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EXPERIMENTAL STUDY ON STRENGTHENING OF REINFORCED CONCRETE SHORT COLUMNS USING FERROCEMENT TECHNIQUE

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Abstract - *Strengthening improve the load carrying capacity of existing columns. The simplicity in construction is the most attracting feature of the ferrocement technique*. There *are various wire mesh shapes available in the market then the best one need to be found out and also a need to study the effect of filleting of the corners of existing columns before Strengthening. The number of mesh layer and the method of fastening the wire mesh to the concrete surface those are the parameter which needs to be studied. Sixty four concrete columns are casted in size of 500*150*150 mm in which one is control specimen and other seven specimens are used for finding the best combination of the parameters mentioned above. The specimens are compared on the bases of the ultimate axial load carrying capacities and lateral deflection. Then the results are analyzed from the displacement ductility and energy absorption capacity of the column specimens. The best wire mesh suitable for* strengthening ferrocement technique is found be Diagonal shape mesh.

Key Words*: (Strengthening of existing columns, Study of various wire mesh shapes, the effect of corner rounding, Suitable bounding mechanism, Effect of multiple layer meshes, Effect of various ductility, specimen test analysis, cost analysis).

1. INTRODUCTION

In our construction field Weak structures are made to withstand heavy loads by Strengthening. It improves the service life of structures. . Lack of load carrying capacity may also be due to the construction errors, air, cracks and water pollutants. If proper attention is not given to these structures it may lead to 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 critical problem can solved only by the strengthening. Framed structures are built based on the concept of weak beam and strong column, that means column elements which can never be allowed to fail. The failure of columns spread like a wave effect to the entire structure and The results continuous failure of all the subsequent stories. So column are the most important elements of a structure. The deficiency in strength of the column over come only by the process of restrengthening. The strength of columns depends on the grade of concrete and the area of longitudinal bars. By the application of external covering and jacketing significantly improve the ultimate load carrying capacity of the column element. The implementation of this method is highly successful in earthquake resistance structures. It can produce better ductility nature to the structure. The more the structure deforms the better the energy absorption and cracks may appear on the structure. Cracks are essentially places where the energy gets released. The nature of cracks can be studied from its pattern and size. There are various methods 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 easiest method by which jacketing can be done. Strengthening by

- *FRP Confinement.*
- *Steel jacketing.*
- *GFRP jacketing*
- *Ferro cement jacketing*

1.1 Scope of investigation

Ferrocement technique is one of the most economic methods compared to other methods such as steel jacketing, fiber reinforced polymer jacketing, carbon fibre reinforced polymer jacketing etc., The main aim of this project is to find the best combination which contributes to increase in the axial load carrying capacity.

1.2 Objectives

- *Identify the improvement in axial load carrying capacity with various wire mesh shapes*
- *Analyze the effect of corner rounding on strengthening.*
- *Determine the suitable bounding mechanism for strengthening.*
- *Compare the effect of multiple mesh layers*

2. METHODOLOGY

First step of the project is Mix design based up on the Literature Review is IS 10262:2009 ,then the Second step Design of Column with 331KN, load carrying capacity, In thired step Casting of Columns, In fourth step Strengthening of columns using various mesh shape ferrocement jacketing ,Fifth step is testing of column. From the above steps can produce a better and economic result for the design.

MATERIALS USED

Cement

In this experimental purpose 53 grade ordinaryPortlancement conforming to IS 12269 is used. Its physical properties obtained from the tests are given in table 3.1

Table 3.1: Physical Properties of cement

Sl. No	Properties	Obtained Values
1.	Fineness	9%
2	Initial Setting time	34 min
3	Final setting time	5 hour 40 min
4	Compressive strength – 7 days	25N/mm^2
5	Compressive strength – 28 days	35N/mm^2
6	Standard consistency	32%
7	Specific gravity	3.12

Fine aggregates

Fine aggregate in the concrete mixture is M sand. Sieves of size 4.75 mm,2.36mm, 1.18 mm,6.. micron,300 micron, 150 micron and 90 micron are used for sieving. The specific gravity of fine aggregate is 2.6.

