EVALUATION OF DISTRESSES IN RCC FRAME STRUCTURE; CASE STUDY OF SCHOOL BUILDING AT BHIMORA

Ankur M Goyal[1], Tejpal Goda[2], Siddharth Shah[3]

1,2,3 Department of Civil Engineering, Marwadi University, Rajkot, Gujrat, India

ABSTRACT. Due to environmental attacks and poor maintenance, the RCC framed structure "L.M. Vora Uttar Buniyadi Kanya Chhatralay, At village Bhimora, Di. Surendranagar, Gujrat. had experienced various types of distresses. The durability of the concrete might not have been taken into account in the structural design. The aim of present study is to assess the amount and cause of distress in various parts/members of the entire school building for restoring the strength and serviceability.

For structural health evaluation Rapid Visual Survey, Ultra Sonic Pulse wave test, Rebound Hammer test, Rebar Locator, and Carbonation test were performed. It was found that distressed in main structural members like column and beam was not significant but, damages like spalling of concrete due to corrosion of reinforcement and vegetation growth in cracks was predominant in the slab, chhajjas, and parapet walls

Keywords: Building, rehabilitation, structural deterioration, NDT Testing, RCC structure

Ankur M Goyal is Post Graduate Student in Civil Engineering Department, Faculty of PG studies at Marwadi Education Foundation Group of Institutions, Rajkot-360003, Gujrat INDIA.

Prof. Tejpal H Goda is an Assistant Professor in Civil Engineer Department, Faculty of Engineering at Marwadi Education Foundation Group of Institutions, Rajkot-360003, Gujrat, INDIA.

Dr. Siddharth G Shah is a Professor and Head of Civil Engineer Department Faculty of PG studies and research at Marwadi Education Foundation Group of Institutions, Rajkot-360003, Gujrat, INDIA.

INTRODUCTION

As the time passes strength of concrete will be reduced due to corrosion, carbonation, alkali acid attack, earthquake, and different environmental condition. Structure can be deteriorated due to various reasons like quality of concrete ingredient, poor workmanship, poor maintenance, structural design problems, and various loadings acting on structure. For structural strength improvement, it is essential to get an idea about the reasons of distress. According to this reasons and amount of deterioration most appropriate strength improvement technique will be adopted. To overcome these damages, repair, rehabilitation and retrofitting are the different methods for structural health improvement.

Present work is focused on rehabilitation of RCC frame building. For finding current condition of concrete and recent strength of concrete Non Destructive test is conducted. AS par the results of NDT testing and visual inspection of building appropriate rehabilitation method will be adopted for various deterioration of building.

In present study, L. M. Vora Uttarbuniyadi vidhyalay Kanya chhatralay At. Bhimora, near chotila, is selected as case study site.This government school building was constructed in 1982.

CURRENT MATERIAL REQUIREMENTS FOR CONCRETE

Given the paper is concerned with sustainable options for fibre reinforced polymer (FRP) composites as "A matrix of polymeric material that is reinforced by fibres or other reinforcing material". The fibres are usually glass or carbon, while the polymer is usually an epoxy, vinyl- ester or polyester thermosetting plastic. High strength-weight ratio, high stiffness- weight ratio, flexibility in design, non-corrosiveness, high fatigue strength and ease of application. Glass fibre sheet (**GFRP**)are found to be highly effective for strengthening of RC beams because of its flexible nature and ease of handling and application, combined with high tensile strength – weight ratio and stiffness.

PROCESS FOLLOWED FOR REHABILITATION

Preliminary Vulnerability Study

The different observation on preliminary study observed on site are mention as below, based on which we can further decide repair or rehabilitation work process:

- School building is situated on hard rocky soil strata.
- This school building is G+1 RCC framed building situated on column footing.
- About 200 students are living and studying under this school building
- So many cracks on exterior wall of the building, cracks at the lintel level of building on first floor of building.
- Many chajjas are deteriorated due to weathering of concrete and corrosion of concrete.
- Main steel in Slab is corroded and due to this corrosion slab starts deflection.
- Beam have flexural crack of 2mm at the first floor
- Lintel level beam over the window is deteriorated and steel diameter is reduced to 5 mm diameter due to corrosion of the steel.
- About 80% chajjas have problem spalling of concrete.

Determination of Causes of the damage of components

For the various deterioration of structural members, it is important to find the root cause for the damage. It's too easy and safe to rehabilitate the building after finding the real cause of the damage.

