Seismic collapse safety of RC circular bridge pier retrofitted with fibre reinforced polymer

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Abstract

In recent years, the use of fibre reinforced polymer (FRP) composites sheets used to enhance the lateral confinement for improved ductility and strength of reinforced concrete (RC) bridge piers. The collapses of bridge structures in past and recent seismic events have raised concerns regarding the adequacy of lateral confinement of existing bridges to prevent the partial or total collapse. This research deals the seismic collapse safety of existing RC bridge piers retrofitted with FRP and compares with existing old RC bridge piers designed without consideration of seismic design guidelines. The collapse safety performance of FRP retrofitted RC bridge pier was evaluated using 20 different ground motions to compare the performance of FRP retrofitting system. Using incremental dynamic time history analysis, the collapse risk of the FRP retrofitted bridge piers was evaluated considering uncertainties in ground motion characteristic and structural modelling. The outcome of the research will provide an estimate of the dynamic capacity of the FRP retrofitted bridge piers and demonstrate the effectiveness of FRP-retrofitting technique as an external reinforcement.

Keywords: fiber reinforced polymer; bridge piers; base shear; displacement; stiffness; confinement ratio; nonlinear analyses

1 Introduction

Highway bridges play a vital role in the development of country's economic activity; hence bridges are the crucial component of transportation system. They provide smooth and fast transportation by establishing links between cities and across the country. In the early advance of country, measures were adopted to improve transportation safety, accessibility, and economic efficiency. Conversely, numbers of existing reinforced concrete (RC) highway bridges in North America were built when the seismic design guidelines were at an early stage of development. Moreover, earthquake risk levels have been recently increased throughout the globe, which might affect the seismic performance of existing highway bridges.

There are numerous studies which attempted to explore the feasibility of fiber reinforced polymer (FRP) confinement system for the seismic retrofit of concrete piers. Some of these studies [1], [2], [3], [4], [5] investigated lateral load carrying capacity of RC pier with FRP confinement technique. The results of these studies have demonstrated that the shear failure was prevented and significant improvement obtained in the ductility of the retrofitted piers.

In this study, the seismic collapse vulnerability assessment of non-seismically designed RC bridge piers retrofitted using FRP jacketing is conducted. A nonlinear finite element analysis has been applied to conduct the study, which was first validated with experimental data of retrofitted RC circular bridge piers. The structural response of the retrofitted bridge piers under severe seismic action much different compared to regular bridge pier. The study focuses on quantifying the inelastic demand and capacities of FRP retrofitted non-seismically designed RC circular bridge piers using incremental dynamic analysis (IDA). The behavior and response

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