Coarse aggregates

Crushed stones of 20mm were used as coarse aggregate. The specific gravity of coarse aggregate is 2.9. Sieve analysis was carried out to determine the particle size distribution of coarse aggregates. Sieves of size 20mm, 12.5mm, 10mm, 6.3 mm and 4.75 mm were arranged in order and mechanically sieved.

Water

Fresh or clean water which was free from all impurities, was used for the entire work of concrete preparation and curing.

Steel

Here using 8mm, 12mm diameter reinforcement for the short column consists of Fe 500 grade steel.

GI wire mesh

For jacketing is Galvanized iron meshes are used. There are four different types of wire meshes, square welded, square woven, hexagonal mesh and diagonal mesh.

2.1 CONCRETE MIX DESIGN

In this study M20 mix is used. 0.52 is water cement ration used. Twelve cube specimens are casted and tested (at an interval of 7 and 28 days) to determine the compressive strength. The concrete mix is designed according to IS 10262, with water cement ration of 0.52 and the mix proportion obtained is 1:1.1.794:3.21

Material	Cement	Fine Aggregate	Coarse Aggregate	Water
Mass kg/m^3	379.15	680.23	1217.1	197.16

Table 3.2: Details M20 mix

2.1.1 REINFORCEMENT DETAILS

*The column is designed as Short Column with an ultimate load capacity of 331kN. The columns are of 150 *150 mm in cross section and 500 mm in length. The cover provided to the reinforcement is 20mm. The lateral ties of 8 mm diameter are provided at as spacing of 90 mm centre to centre.*

2.1.2 DETAILS OF COLUMN SPECIMENS

A number of 64 column specimen are casted. One of the eight columns is used as control column, and the rest is used for strengthening by varying parameters such as mesh shapes, corner rounding and fastening of wire mesh by screws and washers.

Table 2.4: Notations for column specimens

Sl. No	*Notation*	*Details*
1	*CC*	*Control Column*
2	*DM*	*Column Strengthened with diamond mesh*
3	*HM*	*Column Strengthened with hexagonal mesh*
4	*SWM*	*Column Strengthened with square welded mesh*
5	*SWOM*	*Column Strengthened with square woven mesh*
6	*DL*	*Column Strengthened with double layer mesh*
7	*MFW*	*Column Strengthened with mesh fastened with screw and washer*
8	*NCJ*	*Column Strengthened with non conventional jacketing*

2.2 PREPARATION OF COLUMN SPECIMNES

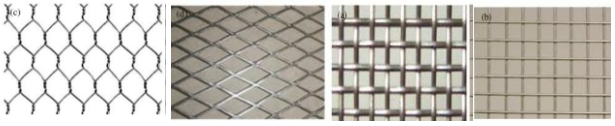
A total number of 64 RC columns of 150x 150x500mm is casted at the laboratory. The concrete is placed in the steel forms, then allowed to set for 24 hours. After 24 hours the forms were removed and the specimens are allowed for curing for 7 days. Then they are prepared for wrapping. The Specimens are grouted after wrapping the ferrocement meshes

2.3 STRENGTHENING OF SPECIMENS

After seven days of water curing the specimens are strengthened. The columns are wrapped with wire mesh and then grout is applied. Ferrocement mortar is applied only after 24 hours once the grout is applied. The ferrocement mortar mix ration is 1:3 and the thickness of ferrocement is about 1 c.m. For DL specimens two layers of mesh is wrapped, the wrapped mesh is fastened with tie wires. Corner rounding is done for NCJ specimen with a chisel the rounded corners are of a radius of about 2cm. In case of MFW specimens the concrete was drilled and plastic plugs are inserted and screw is placed with washers these helped secure the meshes to the original column as close as possible.

1. *Square woven mesh*
2. *Square welded mesh*
3. *Hexagonal mesh*
4. *Diagonal Mesh*

TYPICAL MESH TYPES



2.4 DESCRIPTIONS OF TEST PROGRAM

The columns are tested on the UTM, which have a maximum capacity of 1000kN as. After a curing period of 28 days the surface of columns are cleaned and painted with white cement. for the clear visibility of cracks. For testing the column the loading plate was placed at top and bottom part of the specimen. For wrapped specimens also the procedures were same. Then axial load is applied and it is continued until the failure took place. The axial deformation-load graphs are automatically generated. The lateral deflections are measured by using dial gauges placed on four sides of the column. The accuracy of the dial gauges is 0.01mm. The loading was continued until the load decreased to 25% of the ultimate load in all cases, this is for uniformity in the data recorded.

