Effectiveness of UHPFRC cover for the seismic strengthening of deficient bridge piers

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Abstract

The paper presents the results of an experimental and analytical research program aimed at developing an innovative seismic strengthening technique using Ultra-high Performance Fibre Reinforced Concrete (UHPFRC) cover applied to existing bridge piers with deficient reinforcement detailing. Experimental results on full-scale rectangular bridge pier specimens with cross-sectional aspect ratios of 4:1 and 2:1 subjected to weak or strong axis bending showed that the exceptional mechanical properties of UHPFRC allow eliminating concrete failure modes such as splitting cracks, spalling and crushing, thereby allowing transferring lapped bar forces through the surrounding UHPFRC, as well as failure modes associated with inadequate reinforcement detailing. Refined 3D nonlinear finite element models were developed to provide a numerical tool for evaluating the performance the strengthening technique.

Keywords: Seismic strengthening; UHPFRC; Bridge pier; Lap splice; Bond splitting strength; Nonlinear finite element modelling.

1 Introduction

1.1 Retrofitting of existing bridge piers

Bridges are critical components of the transportation network. The severe damage or collapse of several bridges worldwide observed in past earthquakes have shown their vulnerability to strong seismic events. Reinforced concrete bridge piers built prior to the introduction of the first seismic design provisions around the 1980's in Canada often have inadequate lap splice details located at the base of the piers where large inelastic demand is needed during a seismic event. A common design practice before the 1970's, and even until the 1990's, was to use dowel bars in footings that were lapped with continuing bars at the bottom of columns (Figure 1). Moreover, U-shaped stirrups lapped in the cover only were often used while little if any lateral support was provided for longitudinal bars along the long faces of wall or rectangular bridge piers.

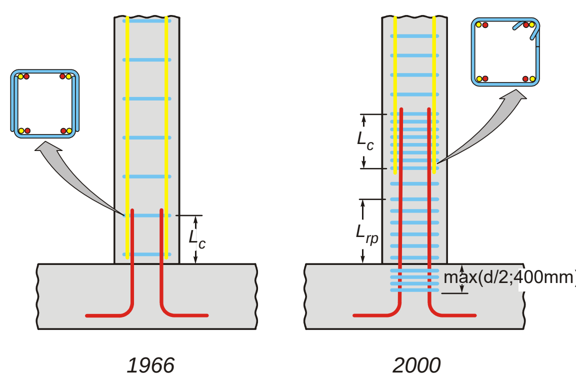

Figure 1. Evolution of reinforcement detailing requirements in the Canadian Bridge Code [1]

These lap splices lack in strength and ductility to withstand major earthquakes due to a combination of too short splice length (24 to 36 d_b) and poor confinement immediately above the footing. Different research programs have highlighted that

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