New Method For Mitigation of Concrete Bridge Piers

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Abstract

To control the residual displacements of concrete structures under severe earthquakes, there are a few efficient methods. All of these methods have been imposed self-centering tendency by post-tensioning technique. There are several examples of damaged bridges that have lost their serviceability and safety due to large residual displacements of their piers (columns) after severe earthquake. Even though seismic codes ensure life safety for bridges, large residual displacement after severe earthquake may make the bridge useless. In this paper, a new method is proposed in order to reduce the residual displacements of concrete columns. The optimized position and percentage of high strength rebar will also be determined to minimize residual displacements. Result of analyses revealed that this method can effectively reduce residual displacements.

Keywords: Residual Displacement, Self-Centering Tendency, High Strength Rebar

1. INTRODUCTION

In recent years, a high ductility capacity is expected of bridge columns located in regions of high seismicity, like California and Japan, to ensure economical designs with adequate protection against collapse during strong ground shaking [1].

Even though seismic codes ensure life safety for bridges, large residual displacement after severe earthquake may make the bridge useless. For example, after 1995 Hyogo-ken Nanbu earthquake (Japan), more than 100 reinforced concrete bridge columns experienced a tilt angle of more than 1 degree (1.75% drift). These columns had to be removed and new columns built because of the difficulty of setting the superstructure back to the original alignments and levels [2]. So, controlling the residual displacement of bridges would keep fundamental infrastructures safe and functional.

Several new structures have been developed to reduce residual displacements in which post-tensioning technique as well as unbonded strands and rebars were essence of these methods. Experimental studies on precast beam-to-column joint subassemblages with unbonded posttensioning were conducted by Priestley & MacRae [3]. Another design concept utilizing both unbonded posttensioning and mild steel in hybrid moment-resisting precast connections was tested by Stanton et al. [4]. Both of these studies showed that the use of unbonded posttensioning greatly reduced residual drift. Iemura et al. proposed the use of unbonded high-strength bars in reinforced concrete bridge columns to obtain positive post-yield stiffness, thus reducing the residual displacements [5].

Last innovative method for reduction of residual displacements of concrete columns has been developed by Mahin & Sakai [5, 6, and 7]. They replaced some mild rebars of concrete columns with a longitudinal post-tensioning tendon at the center of columns section. One of their dynamic test showed that this method can reduce residual displacement of circular column with the height of 2.44 m and 40.6 cm in diameter from 28.5 cm to 10.7 cm. Finally, they added a steel jacket to provide additional confinements in the region of plastic hinge. However their dynamic analyses provided poor estimations of residual displacements.

In this paper, a new method will be proposed to reduce residual displacements by the use of High Strength Rebars (HSR). This method is different from the most researched method for reduction of residual displacement, i.e., post-tensioning technique. Some HSR will be replaced or added to the column's section as closed as possible to the center of columns.