A LITERATURE REVIEW ON THE EFFECT OF FERROCEMENT AND FRP COLUMN JACKETING

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ABSTRACT

Reinforced concrete is most widely used construction material. Columns are one of the important structural elements in the structures. Retrofitting refers to the addition of new technology or features to older systems to restore the required strength. Jacketing construction is one of the preferred methods of retrofitting. Ferrocement confinement for retrofitting of structural elements is one of the effective techniques. As because of the notable properties of ferrocement, wider applications such as fire resistance, low self weight, water proof, durability, crack resistance etc makes it an ideal material. Fiber reinforced polymers (FRP) have been extensively used in order to strengthen concrete columns. The advantages of FRP technique compared to other similar techniques include of light weight, high strength, good environmental resistance etc. This paper presents the compilation of the literature review of ferrocement and FRP jacketing for restrengthening the concrete column. All the casted specimens are tested by applying load. Axial load, lateral bulging, crack pattern etc of column will be measured for the effectiveness of all two type jacketing.

Keyword: - *Restrengthening, ferrocement jacket, FRP jacket.*

1. I NTRODUCTION

Reinforced concrete is a composite material which shows very good performance in terms of durability and structural behavior except for those zones that are exposed to severe environmental influences and high mechanical loading. Structures which constructed undergo deterioration with use and time. Earthquake, flood, environmental pollution, faulty construction, chloride attack, inadequate design etc are some reason for deterioration. Replacement of particular structural element may lead to the integrity of the connecting member and it is also difficult and expensive task. Retrofitting of damaged structural element is one of the best solutions instead of replacing it. By retrofitting the strength and load carrying capacity of structure is increased to a significant amount.

Retrofitting can be done in two ways, such as global retrofitting and local retrofitting. In case of global retrofitting the entire structure is retrofitted to fulfill the serviceability requirements, but in case of local retrofitting only a specified part of the structure is strengthened or replaced. Global retrofitting of a RC structure can be done by adding shear walls, adding infill walls, adding bracings etc. Local retrofitting is a technique in which an elemental part of a structural unit is retrofitted and this can be carried out by jacketing of columns, jacketing of beams, jacketing of beam column joint, strengthening of individual footing etc. Jacketing construction is one of the most preferred methods of retrofitting. Various literatures are referred and the main focus is on the comparative study on the effect of ferrocement and FRP column jacketing. Ferrocement confinement for retrofitting of structural elements is one of the effective techniques. As because of the notable properties of ferrocement, wider applications such as fire resistance, low self weight, water proof, durability, crack resistance etc makes it an ideal material. Fiber reinforced polymers (FRP) have been extensively used in order to strengthen concrete columns. The advantages of this technique compared to other similar techniques include of high strength, light weight and good environmental resistance. From previous works the results showed that both the methods are effective to retrofit concrete columns.

2. LITERATURE REVIEW

Amrul Kaish.A.B.M [3] et al. (2013) conducted study on "Ferrocement Jacketing for Restrengthening of Square Reinforced Concrete Column under Concentric Compressive Load". The paper generally focus on the improvement methods in square ferrocement jacketing technique for restrengthening of already constructed RC building column. The two different approaches considered such as 1) strengthening all the corners 2) reducing stress concentrations at corners. Here both approaches are considered in three different square jacketing methods. In case of square jacketing, test results and crack pattern reveals that both the two approaches are effective to rectify the stress concentration issues. Whereas all the corner strengthening is highly suitable than reducing of stress concentrations at corners.

Amrul Kaish.A.B.M [2] et al. (2012) conducted a study on "Improved ferrocement jacketing for restrengthening of square RC short column". In this study three new square ferrocement jacketing techniques are proposed, such as Square jacketing with single layer wire mesh and rounded column corners, Square jacketing using single layer wire mesh with shear keys provided at the center of each face of column, Square jacketing with one layer wire mesh and two extra layers mesh provided at each corner, and entire study was carried out experimentally. Test results and the crack patterns of tested specimens show that all three improved square ferrocement jacketing techniques are effective to overcome the stress concentration problem of conventional square ferrocement jacketing. As far as the studies considered the best performance was shown by Square jacketing with single layer wire mesh and two extra layers mesh at each corner jacketing in carrying concentric loading and also in case of eccentric loading, RSL type ferrocement jacketing shows best performance.

