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RETROFITTING OF COLUMN

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***Abstract:-** To improve the performance of any structure under seismic condition and future earthquake is very essential now-a-days because earthquakes have occurred in the recent past in India varying magnitude. So, it is quite important to develop some innovative techniques, materials and solution for the structural repair, seismic strengthen and retrofitting of existing buildings. Selection of right materials and right technology is a challenging task for the structural engineers over some conventional method.*

Jacketing is the most popularly used method for strengthen the building columns. The most common types of jackets are steel jacket, reinforced concrete jacket, fiber reinforced polymer composite jacket, jacket with high tension materials like carbon fiber etc. In this paper, To compare the axial load carrying capacity of retrofitted square columns with reference square column of size (240mmx240mmx720mm), hence to determine the suitability of RC jacketing technique for this. Use of standard and innovative repair materials, appropriate technology, workmanship and quality control during implementation are the key factors for successfully repair, strengthen and restoration of damaged structures.

***Keywords-** Retrofitting, column, Jacketing, strength*

INTRODUCTION

A column is a very important component in a structure. It is like the legs on which a structure stands. It is designed to resist axial and lateral forces and transfer them safely to the footings in the ground. Columns support floors in a structure. Slabs and beams transfer the stresses to the columns. So, it is important to design strong columns. Retrofitting is the modification of existing structures to make them more resistant to ground motion, or soil failure due to earthquakes. Protection of the lives of building occupants in an earthquake is the main goal of the retrofit (this is referred to as “life safety” performance in building codes).The behaviour of columns in tall structures is very important since column failures lead to additional structural failures and can result in total building collapse.

Jacketing of columns is needed when the load carried by the column is increased due to either increasing the number of floors or due to mistakes in the design. It consists of added concrete with longitudinal and transverse reinforcement around the existing columns. This type of strengthening improves the axial and shear strength of columns while the flexural strength of column and strength of the beam-column joints remain the same. A major advantage of column jacketing is that it improves the lateral load capacity of the building in a reasonably uniform and distributed way and hence avoiding the concentration of stiffness as in the case of shear walls. This is how major strengthening of foundations may be avoided. In addition, the original function of the building can be maintained, as there are no major changes in the original geometry of the building with this technique. Jacketing of columns is needed when the load carried by the column is increased due to either increasing the number of floors or due to mistakes in the design. Jacketing is practiced when the compressive strength of the concrete or the percent and type of reinforcement are not according to the codes’ requirements and also when columns is exposed to an earthquake, an accident such as collisions, fire, explosions.

The most common types of jackets are steel jacket, reinforced concrete jacket, fibre reinforced polymer composite jacket, jacket with high tension materials like carbon fibre, glass fibre etc. Although many traditional methods can be adopted, the application of a carbon-fiber reinforced plastic sheet (CFRP sheet) impregnated with epoxy resin for RC structures strengthening or retrofitting has received considerable attention due to its high-strength, light-weight, quick and easy manageability on-site, high resistance against corrosion, and ease fabrication.

Objective:-

1. To increase the axial strengthening of non-slender (short) reinforced concrete columns.
2. To compare the axial load carrying capacity of retrofitted square columns with reference square column of size (240mmx240mmx720mm). Hence to determine the suitability of RC jacketing technique.

Retrofitting:-

Retrofitting is the modification of existing structures to make them more resistant to ground motion, or soil failure due to earthquakes. Protection of the lives of building occupants in an earthquake is the main goal of the retrofit (this is referred to as "life safety" performance in building codes).

