Structural Rehabilitation and Strengthening of Column using Micro Concrete and Additional Reinforcement

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ABSTRACT

One of the challenges in strengthening of concrete structures is the selection of strengthening methods that will enhance the strength and serviceability of the structure while addressing limitations such as constructability, building operations, and budget. Additional strength may be needed due to the deficiency in the structure's ability to carry the original design loads. Deficiencies may be the result of deterioration. A 25 year old existing three storey RC framed commercial building situated in Arumbakkam, Chennai is taken for this study. In this building 20 peripheral columns were damaged because of over cover thickness, poor material used for the construction, So that the outer surface of the concrete will crack and spalling the surface. Additionally the floor load 10 kN/m^2 of the building will be increased due to the storage of bulk quantity of material. So the strength of the existing column is checked using STADD.Pro V8i and it doesn't satisfy the structural requirements as per IS 1893 (Part 1) 2016. In order to counteract this problem, many different retrofit methods are available. In which we adopt reinforced concrete jacketing method. It involves adding a new layer of micro concrete with longitudinal reinforcement, closely spaced ties and also a suitable bonding agent (Nitozinc Primer) is used for the monolithic action between the old concrete and newly pore (Micro concrete). It increases the seismic resistance of the building without any demolition. It increases both the flexural strength and the shear strength of the beam, the ductile behaviour, lateral load capability of the building strength of the column is also improved.

Keywords : *Micro Concrete, RCC Jacketing Method*

1.INTRODUCTION

1.1 General

Jacketing is the most popularly used method for strengthening of building columns. Retrofitting can generally be classified in two categories: Global and the local. The Global retrofitting technique targets the seismic resistance of the building. It includes adding of infill wall, adding of shear wall, adding of steel bracings and base isolation. Adding of infill wall in the ground storey is a viable option to retrofit buildings with soft storey. Shear walls can be introduced in a building with flat slabs or flat plates. A new shear wall should be provided with an adequate foundation. Steel braces can be inserted in frames to provide lateral strength, stiffness, ductility, and to improve energy dissipation. These can be provided in the exterior frames with least

disruption of the building use . Local retrofitting technique targets the seismic resistance of a member. The local retrofit technique includes the concrete, steel or Fibre reinforced polymer Jacketing to the structural members like beams, columns, beam column joint, foundation. Concrete jacketing involves adding a new layer of concrete with longitudinal reinforcement and closely spaced ties. The jacket increases both the flexural strength and the shear strength of the beam or the column. The following are the advantages of retrofitting. It increases the seismic resistance of the building without any demolition. It increases the ductile behaviour and lateral load capability of the building Strength and stiffness of the building is also improved.

1.2 Jacketing of Columns

Jacketing of columns 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. It is also observed that the jacketing of columns is not successful for improving the ductility. 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

1.3 Types of Jacketing

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.

a. Reinforced Concrete Jacketing
b. Steel Jacketing.
c. Fibre Reinforced Polymer Composite Jacket
d. Steel fibre Reinforced polymer composite jacketing.

1.4 Reinforced Concrete Jacketing

Reinforced concrete jacketing can be employed as a repair or strengthening scheme. Damaged regions of the existing members should be repaired prior to their jacketing. 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.

(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 as illustrated.

(iii)Rehabilitated sections are designed in this way so that the flexural strength of columns should be greater than that of the beams. Transverse steel above and below the joint has been provided with details, which consists of two L-shaped ties that overlap diagonally in opposite corners.

(iv)The longitudinal reinforcement usually is concentrated in the column corners because of the existence of the beams where bar bundles have been used . It is recommended that not more than 3 bars be bundled together. Windows are usually

bored through the slab to allow the steel to go through as well as to enable the concrete casting process.

1.5 Objective

- To strengthening of column using additional concrete .
- To analyze the existing building for the additional live load.

