PRECAST SEGMENTAL POST-TENSIONED CONCRETE BRIDGE COLUMNS FOR SEISMIC REGIONS

by

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ABSTRACT

Precast concrete bridge construction has been proved to be an efficient solution in accelerating bridge construction and minimizing traffic disruption. However, due to concerns with the seismic performance of such type of construction, its application in seismic regions is limited. This research presents results of the development of precast segmental post-tensioned concrete bridge columns for use in seismic regions. The developed bridge columns adopted unbonded post-tensioning systems to decrease prestress loss due to strong seismic events. In addition, to increase hysteretic energy dissipation, mild steel energy dissipation bars (ED bars) which are continuous across the segment joints are added to the columns. Moreover, the ED bars are additionally unbonded at the critical joint to avoid premature fracture.

A simplified analytical model for static pushover analysis and a three-dimensional detailed finite element model for cyclic analysis of the proposed bridge columns are developed in this research. In addition, a stiffness degrading hysteretic model is proposed for response-history analysis. With the analytical models, a parametric study is conducted to examine the seismic performance of the proposed columns with different design parameters.

A two-phase experimental program is designed to verify the findings of the analytical study and to address constructability issues of the proposed segmental columns. The first phase focuses on testing of the ED bars at the critical joint. A methodology is proposed to design the additional unbonded length for the bars, taking into account low cycle fatigue of steel and progressive damage of bond. The second phase is testing of seven large scale segmental column specimens. Each specimen has a foundation, four precast column segments with hollow cross sections and a precast cap beam with a total height of 5.7 m (18.7 ft). Four specimens are tested with cyclic loading and three with pseudo-dynamic loading. The test results show that three types of ductile precast segmental columns are successfully developed with different hysteretic characteristics in terms of energy dissipation, lateral strength and residual displacement.

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