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Photogrammetric measurements of RC bridge column deformations

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ABSTRACT

The determination of the location of nonlinear response in structural systems is an important step to predict the performance of the system under different loading conditions. In bridge columns, these nonlinear deformations generally occur over a finite hinge length. A model of hinging behavior in reinforced concrete bridge columns will help guide proportioning, detailing and drift estimates for performance-based design. Data was collected during the NEESR investigation of the seismic performance of four-span large-scale bridge systems at the University of Nevada Reno that details deformations in column hinging regions during response to strong shaking events. A photogrammetry method was applied using a reference grid on the top and bottom column surfaces to record and analyze deformations in the plastic hinging regions. The method of application in this study holds several advantages over traditional sensors including that it is a remote visualization technique, inexpensive and simple to analyze the results. The surface deformations and rotations of a reinforced concrete bridge column under dynamic loading has been examined and compared with the results obtained from traditional instruments. The photogrammetry method performed very well to track the lateral and vertical displacements at the points on the grid surface as well as the deformed shape of the hinging regions, but the results of secondary calculations, such as rotations of the column, had limited success.

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1. Introduction

This research aims to record and analyze deformations in plastic hinging locations in concrete bridge structures through an investigation of actual hinging behavior in large-scale tests of bridge systems subjected to multiple excitations. In order to evaluate the behavior of plastic hinging regions, a photogrammetric method was used to remotely track deformations of the concrete surface. Photogrammetry is a non-invasive technique of remote visualization of the target components and a computer rendering of the motion [1]. The tracked motion of the target components, which were discrete points on the column surface along the joint regions, was reduced using a computer program to obtain the lateral displacements of the points and to calculate the vertical and cross-sectional rotation between these points. Photogrammetry measurements were recorded at the bottom and top hinging regions of the column. The analysis of simple and inexpensive photogrammetric data was the main focus of this study.

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2. Experimental program

Previous research of reinforced concrete column hinging behavior has focused on small-scale component tests under static loadings. Most of these tests were of cantilever columns in single curvature response [2–15]. Only two studies have included dynamic tests of reinforced concrete bridge columns to determine the deformations in hinging regions [16,17]. The four-span reinforced concrete bridge that was tested at the University of Nevada Reno (UNR) laboratory on February 12–15, 2007 was significant because it was a large-scale bridge system with columns in double curvature response. In addition, strong earthquake motions were applied in the longitudinal and transverse directions of the bridge.

Traditional instrumentation that has been widely used to collect deformation data from static and dynamic tests includes LVDTs (linear variable differential transformers), displacement transducers, accelerometers, and strain gages. These instruments are attached to the concrete surface and require electrical connection to a data acquisition system. As damage occurs to concrete elements, the cover concrete can spall, gages can fail, and data may be lost. A newer method used to collect deformation data is by photogrammetry with an advanced non-contact measurement system such as the Krypton system [18].