

Strengthening of RC cylindrical columns using Micro concrete Jacketing

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ABSTRACT: Earthquakes of varying magnitude have occurred in the recent past in India, causing extensive damage to life and property. Seismic protection of buildings is a need-based concept aimed to improve the performance of any structure under future earthquakes. Some recently developed materials and techniques can play vital role in structural repairs, seismic strengthening and retrofitting of existing buildings, whether damaged or undamaged. Jacketing is the most popularly used method for strengthening of building columns. Strengthening or repairing deteriorating concrete structures has now become a major challenge to construction activity all over the world. It increases the seismic resistance, strength, stiffness, ductile behaviour and lateral load capability of the building without any demolition. There are different methods of jacketing like using concrete, steel, fibre reinforced polymer, etc. In this paper, micro concrete jacketing for strengthening damaged columns is experimentally studied.

KEYWORDS: Jacketing, Strengthening, Seismic Resistance, Micro concrete

I. INTRODUCTION

Reinforced concrete is one of the most abundantly used construction material not only in the developed world, but also in the remotest parts. Column is one of the most important structural elements, which is designed to support mainly the compressive load and its failure can lead to the failure of a storey and the building. Retrofitting is a technique to enhance the structural capacities including the strength, stiffness, ductility, stability, and integrity of a building that is found to be deficient or vulnerable and can effectively raise the performance of a building against earthquake to a desired level to satisfy the requirements of an upgraded design seismic code. The building need not be deteriorated or damaged. The retrofit is intended to mitigate the effect of future earthquakes.

Existing structures need strengthening in the following circumstances:

1. Buildings have not been designed and detailed to resist seismic forces.
2. Buildings might have designed for seismic forces, but as per old seismic codes.
3. The lateral strength of the building does not satisfy the seismic forces as per the revised seismic zones or designed base shear.
4. Construction is apparently of poor quality.
5. There have been additions of change of use of building with increased vulnerability.

Micro concrete is ready to use mixture that is made strictly under quality control in the factories. The material is based on Portland cements, graded aggregates and fillers, and additives which impart controlled expansion characteristics in the plastic state, while minimizing water demand. The low water requirement ensures high early

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strength and long-term durability. It is highly fluid to allow for placement without vibration and contains no chloride admixture.

II. RELATED WORK

Ahmed M. El-Kholy, et.al (2015) [8], in his paper presents a practical confinement configuration consisting of single Expanded Metal Mesh (EMM) layer in addition to regular tie reinforcement. The EMM layer is warped above ties. The proposed transverse reinforcement, with various volumetric ratios of ties, was investigated in sixteen square short RC column specimens categorized in two groups according to their slenderness ratios. The specimens were cast in vertical position simulating the construction field and they were tested under concentric compression till failure. The results indicated that the columns, confined with proposed lateral reinforcement, revealed significant improvement in the strength and ductility. Also, high reduction in ties volumetric ratio with no loss in ultimate load could be achieved by installing the EMM layer.

Cosmin Enuica, et.al (2010) [9], in his paper deals with the results and design conclusions based on an experimental programme and its application to a structural rehabilitation. The experimental programme presents the strengthening effect of RC columns by coating with new RC jacketing. Methods of increasing bond between old and new concrete are analysed: no bonding agent; surface chemical bonding agent; mechanical fixed connectors; chemical fixed connectors. The analysed strengthening solutions are applied on an existing four storeys RC framed structures built in 1940 and located in a seismic zone. The structure presents poor quality concrete, poor reinforcement detailing and weakness of reinforcement at present-day magnitude of seismic action.

Hazem M.F. Elbakry, et.al (2016)[6], An experimental program consisting of seven reinforced concrete cube specimens having two-side jackets and four reinforced concrete cube specimens having four -side jackets was conducted. Direct shear tests were adopted for this study as they represent the state of stresses usually exists in actual situations. It was found that increasing the substrate concrete surface roughness by hand-chiselling considerably improved the bond strength compared with grinding. The confining effect of stirrups used in four-side reinforced concrete jackets proved to be effective in enhancing the overall bond strength and could outperform the effect of dowels.