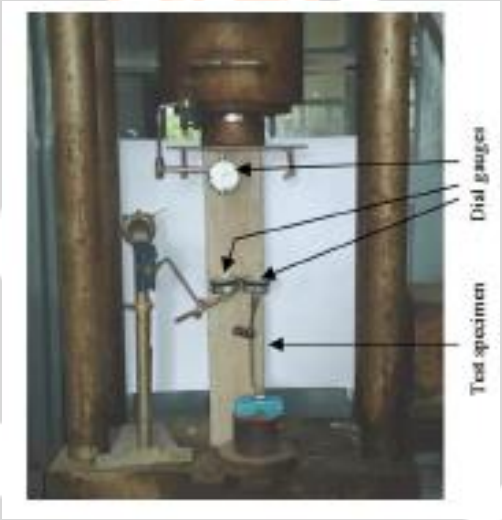


Fig -1: Test setup

(source: Amrul Kaish.A.B.M et al./Construction and Building Materials 2012)

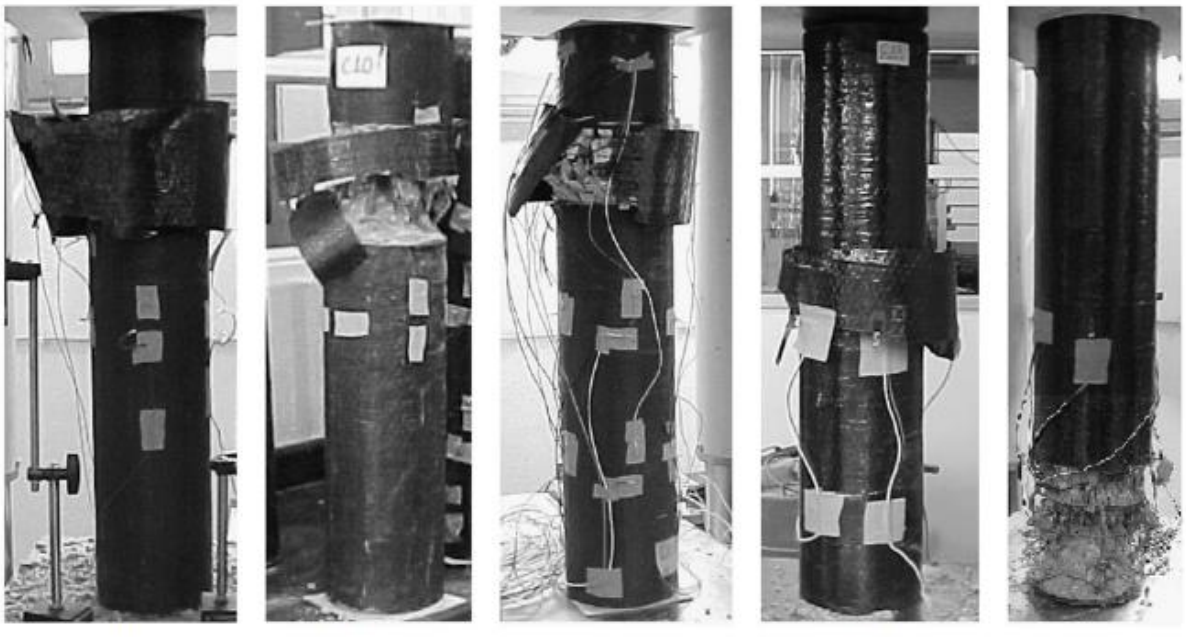
Amrul Kaish.A.B.M [5] et al. (2015) in his paper "Axial behavior of ferrocement confined cylindrical concrete specimens with different sizes" is investigated by experimental studies. Each type of specimens is confined with one layer and two layer welded wire mesh ferrocement jacket having a constant thickness of the jacket. Experimental results show the effectiveness of ferrocement confinement in energy absorption, enhancing the strength and capacity ductility of concrete specimens.

