Experimental Study on Improvement in Axial Load Carrying Capacity of Reinforced Concrete Columns Strengthened with Ferrocement Technique

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***Abstract*— Strengthening is one the easiest ways to improve the load carrying capacity of existing columns. Among the wide range of options available for strengthening of concrete columns, ferrocement technique is attracting much significance because of its simplicity and cost aspect. There are various wire mesh shapes available in the market and among them the best one need to be found out. In this study five 500*150*150 mm size concrete short columns are casted in which one is control specimens and four specimens are used to find the best wire mesh shape for strengthening purposes. The specimens are compared by recording axial loads and displacements and lateral deflection. Diamond mesh shaped is found to have the highest increase in axial load carrying capacity and is best suited for ferrocement confinement in concrete columns.**

Keywords*— Strengthening, Ferrrocement, wire mesh, axial loads

I. INTRODUCTION

Weak structures are made to withstand heavy loads by the process known as strengthening. Strengthening improves the service life of structures. Often buildings and structures subjected to change in the utility need to be strengthened. Lack of load carrying capacity may also be due to the construction errors, cracks, and air and water pollutants. A single element which is expected to fail, has the potential to cause progressive collapse of other elements by the creation of new paths for energy release. If proper attention is not given to these structures it leads the failure of buildings which in-turn cause heavy money loss and in such cases structural elements may have to withstand loads higher than for which the elements are designed and it may prove to be very costly for the entire structure to be rebuilt. This is where the need of strengthening the elements comes into play. Framed structures are built based on the concept of weak beam and strong column, this means columns are those elements which can never be allowed to fail. The failure of columns can lead to catastrophic effects and continuous failure of all the subsequent stories. Thus columns are the most important elements of a structure. Perfomance of columns can be largely affected by the spacing of ties and hook angle, columns which lack the confinement possess a potential threat of failure. Columns that which are deficient in strength must be made stronger by the process of restrengthening. The strength of columns depends on the grade of concrete and the area of longitudinal bars, once casted these two parameter cannot be changed. The failure of columns is due to the either crushing of concrete or due to the buckling of steel bars. Confinement of columns externally can significantly improve the ultimate load carrying capacity of the column element [1]. There are various methods of providing external confinement such as fiber reinforced polymer confinement, steel jacketing, glass fiber reinforced polymer jacketing, ferrocement jacketing etc. Among these ferrocement jacketing is the easisest method by which jacketing can be done. Ferrocement means steel wire mesh embedded inside ferrocement mortar. The raw materials for ferrocement jacketing is available more easily than any other jacketing methods. The wire mesh used in jacketing is made of Galvanised iron and is available in local hardware stores. The ease of application is also comparatively easier than other methods. Ferrocement jacketing do not require technical expertise as in case of other jacketing methods and its application do not affect the aesthetic appeal of the building since it is easy to be moulded into any shape and form [2]. Advanced jacketing by rounding of corners gives higher load carrying capacity than column strengthened with sharp corners [3]. Bonding agents had no effect in improving the strength of ferrocement jackets [4]. Bo li et.al showed that anchor bolts used in the interface of ferrocement and concrete columns inproved the performance considerably. Mohammad Taghi Kazemi et.al [5] studied the shear performance of ferrocement jacketing and found that expanded metal mesh can be used to improve the shear deficient columns The main objective of this research is to investigate the best wire mesh available in the market. Wire meshes are available in various shapes such as welded mesh, woven mesh, hexagonal mesh, and diamond shaped mesh. The shapes in which the wires are woven is expected to affect the load carrying capacity of the column which is strengthened

II. THE EXPERIMENTAL INVESTIGATION

A. Experimental Sample

Experimental study is done to find the best wire mesh shape for strengthening purpose. The RCC columns are strengthened with Diagonal mesh (DM), Hexagonal Mesh (HM), Square welded mesh (SWM) and Square woven mesh (SWOM). The shapes of the wire meshes used in ferrocementing is shown in Fig 1.