Kale Shekhar et.al (2016)[7], conducted a study to investigate the effect of specimen size on the confinement action of ferrocement jacket. Three types of 27 concrete cylinders with diameters of 150, 100, and 75 mm are cast and tested under axial compression. Each type of specimens is confined with single layer and double layer welded wire mesh ferrocement jacket having a constant thickness of the jacket. The experimental results demonstrate the effectiveness of ferrocement confinement in enhancing the strength, ductility and energy absorption capacity of concrete specimens. The confinement action is found more effective in case of smaller specimens. The failure pattern and stress-strain behaviour indicates that single layer mesh ferrocement jacket cannot provide significant external confinement. However, double layer mesh ferrocement jacket can provide sufficient confinement to enhance the behaviour of confined concrete.

Manikandeswaran ,et.al (2015)[3], in their paper ,two methods for strengthening of columns are compared by experimental investigation: ferrocement jacketing and jacketing by means of steel angle and strips .The cross sectional dimensions of the columns are 200mm X 200mm and the height of the column was 550 mm, 4 number of 12 mm diameter longitudinal bars, 6 mm bars at a spacing of 180 mm, tie bars, thickness of ferrocement jacket is 12 mm, 4 steel angles and steel strips of width equal to 32 mm and 5 mm thickness are used They found that jacketing improves the load carrying capacity appreciably as compared to the reference columns. The ultimate load carrying capacity of columns strengthened by steel angles and strips were found to be increased by 40%. The ultimate load carrying capacity of column strengthened by ferrocement jacketing was found to be increased by 65%. The ferrocement jacketed columns show less deflection at higher ultimate loads when compared with that of the reference columns and column strengthened by steel angles and strips.

Md. Mozaffar Masud, et.al (2016) [4], conducted a study to investigate the effect of confinement using ferrocement as wrapping material on the circular RC columns. The main objectives are to study load carrying capacity of column through external confinement, to study first crack load and mode of failure and to study the effect of ferrocement

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confinement with different layers of wire mesh .External confinement increases the load carrying capacity of RC columns. One layer of confinement with ferro cement jacket increases load carrying capacity up to 23.8 % while two layers increases to 55.2 %.

Mukesh Choudhary, et.al (2016)[5], this paper focuses on some of the important properties and step by step approach for structural strengthening of damaged concrete structures with micro concrete. Micro concrete is mainly useful for core structural repairs such as column jacketing and the micro concrete effectively fills recess of broken members and penetrates behind reinforcements due to its fluidity. Strength gain is also more.

Rahul Dubey , et al .(2016)[2], conducted a study on the effectiveness and suitability of self compacting concrete (SCC) mixes as a retrofitting material and its use as jacket for cylindrical columns.6 control specimens, and 36 primary specimens, initially distressed to 80–85% of theoretical stress level .The control specimens were of diameter 160 mm and height 600 mm, cast in M20 conventionally vibrated concrete, reinforced longitudinally with six bars of 12 mm diameter and five lateral ties of 8 mm diameter as transverse reinforcement. Jacket reinforcement is WWM 25 mmX25 mm made of 3 mm diameter wire. SCC jacket with WWM as reinforcement increases the ultimate load carrying capacity of column specimen. Axial load carrying capacity of the retrofitted confined column improves, because the compressive strength of the confined concrete enhances by the confinement effect. The strong jacket when provided around weak core shall increase load carrying capacity of core because of the confinement effect.

Sayan Sirimontree, et.al (2015)[1],studied on behaviours of reinforced concrete (RC) column encased by longitudinal steel and ferrocement under static axially loading. RC column specimens are encased by vertical steel reinforcements, wrapped by varying amount of wire mesh and then covered with cement mortar. Optimum number of wrapping round of wire mesh is 13 (specimen CF-13) .It can be noticed that concrete core is prevented from failure by ferrocement lead to increase of column ductility .Strength and ductility significantly improved by the increase of the volume of wire mesh. Increasing of ductility is caused by the efficient confinement of wire mesh and mortar cement composite.

Abdullah, et.al (2003) [10], in his study presents behaviour and strength of reinforced concrete (RC) columns strengthened with ferrocement jackets. A total of six identical reference columns were prepared and tested after being strengthened with circular or square ferrocement jackets. Other than the ratio of axial load, parameters studied include the jacketing schemes, and the number of layers of wire mesh. Unless failure occurred at an earlier stage of loading, the columns were tested under cyclic lateral forces and constant axial load. Test results show that by providing external confinement over the entire length of the RC columns, the ductility is enhanced tremendously. Also, test results of this investigation revealed that the design method, proposed earlier by the authors, is very effective.

