

# Evaluation of Seismic Performance and Proposing the Reinforcement Methods for the Bridge with Rocking Piers Penetrating the Railway Platform

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## Abstract

Among the notable damage to the expressway in the 2016 Kumamoto earthquake is the collapse of bridges with rocking piers. If the hinges of the rocking piers are damaged by an unexpected earthquake, the entire bridge system may collapse because bridges with rocking piers don't have structural redundancy. In this paper, a bridge with a unique rocking pier penetrating a railway platform is focused on. We evaluated the seismic performance of the bridge, verified the collapse process, and proposed seismic reinforcement methods. Based on the results, it was confirmed that the displacements of the rocking pier exceeded the allowable values for an extreme earthquake. We proposed a measure to suppress the displacements and building a new pier to support the superstructure so that the collapse of the rocking pier would not lead to a bridge collapse.

**Keywords:** Rocking pier, dynamic analysis, pushover analysis, seismic performance evaluation

## 1 Introduction

Many infrastructures were severely damaged by the 2016 Kumamoto earthquake. In particular, among the notable damage to expressways is the collapse of bridges with rocking piers. A rocking pier has hinges at the upper and lower ends and it cannot stand alone. Figure 1 shows a rocking pier bridge damaged by the Kumamoto earthquake and the state of the rocking piers. In response to this type of damage caused by the Kumamoto earthquake, the Japanese government requires road managers to implement appropriate seismic

reinforcement measures for bridges with rocking piers and issued basic guidelines for seismic reinforcement, including examples of seismic reinforcement methods [1]. There are several bridges with rocking piers in the Hanshin Expressway network, and we have been taking



Figure 1. Damage of rocking piers