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: 7.53
Volume 4, Issue 4, April 2024

Economic Study of Strengthening of Existing RCC Building

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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.

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.**

Objectives

Following are the objectives of the present study;

1. To study various strengthening methods for RCC building.
2. To suggest the economically suitable strengthening technique for RCC building.
3. To find post strengthening strength of building through case study.
4. Comparison of cost to find which technique is suitable and more economical.

II. LITERATURE REVIEW

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III. RESEARCH METHODOLOGY

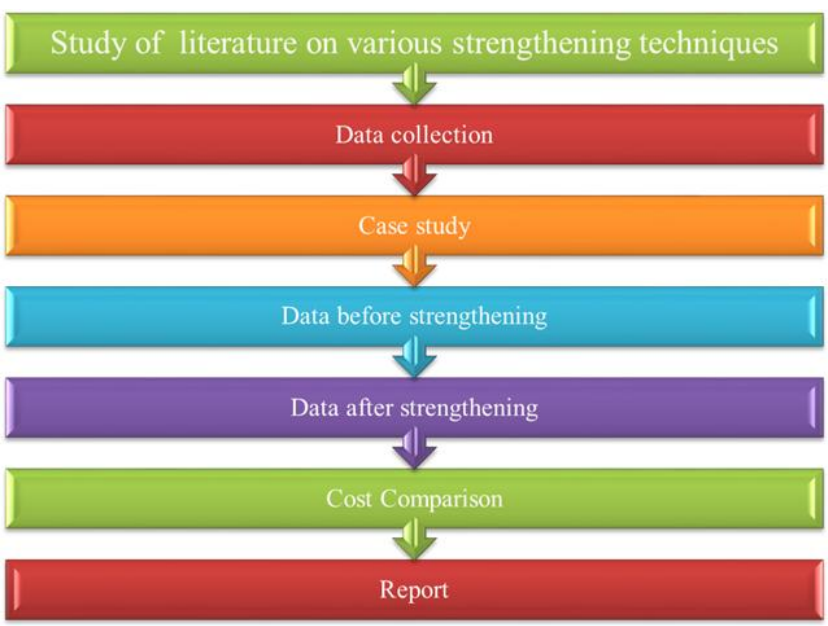

Fig 1: -Methodology

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IV. CASE STUDY

For study of existing RCC structure, I have selected G+2 framed structure of old College building which was constructed in 2015 and after 5 years of construction, NDT was carried out due to excessive vibration and cracking observed in RCC elements. It was observed that the strength of some columns, beams and slabs are less than 15 MPa but these elements were designed for M25 grade of concrete. Due to poor strength, Slabs are vibrated during walking while some vertical cracks were observed in beams.

So, after NDT by Rebound Hammer test, Management has decided to strengthen the RCC element

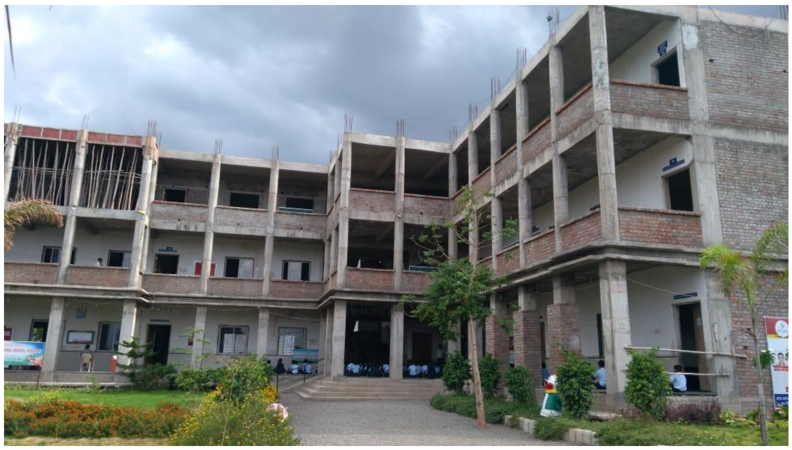

Fig 1.1 Site

After visual inspection, observation and impact of small metal hammer on the concrete surface, it is decided to measure the strength of existing structural members like slabs, beams and columns at different floor level by nondestructive testing and also by taking some cores to judge the quality of concrete. Fig.9 shows testing of concrete core and NDT by Rebound Hammer and Ultrasonic Pulse Velocity Tester. Size of concrete core was taken as 70mm diameter and 140 mm deep. Table No.5, 6 and 7 show the test results of NDT by rebound hammer and ultrasonic pulse velocity test on existing RCC elements and concrete core test taken from slab, beam and column at particular section before strengthening.

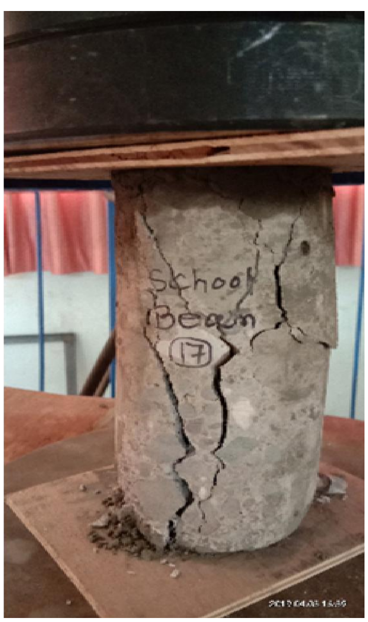

Fig. 4.2 : (a) Concrete Core Testing

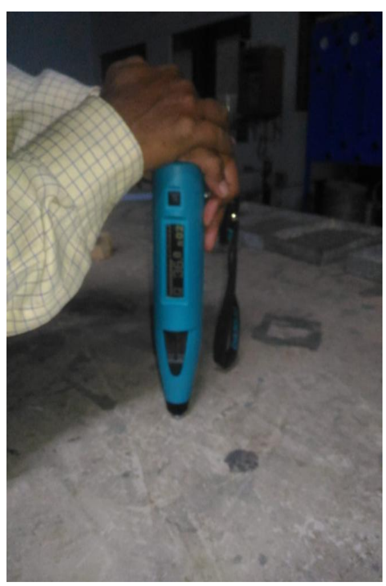

Fig. 4.2 : (b) Rebound Hammer test on slab

Fig. 4.2 : (c) Rebound Hammer test on Column and Beam

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Table No.4: Test results of NDT and concrete core test taken on floor slab.

