effective method to seismically isolate the structural members however the nonlinear properties of the elastomeric bearing must be defined more realistic. The mechanical behaviour of HDR-S is strongly dependent by the inner temperature. This phenomenon is needed to take in consideration specially on application to cold regions [4]. Thus, the main important key point is to determine the realistic nonlinear behaviour of