Seismic Upgrade of Beam-Column Joints with FRP Plates

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ABSTRACT

Many opportunities are becoming available for using composite materials to strengthen/upgrade existing reinforced concrete (RC) structures. the objective of the rehabilitation is to upgrade the shear strength of these joints and reduce the potential for bond-slip of the bottom bars of the beam. Fiber reinforced polymer (FRP) sheets are wrapped around the joint to prevent the joint shear failure. The FRP plates provide flexural strengthening, whereas the lay-up laminates provide confinement and shear strengthening. Along with the modeling of such upgraded connections to assess the increase of strength and/or ductility provided by the composite reinforcement, an experimental program was planned and it is being undertaken. A preview of it is given in this paper together with an explanation of its philosophy; furthermore, interesting preliminary results are presented and discussed. It appears that the proposed upgrade method will have a significant impact of the engineering practice in the near future.

Keywords: Seismic retrofitting, RC beam-column, FRP plates

1. INTRODUCTION

Recent earthquakes in urban areas such as 1995 Hanshin-Awaji (Kobe) and the1999 Kocaeli (Turkey) and the 2003 bam(Iran) have repeatedly demonstrated the vulnerability of existing structures to seismic deformation demands. These structures were designed and detailed for gravity loads and lateral forces that are lower than those specified by the current codes. Post-earthquake examination of these structures showed that one of the weakest links in the lateral load-resisting system is the beam–column joint. Fig. 1 shows the exterior joint failure in a reinforced concrete building after the 1999Kocaeli earthquake. Exterior beam–column joints are more vulnerable than interior joints, which are partially confined by beams attached to four sides of the joint and contribute to the core confinement. There are some differences between the shear response of interior and exterior joints when subjected to earthquake ground motion due to joint confinement by beams. However, the bond-slip mode of failure of exterior and interior joints is similar. FRP systems have been shown to increase the shear strength of existing concrete beams and columns by wrapping or partially wrapping the members. Orienting FRP fibers transverse to the axis of the member or perpendicular to potential shear cracks is effective in providing additional shear strength. Increasing the shear strength can also result in flexural failures, which are relatively more ductile in nature compared with shear failures. Shear strengthening of reinforced concrete beam-column using fiber-reinforced polymers has been studied intensively in the last decade, even if shear for simple RC beams is not fully understood. The design equations for RC beams used in the main current design guidelines are based on semi-empirical approaches. The shear capacity of the beams is computed by adding the contribution of the concrete and the steel stirrups. In many cases, using the same procedure, the shear strength of the RC beams strengthened with composite materials is computed by adding the contribution of the FRP. While the empirical design equations for RC beams were validated with extensive experimental results, the equations for predicting the shear resistance of FRP strengthened RC beam-column are often compared with a small number of experiments and using test series.