3.STRUCTURAL AUDIT

Structural audit is important tool for knowing the real status of the old building. The existing structure is a two storey commercial building built in 1994 located in Arumbakkam, Chennai. It is made of reinforced concrete with concrete compressive strength of 25 MPa and rebars with yield stress of 415 MPa. The building has a 345.34 m^2 (31.48 mx 10.97m).This building have 20 peripheral columns and 6 inner columns. In this building 20 peripheral columns were damaged due to providing over cover thickness, poor material used for the construction so that outer surface of the concrete was cracking and spalling. The axial loads to the column will increases due to the adding of one storey vertical extension. So that the suitable strengthening technique is required to increase the load carrying capacity

3.1 Purpose of the Structural Audit:

- To save life and property
- To know the health of the building and to project the expected future life.
- Highlights the critical areas that need to be attended with immediate effect.
- To proactively assist the residents and the society to understand the seriousness of the problem and the urgency required to attend the same.
- To comply with municipal or any other statutory requirements.

obtained by above method

Rebound Hammer Test

The test is performed as per guidelines given by IS:1331(part 2) to estimate the in situ strength of concrete bassed on the correlation was established between I situ strength at the particular location & rebound numbers.

- In this area 12point at approximate 30mm apart are selected in grids
- By holding the rebound hammer at right angles to surface of the concrete member, 12readings are taken at selected points. On these readings, abnormally high& low abnormally low result are eliminated & average of the balance readings is worked out
- Taking into consideration the factor influencing hardness of the concrete surface like moisture condition of the surface, carbonation test etc..
- The compressive strength of concrete against each rebound hammer is obtained from graph

- The statistical analysis is carried out for this set of values of compressive strength obtained by above method

TABLE 3.1 Rebound Hammer Test IS;1331(Part 2):1992

Average Rebound	Quality Of Concrete
> 40	very good
30 - 40	Good
20 - 30	Fair
<20	poor and / or delaminated
0	very poor and / or delaminated

TABLE 3.2 Rebound Hammer Test Values

Column No	Rebound number	Compressive strength N/mm^2	Average Compressive strength N/mm^2
C20	34	31	27
	32	28	
	30	24	
	34	31	
	30	24	
	30	24	
C15	31	26	26.83
	32	28	
	30	24	
	34	31	
	29	22	
	33	30	
C5	30	24	25.83
	32	28	
	29	22	
	31	26	
	30	24	
	34	31	

Rebound Hammer test is carried out for the sample columns (C20, C15, and C5) to determine the compressive strength of the existing building.

3.2 Sample Visual Observation

- Peripheral columns have wider cracks due to the over cover thickness.
- Saplling are occurred in outer surface of the column.
- Column rebars are exposed due to spalling.
- No corrosion is occurred in the rebars

4.ANALYSIS AND DESIGN

4.1 Preliminary Study

Building is located in Chennai, it's a commercial building G+2 structure, and building is 25 years old. Other details are given below.

Type of structure = RCC building

Building area = 345.34 m^2

(31.48m x 10.97m)

Zone = III

Layout = as shown in figure

Number of stories = G+2

Ground storey height = 3.5m

Floor to floor height = 3.5m

Parapet wall = 150 mm thick

Wall thickness = 230 mm thick

Total depth of the slab = 150 mm

Density of RCC concrete = 30

Unit weight of brick masonry = 20

Weight of floor finish = 1.5

Live load on floor = 5 kN/m^2

Type of soil = hard soil

4.2 Load Calculation

The building is considered to be situated in zone III. It is a commercial building.