Test set up UTM

CRACKPATTERN

3. RESULT AND DISCUSSIONS

The results of strengthened specimens are compared with that of the control specimen. Comparison of load deflection curve, energy, absorption capacity and displacement ductility are presented. The crack patterns of the specimens are also discussed.

3.1 TESTS ON CUBES

Compression test are conducted on 15x15x15cm size cube after 7 and 28 days. Clean and surface dried specimens are placed in the testing machine .The load plates was placed at two ends of the specimen .and load was applied gradually and maximum load was recorded. Mean of the three results were taken as the cube crushing strength.

Sl.No	7^{th} daystrength (N/mm^2)	28^{th} day strength (N/mm^2)
1	20.2	26.9
2	20.8	27.2
3	19.5	26.6

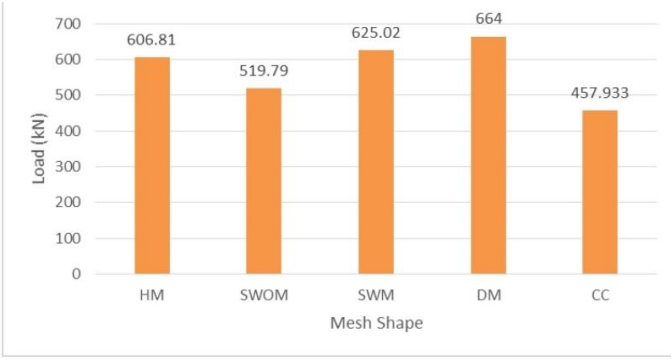
Compression test results

3.2 TEST ON COLUMNS

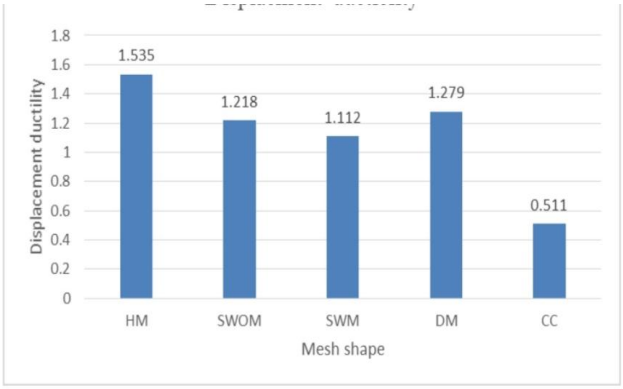
Failure Pattern

- *Control column*
- *HM Specimen*
- *DM Specimen*
- *MFW Specimen*
- *NCJ Specimen*
- *DL Specimen*

Comparison of the failure pattern tested on control column and various specimens results are following and axial load carrying capacity, effect of ductility on various specimens be tested

