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Analytical Study Assessment of a Bridge with Pretensioned Rocking Columns for Rapid Construction

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Abstract

A two-span, quarter-scale, precast concrete bridge with pretensioned rocking columns was tested on the shaking tables at the University of Nevada, Reno in 2014. The columns were designed with partially unbonded strands to provide re-centering; locally debonded reinforcing steel to delay bar fracture; and confining steel tubes at their ends to protect the concrete against spalling. The residual drift ratios in the bridge were never larger than 0.4%, even after peak drift ratios more than 12%. The only major damage observed during testing was the fracture of the deformed bar reinforcement, first occurring at a drift ratio of 5.7%. To investigate methods to delay bar fracture in this bridge, analytical models were developed and calibrated using the experimental results. These models suggest that low-cycle fatigue likely caused reinforcement fracture in the tests and fracture could be delayed by using a longer debonded length of the reinforcement.

Keywords: bridges; rapid construction; shake-table; pre-tensioned concrete; connection; precast concrete; seismic; low cycle fatigue; analytical modelling; rocking structures

1 Introduction

New bridge systems have been developed that attempt to delay, or even eliminate, damage to the column concrete after an earthquake. In order to prevent cover spalling, these systems provide confinement to the plastic hinge regions of the column through either steel jackets [1, 2] or fibre reinforced concrete [3, 4]. Retaining the concrete cover prevents bar buckling, and the absence of bending strains delays fracture of longitudinal reinforcement until the onset of axial low-cycle fatigue.

These systems are intended to provide higher levels of performance than conventional reinforced concrete bridges, which are typically designed to meet only life-safety expectations.

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