IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 2, November 2023

Rehabilitation of RC Structure by Using Ferrocement Jacketing

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Abstract: *Many structures fail or deteriorate before completion of its intended life span due to poor quality of material used, lack of mix design, poor workmanship, attacked by environmental agencies, etc. Sometimes due to slenderness of column or less reinforcement provided than actual requirements, less depth/thickness provided in flexural members, etc. feels excessive vibration during walking on floor ultimately develops cracks. Strength of such structural elements can be found by using non-destructive tests like Rebound hammer test, ultrasonic pulse velocity test, etc. If strength of existing structural elements is less than desired strength then structural consultant suggested strengthening of structural elements. There are various methods used in strengthening of existing structural elements like pressure grouting, fibre wrapping, chemical treatment, structural steel support, jacketing, etc. But these techniques are very costly and need precise quality control activity. In the present of investigation, strengthening of beam and column elements of a building by ferrocement techniques and steel jacketing were carried out and cost and cost comparison and strength results before and after strengthening are presented. It is observed that the strength og structural by ferrocement technique is cost effective than steel jacketing technique. And also has increase in the strength of RCC elements.*

Keywords: Strengthening, Ferrocement, Steel Jacketing

I. INTRODUCTION

Concrete is one of the most widely used building materials in the world because of its multiple advantages. Reinforced Concrete structures regardless of the experience gained over years still require repair and strengthening because of natural reasons, human mistakes and change in loading conditions. This necessitates the retrofitting of existing structures to meet safety requirements in seismic areas and where the load carrying capacity has to be enhanced. Research works have proved that the strength and deformation of RC columns can be increased through confinement of concrete core by jacketing techniques. The commonly used materials for jacketing include reinforced concrete, steel, fibre reinforced polymers (FRP), fibrocement etc. Though commonly used RC jackets enhance the strength and improve overall performance, they require labour intensive procedures. Also, these techniques increase member size and hence add to the dead load, reduce the available space and also alter stiffness. Researchers have established FRPas an efficient confinement material than conventional ones. However, FRPisan expensive material and it requires skilled labour for wrapping.

Reinforced concrete (RC) structures often suffer damages due to overloading, natural disasters (like earthquake, tsunami, cyclone, flood, etc.), fire, various environmental effects (like corrosion), change in building usage,etc., before reaching their intended design life. These damages may cause failure of structural elements. If proper attention is not paid in this regard, entire structure could fail to carry its design load and catastrophe could happen.Failure of the most authoritative structural element such as column may lead to total collapse offrame-structured building as it is the only structural element that conveys the total vertical loads of the building to the ground. This member could lose its strength and stiffness due to damages occurring in its service life. Therefore repair or reconstruction is necessary in case of noticeable crack, so that they can carry loads and transmit them to the ground. One So the carry loads and transmit them to the ground.

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1.1 Problem Statement

Generally the life of RCC buildings is considered 50 years, but due to poor workmanship and environmental factors the RCC building get deteriorate and the strength get reduce. The reduction in strength can lead to building collapse or an element collapse which can lead to human injury. So, **structural failure or deterioration before completion of its intended life span.**

1.2 Scope of Work

The need of retrofitting in reinforced concrete beam and column, especially in the case of bridge piers and high rise structure, is growing. In our country alone, there are nearly small and medium size bridges in need to repair.

The used of advanced composite materials in the form of jackets, for rehabilitation purposes, in an emerging concept.

These materials are extremely expensive and guidelines for their optimum usage are needed. The present work is focused towards realizing the objective. Present work is done to cover different retrofitting purposes like improving the moment carrying capacity of reinforced concrete beams subjected to torsion.

1.3 Objectives

Following are the objectives of the present study;

- To study rehabilitation of RC beam and column by using ferrocement jacketing wrapped by welded mesh.
- To study increase in load carrying capacity of strengthened beam an columns.
- To determine the flexural rigidity of the RC beam retrofitted in single and double layer wrapping by measuring deflection of retrofitted beam and compare with control beam.
- Comparison of test results to find increase in strength after jacketing with welded mesh.