- There was structural crack in beam due to overloading on member
- There are Corrosion of steel at lintel level due to Corrosion of steel at lintel level
- Almost all the outer walls have weathering effect and permeability problem, hence plaster has been deteriorated.
- All the reinforcement corrosion problems have the same reason is carbonation

Detailed Investigation*:*

Here Non- Destructive testing methods are used for evaluation of structural members. NDT is favorable because this will measure recent strength of existing building without causing damage and also this will not take too much time for testing of the structure.

a. Rebound Hammer Test*:*

Schmidt rebound hammer is works on the principle that the rebound of an elastic mass depends on the hardness of the surface against which the mass impinges. There is a theoretical relationship concrete strength and rebound number of hammer. Columns and beams was tested for measuring the strength of the member. As the result shows 76% members have fair strength. Hence repairing is required

Table 1 & 2 Indicating Summary of NDT test

Rebound Value	Number of Readings (In %)
0-10	0
0 – 20	16
20 – 30	76
Above 30	8

Average Rebound Value	Quality of Concrete
0-10	Very Poor
10 – 20	Poor
20 – 30	Fair
Above 30	Good

b. Ultrasonic pulse Velocity test*:*

Direct method and indirect method are used here for UPV testing. To reduce reflection at the boundaries grease used as liquid coupling material. According to elastic modulus and concrete strength, ultrasonic pulse velocity is influenced. The results of UPV testing are as following:

Table 3 & 4 Summary result of UPV test

Pulse Velocity (km/s)	Number of Readings (In %)
0.0-1.0	4
1.0 – 2.0	88
2.0 – 3.0	4
3.0 – 4.0	4

Pulse Velocity	Number of Readings (In %)
Below 3.0	Doubt Full
3.0 -3.5	Medium
3.5 - 4.5	Good
Above 4.5	Excellent

As the result shows 88% members have doubt quality of Concrete

c. Rebar locator*:*

Rebar locator is equipment which is to find reinforcement spacing, diameter, clear cover in concrete member. 16mm diameter bar is found throughout all columns and beams. At some places diameter of bar is increased to 20mm due to corrosion of bar.

d. Carbonation test:

Carbonation refers to reaction between carbon dioxide and alkalis in pore solution of the cement paste. As a result, the pH of the pore solution decrease and this will also decrease the passive coating on reinforcing steel. In present study, we have tested the place where corrosion is occurred in concrete member. At almost all the deteriorated members are gives positives result of carbonation test. It becomes colourless at all the places**.**

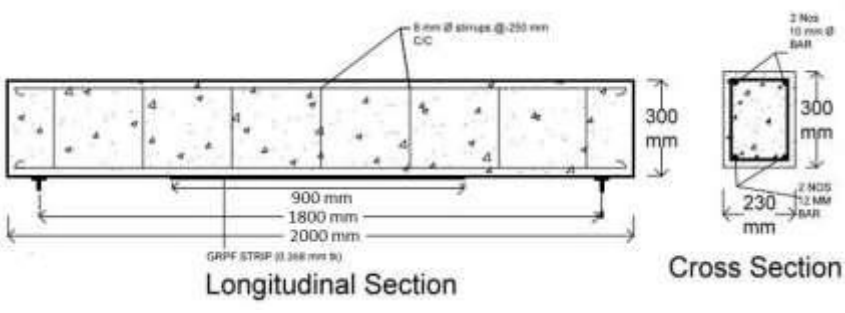
$$Ca(OH)_2 + CO2 \quad \text{---> } CaCO3 \quad + H2\,O$$
$$2NaOH \quad + \quad CO_2 \quad \text{---> } Na2CO3 \quad + \quad H2O$$

Figure 1 Phenolpthelin liquid used for carbonation test

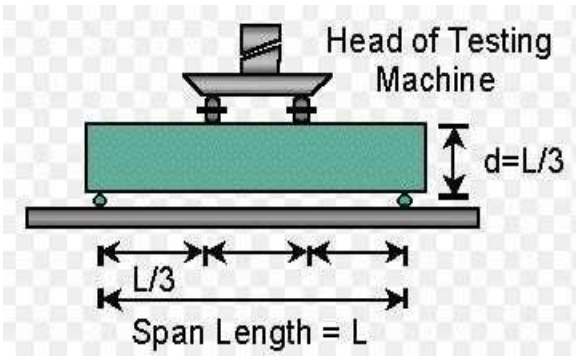
Figure 2 Concrete remains colourless

EXPERIMENTAL WORK

Experimental work has been conducted to accomplish the objective of this research work. At the primary stage, a beam of size 230mm x 300mm x 2000mm was cast of M-20 concrete grade.



Test of beam was carried out in our laboratory. Testing arrangement is sown in figure



Two point loads were applied on beam of 2m through hydraulic jack of capacity 1000KN. A dial Gauge is provided to measuring middle span deflection while applying load.

