Failure Prediction of Full Scale Bridge Pier on 3D Shaking Table Test

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Summary

This analytical study was programmed to predict the dynamic response of a full scale reinforced concrete (RC) bridge pier model in shaking table test. The results of dynamic finite element analysis (FE analysis) using 'FINAL' well agreed with the results of the test about the dynamic response and the failure time of the model with rebar cut-off sections. The data about bond slip of longitudinal bar and strain of hoop were insufficient to predict the brittle failure time of the pier quantitatively. In this study, it was obtained that the criterion focusing on the increment of softening concrete element number is useful to predict the brittle failure time.

Keywords: RC bridge pier; rebar cut-off section; shaking table test; FE analysis.

1. Introduction

1995 Kobe earthquake in Japan caused heavy damage to the traffic life-lines. A representative example is collapse of elevated bridge piers for expressway. The pier had rebar cut-off sections where the number of rebar layer was reduced according to reduction of bending moment.

Failure mode of the pier with rebar cut-off section depends on the characteristics of seismic motion, such as, amplitude and cyclic number of seismic load. For example, such piers of bridge across railroad have not collapsed by 2004 Chuetsu earthquake in Japan, even though its covering concrete fell off the pier. Many experiments were conducted before Kobe earthquake to ascertain failure mechanism of the pier with rebar cut-off section. As a result, a criterion for determining whether the rebar cut-off section causes a failure of pier was established [1]. However, a pier deformation or shear force at failure time is unable to be evaluated quantitatively by the criterion.

In 2008, a shaking table test using a full scale bridge pier model with two rebar cut-off sections were conducted by National Research Institute for Earth Science and Disaster Prevention (NIED). The purposes of the test were to investigate the mechanism of failure at rebar cut-off section and to enhance the accuracy of failure prediction by numerical analyses. The test was held at E-Defense: 3-dimensional (3D) full scale earthquake testing facility in Japan constructed by NIED. Collaterally, an analysis contest on the shaking table test was held. The authors predicted the failure time and failure mode of the pier with good accuracy by using 'FINAL': a nonlinear FE analysis program developed by Obayashi Corporation, and we won the first prise in the contest.

This paper describes the outlines of shaking table test and the predicting analysis model, prediction process of failure time, and comparisons of the test and the analysis results.

2. Outline of 3D Shaking Table Test

2.1 Analysis contest

In the analysis contest, failure time and failure mode were evaluated by comparing with the test and the analysis results. The contest had two divisions: the Fiber analysis division (using fiber elements) and the FEM analysis division (using continuum elements).

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