II. LITERATURE REVIEW

Mini Soman, Jebin Mohan. (2018)[1]:- It observed that, the confinement effectiveness and hence load carrying capacity of column improved with number of layers of wrapping but reduced with increase in aspect ratio and preloading rates. An analytical model is also proposed to predict the ultimate load carrying capacity of columns after rehabilitation. [1]

S. Jaayasree, N. Gansan, Ruby Abraham :- Corrosion of reinforcement is one of the main causes of deteriorstion of RCC structure which affects the load carrying capacity and its durability though it is very difficult to completely eliminate the chances of corrosion, suitable retrofitting strategies can be introduced as a measure for the retrofitting of corrosion damaged structures to gain its original strength.. [2]

Y.V. Ladi and P.M. Mohite. (2013):- stated that . The load deflection characteristics and mode of failure are studied. The test results indicate that, when beam retrofitted with wire mesh in layers at orientations, it significantly increases the load carrying capacity, first crack load, stiffness but deflection is decreases in both flexural and shear strengthening. [3]

Gurbir Singh Benipal, Kamaldeep Singh (2015):- stated that Various retrofitting techniques are used in field and out of all plate bonding technique is considered as the best.. [4]

A.B.M.A. Kaish, M.R. Alam, M.F.M. Zain, M.A. Wahed (2012) stated that , improvement of conventional square ferrocement jacketing technique is focused in this study. [5]

Abdullah, Katsuki Takiguchi. (2003) stated that This study presents behavior and strength of reinforced concrete (RC) columns strengthened with ferrocement jackets. [6]