Amrul Kaish.A.B.M [4] et al. (2014) conducted a study on "Investigated on effectiveness of ferrocement jacketing in square columns". In case of conventional ferrocement jacketing rich mix cement mortar with single or multiple mesh layers are adopted. In this study, to overcome the drawbacks by strengthening corners and reducing stress concentration at corners techniques are adopted. From the test results all adopted techniques are effective than conventional techniques.

Xiong G.J [16] et.al (2011) conducted a study on "Load carrying capacity and ductility of circular concrete columns confined by ferrocement including steel bars". In this paper propose a method to strengthening the columns using ferrocement including steel bars (FS) jacketing in order to increase the load carrying capacity and the ductility of existing circular concrete columns. To study the behaviour of the FS strengthening columns, a comparatively experimental study carried out on three different type of confinements such as bar mat-mortar (BM), FS, and fibre reinforced polymer (FRP) with uniaxial compression load. The ultimate loads, load–strain responses, ductilities and failure modes of various strengthened columns were investigated. The experiment results concrete compressive strength of the FS columns increased 30% compared with that of the BM columns. The confined concrete strength of FRP strengthened columns and FS strengthened columns were similar. It is observed that the ductility, strength and energy absorption capacity of existing concrete columns can be enhanced significantly by providing additional ferrocement cage including steel bars. Due to the occurrence of more cracks in the mortar layer of FS confined concrete columns, the ductility of FS confined columns is higher than those of BM and FRP confined columns.

Mohammad Taghi Kazemi [12] et.al (2005) conducted study on "Seismic shear strengthening of R/C columns with ferrocement jacket". In this experimental study to evaluate a retrofit technique for strengthening shear deficient short concrete column. Ferrocement jacket reinforced with expanded steel meshes is used for the retrofitting of column. Total six short concrete columns, including four strengthened columns were tested under a constant compressive axial force. From the results wrapping of short concrete column specimens, using expanded steel mesh reinforced ferrocement layer significantly increase the shear strength and ductility capacity. In case of shear strengthening of concrete columns expanded meshes were more effective than ties.

Carlos Chastre [6] et al. (2010) focused on "Monotonic axial behavior and modeling of RC circular columns confined with CFRP". This paper focused on the experimental tests was carried out on reinforced concrete columns confined with CFRP composites, and subjected to axial monotonic compression. In order to evaluate the influence of several parameters on the mechanical behavior of the columns, the height of the columns was maintained, while changing other parameters such as, the diameter of the columns, the steel hoop spacing of the RC columns, the type of material and the number of CFRP layers. From the results model and predictive equations represent axial compression behavior of CFRP confined RC circular columns is very well. One of the main advantages is the applicability of this model to a large spectrum of RC column dimensions.



(source: Carlos Chastre et al../Engineering Structures 2010)

Turgay.T [15] et al. (2010) conducted study on "Compressive behavior of large-scale square reinforced concrete columns confined with carbon fiber reinforced polymer jackets". In this study an investigation was carried out on the performance of large-scale square RC columns wrapped with carbon fiber reinforced polymer (CFRP) sheets. Investigation of the total effect of longitudinal reinforcement, transverse reinforcement and FRP jackets on the behavior of concentrically loaded columns are focused in the study. Based on the test results of RC columns, stress–strain curves of the columns are successfully predicted by the analytical approach previously proposed for FRP-confined concrete.

Hafida Bouchelaghem [10] et al. (2011) in his paper "Compressive behaviour of concrete cylindrical FRP-confined columns subjected to a new sequential loading technique" is investigated by experimental studies. The behaviour of cylindrical concrete specimens reinforced by external wrappings made of unidirectional carbon fibre/epoxy and bidirectional glass/polyester layers. In the study uni-axial compression load technique is subjected to the specimens. It consists of sequential loading of the same sample, with the first load step terminated prior to failure of the column. Four types of jacketed specimens by glass fibre (GFRP), and one by carbon fibre (CFRP) composites have been examined. From the study the results shows that the hybrid composite jackets shows a significant increase in compressive strength and maximum radial strains, with low cost of the raw materials involved.