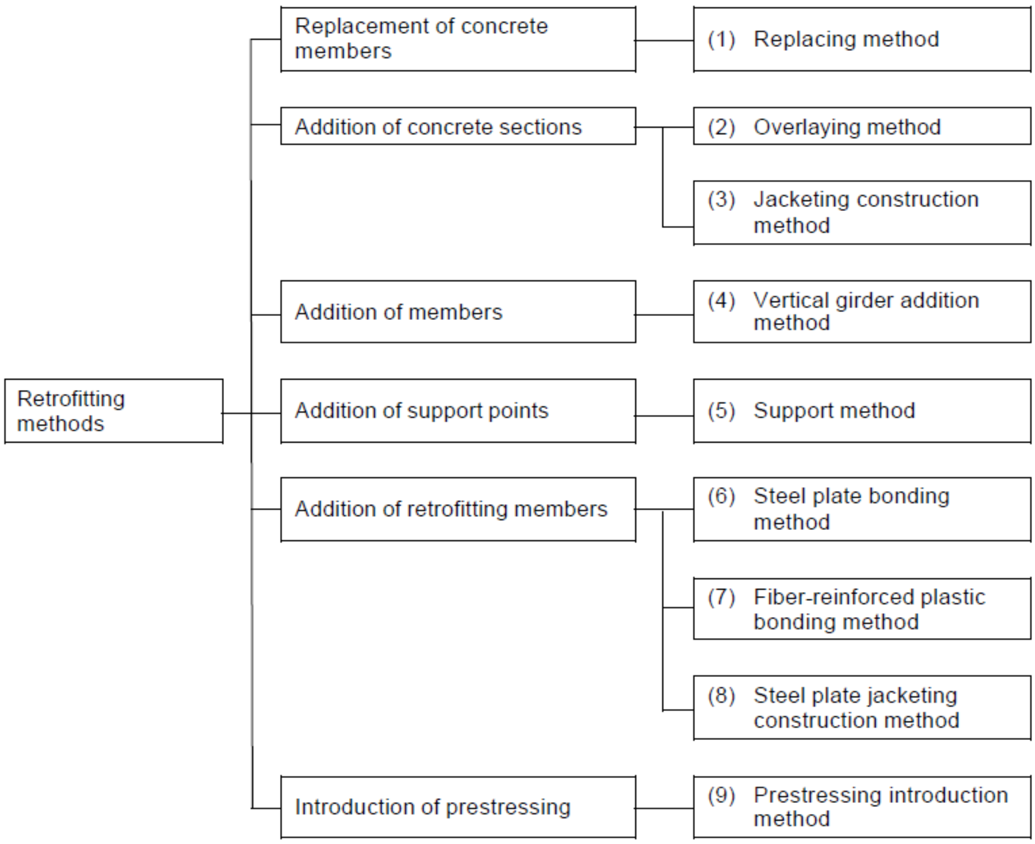

Figure No. 1 (Method of Retrofitting)

The behaviour of columns in tall structures is very important since column failures lead to additional structural failures and can result in total building collapse. The method of retrofitting is shown in figure no. 1.

Jacketing of columns is needed when the load carried by the column is increased due to either increasing the number of floors or due to mistakes in the design. It consists of added concrete with longitudinal and transverse reinforcement around the existing columns. A major advantage of column jacketing is that it improves the lateral load capacity of the building in a reasonably uniform and distributed way and hence avoiding the concentration of stiffness as in the case of shear walls. This is how major strengthening of foundations may be avoided. In addition, the original function of the building can be maintained, as there are no major changes in the original geometry of the building with this technique.

Flow of retrofitting process-

Retrofitting of structure shall proceed as follows:

(a) Identify the performance requirements for the existing structure to be retrofitted and draft an overall plan from inspection through selection of retrofitting method design of retrofitting structure and implementation of retrofitting work.

(b) Inspect the existing structure to be retrofitted.

(c) Based on the result of the inspection, evaluate the performance of the structure and verify that fulfils performance requirements.

(d) If the structure does not fulfil performance requirements and if continued use of the structure through retrofitting is desired proceed with design of the retrofitting structure.

(d) Select an appropriate retrofitting method and establish the materials to be used structure specifications and construction method.

(e) Evaluate the performance of the structure after retrofitting and verify that it will fulfil performance requirements.

(d) If is determined that the retrofitting structure will be capable of fulfilling performance requirements with the selected retrofitting and construction methods, implement the retrofitting work.

METHODOLOGY:-

The series of steps involved are briefly described as under:
(1) Design Mix of Concrete for M25 Grade with nominal maximum size of aggregate as 20mm
(2) Preparation of reinforced concrete columns (120mmx120mmx720mm)
(i) Instrumentation of the 8mm reinforcing bars as main steel and 5.5mm bars as stirrups.
(ii) Construction of the reinforcing cages.
(iii) Casting and curing of Columns.
(3) Jacketing of prepared columns after 28 days (240mmx240mmx720mm
(4) Load – displacement analysis of reference and retrofitted column specimens under pure compressive axial loading.