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III. RESEARCH METHODOLOGY

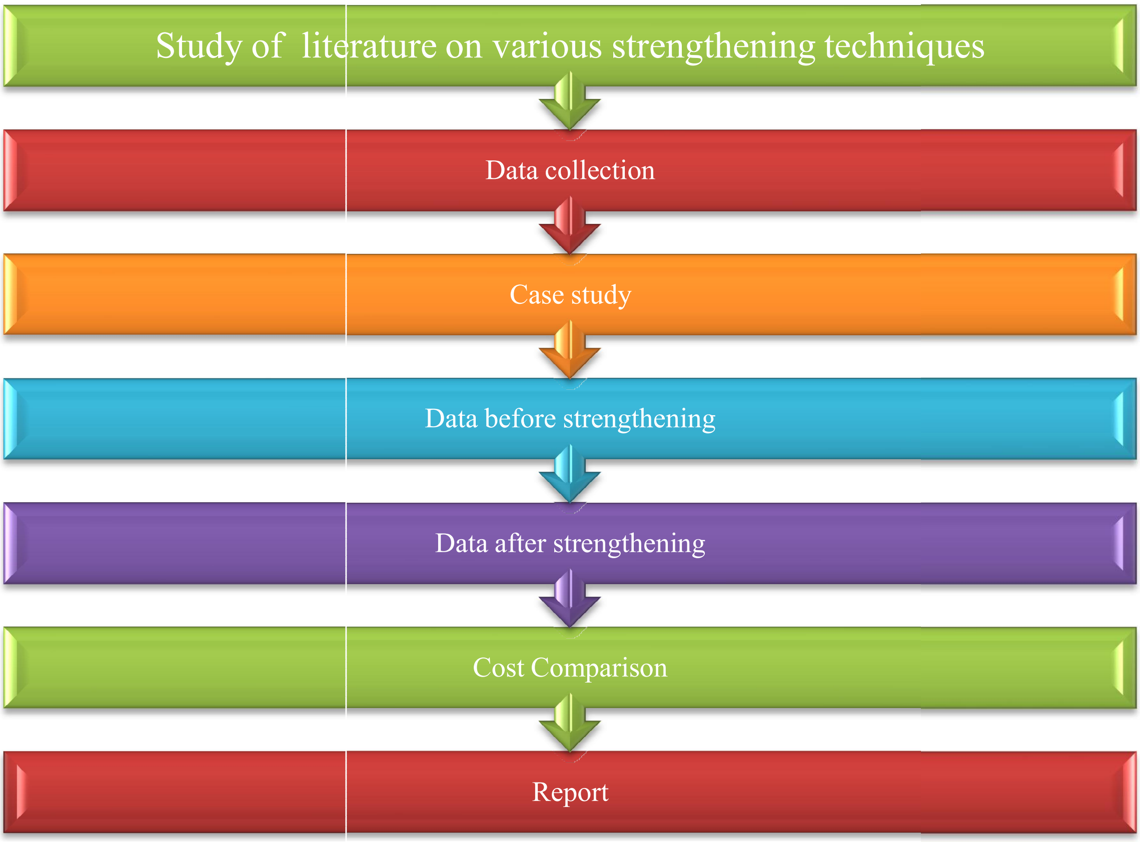

Fig 1: -Methodology

3.1 JACKTING OF COLUMN

The distressed column specimens were jacketed with ferrocement mesh and cured for 28 days, columns that underwent pre-loading up to failure were repaired using morter of 1:2 proportion & the sides of specimen were restored Welded wire mesh having square opening of 12.5 x 12.5 mm opening was tied to the plastered column Mesh was tightened around the faces in square shape, while two layers of wire mesh were in circular shape touching with the edges of column. This circular wrapped wire mesh is functioning for adhering the mortar which takes load from the column. While retrofitting of the column, the shape of changes from square to circular, Full height jacketing was provided with opening of 20mm at both ends to avoid direct loading on ferrocement mesh

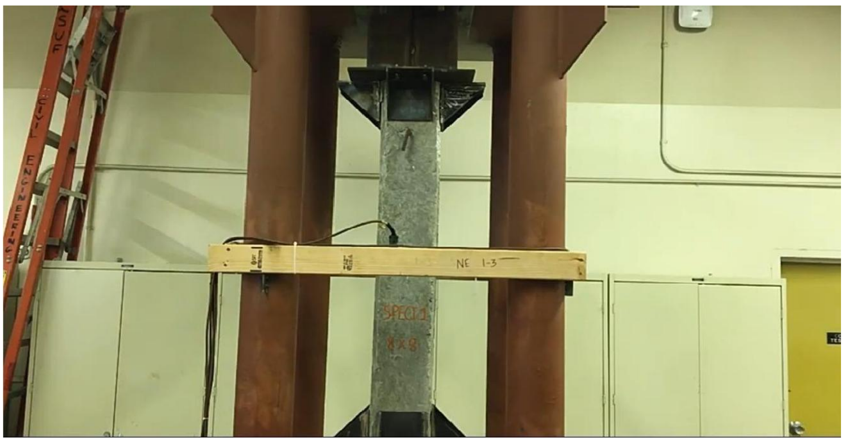

Figure 2. Test setup for specimen

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Control and jacketed columns were tested under axial compressive loading in a Universal Testing Machine (UTM). The test setup is shown in Figure 1 Verticality of the column was ensured during the test to obtain a central loading on the column. The plain faces are to be made at the time of jacketing to columns which avoids the eccentric loading to the column. The axial displacement were noted using LVDT until the failure of specimen. Ultimate load axial deformation and failure patterns of specimens were observed.

3.2 TESTING ON BEAM

All beams were tested one by one. All of them are tested in the above arrangement. The gradual increase in load and the deformation in the dial gauge reading are taken throughout the test. The dial gauge reading shows the deformation. The load at which the first visible crack is developed is recorded as cracking load. Then the load is applied till the ultimate failure of the beam. The deflections at two salient points mentioned for the beams with and without aramid fiber are recorded with respect to increase of load and angle of twist is been calculated and are furnished in table. The data furnished in this chapter have been interpreted and discussed in the next chapter to obtain a conclusion. First all beams are tested as controlled beam or for pre-retrofitting arrangement and then twelve beams are tested for after retrofitting with aramid fibers. Then the experimental results are compared with software for validation. Using dial gauge the angle of twist is calculated by using formula for experimental results.

Figure 3: Experimental setup of the control beam

Casting

In the casting process, all the ingredients were first mixed in dry condition, to the dry mix; calculated quantity of water was added and thoroughly mixed to get a uniform mix. Shuttering oil was applied on the inner face of plywood mould and the reinforcement cage was placed in the position. Concrete was poured in three layers was compacted by tamping rod as shown in fig. The specimens were cured in curing tank for 28 days

Fig 4: - Casting

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3.3 TESTING PROCEDURE

Nineteen beams were designed and casted to fail in flexure only. Six beams were casted as a shear deficient means without shear stirrups. After completion of curing time, beams were tested using universal testing machine of 600 KN capacity with two point loading. The deflections at three points were recorded by using dial gauge having least count 0.01 mm at every 2.5 KN increment of load. Out of twenty five beams three beams were tested as a control beam to find out ultimate load of the beam. Eight beams were distressed by 60% of ultimate load. Balance eight beams were distressed by 80% of ultimate load. Cracking pattern in control beam and experimental set up is shown in Figure

Fig 5:- Beam casting

3.4 PROCESS OF RETROFITTING

After first stage of loading, the distressed beams were retrofitted by using ferrocement jacketing. Ferrocement is another form of reinforced concrete in which cement sand mortar is reinforced with closely spaced MS welded wire mesh. In this study, square grid MS welded wire mesh (wire mesh of 16 mm x16 mm x 0.8 mm diameter) was used for all specimens in single, double layer at 00 and 450 orientations. The surfaces of the distressed beam were roughened by using hacker and wire mesh was wound over it. The mesh was tightened using binding wires. A thick cement paste was applied as bonding agent before application of mortar in order to get a good bond.