Dead load data

- Roof load
  - Self-weight of the slab = 25x0.15 = 3.75 kN/m^2
  - Weight of floor finis = 1 kN/m^2
  - Weight of terrace water proofing = 1.5 kN/m^2
  - Total slab weight on roof = 6.25 kN/m^2
- Floor load
  - Self-weight of the slab =3.75 kN/m^2
  - Weight of floor finish =2 kN/m^2
  - Total slab weight on roof =5.75 kN/m^2
- Wall load
  - Parapet weight of wall =20x0.6x0.15 = 1.8 kN/m
  - Weight of wall =20x0.23x3.5 =16.1 kN/m

Live load data

- Live load on roof = 2 kN/m^2
- Live load on floor = 5kN/m^2

4.3.Existing Building Section

The existing building sections are as follows,

Peripheral column size = 460 x 230 mm

Interior column size = 600 x 230 mm

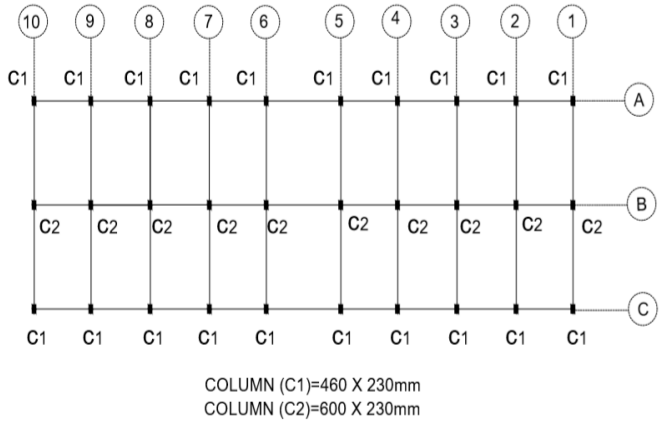
Beam size in longer direction = 600 x 230 mm

Beam size in shorter direction = 500 x 230 mm

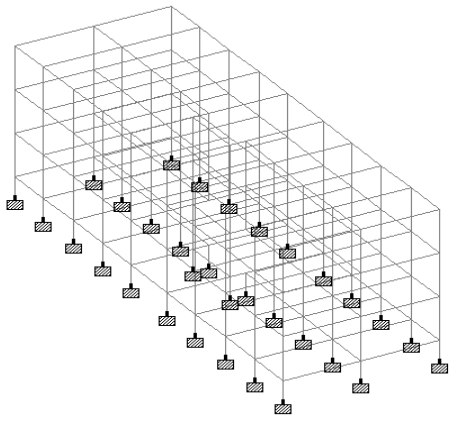
Load Combination

As per IS:1893 (part1) 2002 load combination are generated and analyzed the existing building.

Column Layout



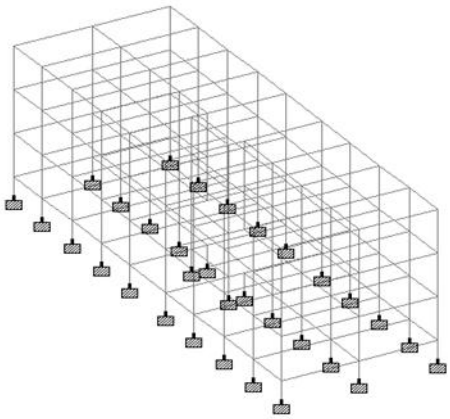
4.3.1 Existing Building Frame



After analysing the building for additional live load on second floor, some beams and pe peripheral columns are unsafe. It is necessary to increase the sections.

4.4 Design For Additional Live Load

4.4.1 Updated Building Frame



4.4.2 Updated Building Section

The peripheral column sections and few interior beams are inadequate in section. So we should increase the section as follows,

Peripheral column size = 600 x 230 mm

Interior column size = 600 x 230 mm

Beam size in longer direction = 650 x 230 mm

Beam size in shorter direction = 500 x 230 mm

TABLE 4.1 Calculation Of Ast For Column Jacketing

S.NO	COLUMN GROUP	Ast Required (mm^2)	Ast required - Existing Ast (mm^2)	Ast for jacketing (mm^2)
I	C1, C10, C11, C20	7000	7000-3927 =3073	3927 (8 nos of 25 mm dia rod)
II	C2,C9,C12,C19, C14,C17	7850	7850-3927 =3923	
III	C3,C8,C13, C18,C4,C7	7650	7650-3927 =3723	
IV	C15,C16,C5,C6	8800	8800-3927 =4873	4908 (10 nos of 25 mm dia rod)

