Cyclic Behavior of Precast Segmental UHPFRC Bridge Columns with Replaceable Damage-Concentrated Elements

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Abstract

A novel precast segmental bridge column was put forward innovatively to contribute to accelerated bridge construction and rapid repair of bridge after earthquake, which is in accordance with the theme called engineering innovations for rapid urbanisation. The proposed bridge column was manufactured with cost-effective ultrahigh performance fiber-reinforced concrete (UHPFRC) incorporating river sand and coarse aggregate. As the potential damaged region, the bottom segment was composed of three parts: inner core zone designed to bear axial loading, outer replaceable UHPFRC plates (RUP) designed to bear lateral loading, and middle replaceable steel dissipaters (RSD) designed to enhance energy dissipation (ED), when the entire bridge structure was subjected to earthquake shock. The rapid repair after earthquake was completed with substitutions of replaceable damage-concentrated elements including RUP and RSD. Cyclic loading tests were conducted on three 1:3 scaled specimens and their repaired specimens. The research parameters included posttensioning (PT) force level and usage of RSD. Test results show that both construction and repair can be very time-saving for the proposed bridge column. Major damage focuses on replaceable damage-concentrated elements while remaining parts are basically intact. All the specimens present good deformation capacity and excellent self-centering feature. Two different failure modes can be found: some specimens failed in the lateral bearing capacity while others failed in the ED capacity. Compared with the original specimen failed in the same failure mode, the repaired specimen has similar lateral bearing capacity and deformation capacity but seriously weakened initial stiffness.

Keywords: bridge column; cyclic loading test; resilience; replaceable element; ultrahigh performance fiber-reinforced concrete (UHPFRC); self-centering; precast segmental construction

1 Introduction

Recent researches showed that precast segmental bridge columns with posttensioning (PT) tendons not only possess advantages of accelerated bridge construction (ABC) but also present self-centering capacity [1]. But for the original design without energy dissipaters, two problems are required to be solved: one is that concrete crushing easily occurs at plastic hinge regions; the other is that energy dissipation (ED) capacity is poor during earthquake shock.

Because of its high strength, superior ductility and enhanced durability, ultrahigh performance fiber-reinforced concrete (UHPFRC) has been tried to be employed in cast-in-place bridge columns as construction material for entire members [2] and used in precast bridge columns as grout material [3]. River sand and coarse aggregate could be incorporated into UHPFRC to make UHPFRC be cost-effective [4]. Utilizing the cost-effective UHPFRC in plastic hinge regions becomes a meaningful choice to solve the first problem. In addition, precast segmental bridge columns would

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