A Thermo-mechanical Coupled Model of Hysteresis Behavior of HDR Bearings

Yuqing Tan, Akira Igarashi

Kyoto University, Uji, Kyoto, Japan

Ji Dang

Saitama University, Saitama, Saitama, Japan

Takehiko Himeno, Yuki Hamada

Kawakin Core-Tech Co., Ltd., Yuki, Ibaraki, Japan

Contact: igarashi.akira.7m@kyoto-u.ac.jp

Abstract

The hysteretic behavior of High Damping Rubber (HDR) bearings is significantly affected by inner temperature and hysteresis self-heating interactions, the stiffness of HDR is increased at lower inner temperature. To introduce the HDR bearings in cold earthquake prone regions, a temperature-dependent hysteresis model is of great concern. In this study, a thermo-mechanical coupled model is proposed for HDR bearings. The model parameters are identified from quasi-static loading tests at ambient temperatures of 23°C, 0°C and −20°C, and the validity of the model is discussed based on a comparison of the numerical seismic response of a bridge model using HDR bearings with the hybrid simulation result at 23°C, 0°C and −20°C. An acceptable agreement can be observed between the model and test result at the 23°C and 0°C under seismic loading conditions.

Keywords: High damping rubber bearing; restoring force model; temperature effect; self-heating; hybrid simulation.

1 Introduction

It is known that the restoring force of High Damping Rubber (HDR) bearings under shear deformation shows considerable temperature-dependence and increases under low ambient temperature environment compared with the case of normal ambient temperature. There have been a number of restoring force models for HDR bearings considering ambient temperature dependence proposed in previous studies. For example, Nguyen et al. [1] proposed a rheology model to describe the rate-dependent hysteresis behavior for HDR bearings at different ambient temperatures. Hwang et al. [2] improved the fractional derivative Kelvin model with consideration of the beginning ambient temperature effect. However, it has been found that the load-displacement behavior of HDR bearings is highly dependent on the inner temperature rather than the ambient temperature, and the stiffness decreases as the number of cyclic deformation increases due to self-heating of the