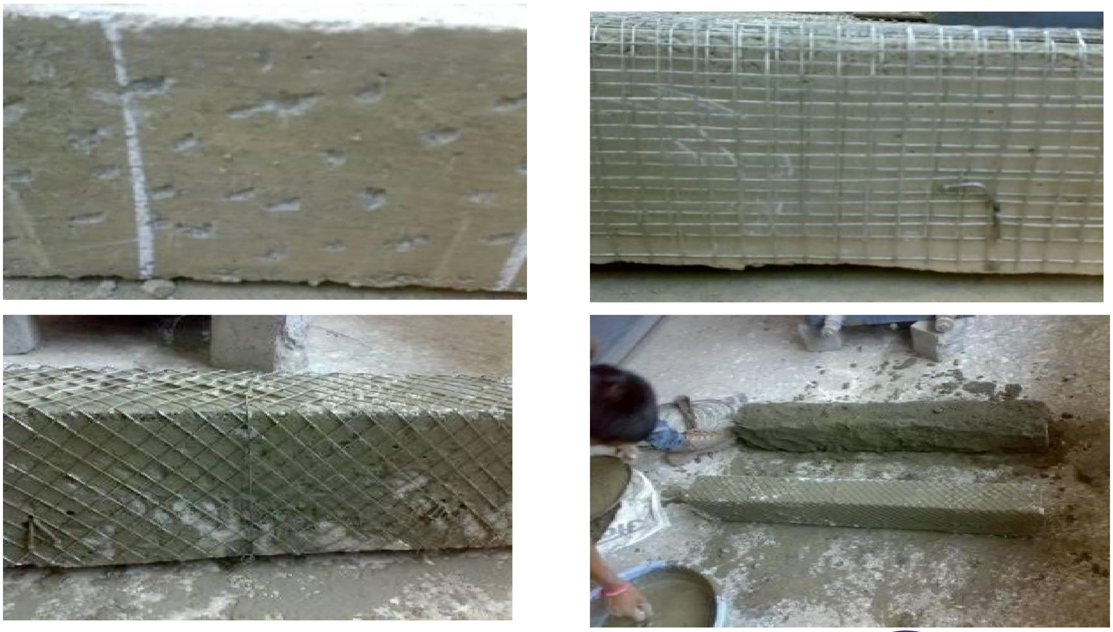

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Figure 5: Process of Retrofitting

Plastering was done with cement mortar having the ratio of 1:3 by weight and water cement ratio was kept as 0.5. The 20 mm thickness of mortar was applied on the beam surface. The retrofitted beams were cured for 28 days in curing tank. Following Figure 5 shows process of retrofitting.

IV. RESULTS AND DISCUSSIONS

For Calculation I have consider a 12m span beam. The rates and weight per unit are taken through market survey.

4.1 Material Rates

Sr. No.	**Materials**	**Size**	**Cost (Rs.)** 2019-20	**Cost (Rs.) 2020-21**
1.	Steel bar	10 mm dia.	36/kg	54/kg
2.	Steel bar	08 mm dia.	34/kg	55/kg
3.	Steel Plate	08 mm thick	60/kg	88/kg
2.	Wire mesh	12 gauge	35/sqm.	40/sqm.
3.	Chicken mesh	0.785 gauge	20 /sqm.	26 /sqm.
4.	Cement	1 bag	350	370
5.	Crushed sand	1 bag	100	120
6.	Admixture	1 litre	500	525

Table 1: Material Rates.

