SEISMIC STRENGTHENING OF SMALL SCALE PLAIN CONCRETE COLUMNS WITH NEW HYBRID STEEL-FRP JACKETS

Mohammad Reza NOORI SHIRAZI
PhD Candidate of Structural Engineering, Faculty of Civil Engineering, Sahand University of Technology, Academic Staff of Islamic Azad University of Chaloos, Tabriz, Iran
m_noori@sut.ac.ir, mrns1981@gmail.com

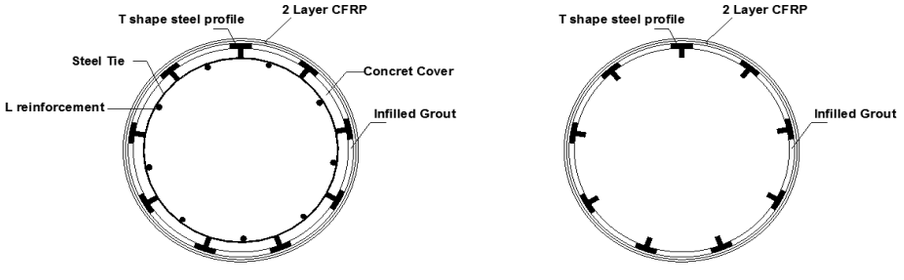
Hassan AFSHIN
Associate Professor, Faculty of Civil Engineering, Sahand University of Technology, Tabriz, Iran
hassanafshin@yahoo.com

Karim ABEDI
Professor, Faculty of Civil Engineering, Sahand University of Technology, Tabriz, Iran
k_Abedi@sut.ac.ir

Keywords: Seismic Retrofitting, Hybrid Steel-FRP Confinement, Particle Image Velocimetry (PIV), Flexural Strength, Energy Dissipation

During recent earthquakes over the world, a large number of existing reinforced concrete structures such as buildings and bridges experienced collapses and damages which have given rise to an ever more urgent need to repair and strengthening of these old structures. Various rehabilitation and strengthening methods was proposed and extended for reinforced concrete structures, but little researches was conducted about strengthening of structural members such as old railroad bridge piers which constructed of masonry or plain concrete materials. However, due to tensile stress induced by lateral loadings such as braking or seismic loading the pier is vulnerable to cracking considering low flexural strength.

Confinement with hybrid Steel-FRP jacket is proposed retrofitting scheme in current study which steel profiles such as steel strip, T-shape steel profiles and other convenient profiles will be attach along the height of columns using resin epoxy binders with wet lay-up procedure. The remained gap between concrete cover surface of column and steel profiles fills smoothly using low strength concrete (or grout). The CFRP fabric wraps around the perimeter of column considering the required layers and thickness. These layers attach using two-part resin epoxy binders to smoothed surface. A schematic view of proposed strengthening method is illustrated in below figure.



(a) (b)

Figure 1. Schematic view of proposed scheme, a) For RC columns b) For plain concrete columns

Longitudinal steel profiles provide required flexural strength for damaged column. FRP wraps implements lateral pressure onto concrete core which refines the ductility and compressive strength. It also restricts the lateral buckling of steel profiles along the height. However the lateral stiffness of column increases somewhat resultant to drastic earthquake effects onto the influenced structure. It is noticeable that this scheme is also suitable for strengthening of RC structural members which

haven't required reinforcement because of old design code philosophy or mass reducing of longitudinal and transverse reinforcement under severe corrosion conditions. The design philosophy of retrofitted scheme explained comprehensively at main text of original paper based on reliable codes equations.

In present study, comprehensive experimental tests were conducted in the structure laboratory of Sahand University of technology. A total of 81 plain concrete cylinders were prepared, which had diameter and height of 84 mm and 345 mm respectively. All specimens retrofitted using proposed scheme. For each studying variable, three specimens were prepared which its data will be averaged based on statistical equations. The variable parameters were including steel strips percentage, the layer number of CFRP and the compressive strength of concrete. The details of parameters were mentioned at Table 1. Moreover and in order to verifying advantages of combined retrofitting scheme ratio to other custom schemes, two layers wrapped cylindrical specimen, four layers cylindrical specimen and one NSM retrofitted cylindrical specimen were constructed and the results compared to each other.

Table 1. The variable parameters of study

Variable Parameters	Studied quantity
Compressive Strength of Concrete	20 Mpa, 30 Mpa, 40 Mpa
Steel Strips Volume Percentage	2%, 3%, 4%
The number layers of CFRP	1 layer, 2 layer, 3 layer

Axial compression tests were conducted using the universal structural testing machine with maximum capacity of 2000 KN. Tests were performed under displacement control at a rate of 1mm/min. Test data recorded using two methods. First, strain gages were used to monitor the axial strain and axial stress of cylindrical specimens. Second, particle image velociemetery (PIV) method was used for calculating the stress-strain curves of specimens accomplished using a digital image correlation code, GeoPIV, which was designed by White et al. (2003). Due to the lower cost and potential of obtaining the whole displacement field on common structural tests, PIV method can be widely used as an alternative to conventional measurement techniques. The extracted data of PIV method will be verify with the data recorded using strain gauges and then other intended parameters of study will be investigate based on PIV analysis. The role of different parameters was examined by comparing axial load-versus-axial and lateral displacement response characteristics (peak force, drift ratios, energy dissipation, and stiffness).

Based on the results, as the strength of concrete increases, the ductility will be increases as well as energy dissipation. Increasing the percentage of steel profiles will enhance drift ratio, energy dissipation and also stiffness of retrofitted columns. The CFRP confinement effect is directly related to the applied layers which the compressive concrete strength, energy dissipation and shear strength of concrete will be enhanced. It was also found that the plain concrete columns strengthened with proposed scheme behaved better than those strengthened only with the single CFRP material or NSM strengthening scheme. The results demonstrate that steel-FRP hybrid confinement is a viable solution toward enhancing the flexural strength and ductility of plain concrete columns under seismic loads.

REFERENCES

Choi E, Rhee I, Park J and Cho BS (2011) Seismic Retrofit of Plain Concrete Piers of Railroad Bridges Using Composite of FRP-Steel Plates, *Composites: Part B*, 42: 1097-1107

Fayyada TM and Leesb JM (2014) Application of Digital Image Correlation to reinforced concrete fracture, *Procedia Materials Science,* 3: 1585-1590