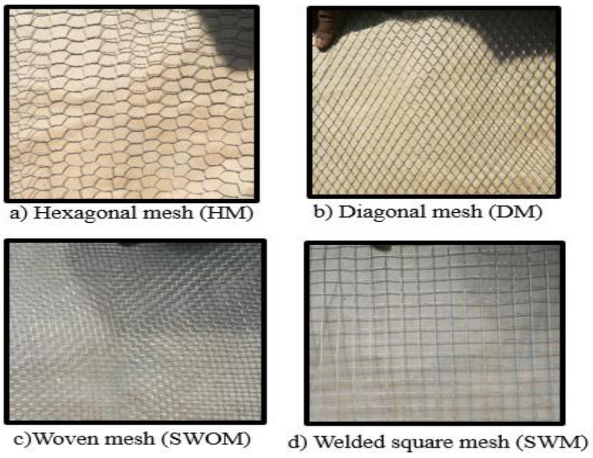

Fig 1. Mesh shapes

Reinforcements for columns were prepared and was placed inside the mould. The longitudinal reinforcements consisted of 4 longitudinal bars of 12mm diameter, stirrups used was of diameter 8mm and was kept at a spacing of 90mm c/c. The details of the specimens are shown in Fig 2. All the bars used has a yield strength of 480.5 N/mm^2 and ultimate strength is 598.5 N/mm^2 The surface of the mould is oiled before concreteing to prevent concrete from sticking to the mould surface. The columns were given a cover of 20mm on all sides. The column specimens were casted as shown in figure as shown in Fig.3. There are five column of length 500mm and of square cross section 150mm*150mm, out of which four columns are strengthened and one is control column (CC). The process of demoulding is done after one day of casting and is cured by placing in curing tank for a period of seven days and after that curing was done by wrapping with damp clothes.

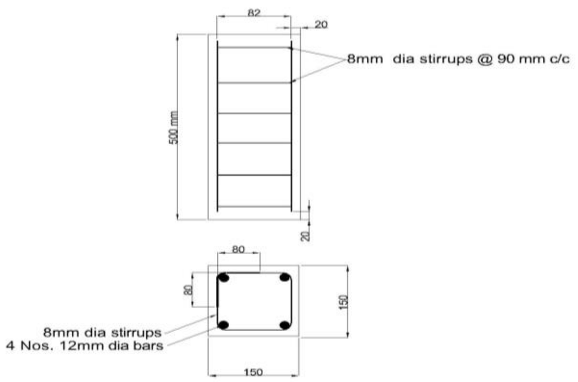

Fig 2. Reinforcement details

Fig 3. Casted specimens

B. Mix design

The concrete mix used for the casting of specimens is M20 grade with a mix ratio of 1:1.794:3.21 and a water cement ratio of 0.52. The 28 day compressive strength result showed a strength of 27.27 kN/mm^2. The mix design has been done as per IS 10262. The material used in the concrete mix consist of cement OPC grade 53, coarse aggregate 20mm size with specific gravity 2.9, fine aggregate used in washed M sand with specific gravity 2.6. The slump value of the mix was kept at 75mm.

C. Preperation of Ferrocement jackets

Raw materials for ferrocement jacketing consist of plastering sand and OPC 53 grade cement. The consistency of the mortar is such that it is possible to be applied and sticks to the concrete surface. The ferrocment mortar mix is prepared in the ratio 1:3 (cement: sand). Strengthening of concrete columns is done after 7 days of curing in water. Before the application of mortar, the concrete column surfaces has been grouted to ensure contact between steel mesh and concrete surface, it also creates a rough surface for ferrocement mortar to bind. After grouting the wire mesh is wrapped around the column specimens and they are fastened using four steel ties. Cross section of jacketed specimen is shown in fig. 4.

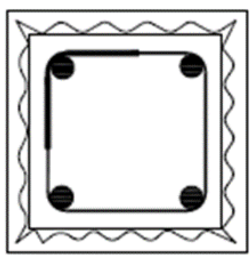

Fig 4. Jacketing detailing

D. Experimental Setup

To study the axial load carrying capacities of RCC columns confined with ferrocement axial load is applied on UTM and load displacement curves are recorded on computer. Dial gauges are placed on four faces of the columns to read the lateral deflection. The least count of the dial gauges are 0.01mm. The gauges are magnetic and the base of which were attached to iron surfaces to ensure stability. The axial displacement values are recorded automatically on the computer along with the axial loads. The experimental setup is shown in the Fig. 5.