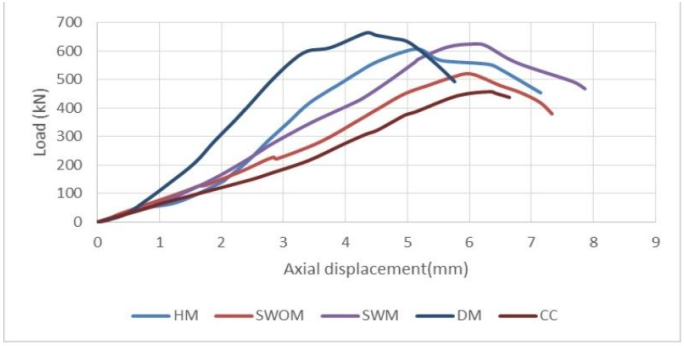


Graphical representation of ultimate load

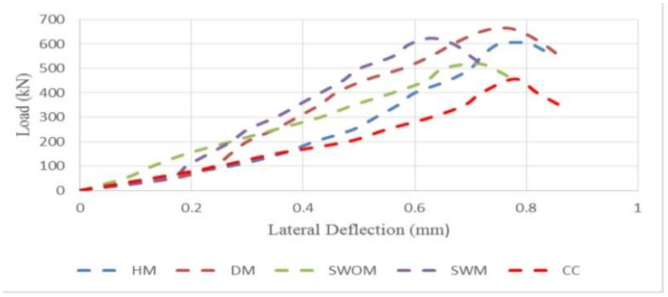


Displacement ductility

LOAD VS DISPLACEMENT & LATERAL DEFLECTION



Load vs axial displacement



Load-lateral deflection

Displacement ductility

Mesh shape	P_{umax}	Yield Load	Y	$0.8P_{umax}$	u	u/y
DL	606	454	4.95	484	7.1	1.43
SWOM	519	389	5.95	415.2	7.25	1.22
MFW	757	567	3.7	678	5.5	1.49
SWM	625	468	6.15	500	6.75	1.10
NCJ	587	440	2.9	628	6.55	2.26
DM	705	528.7	5	564	6.3	1.26
HM	664	498	3.85	531	5.5	1.43
CC	457	343	6.3	365	7.2	1.14

Crack pattern

4. COST ANALYD

4.1 Material

Item	Cost (Rs)	Unit
Cement	370	50Kg
M sand	63	25 Kg
GI Wire mesh	100	$1m^2$
Cost of hardener	820	1ltr
Cost of resin	520	1 ltr
CFRP	6000	1 Kg
GFRP	176	1 Kg
Steel	58	1 Kg

4.2 Approximate cost of different strengthening methods

The analysis indicates that among all the four different methods CFRP is the cheapest method followed by ferrocement technique. Both CFRP and GFRP uses epoxy resins which will make the cost of application even higher. Steel jacketing requires specialized tools and labour whereas ferrocement jacketing does not need any special labour or tools and the extra cost is minimum for ferrocement due to this reason.

Method of strengthening	Approximate cost of strengthening one column(Rs)
CFRP	2000
GFRP	300
Ferrocement	600
Steel Jacketing	1000

5. CONCLUSIONS

The increase in ultimate load carrying capacity of Diamond mesh shape strengthened column (DM-705kN) compared to control column (CC-457kN) is 54.3%.

- *The increase in ultimate load carrying capacity of Hexagonal mesh shape strengthened column (HM-664kN) compared to control columns is 45.3%.*
- *The increase in ultimate load carrying capacity of Square Welded mesh shape strengthened column(SWM-625kN) compared to control columns is 36.8%.*
- *The increase in ultimate load carrying capacity of Square woven mesh shape strengthened column (HM-519kN) compared to control columns is 13.6%.*
- *The column strengthened with wire mesh fastened with screw and washers(MFW-757kN) specimen sowed an increase in ultimate load of 65.6% compared to control specimen and this is 20.3% more than HM specimen which uses the same mesh.*
- *The column strengthened with double layer mesh (DL-606kN) specimen showed an increase in ultimate load 32.6% compared to control specimen and this is 19% more than specimen which uses the same mesh.*
- *The decreasing orders of energy absorption capacity of specimen are NCJ, SWM, DL, MFW, DM, HM, SWOM, CC.*
- *The decreasing orders of displacement ductility value are NCJ, MFW, DL, HM, DM, SWOM, SWM, CC.*
- *The diamond mesh shape showed the highest axial load carrying capacity.*
- *Non-conventional jacketing is better than ordinary jacketing.*
- *Use of screws for fastening the mesh improves the load carrying capacity.*
- *The load carrying capacity increases with the number of layers of mesh.*

6. REFERENCES

- ***A.B.M.A Kaish**, M.R. Alam, M.F.M.Zain, M.A Wahed "Improved ferro cement jacketing for restrehgthening of square RC short column"*

- ***Huzem M F**. Elbakry, Ahmed M. Tarabia "Factors affecting bond strength of RC column jackets" Alaxandria Engineering Journal (2016)55.5767*

- ***Muhammad Taghi Kazemi**, Raza Morshed "Seismic shear strengthening of R/C columns with ferro cement jacket" Cement Concrete Composites 27 (2005) 834842*