Muhammad Hussain [13] et al. (2015) conducted study on "Experimental Investigation of CFRP wrapped low and normal strength concrete cylinders". In this experimental study carbon fibre reinforced polymer (CFRP) jacketing was investigated on the effect of range of cylindrical concrete on compressive strengths. Two grades of concrete compressive strength were used in this experimental study that is, low strength and normal strength. The test was carried out on low strength and normal strength concrete cylinders in terms of confined compressive load. The results obtained shows that the carbon fibre reinforced polymer jacketing is more effective for low strength concrete rather than the high strength.

Yuvaraj Rolli [19] et al. (2015) in this study "An experimental study on strengthening of RC square columns by circularizing and wrapping with FRP" explain two methods of concentrically loading condition on existing reinforced square solid segments. Columns of group one were reference columns with no confinement, second group corners of the columns were rounded to 20 mm round corners that were horizontally wrapped with three layers of CFRP. The sides of the square columns of the group three were bonded with four circular segmental pieces of concrete, and cross section of the column were modify from a square shape to a circular shape. Then each column was wrapped with three layers of CFRP. In the third group sides of the segments has segmental round structure, and before changing the cross section of the columns from a square to a circle every column was wrapped with three layers of CFRP. This technique of confining square segments with segmental round sections has proved to be success. The test results obtained from the study shows that confining methods improves the load carrying capacity and the maximizing the load-carrying capacity shows in the square column to circular section method of modification.

Pragasit Juntanalikit [14] et al. (2015) in this paper "Experimental and numerical study of strengthening non-ductile RC columns with and without lap splice by Carbon Fiber Reinforced Polymer (CFRP) jacketing" presents an effective method for strengthening using externally bonded Carbon Fiber Reinforced Polymer fabrics to enhance the shear capacity and confinement of reinforced concrete columns. To study the behavior of CFRP-strengthened RC columns with and without short lap-splice length, by columns jacketed by CFRP sheets and tested under quasi-static cyclic loading. To study the effect of lap splice three columns were provided with short lap-splice length of longitudinal reinforcements at the plastic hinge location. The experimental results indicate that, by means of CFRP jacketing, the shear strength under reversed cyclic loading is significantly improved as compared to the un-strengthened columns tested in the previous studies.

Falsafi.T [8] et al. (2010) conducted a study on "Experimental Study on Behaviour of Prismatic and Cylindrical Hollow Concrete Columns Reinforced with FRP Materials". In this research, behavior of prismatic and cylindrical hollow concrete columns with FRP wrapping was studied. Prismatic and cylindrical hollow concrete columns were wrapped in one, two and three layers of carbon and glass polymers. The axial and lateral strains until FRP spalling measured using strain gages. From the test results, the strength and ductility of specimens increased using wrapping technique and the seismic behavior of cylindrical specimens was improved more than prismatic ones. As compared to glass fiber carbon fiber wrapping show improved results.

Guoqiang Li [9] et al. (2006) conducted a study on "Experimental study of FRP confined concrete cylinders". In this study, FRP jacketed concrete cylinders and FRP tube encased concrete cylinders were prepared for the further investigation. Six fiber orientations and two FRP wall thicknesses were used for the jacketing the cylinders two types of fiber reinforced polymer confined concrete cylinders were prepared,. Concrete with normal to high strength were used and both bonded and unbonded interfacial conditions were also considered in this study. From the results it is observed that insufficiently confined cylinders behave similar to unconfined cylinders. The concrete is damaged due to the lower axial stiffness of FRP and larger transverse Poisson's ratio, FRP cannot confine the concrete core. As confinement ratio increases rate of increase in confinement effectiveness decreases nonlinearly. From the models and test results a considerable deviation is found between the prediction by existing design-oriented confinement.

Chau-Khun Maa [7] et al. (2017) conducted a review paper on "Repair and rehabilitation of concrete structures using confinement: A review". Repair and rehabilitation is one of the most important emerged construction activities globally of existing damaged concrete structures. Confinement is one of the effective and rapid repairing techniques. This method is proven that in damaged concrete it is efficient to restoring the original capacities of. In repairing damaged concrete structures number of investigations has been done to confirm the suitability of these techniques, there are several barrier that hindered the widespread use this method in practical. From the study confinement repair techniques are effective to restore the original capacities of damaged concrete members. To establish sufficient design guidelines more investigations are still required and also ensure the durability of the repaired concrete member confinement pressure loss over a service period should be tested.