TABLE 4.2 Calculation Of Ast For Beam Jacketing

FLOOR NO	BEAM NO	BREADTH (mm)	DEPTH (mm)	EXISTING BUILDING BEAM Ast(mm^2)		NOMINAL RF FOR BEAM JACKETING(mm^2)	STRRUPS (mm^2)
				TOP	BOTTOM	BOTTOM	
Second Floor	B3 to B16	330	650	3-25mm	3-32mm	3-25mm	8mm-150C/C

Fig4.1 Reinforcement Detailing of column

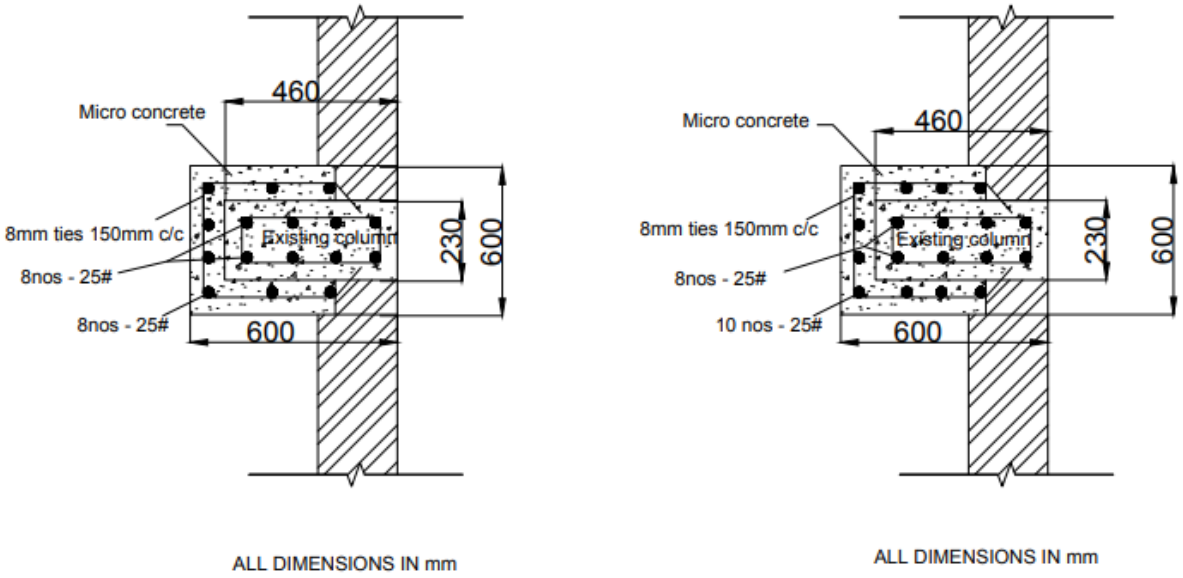
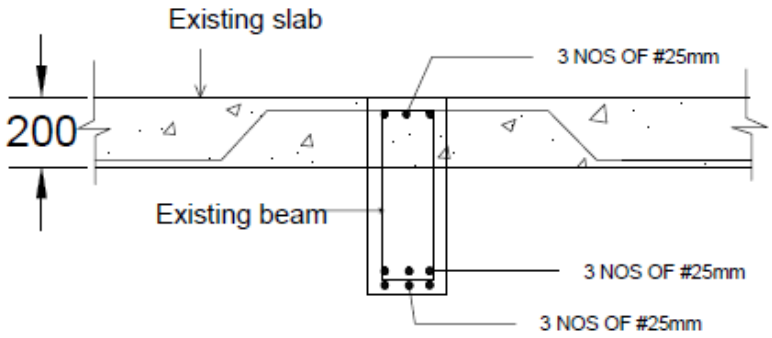


Fig 4.2 Reinforcement Detailing of beam



Existing beam depth = 600 x 230 mm
updated beam depth = 650 x 230 mm
All dimensions in mm

5.CONSTRUTION TECHNIQUE OF JACKETING

5.1 Excavation of Soil

- Earthwork excavation is carried out around the 20 peripheral column. In this building, there are 10 columns on one side of the building and remaining 10 columns are in the another side.
- So for the safety against settlement of the building during the excavation process, we carried out the excavation process in zigzag manner which means the even columns are excavated in the one side of the building first. At the same time the odd columns are excavated in another side of the building.
- The existing soil stratum is hard and excavation is carried out up to the depth of footing which is 1.5m.

