Analysis of Seismic Damage Mechanism for Plain Concrete Pier of Railroad Bridge and Proposal of Seismic Retrofitting Methods

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Key Words: Plain concrete piers, Cold joint, Horizontal gap, Refined DEM, Earthquake, Seismic retrofitting methods

1. Introduction

Serious damage to plain concrete piers of railroad bridges has been caused by large earthquakes such as the 2004 Mid Niigata Prefecture Earthquake. The typical damage is horizontal gap on the cold joint of a pier (Fig.1-left). The RC jacketing method is generally used for retrofitting piers, but this method cannot be used for bridges on the river because cross-sectional area of a river is reduced. Therefore the seismic retrofitting method that does not reduce cross-sectional area of a river is required. This study analyzes damage to Uonogawa bridge that is located in Niigata Prefecture using a refined version of the distinct element method (Refined DEM)[1] and proposes the seismic retrofitting methods. In addition, since it is said that Nankai Trough Earthquake will most likely occur, this study evaluates the seismic safety.

2. Refined DEM

In refined DEM, a structure is modeled as an assembly of rigid elements like the DEM. The improvement point is that the surface of an element is divided into many segments and both a spring and a dashpot are attached to representative points of segments. By discretizing the surface of elements, the spring constant is derived theoretically based on 3-dimensional stress-strain relationship.

3. Analysis

Seismic behavior of the pier of Uonogawa bridge is simulated by two types of the ground motions: the 2004 Mid Niigata Prefecture Earthquake and simulated Nankai Trough Earthquake (Fig.1-right). Then horizontal gap on the cold joint is caused. Therefore this study proposed three kinds of the seismic retrofitting method that can inhibit horizontal gap: retrofit with H-steels (Fig.2), retrofit with steel plate, and retrofit with steel bars. Seismic behavior of the analysis models for these methods is simulated and the validity of these methods is confirmed.

4. Conclusion

In this study, an existing bridge pier is took as an example, and simulated by using refined DEM. Seismic behaviors of the plain concrete pier were revealed and its weakest points for an earthquake were shown in the simulations. Three kinds of seismic retrofitting model were proposed and the validity of these methods was verified by the fracture analysis.

Reference

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2) Disaster Investigation Team of Kyushu Institute of Technology : The 2004 Mid Niigata Prefecture Earthquake.－the Second Disaster Investigation －, http://www.civil.kyutech.ac.jp/pub/kosa/ijikenHP/tyuuetujisin20041025.pdf

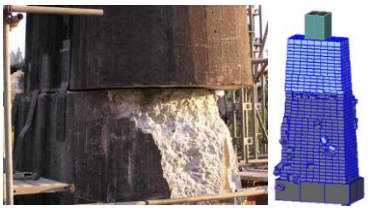

Fig.1 Horizontal gap on the cold joint[2](left) and Reproducible analysis(right)

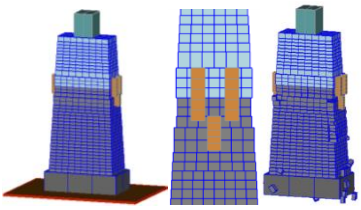

Fig.2 Retrofit with H-steels (left : general view, center : side view, right : analysis result)