Abdullah [1] et al. (2003) in this paper "An investigation into the behavior and strength of reinforced concrete columns strengthened with ferrocement jackets" generally deals with the strength and behavior of ferrocement jacketed reinforced concrete columns. This Study mainly focus on seismic performance improvement in reinforced columns. Reference columns are prepared and it was tested after strengthened with square and circular ferrocement jackets. The parameters considered in this study were ratio of axial load, jacketing schemes, and number of wire mesh layers. From the test results it is obtained that the external confinement enhances the ductility of the column. Stable and ductile response were shown for all the circular and square ferrocement jackets for strengthening square reinforced concrete columns.

Jaya K.P [11] et al. (2012) focused study on "Strengthening of RC Column using GFRP and CFRP". Seismic retrofitting of reinforced beam and column using Glass Fibre Reinforced Polymer (GFRP) and Carbon Fibre Reinforced Polymer (CFRP) with number of warpping layers, and the test conducted by subjected to constant axial loading and reverse cyclic loading. Both GFRP and CFRP increase the ductility and energy absorption capacity of reinforced beam and column.

Yaqub.M [17] et.al (2013) in his study "Strength and stiffness of post-heated columns repaired with ferrocement and fibre reinforced polymer jackets" compare the effect of ferrocement and fibre reinforced polymers (FRPs) jackets for the repair of post-heated square and circular reinforced concrete columns. In this study, test specimens considered are non-heated and non-repaired, post-heated and non-repaired and post-heated and repaired columns. Repair of heated columns are done by using Glass fibre reinforced polymer (GFRP), carbon fibre reinforced polymer (CFRP) and ferrocement jackets. All the column specimens are tested by axial compression load. In this study they have done experiment on square and circular columns. From the test results it was concluded that a possible combination of ferrocement and FRP jackets shows better response against structural damage from a fire and to restore the required stiffness, strength and ductility of the structure.

Yuan-feng Wang [18] et al. (2011) in this paper "Size Effect of Concrete Short Columns Confined with Aramid FRP Jackets" 99 confined concrete short columns wrapped with aramid FRP (AFRP) jackets and 36 unconfined concrete short columns with circular and square cross sections and the columns are tested under axial compressive loading. The square specimens were divided into five groups, and the circular specimens were divided into six groups, with each group containing different levels of the AFRP's confinement. Evaluation is done by statistical analyses to the size and interaction effects between the specimen size and the AFRP's confinement. By modifying Bazant's size-effect law a size-dependent model for predicting the strength of the columns was developed. From the experimental results the strength of AFRP-confined concrete short columns had a significant effect on the size of a specimen, lesser effect on the axial stress-strain curves, and lesser effect on the failure modes.

3. CONCLUSION

The main purpose of the Compilation of these literatures is to formulate and investigate plan for strengthening the column. The effectiveness of ferrocement and FRP composites jacketing of deficient columns is very critical and has scope for research. From the investigation of ferrocement jacketed RC square and circular columns under concentric loading, confinement improves the ultimate load carrying capacity, ultimate axial deflection and ductility of RC column. Studies of square column mainly two approaches are considered such as strengthen all the corners and reducing stress concentration at the corners and from the test results and crack pattern shows that both the approaches are effective. In this strengthen all the corners practically more suitable than reducing stress concentration. In case of circular columns with number layers of wire mesh increases than that confinement improves the ultimate load carrying capacity, ultimate axial deflection and ductility of RC column. And also Crack patterns of tested circular column specimen with number of layers increase.

Use of carbon and glass FRP resulted in remarkable improvement in the behaviour of columns resulting in significant increase in ductility, energy absorption capacity and strength. From the reviews made, there shows the increase in strength for retrofitted columns rather than non jacketed column until failure. Since the behaviour of FRP is linear elastic to failure, it gives no sign of warning before it ruptures. Research is needed to improve its mode of failure. The GFRP and CFRP are susceptible to environmental effects such as freeze and thaw, temperature variation and moisture. The parameters considered are type of material, number of FRP layers, size of column etc. Number of layers increases the effectiveness of confinement also increases.

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