Prior to the Load-Displacement analysis of columns under pure axial loading, various laboratory tests were also conducted;
(a) Slump Test and Compaction factor test **-** for determining the workability or consistency of fresh concrete. (Design mix M25)
(b) Specific gravity test **-** for determining the Specific gravity of Coarse Aggregate, Fine Aggregate and cement used.

The loading arrangement and instrumentation is as follows:
The loading arrangement consisted of a reaction frame, Column specimen, Compression Testing Machine, digital load indicator and computer screen. All the test specimens were placed in water for curing of 28 days. Once removed from water, all the specimens were air dried before the testing. The dimensions of each specimen shall be measured before testing. Preparation of the surface is done using cement paste. A Reference column of size (120 mm x 120 mm x 720 mm) and (240 mm x 240 mm x 720 mm) and a retrofitted column of size 240mm x 240mm x 720mm were fitted in vertical direction on the compression testing machine of capacity 3000KN .Then the jack was placed on the column specimen. Both control specimen and jacketed columns are tested until failure. Moreover, two ply boards were used both at the top and bottom face of the column to prevent slipping and any sort of damage to compression testing machine

Material:-
1. Cement:**-**
2. Fine Aggregate
3. Coarse Aggregate
4. Admixture

Testing of Cubes:-
Cubes must be cured before they are tested. Unless required for test at 24 hours, the cube should be placed immediately after demoulding in the curing tank or mist room. The curing temperature of the water in the curing tank should be maintained at 27-30°C. If curing is in a mist room, the relative humidity should be maintained at no less than 95%. Curing should be continued as long as possible up to the time of testing in table No. 1 and figure no. 2.

Table No.1 (Compressive strength of cubes)

Sample No.	Strength (Nmm^2)
1	33.3
2.	38.5
3.	36.1

Figure No. 2 (Compression of testing Machine)

Preparation of RC Column:-

There are 15 no. of columns were casted. Out of which 12 columns were the dimensions of 120mm x 120mm x 720mm and the rest of the 3 columns were of the dimensions of 240mm x 240mm x 720mm. Three out of the 12 are smaller columns (120mm x 120mm x 720mm) were taken as reference so that they can be comparable with the rest of the 9 columns to be retrofitted after 28 days. Whereas control specimen of size 240mm x 240mm x 720mm were casted and cured for 56 days such that the effect of size is taken into consideration.

RC Jacketing with rebar:-

Reinforced concrete jacketing can be employed (as shown in figure 3) as a repair or strengthening scheme. Damaged regions of the existing members should be repaired prior to their jacketing (as shown in figure 3). There are two main purposes of jacketing of columns:
(I) Increase in the shear capacity of columns in order to accomplish a strong column-weak beam design and
(II) To improve the column's flexural strength by the longitudinal steel of the jacket made continuous through the slab system are anchored with the foundation. It is achieved by passing the new longitudinal reinforcement through holes drilled in the slab and by placing new concrete in the beam column joints.

Figure No. 3 (Re-baring)

TEST AND RESULT:-

All test results are clearly shown in below table and figure.
(1) Sieve analysis
(a) Fine Aggregate:-

