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RC connections strengthened with FRP sheets using grooves on the surface

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Abstract

In this paper, an experimental study has been conducted on strengthening of reinforced concrete (RC) connections by FRP sheets. The innovation of this research is using narrow grooves on critical regions of connection to increase the adherence of FRP sheets and prevent their early debonding. Therefore, four RC connections were made and tested under a constant axial load on the column and an increasing cyclic load on the beam. The first specimen, as the standard reference specimen, had close tie spacing in ductile regions of beam, column and panel zone based on seismic design provisions, and the second specimen, as the weak reference specimen did not have these conditions in all regions. Two other weak specimens were strengthened using two different strengthening patterns with FRP sheets; one by ordinary surface preparation and the other with surface grooving method for installing FRP sheets on the connection. The results showed that ultimate load and ductility of the weak specimen compared to standard specimen decreased 25% and 17%, respectively. The shear failure and concrete crushing were prevented in the ductile regions of the beam and panel zone in both strengthened specimens. Also, it was observed that early debonding of FRP sheets was prevented in the strengthened connection with grooving pattern and so had desirable ductility and bearing capacity similar to the standard specimen.

Keywords: *RC connection, Strengthening, FRP sheets, Load capacity, Surface grooving, Debonding.*

1. Introduction

For supplying adequate ductility of reinforced concrete (RC) members and connections, special requirements are considered in design codes. Close tie spacing in the panel zone and critical regions of beam and column for increasing their ductility are among these important requirements [1-2]. These seismic and ductility requirements have not been considered in some of RC structures designed and built based on the old design codes in the recent fifty years, so shear failure was observed in many members like panel zones due to reduction of concrete confinement and ductility. Therefore, structure strengthening is necessary to prevent probable damages during earthquakes [3-5]. One of the most common solutions for rehabilitation of RC frames is confining column and panel zone to a new concrete with the longitudinal and transversal reinforcements [6].

Another technique for repairing damaged RC frames is evacuating the concrete core of beam-column connection, and then filling it with high strength no-shrinkage mortar (70 MPa) or using HPFRCC[1] for strengthening RC frames or epoxy pressure injection technique [7-11].

Rehabilitation techniques of external epoxy-bonded steel plates or steel prop and curb method were widely used to increase the ductility of joints [12-14]. FRP sheets were used to improve many concrete elements such as columns particularly for seismic rehabilitation [15]. More recently, FRP sheets and CFRP rods (in NSM[2] method) have been used in bending and shear rehabilitation of RC connections [16-17] in order to increase load bearing capacity, ductility and other parameters of connections [18-28]. Usually, these sheets are installed locally on one or some faces of RC members with ordinary surface preparation method [29-30], but still there is high probability of early debonding of FRP sheets from concrete surface before rupturing at ultimate tensile strength (strain) [31-33]. Grooving the concrete surface before installing sheets is one of the newest surface preparation methods to increase the adherence between sheets and concrete surface [34].

In this study, the effects of ties spacing (in panel zone and critical regions of the beam and column) on behavior and failure of connections are studied. Also, two retrofitting patterns with FRP sheets are used for strengthening weak connections. Their beneficial effects (compared to weak and standard connections) are investigated. Furthermore, ordinary surface preparation and grooving method are used for installation of sheets, so

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