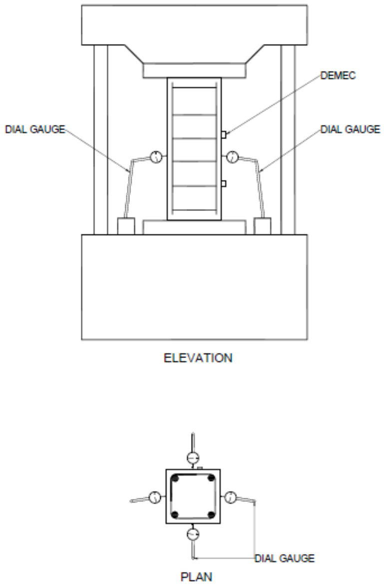

Fig 5. Test setup

For testing the specimen is mounted on Universal Testing Machine (UTM) (100 Ton Capacity) and is axially loaded as shown in Fig.6. The load is applied by the movement of lower jaw of UTM. Dial gauges are used to measure the dilation or lateral deflection. The loading is continued and the corresponding readings of the dial gauges are also recorded.

This procedure is continued until the load decreases to 25% of maximum load capacity of column.

Fig 6. Test set up mounted in UTM

III. RESULTS AND DISCUSSION

The crack patterns of failed control specimen is shown in Fig. 7, which shows that the failure is by crushing of material and it is as expected in in case of a short column. The failure patterns of strengthened specimens are shown in Fig 8, and the number of cracks are comparatively much lesser than the control specimens

The results of the compression test are shown in Fig 9. It shows the load vs displacement curve. For uniformity the graphs are shown till the load reduces to 25% of ultimate load. The load vs. lateral deflection value is shown in Fig 10. A comparison of ultimate load carrying capacity of different specimen is shown in Fig 11. Displacement ductility can be defined as the ratio of displacement at ultimate load to that at the yield load, the comparison of which is shown in Fig 12. Energy absorption capacity is defined as the area under the load displacement graph, the comparison of energy absorption capacity is shown in Fig 13.