Cost Calculation

Beam considered of 12m x 0.3048 m x 0.6096m

i) For steel jacketing:-

Steel required = 12 X 0.15 X 8 = 14.4 m^2
20 X 0.15 X 0.6096 = 1.8288 m^2
20 X 0.15 X 0.3048 = 0.9144 m^2

17.1432 m^2

Steel quantity (kg) = 17.1432 x 62.80 ($1m^2$ = 62.80 kg)
= **1076.59296 kg**

Cost of steel = 1076.59296 x 60 (60 Rs/kg)
= 64,595.5776
= **64,596 Rs**

Labour Cost **= 3 x 1000 x 3**
= 9,000 Rs

Miscellaneous Cost **= 2,000 Rs**

Total Expenditure **= 64,596 + 2,000 + 9,000**
= 75,596 Rs

DOI: 10.48175/IJARSCT-13873

ii) For ferrocement technique:-

Steel required -

i) Weight:-

a) 10 mm – $D^2L/162.28$ = 0.616 kg

b) 08 mm - $D^2L/162.28$ = 0.395 kg

ii) Steel quantity (kg) -

a) 10 mm - 0.616 x 12 x 16 = 118.272 kg

b) 08 mm - 79 x (0.3048 + 2(0.6096) = 47.55642 kg

iii) Cost of steel-

a) 10 mm - 118.272 x 45 = 5322.24 Rs (45 Rs/kg)

b) 08 mm - 47.55642 x 43 = 2044.926 Rs (43 Rs/kg)

7367.166 Rs

For 12mm thick coat

Plastering for $1m^2$ = 1.33 x 0.012

= **0.01596 m^3**

Beam volume = LxBxH

=12 x 0.3048 x 0.6096

= **2.229 m^3**

Surface area = both side of Beam + Base of beam

= 2(12 x 0.6096) + (12 x 0.3048)

= 18.288

= **18.5 m^2**

Quantity for 12m Beam Material = 0.01596 x 18.5

= **0.28728 m^3**

Quantity of Material: - (1:3)

i) Cement = 1 x (0.28728/4) = **0.07182 m^3**

ii) Sand = 3 x (0.28728/4) = **0.21546 m^3**

Quantity of Material (kg):-

i) Cement = 0.07182 m^3 x 1440 kg/m^3

= 103.4208 kg

= **150 kg (approx.) =3 bags**

ii) Sand = 0.21546 m^3 x 1600 kg/m^3

= 344.7360 kg

= **350 kg (approx.) = 7 bags**

Cost of material:-

i) Steel bar =7367.166 Rs = **7,367.166 Rs**

ii) Cement = 3 x 350 = **1,050 Rs**

iii) Crush Sand = 7 x 100 = **700 Rs**

iv) Wire mesh = 18.5 x 35 = 370 **Rs**

v) Chicken mesh = 18.5 x 20 = 185 **Rs**

Labour Cost = 3 x 1000 x 3
= 9,000 Rs

Miscellaneous Cost = 2,000 Rs

Total Expenditure = 9,949.666 + 2,000 + 9,000
= 20949.67 Rs

4.2 Cost Comparison

Sr. no	Materials	Steel jacketing	Ferrocement
1.	Steel bar (10 mm)	-	5322.24
2.	Steel bar (08 mm)	-	2044.926
3.	Steel Plate (08 mm)	64,596	-
4.	Wire mesh (12 gauge)	-	370
5.	Chicken mesh (0.785 gauge)	-	185
6.	Cement	-	1,050
7.	Crushed sand	-	700
8.	Miscellaneous	2,000	2,000
9.	Labour (3 no)	9,000	9,000
10.	Overhead (5%)	3,779.8	1047.483
	Total	79,376	21,997.15

Table: Cost Comparison

V. CONCLUSION

After studying this technique, we find its importance and its implementation need in construction project management. reviewing all the literature materials and through case study approach we can successfully implement the Ferrocement Jacketing method.

- Strengthening a RCC building is a better option than demolition and construction.
- Depending upon the various factors we can select suitable technique of strengthening.
- As per study done Ferrocement Saves nearly 3.6 times cost as compare to steel jacketing.
- Thickness of strengthening by ferrocement is much less than that of steel jacketing.
- Strength of RCC columns and beams can be significantly improved by ferrocement jacketing.
- After ferrocement jacketing, strength of structural concrete is 1.5 to 2 times improved than old concrete of existing columns.
- Ferrocement jacketing gives better bond between old and new matrix due to evenly spaced chicken meshes wrapped over old structural concrete and also inserts with re-barring.
- Excessive vibration developed in the floor cease due to increasing size of structural element.
- Ferrocement technique is more suitable and economical than other strengthening techniques.

VI. ACKNOWLEDGEMENT

The author thankfully acknowledges to Prof. S. R. Dharne, Professor of Civil Engineering Department, TSSMs Bhivarabai Sawant College Of Engineering And Research, Narhe, Pune, India for their motivations and infrastructural support to carry out this research.

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