Seismic Performance of Precast Segmental Bridge Piers with High-strength Bars based on Cyclic Loading Test and Numerical Simulation

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Abstract

Compared to cast-in-place (CIP) piers, precast segmental bridge piers benefit the accelerated construction, and easy-to-repair after an earthquake. Nevertheless, precast segmental piers also suffer from lower energy dissipation capacity. High-strength bars (>500 MPa) incorporated with precast piers, as energy dissipation bars, have great potential to improve their seismic performance. This paper presents the cyclic loading tests of the ductile, flexural-dominated precast piers with both high-strength (HRB600) and conventional (HRB400) bars. The experiment witnessed the minor damage in the plastic hinge zone and small residual displacement. With respect to conventional bars, high-strength bars apparently enhanced not only load capacity but energy dissipation. The skeleton curve of cyclic loading test can be precisely predicted by the analytical pushover method, which is based on the plane assumption and considers the effect of bond length between high-strength bars and the grouting mortar. A new finite element model based on the fiber-cross section implemented in Opensees, is proposed and capable of accurately simulating the hysteretic behavior of these precast piers.

Keywords: precast segmental pier; high-strength reinforcement; pushover; fiber model; hysteretic curve.

1 Introduction

Precast bridge piers became attractive due to its great advantages over on-site construction piers: fast construction, high quality control, low environmental impact, low life-cycle cost, etc. In spite of these advantages, precast segmental piers have mainly been constructed extensively in low seismicity areas. The further application in high seismicity areas is hindered due to the lack knowledge of their seismic behaviors triggered by the joints between segments.

Numerous experiments were performed to investigate seismic behaviors of precast segmental piers with conventional (denoted as "L" hereafter) reinforcements [1][2] as energy dissipation (ED) bars. Recently, high-strength (denoted as "H" hereafter) ED bars with yield strength greater than 500 MPa have been employed in practice. Due to the high strength and greater energy dissipation capacity [3], "H" ED bars are expected to enhance seismic behaviors of concrete members. With the equal strength, "H" ED bars can alleviate the congestion of "L" ED bars frequently occur at the junctions of different concrete members. Nevertheless, only a few researchers began to adopt "H" ED bars in bridge piers until recently [3] [4]. The research of precast segmental piers with "H" ED bars is even insufficient.

In this study, three precast segmental piers were fabricated and tested under cyclic loading, and they were compared with the CIP pier from Wang's test [5]. The effects of construction strategies, "L" or "H" ED bars, and reinforcement ratios on seismic behaviors of bridge piers were experimentally investigated. An analytical method is proposed for

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