A.B.M.A. Kaish et.al (2014) [11], investigated the effect of specimen size on the confinement action of ferrocement jacket. Three types of 27 concrete cylinders with diameters of 150, 100, and 75 mm are cast and tested under axial compression. Each type of specimens is confined with single layer welded wire mesh ferrocement jacket having a constant thickness of the jacket. Failure pattern indicates that confinement effect of ferrocement jacket is effective throughout the height of specimens.

Sachin S. Ravala, et.al (2013)[12], employed Four different methods have been employed for jacketing of RC beams, i.e. use of dowel connectors and micro-concrete, bonding agent and micro-concrete, combined use of dowel connectors, bonding agent and micro-concrete and use of only micro-concrete without dowel connectors and bonding agent.Beams of size 150 mm x 300 mm x 2100 mm are used. For smooth surface jacketed beams, highest load carrying capacity has been observed using jacketing technique of combined dowel connectors and bonding agent with micro-concrete as compared to other jacketing techniques used. For chipped surface jacketed beams, highest load carrying capacity has been observed with jacketing technique of using only micro-concrete as compared to other jacketing techniques used.

III. EXPERIMENTAL PROGRAM

An experimental investigation was carried out to understand the effect of jacketing RC cylindrical columns using micro concrete as the jacketing material. Tied wire mesh is used as additional reinforcement in the jacketed region. A steel cage with main steel 4 numbers of 8 mm diameter of grade Fe-415, lateral ties of 6 mm diameter at 150 mm centre to centre spacing is the reinforcement of control column as shown in fig.1.

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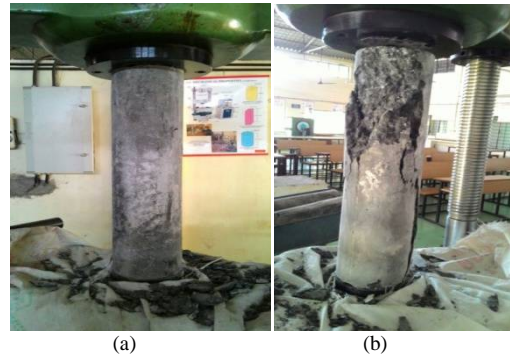


Fig.3. Testing of Control Column (a) Ready for testing(b) After failure at ultimate load

The procedure for jacketing of columns is as follows(fig.4):

- Control columns are loaded up to 80 % ultimate load.
- The outer cover of control column is chipped off using chisel and hammer.
- Coating araldite and hardener over the chipped surface for binding old and new concrete.
- Tie the wire mesh in required diameter.
- Place the chipped column in the mould.
- Place the wire mesh around it.
- Pour the mixed concrete into the mould as the outer jacket and properly level the surface.
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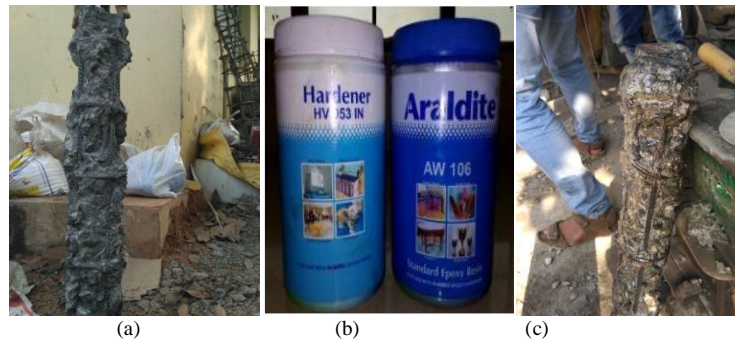


Fig.4. Procedure for jacketing column (a) Chipped column (b) Bonding agent(c)Chipped column coated with bonding agent(d)Mould ready for jacketing(e)Finished specimens

The specimens were named as below:

CC - Conventional Concrete jacketed column

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MJ - Micro concrete jacketed column

IV.RESULTS AND DISCUSSION

The ultimate load was obtained as 422 kN for conventional concrete jacketed column and 700 kN for micro concrete jacketed column. The test set up is shown in fig.5 and fig.6. Comparing with the control specimen, there is 12.5 % increase in load carrying capacity for conventional concrete and 86.6 % increase for micro concrete jacket. Among the two types of jacketing, micro concrete jacketing has more ultimate load, i.e. 25.3 % increase when compared with concrete jacket. The bar chart shown in fig.7 clearly shows the comparison of ultimate loads.



