A Review on Strengthening of RC Short Columns with Ferrocement Jackets

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Abstract- *This paper represents the overall review about the change in structural behavior and strength of Reinforced concrete short columns when strengthened with ferrocement jackets. The installation of reinforcement in RC short columns using closely spaced lateral ties not only creates a problem of much increased honeycombing, but also adds to it a plane of weakness between core and the concrete cover. In order to overcome this failure of RC short columns even before its service period is over an immediate attention is required in and it can be done by replacing the damaged part of reinforced concrete by Ferrocement jackets. In the past few decades, ferrocement come out as a long lasting strengthening material because of its superior mechanical properties and high in-plane strength. This paper also focuses on the effect of increased no. of wire mesh layers at different orientations and it was found that ferrocement jackets increases the overall load carrying capacity, first crack load, and the total stiffness of column, but the deflection decreases to a large extent.*

Keywords- Reinforced concrete, Short Columns, Strengthening, Ferrocement Jackets and wire mesh

I. INTRODUCTION

Reinforced concrete is the commonly used material for the construction of structures which are designed in accordance to the specifications given in the standard codes to meet the service life of the structure. Columns are one of the most important structural member which transfers the entire loads to the foundation. The behavior of columns in tall structures is very important since column failures lead to additional structural failures and can result in total building collapse.Replacement of the damaged structural elements is very difficult and cost intensive process which in fact creates a high risk to the integrity of other connecting members of the structure. Thus, in order to restore the required strength of the damaged structure, retrofitting technique is the only solution to be used all over the world. Basically, Retrofitting can be done in two different ways, depends on the extent of damage and the position of specific structural member:

- Global Retrofitting
- Local Retrofitting

In case of Global Retrofitting, the entire structure is retrofitted which involves the overall analysis and design of the entire structure as per the specifications given in standard codes. Whereas, in case of Local Retrofitting, only a specific structural member is either strengthened or totally replaced. Jacketing technique is the most preferred method of retrofitting used both in practical and experimental purposes and can be applied by the following techniques including the traditional RC jacketing:

1. Wrapping the sheets of fiber reinforced polymers such as carbon fiber and glass fiber reinforced polymers. (CFRP) and (GFRP)
2. Classical Reinforced concrete jacketing. It can be done with or without Rebaring, depending upon the core size of column.
3. Confinement with Ferrocement. i.e. Wire mesh Mortar Jacketing.

In comparison to the above, strengthening with ferrocement confinement is the oldest and cost effective technique used to retrofit or repair the damaged concrete structures. Ferrocement is a type of thin wall reinforced concrete commonly constructed of hydraulic cement mortar reinforced with closely spaced layers of continuous and relatively small size wire mesh which provides ductility to the otherwise brittle concrete. (Ferrocement matrix + Wire mesh) The dispersion of small diameter steel wire mesh in the entire volume of the cement mortar improve a large number of engineering The unique properties of ferrocement such as water proof, fire resistant, durability, low self-weight and crack resistant makes it an ideal material for wider applications.

II. LITERATURE REVIEW

Muhammed Salih D.S and C. Arunkumar _ 2016 [1]:

This paper investigates the retrofitting of column using ferrocement with different percentage of polypropylene fibre, and hence concluded that Strengthening of column using ferrocement with the application of polypropylene fibre was found to be much effective and innovative practical technique

for strengthening the damaged columns. Moreover, due to addition of polypropylene fibre for retrofitting of columns, no spalling of concrete cover was found under ultimate axial loading but widening of the cracks on corners of each face of strengthened column was observed.

Shubham R. Dakhane et. al._2016 [2]:

In this research paper, the thorough analysis of the construction material used in the preparation of ferrocement and concluded that houses in ferrocement can easily sustain in earthquake up to scale 7.5-8.Even this technique can be used for retrofitting of water structures and the use of ferrocement layers will substitute as shear reinforcement in the joint region. Further, ferrocement construction is an exciting alternative to the conventional wooden and masonry methods.

Mohamed A. Tarkhan _ 12-2015 [3]:

In this experimental study, it was investigated that under concentric loading conditions, RC columns can be strengthened significantly with enhanced strength and performance using ferrocement jacket. After strengthening, all test columns showed higher deformation at ultimate load, increase in ductility ratio, and considerable increase in energy absorption as well. Moreover, high pre-loading levels resulted in lower gain in the load carrying capacity and energy absorption, yet increase in gain in the ductility ratio. Columns pre-loaded to 50% of the ultimate load of control column showed higher gain in the ultimate load and energy absorption than those pre-loaded to 75% however the increase in the ductility ratio was the least.