Sr. No.	Particulars (1st Floor slab, M25)	Rebound Hammer Test		Ultrasonic Pulse Velocity			Core Test, Size of core =70 mm Ø X 140 mm Ht.	
		Angle	Ave. comp. Strength, MPa	Transmission type	Ave. velocity km/s	Ave. Comp. Strength, MPa	Mass Density, kg/m^3	Comp. Strength, MPa
01	Span-1		13.00		2.225		2081.69	8.36
02	Span-2		12.15		1.587		2073.97	8.87
03	Span-3	+90^0	13.50	Indirect/ Surface	1.632	< 10	2086.65	7.56
04	Span-4		14.25		2.36		2002.18	10.11
	Span-5							
05			14.00		2.31		2105.46	9.60

Table No.5: Test results of NDT and concrete core test taken on Columns

Sr. No.	I. mark Column No.(Gr./ I/II) Size of column: 230mmX500mm	Rebound Hammer Test	Core Test Size of core :70mmØ X 140mm Ht.	
		Ave. Compressive strength	Mass Density, kg/m^3	Compressive Strength N/mm^2
1	C7- 2nd floor	17.50	2122.38	14.05
2	C8- 2nd floor	13.00	2123.33	12.36
3	C17- Gr/1st /2nd	13.50	2256.43	10.03
4	C18-1st /2nd	10.00	2151.12	12.08
5	C19- Gr/1st /2nd	11.50	2272.11	10.18
6	C22- Gr/1st	10.50	2201.78	12.43
7	C23- Gr/1st	14.00	2134.35	16.87
8	C33-Gr/1st	15.00	2131.39	17.89
9	C39-1st / 2nd	12.50	2109.78	11.32
10	C41-Gr/1st	11.50	2129.76	13.78
11	C34-Gr/1st	14.50	2321.09	13.11
12	C35-1st /2nd	17.00	2301.27	15.78

Table No.6: Test results of NDT and concrete core test taken on beams.

Sr. No.	Beam No. grade of concrete (Gr./ I/II), Size	Ave. Compressive strength	Mass Density, kg/m^3	Compressive Strength, N/mm^2
1	B63- M30, Gr Floor, 10m span, Continuous, 230X750mm	19.50	2327.72	17.63
2	B63-1st, M30, 1st Floor, 10m span Continuous 230X750mm,	18.00	2348.31	15.89
3	B70-Gr Floor, M30, 9m span, S.S. 230X600mm	17.50	2291.79	15.67
4	B33-2nd floor, M30, 6m span, SS 230X450	16.50	2256.43	18.032
5	B12-2nd floor, M30, 6m span, SS 230X450	15.00	2159.12	14.24

It is observed that the strength of most of structural elements tested using NDT and concrete core test were less than 60% of characteristic compressive strength of concrete. Due to less strength, the floors were vibrated during movement of men and materials and also vertical cracks are developed at particular locations in beam (Near support and at center). In case of beam of large span (8 to 10m), cracks were developed in the middle one third of span. It might be due to less reinforcement provided than required at bottom and weak bond developed due to lesser compressive strength of concrete and voids present in concrete or porous concrete (as mass density of concrete core was found to be less than 2400 kN/m^3.

It is observed that the compressive strength of structural elements after strengthening by ferrocement techniques gives better results of strength (1.5 to 2 times more than old RCC elements). A Ferrocement technique gives uniform, consistent and better results of strength than any other method of strengthening. A beam of 10m span strengthening by steel jacketing suggested by consultants spent about seventy five thousand rupee while strengthening by ferrocement needs less than half the cost. That means ferrocement technique gives better performance with economy than other strengthening techniques

Table No.7: Test results of NDT after strengthening by ferrocement jacketing.

Sr. No.	I. mark	Ave. Rebound No.	Standard Deviation	Ave. Compressive strength	C. Strength before strengthening	Remark (Increase in strength)
1	C33-Gr	51	5.9	32.00	15.00	133.33%
2	C39-1st	47.8	3.7	30.50	12.50	144.00%
3	C41-Grt	49.1	4.1	31.50	11.50	173.91%
4	B63- , Gr Floor	54.6	3.9	33.50	19.50	71.79%
5	B63- , 1st Floor	49.7	4.3	31.50	18.00	75.00%

VII. RESULTS AND DISCUSSIONS

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

Material Rates

Sr. No.	**Materials**	**Size**	**Cost(Rs.)** 2019-20	**Cost(Rs.) 2022-23**
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 No.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

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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**
= <u>75,596 Rs</u>

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 = $0.07182\ m^3 \times 1440\ kg/m^3$
= 103.4208 kg
= **150 kg (approx.) =3 bags**

ii) Sand = $0.21546\ m^3 \times 1600\ kg/m^3$
= 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**

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 No.: Cost Comparison

IX. CONCLUSION

After studying this technique, we find its importance and its implementation need in construction project management.

- 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.

ACKNOWLEGEMENT

The author thankfully acknowledges to Prof. S. S. Ambhaikar, 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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