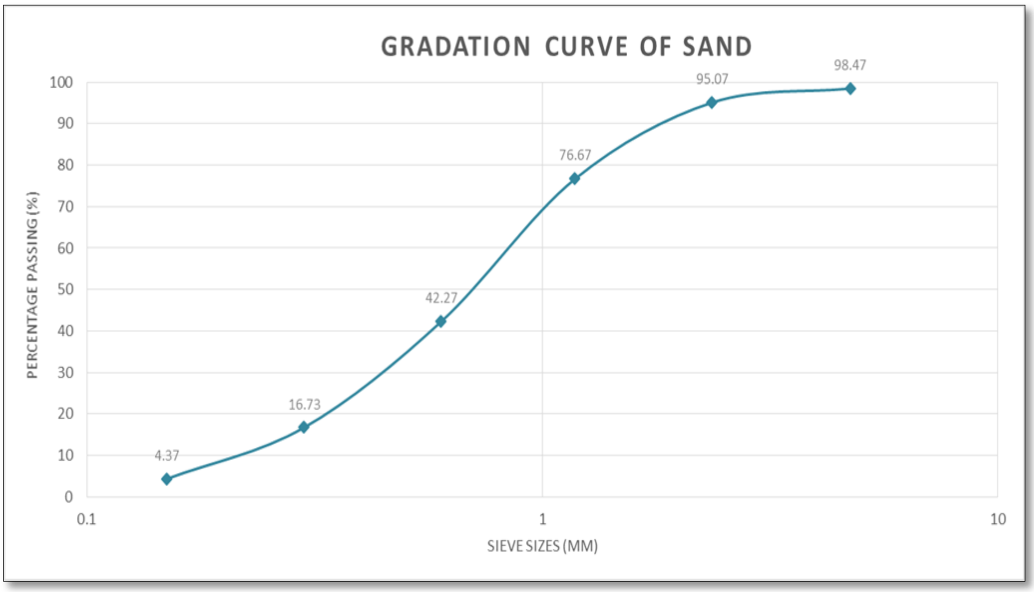

Figure No. 4 (Gradation curve for fine aggregate)

Table No. 2 (Sieve analysis of fine aggregate)

S. No	Sieve sizes (mm)	Mass retained (gm)	Cum. Mass retained (gm)	Cum. Percentage retained	Cum. Percentage passing (%)
1.	4.75	15.33	15.33	1.53	98.47
2.	2.36	34	49.33	4.93	95.07
3.	1.18	184	233.33	23.33	76.67
4.	0.6	344	577.33	57.73	42.27
5.	0.3	255.33	832.66	83.27	16.73
6.	0.15	123.66	956.32	95.63	4.37
7.	Pan	43	1000	100	0.00

(b) Course Aggregate:-

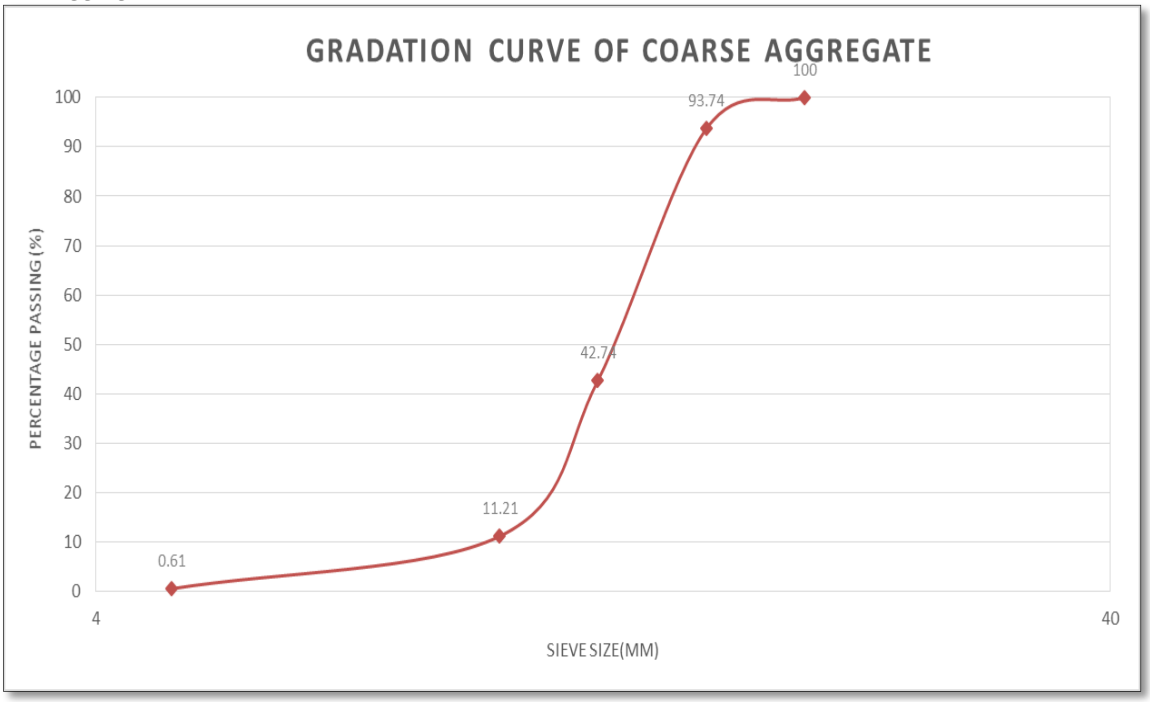

Figure No. 5 (Gradation curve for course Aggregate)