Ornela Lalaj, Yavuz Yardım, Salih Yılmaz_2015 [4]:

This research paper stated that Ferrocement is the oldest form of the reinforced concrete, dating back two centuries. It is composed of mortar and galvanized steel wire mesh. It is used for a wide range of application including construction of boats, water tanks, slabs and roofs, and lining of tunnels. Nowadays, reinforced concrete is widely known and used material, whereas ferrocement has limited applications. New applications have been developed in the recent years, such as low cost dwelling buildings and strengthening of a wide variety of structural elements.

R. Hafiza, S. Sameen, T. Rahman_2015 [5]:

This paper investigates the column specimens for the ultimate load capacity and stressed samples confined with ferrocement using welded wire mesh as the confining material. In case of pre-stressed specimens, the results showed that the ferrocement confinement increased the load carrying capacity to 33%.In case of stressed samples to a value of 60% and 80% of the ultimate load capacity, the confinement enhanced the ultimate load capacity to 28% and 15% respectively. With the confinement the column specimens failed in a ductile manner as compared to brittle failure of the control specimens.

Veena M and Mini Soman_2014 [6]:

This research paper investigates the use of improved ferrocement jacketing to strengthen the RC short square columns and concluded that ultimate load carrying capacity for advanced jacketed square columns improved by 1.45 times compared to that of control specimens whereas the improvement was only 1.30 times for conventionally jacketed specimens. The energy absorption capacity for advanced jacketed specimens were improved by 145% but for conventionally jacketed specimens, the improvement was only 95%. Moreover, Displacement ductility factor for advanced jacketed specimens improved by 102% compared to control specimens but for conventionally jacketed specimens, the improvement was only 60%.

Kaish et. al. _2012 [7]:

In this experimental study, the effect of ferrocement jacketing with some improved modifications for three types of ferrocement jacketing techniques were used to confine the column specimens that are; square jacketing with single layer wire mesh and rounded column corners (RSL); square jacketing using single layer wire mesh with shear keys at the centre of each face of column (SKSL) and square jacketing with single layer wire mesh and two extra layers mesh at each corner (SLTL) are considered for this purpose and the observed results were compared.

Xiong et. al. (2011) [8]:

This paper studied the load carrying capacity and ductility of Reinforced concrete circular columns confined by ferrocement including steel bars (FS) where they are proposed to increase the compressive strength and ductility of column. Hence concluded that columns confined due to ferrocement along with additional steel bars showed higher ductility, compressive strength and energy absorbing capacity than BS or FRP strengthened circular columns.

III. CONCLUSION

In general, a comprehensive literature review of the work done in the past was studied in order to get a better idea of the key issues relevant to strengthening of RC columns with

ferrocement jacketing. The existing investigations have revealed that the use of Ferrocement technique improves the ultimate load carrying capacity of columns and, in many cases, even allows the structure to carry the heavy seismic loads. In addition to that, the ductility of the columns shows a large improvement. With the increased demand of repairing and retrofitting in the field of structural engineering, Ferrocement will continue to grow as an economical and long lasting retrofit material. Based on this review, following conclusions and recommendations are drawn:

- The ultimate load carrying capacity of columns increases by providing ferrocement jackets.
- The ductility of columns shows a better improvement.
- Increase in the total energy absorption and Displacement ductility factor
- Deflection shows a sharp decline if compared with the ultimate load carrying capacity.
- It is essential to find out a specific position in the damaged portion of concrete rather than confining the whole structural member, so that the overall cost for confinement will be economical.
- Modifying the corners of columns from pointed to round will eliminate the corner stress concentration and improve ferrocement confinement effectiveness.
- Increasing the no. of layers of wire mesh should be such that a minimum cover is provided on inner and outer faces.
- For better results, different layers of wire meshes should be interconnected by providing a rebar, such that confinement may not fail early.
- It is recommended to take orientation into consideration as Proper orientation of wire mesh can make a big difference to withstand heavy axial loads. For example, a column wrapped with a wire mesh at an orientation of 45° increases the ultimate load carrying capacity.

Further, from the review and discussion of the literature, it was also concluded that there is a need to perform an additional experimental work on the retrofit of columns by composite jacketing, such that ferrocement can be comparable with other types of jacketing.

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