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NONLINEAR SEISMIC BEHAVIOR OF A RC FRAME REPAIRED BY FRP LAMINATES

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Abstract

Strengthening reinforced concrete (RC) frames and unreinforced masonry (URM) infill walls with fiber reinforced polymer (FRP) has been proved a very successful procedure. Although there are numerous researches on the behavior of FRP-strengthened RC columns and beams as well as URM infills, few investigations have been made on the overall effect of FRP strengthening on RC frames with URM infill walls. This paper discusses the effects of using different amounts of FRP on RC frames with various configurations including the number of stories, spans, and locations of infills and so on. The infill walls were modeled according to the equivalent strut model and the effect of strengthening was considered as a tensional strut crossing the compressive strut representing the URM infill wall. The models also were subjected to push-over loading and the improvement in their behavior is investigated.
Keywords: RC frames, URM infill walls, FRP strengthening, push-over analysis, story drift

1. INTRODUCTION

In recent years, and from experiences of poor behavior of buildings designed according to codes' regulations happened during past earthquakes, building standard codes have increased their design requirements. These new regulations are mainly aimed to reduce damage of newer buildings to acceptable levels in the event of a moderate to strong earthquakes. However, older buildings, which were designed by codes that are now known to provide inadequate safety, are likely to be vulnerable to severe damage or collapse under strong seismic excitation. Past earthquakes have demonstrated that these older buildings would have survived, in most cases, with a reasonable upgrading. The main drawbacks of the older RC buildings are insufficient lateral stiffness, low ductility and inadequate load-bearing capacity [Ghobarah et al., 2000]. These results in brittle shear failures especially at the joints, soft story and column sideways collapse [Bracci et al., 1995]. On the other hand, according to extensive researches and from past experiences in different earthquakes, masonry infills play a significant role in load-bearing action during earthquake. They influence the overall behavior of buildings in terms of considerably increasing the strength and stiffness and energy dissipation capacity [Moghaddam et al., 1987, Mander et al., 1993, FEMA 306, Decanini et al., 2002]. But in many standard codes, including Iranian code of practice for seismic resistant design of buildings, their effect is underestimated if not ignored. Since infills tend to show a brittle behavior at the final loading stages, a retrofit procedure capable of enhancing ductility of infills is more preferable. Among different strengthening/retrofitting techniques URM infills, using FRP jacketing for RC columns and beams and FRP strips or laminates for URM infills seems one of the best techniques. This is mainly because using FRP is quicker to implement, adds no weight to the existing structures, has very little aesthetic impact and is corrosion resistant [Teng et al., 2002, 2003, Xiao, 2004]. The lateral drift performance of a multi-story building is an important indicator that measures the level of damage to the structural and non-structural components of buildings [Ghobarah et al., 2000, SEAOC, 1995, ATC-40, 1996, FEMA 274, 1997, Moehle, 1991]. Lateral drift design is particularly challenging as it requires the consideration of an appropriate stiffness distribution of all structural elements and, in a severe seismic event, also the occurrence and redistribution of plasticity in the elements [Zou et al., 2006].

2. DESCRIPTION OF THE MODEL AND ASSUMPTIONS

In order to study the effects of strengthening infills and frames with FRP, models which had been investigated experimentally were selected which is a 3-bay, 4-story building [Nakano et al., 2004]. The specifications of beams are as follows: $80 \times 60cm$, 10-D29mm, D13mm@100mm. the columns are