5.2 Surface Preparation

- Removing/chipping up to 50mm or till the cover crete and sound substrate is reached.
- Cleaning of existing loose concrete carefully by manual or low impact frequency hammer without damaging the core concrete including cleaning the surfaces by compressed air jet complete including removing loose concrete around the reinforcement.
- The Column should be exposed at the Plinth level so that proper anchoring to the ground is achieved.
- Edges of chipped patch shall bear vertical reverse cut with minimum depth at edges as 0 mm. (Prepared patches to be got checked before applying bond coat) all loose/sound concrete around corroded bar has to be removed to prepare well defined patch.
- Wire brush again to remove remaining loose material and finish by thoroughly washing down with clean water. Repeat if necessary

5.3 Drilling on Column

- Drilling is the process of making a hole to insert a reinforcement on column. The distance between the hole is based on the design requirement.
- Longitudinal rod size is 16mm.so we should make hole in 18mm diameter upto 6 inches in column pedestal.
- Lateral ties rod size is 8mm. so we should make hole in 10mm diameterupto 4 inches and 6 inches spacing on each ties.

5.4 Additional Reinforcement

- Cut 16mm dia/actual size of the bars as main reinforcement to the required length with the entire length of the Column
- Tie them to the prefixed shear connectors or with the main bars to damaged
- structural elements including anchoring /welding ,bending, placing etc.,, excluding the cost of steel reinforcement so that the additional rebar acts monolithic with the existing ones and core concrete.

- Additional reinforcement bars shall be provided with mild steel bars conforming to IS:432 (Part-1) or HYSD bars conforming to IS: 1786 (Grade Fe 500/Fe 415) or both unless otherwise approved by the Engineer-in-Charge

5.5 Anti Corrosive Coating

- Mix and apply Fosroc **Nitozinc Primer**/equivalant, two component, zinc rich, epoxy primer to the exposed rebars all around in two coats and allowed to fully dry.
- The applied surface shall not be exposed to open sky for a long time and should be reinstated with micro concrete or polymer modified concrete immediately.

5.6 Bonding Agent

- After providing anti corrosive protection, the structural elements surface shall be prepared suitably using an epoxy based bond coat, so that the jacketed concrete may bond well with existing/ old concrete.
- The bonding agent shall be an epoxy based two component resin system like Nitobond EP/equivalant. The base and hardener of the epoxy jointing compound shall be mixed mechanically using a slow speed heavy duty drilling machine strictly following the manufactures guidelines.
- The use of part packs shall not be permitted. Once mixed, the bonding agent shall be used within the prescribed period.
- Exposed concrete surfaces shall be cleaned to remove any traces of dust, loose concrete etc. with the help of compressed air. If the primer applied on steel forms a thin film on concrete, it shall be chipped and removed before applying bonding agent.
- Surface should be washed thoroughly with water and dried before the application of bonding agent.

- The mixed bonding agent shall be applied to the prepared surface by medium stiff bristled brush. Special care shall be taken to ensure that all imperfections are coated, particularly behind exposed reinforcing bars.