Fig.5. Testing of Conventional Concrete Jacketed Column (a)Ready for testing(b) After failure at ultimate load



Fig.6. Testing of Micro Concrete Jacketed Column (a) Ready for testing (b) After failure at ultimate load

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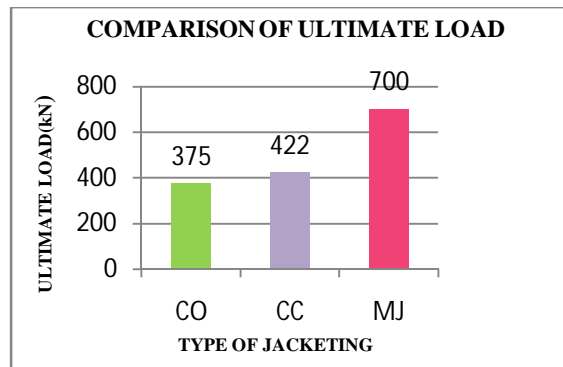


Fig.7. Comparison of ultimate load of specimens

The axial deformations of columns were measured using dial gauge arrangement. The load deflection diagrams were plotted (fig.9) and compared for various jacketed specimens (fig.8). It was observed that micro concrete jacketed column has higher load carrying capacity at less axial deformation.

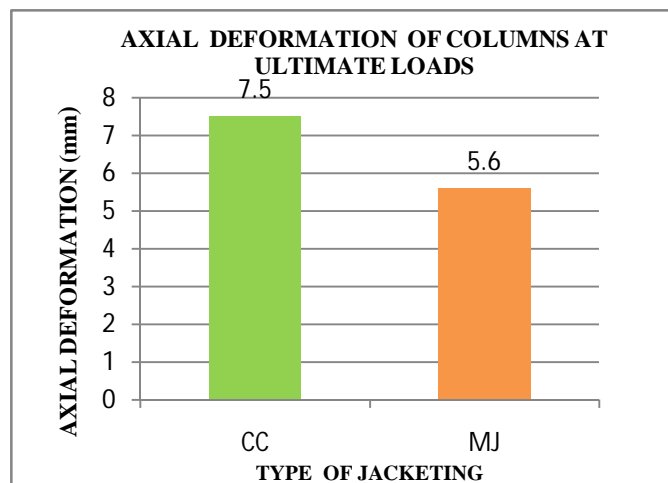


Fig.8. Comparison of axial deformation at ultimate load of specimens

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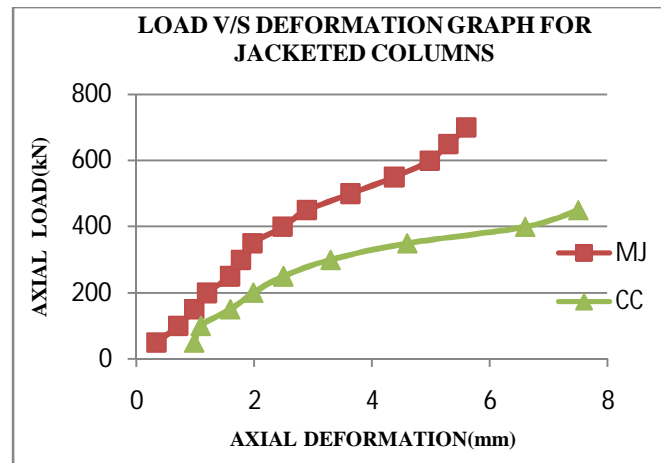


Fig.9. Load v/s Axial deformation graph for jacketed specimens

The failure or crack pattern of both control and jacketed specimens were observed. The control specimens failed suddenly while jacketed specimens failed gradually. Conventional concrete jacketed column failed by gradual crushing while vertical splitting cracks or spalling of concrete outside wire mesh layer was observed in micro concrete jacketed column specimen (fig.10).



Fig.10. Crack pattern of Jacketed Columns (a) Concrete Jacketed column (b) Micro concrete jacketed column

IV. CONCLUSION

In this paper, the effect of jacketing distressed columns was studied in terms of ultimate load, axial deformation and failure pattern. The process of jacketing must be done carefully and it was understood that the difficulty of compaction and skilled labour in concrete jacketing was overcome in case of micro concrete jacketing in which no compaction is required. Conventional concrete jacketed column showed an increase of 12.5 % in ultimate load. When compared with control column, micro concrete jacketed column showed 86.6 % increase in ultimate load

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and with concrete jacketed column showed an increase of 65.8 % in ultimate load and decrease of 25.3 % in axial deformation.

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