Fig 7. Failure pattern of control specimen

Fig 8. Failure pattern of strengthened columns

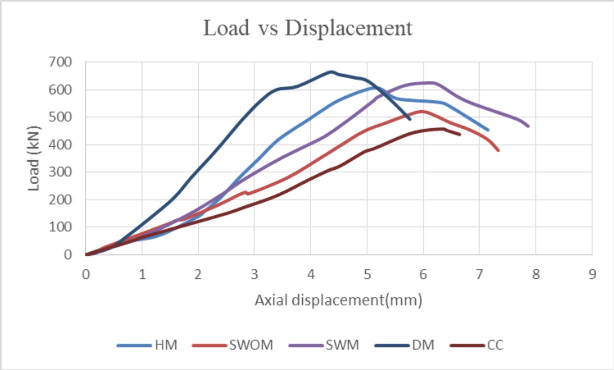

Fig.9. Load vs displacement

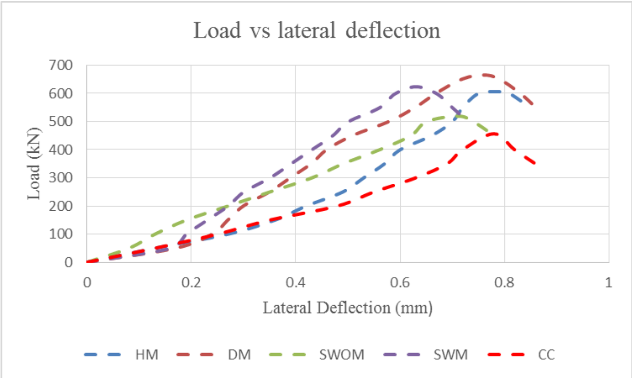

Fig.10. Load vs lateral deflection

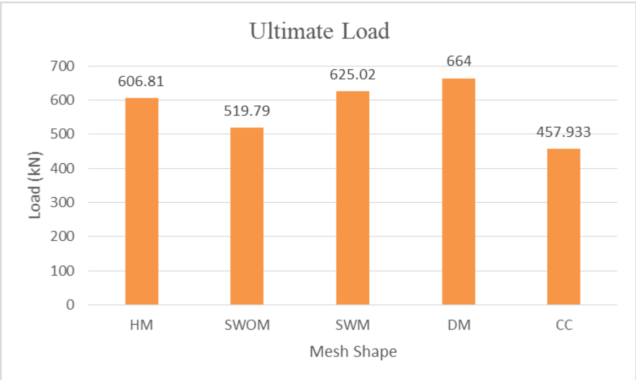

Fig 11. Ultimate load

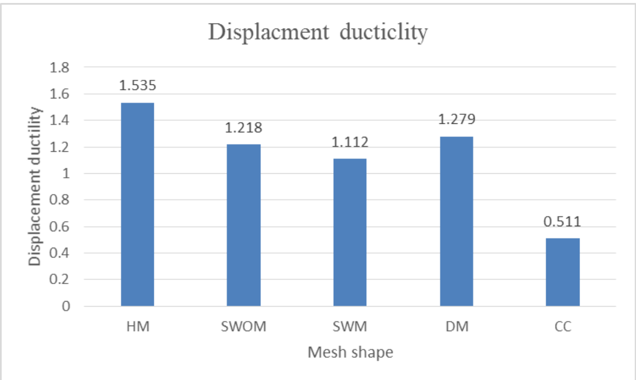

Fig 12. Displacement ductility

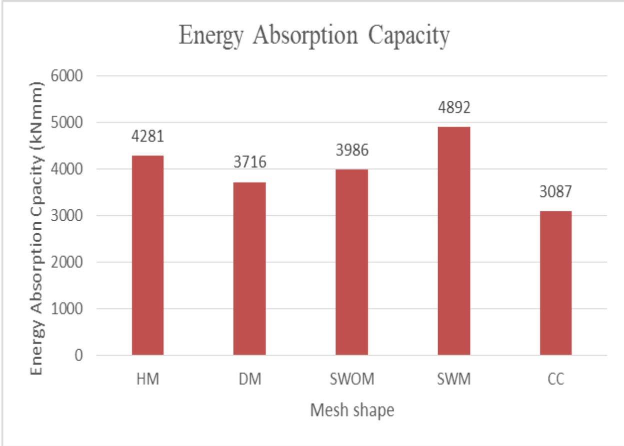

Fig 13. Energy absorption capacity

IV. CONCLUSION

The experimental study consisted of 5 concrete columns which were tested under axial force on a UTM. Among the five columns one was kept as control column and the other four were jacketed with different meshes. The parameter considered for the study is shape of wire mesh. The following remarks can be drawn from this experiment. Energy absorption and displacement ductility are factors that influence the earthquake resistance of the structures.

- The axial load carrying capacity is maximum for diamond mesh shape and is 32.5% higher than the control specimen.
- The energy absorption capacity is highest for columns strengthened with square welded mesh and is higher than the control specimen by 58.4%.
- The displacement ductility value is highest for hexagonal mesh with 200% increase compared to the control specimen. Which indicates that hexagonal mesh is suitable for earthquake resistance.

The overall results show that the diamond mesh shape is the best one which is suggested for strengthening of reinforced concrete columns using ferrocement technique.

REFERENCES

[1] Veena M et.al Strengthening of RC Columns Using Ferrocement Jacketing *Volume 5, Special Issue 14, December 2016 IJIRSET ,*
[2] Kazemi MT, Morshed R. Seismic shear strengthening of R/C columns with ferrocement jacket. Cem Concr Compos 2005;27(4):834–42.
[3] A.B.M.A. Kaish et.al Improved ferrocement jacketing for restrengthening of square RC short column *Elsevier 2012*
[4] Hazem M.F. Elbakry et.al Factors affecting bond strength of RC column Jackets *Elsevier 2016*
[5] Mohammad Taghi Kazemi , Reza Morshed Seismic shear strengthening of R/C columns with ferrocement jacket *Elsevier 2005*
[6] Hazem M.F. Elbakry , Ahmed M. TarabiaFactors affecting bond strength of RC column Jackets *Elsevier 2016*
[7] Dr. B. Palani et.al Experimental study on flexural behaviour of ferrocement panels with silica fume as admixture and replacement for cement *International Journal of Civil Engineering and Technology (IJCIET) Volume 8, Issue 6, June 2017*

[8] Muhammed Salih D.S .et.al Strengthening of Reinforced Concrete Column using Jacketing Technique *International Conference on Engineering Innovations and Solutions(ICEIS – 2016*) 7) Seismic shear strengthening of R/C columns with ferrocement jacket *Elsevier 2005*
[9] S.M. Mourad, M.J. Shannag Repair and strengthening of reinforced concrete square columns using ferrocement jackets. *Elsevier 2012,*
[10] IS 383, IS 456, IS 10262