5.7 Micro Concrete Application

- The micro concrete base material shall be mixed with water while jacketing for a thickness of 50mm
- The micro concrete should have a minimum characteristic compressive strength of 50Mpa at 28 days. An approved grout concrete mixer of slow speed heavy duty drill shall be used for the mixing of the micro concrete.
- It will be ensured that the machine capacity and the number of operators is adequate to enable grouting to be carried out as a continuous operation.
- The quantity of water required to achieve a fluid consistency must be accurately measured for each mix and the exact quantity of water shall be used as per the Manufactures guidelines of 0.16 w/c ratio.
- The mixed material shall be placed within 20 minutes of mixing to gain full benefit of the expansion process. Proper hopper arrangement needs to be provided in such a way that the micro concrete should travel along the hopper and the shutter to avoid entrapped air.
- Continuous material flow is required and the material should be poured or pumped through a flexible tube, minimum diameter 50mm, to the lowest point in the form.
- The micro concrete shall be poured continuously into the form work from only one side such that no air is entrapped. The form work shall be removed after 3 days.
- After concrete in the jacket portion of the structural elements in the particular stage has attained its strength, props placed for supporting corresponding structures are to be removed.Curing is mandatory for micro
- concrete which can be done with regular water curing

7 DISCUSSION AND CONCLUSION

7.1 Discussion

The purpose of this project was to assess the analysis of an existing RC structure and to provide retrofitting in case the members fail. In this project the age of the building is 25years old, G+2

R.C.C Structure. Structural audit has been completed on the building. The plan and reinforcement details of the building were provided. Analysed the building using STAAD pro software for the increment of live load, the present building strength is calculated. In this audit slabs, beams and footings are safe, but few beams and columns are unsafe.. Hence it is found that few extra RCC jacketing is required for structural purpose use.

7.2 Conclusion

- It is advisable to monitor the building health periodically if any future expansion or live load increase by taking a professional opinion. Non-destructive testing should be carried out if buildings found deteriorated and damaged over time.
- R.C.C retrofitting technique is significant improvement in moment resisting capacity, shear strength capacity in Beam and Axil load carrying capacity in column, But dead load is increased and carpet area is reduces.
- R.C.C structures can be strengthened by micro concrete and additional reinforcement with Epoxy resin concrete bonding agent
- Added concrete should be non-shrinkage with characteristics of a self-compacting, high strength and high durability concrete.

So micro concrete is used to satisfy the above requirements.

Future scope for the work

Project work has focused on strengthening the RCC buildings. There is a large scope to create awareness in the occupant‟s residents of the buildings those may have complete the service period and or will probably be completing the service period in short future. All such buildings in and all the metro cities in the state and country can be retrofitted with suitable technique to save the lives and property.

REFERENCES

[1] Guruprasad Biradar, C H Prakash, Dhavala Suresh, Shiva Kumar Ks „ Structural Strengthening Of Reinforced Column‟ (IRJET) e-ISSN: 2395 -0056, Volume: 03 Issue: 08 | Aug-2016

[2] Shri. Pravin B. Waghmare: „Materials And Jacketing Technique For Retrofitting Of Structures‟, International Journal of Advanced Engineering Research and Studies EISSN2249 – 8974.

[3] Dr. Adnan S. Al-Kuaity : „Rehabilitation Of Damage Reinforced Concrete Columns‟, al-qadisiya journal for engineering sciences (2010) vol. 3 no. 1.

[4] Manish Kumar (2016), “Structural Rehabilitation, Retrofitting And Strengthening of Reinforced Concrete Structures” International Journal of Civil, Environmental, structural, Construction and Architectural Engineering Vol: 10, No: 1.

[5] Shri. Pravin B. Waghmare (2011), "Materials And Jacketing Technique For Retrofitting of Structures" International Journal of Advanced Engineering Research And Studies E-ISSN2249 – 8974, Vol. I, Issue I 15-19.

[6] ACI Committee 437, (1991), - Strength Evaluation of Existing Concrete Buildingsl, American Concrete 15 Institute.

[7] Guide for Evaluation of Concrete Structures Prior to Rehabilitation (ACI 364. 1R-94(99)), By ACI Committee 364, Rehabilitation.

[8] IS 456 : 2000 – “Plain And Reinforced Concrete – Code Of Practice”

[9] IS 15988: 2013 – “Seismic Evaluation And Strengthening Of Existing Reinforced Concrete Building – Guidelines”