8th International Congress on Civil Engineering,
May 11-13, 2009, Shiraz University, Shiraz, Iran

Upgrading the Performance Level of Frames Using Fiber Reinforced Plastic Sheets

Arsalan Niroomandi[1], Alireza Maheri[2]

1- Seismic Retrofitting Center, Shiraz University, Iran
2- Department of Aerospace Engineering, University of Bristol, UK

a.niroomandi@yahoo.com

Abstract

This paper demonstrates the results of a research into the capabilities of Fiber Reinforced Plastic (FRP)-retrofitting in enhancement of the performance level of Reinforced Concrete (RC) frames. The flexural stiffness of FRP-retrofitted exterior and interior joints of each level of the frame has been determined using Nonlinear Finite Element Analysis (FEA). Having obtained the stiffness, the seismic performance of the FRP-retrofitted frames has been determined by employing a software tool developed based on pushover method. The seismic performance of the retrofitted frames is compared with the corresponding plain frame as well as an existing RC frame that has been retrofitted with steel-braced. The results show that the performance level of the FRP-retrofitted RC frame is upgraded in comparison with the original one, and keeping the performance level of the frame safety.

Keywords: Performance Based Design, Nonlinear Static Analysis (Pushover), Reinforced Concrete Frame, Web-bonded FRP-Retrofitting, Steel Braced.

1. INTRODUCTION

In recent years, performance-based design method has been considered in the seismic design codes worldwide. In this newly developed seismic design approach, nonlinear pushover analysis becomes important in identifying the damage patterns and levels for assessing the inelastic behavior of the structure and for understanding the seismic failure modes of the structure for retrofitting purposes. Pushover analysis estimates the seismic displacement demand of the structure with an Equivalent Single Degree Of Freedom (ESDOF) system and allows monitoring of global and local deformations, yielding process and strength deterioration.

Recently, Fiber-Reinforced Polymers (FRP) have been utilized for retrofitting or upgrading RC structures. Parvin & Granata [1] indicated that when joints of an RC frame were reinforced with FRP laminates, the moment capacity was increased up to 37 percent. Mahini et al. [2] proposed a method in strengthening of exterior beam-column joints using web-bonded FRPs. They tested the effectiveness of web-bonded CFRP on energy absorption capacity of $1/2.2$ scale RC joints in order to evaluate the possibility of relocating the plastic hinge location away from the face of the column. Their experimental studies showed that the FRP repairing/retrofitting system can restore/upgrade the integrity of the joint, keeping/upgrading its strength, stiffness and ductility, and shifting the plastic hinges from the column face toward the beam in such a way that the joint remains elastic. Results of another research carried out on plastic hinge relocation using web-bonded FRPs has been reported by Smith and Shrestha [3], indicating the practicality and effectiveness of this method. In another experimental study Balsamo et al. [4] evaluated the seismic behavior of a full-scale RC frame repaired using CFRP laminates. They indicated that the repaired frame had a large displacement capacity without exhibiting any loss of strength and which provided energy dissipation very similar to that of the original frame.

In this paper, the performance of an existing original moment resisting RC frame is assessed and the results are compared with corresponding FRP-retrofitted and steel-braced frames. For this purpose, an eight storey three bay RC building which was retrofitted by Maheri & Akbari [5] using steel bracing systems is retrofitted again with CFRP web-bonded technique in order to compare their seismic performance.

2. DESCRIPTION OF SELECTED RC FRAME

Figure 1 shows the selected frame for this study. The design dead and live loads are assumed to be 2750 kg/m and 1750 kg/m respectively. The compressive strength, f_c' and tensile strength, f_t of the concrete