Table No. 3 (Sieve analysis of course aggregate)

S. No.	Sieve Sizes	Mass Retained	Cum. Mass Retained	Cum. Percentage Retained	Cum. Percentage Passing
1	20	0	0	0	100
2	16	62.66	62.66	6.26	93.74
3	12.5	510	572.66	57.26	42.74
4	10	315.33	887.99	88.79	11.21
5	4.75	106	993.99	99.39	0.61
6	PAN	6	1000	1000	0.00

(2) Ring Test:-

Table No. 4 (Result of J-RING Test)

Grade of concrete	Mix proportions	W/C ratio	Plastizer	T500 (sec)	Slumpflow spread (mm) $S_j=(d_{max}+d_{perp})/2$
M25	1:2.28:2.10	0.43	6.91 lit	11.5	545

(3)Slump Test:-

Table No.5 (Result of Slump Test)

Grade of concrete	Mix proportions	W/C ratio	Plastizer	T500 (sec)	Slumpflow spread (mm) $S_j=(d_{max}+d_{perp})/2$
M25	1:2.28:2.10	0.43	6.91 lit	5.1	613

(4) Silt Content in Sand

Table No. 6 (Silt Content)

S. No.	Details	Sample number 1 (mm)	Sample number 1 (mm)	Sample number 1 (mm)	Mean value
1	Volume of sample $=V_1$ ml	93	89	92	
2	Volume of sample $=V_1$ ml	3.5	3	3	3.46
3	Percentage of silt by volume (V_2/V_1)x100	3.76	3.37	3.26	

(5) Testing of Reference Column:-

Table No. 7 (Result for Reference Column)

Column	Dimensions	Observed experimental ultimate load (kN) $P_{u(exp)}$	Average ultimate load (kN)	ultimate load by IS code approach (kN) $P_{u(IS)}$
C	120mmx 120mmx 120mm	302	315.66	230.64
		327		
		318		
C^*	240mmx 240mmx240mm	1502.3	1409.06	724.44
		1221		
		1503.9		

Table No. 8 (Comparison of reference & retrofitted Column)

Columns	Description	Dimensions	Observed experimental ultimate load (kN) $P_{u\,(exp)}$
C	Control specimen -1	120mmx 120mmx 720mm	335.66
C^*	Control specimen -2	240mmx 240mmx 720mm	1442.40
C_1	RC Jacketing (with rebar)	240mmx 240mmx 720mm	1325.26

CONCLUSION:-

Based on the test results of control specimens and retrofitted columns using RC and ferrocement jacketing, the following conclusions are drawn:

1. The observed ultimate load carrying capacity for various columns were compared and it was found that the retrofitted columns C1, C2 and C3 were 3.43 , 3.94 and 1.62 times greater than the control specimen C.
2. RC Jacketing with and without dowel rebar increase the ultimate load carrying capacity of retrofitted columns C2 and C1 by 80% and 91% compared to control specimen C* which was casted with the same dimensions and reinforcement of the RC jacketed columns.

3. The Indian Standard code (IS) is conservative and it gives much lower value with respect to retrofitted columns C1, C2 and C3 respectively.
4. A slight improvement was observed by using a dowel rebars in the jacketing of column.
5. The failure of ferrocement jacketed specimens caused due to spalling of concrete from the corners, thus signifying the large stress concentration at the corners.
6. The RC jacketed specimens did not show any visible defect between the old concrete and the concrete in the jacket. Moreover, the roughening of the surface of the existing concrete by chisel and hammer was found to be satisfactory for the type of tests conducted.
7. From the strength consideration, RC Jacketing with rebar is preferred.

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