Grade of concrete	Design load (In KN)	Experimental load (In KN)
M – 20	50 KN	68

Then beam was wrapped by 0.358mm thick GRPF sheet. 900mm long GRPF sheet was attached at the bottom side of the beam. Redwoop Flexoplus material is used as adhesive material for wrapping of beam. Wrapped beam been cured for 24 hours at room temperature

Grade of concrete	Design load (In KN)	Experimental load (In KN)
M – 20 (wrapped)	62.5	81.6

As the result shows strength of the beam is increased 20% compared to simple RCC beam.

REPAIR STRATEGY

The following approach is adopted for rehabilitation of building:

A. Repair procedure*:*

The repair of structural member was carried out as follows,
i.Removal of deteriorated plaster/ concrete

At the areas, where plaster/ concrete cover had spalled down e.g. Exterior wall, slab, soffit of beam, column corners and loose concrete material should be removed. The beams and slabs were supported with props before removing of deteriorated concrete. All dust and loose particles resulting from such pretreatment was removed by washing with water under pressure

ii. Removal of corrosion on steel reinforcement

Corrosion on steel should be removed first by light hammering and manual chipping. If steel corroded more than the half of the diameter of rod, then entire steel reinforcement should be replaced with new reinforcement bar of same diameter. Then one coat of rust remover was applied all around the steel rebar.

iii. Use of bond coat of acrylic polymer

All surfaces prior to application of bond coat was thoroughly inspected and made free from any deleterious materials such as oil, dust, dirt etc. Use of bond coat of acrylic polymer will make proper bond between old concrete and new concrete.

iv. Repair of RCC columns, beams, slabs by polymer modified rich mortar

The building was originally constructed with M-20 with minimum strength requirement of 20 N/mm2. So for repairing work rich polymer modified mortar have compressive strength of minimum 25 N/mm2. So that it can withstand all weathering conditions and provide proper cover to old concrete.

v. Jacketing of columns with rich concrete

Main aim of Jacketing is to increase section modulus by increasing size of the element. Columns were jacketed with new rebar and jacketing with concrete is about 75mm all around to increase its strength and stiffness and to protect reinforcement from further corrosion

vi. FRP wrapping for strengthing of beam and columns

Cracks can be generated Due to design errors, overloading then design load and deterioration by weathering action. So cracks and deflection of members can be prevented by wrapping on member. Glass fiber wrapping and carbon fiber wrapping are the method according to material used for wrapping. Different wrapping pattern and method is used as per the strength requirement.

vii. Crack sealing in masonry walls with polymer modified rich mortar

Before starting repairing treatment, it is necessary to remove loose dust, mortar, and concrete by wire brush. The plasticized expanding grout admixtures along with Styrene Butadiene Rubber (SBR) polymer was used for sealing of masonry wall cracks.

viii. Re-plaster and acrylic paint on exterior wall

To prevent further deterioration and weathering effect re-plastering is used for slab, parapet, exterior walls. For re-plastering of member rich quality cement mortar with acrylic paint is used.

DISCUSSION

TYPE OF DAMAGE	TESTING / RVS	TENTATIVE CAUSES OF DAMAGE	REMEADY	MARERIAL SPECIFICATION
External walls (W1-8, W8-15, W1-2, W2-3, W4-5, W5-6, W6-7, W15-22, W30-31	RVS	Weathering effect, water permeability, efflorescence	Remove deteriorated mortar, replace damaged member (if required), plaster with good quality mortar	Plaster with rich mortar (C:S = 1:3) and REDWOOP BUTABOND SBR mixture
Bending in beam	RVS	less reinforcement, higher load,	Wrapping by Carbon Fiber reinforced plastic	Wrap FRP by using epoxy putty to fill small surface voids and make bond between concrete and wrapping material or use extra MS FLAT or I Sec.
corrosion of steel at Chhajja	RVS, Carbonation Test	carbonation of concrete, weathering effect	remove rust from steel, remove loose concrete, replace reinforcement (if required), Re-remove rust from steel, use steel inhibitor, remove loose concrete, replace reinforcement (if required), shotcrete	For mortar use C:S = 1:3 and use higher grade of concrete with more workability with mixing of REDWOOP BUTABOND SBR, Use Sikka CNI for protection against corrosion
Corrosion of steel and falling of concrete at	RVS, Carbonation test	carbonation of concrete, less clear cover, efflorescence		For mortar use C:S = 1:3 and for Concrete use higher grade of concrete with more workability, Use Sikka CNI for protection against corrosion
Corrosion of steel at lintel level	RVS, Carbonation test,	Carbonation of concrete, poor workmanship, environmental effect	Remove loose concrete, remove rust from steel, use steel inhibitor, replace reinforcement (if required), shotcrete	Use Sikka CNI for protection against corrosion, use REDWOOP BUTABOND SBR mixing with rich concrete
strength of column	Non Destructive Test	Poor workmanship, concrete deterioration	Remove loose concrete, Fill honeycombing and cracks with REDWOOP MICROCONE RG(L)	mix well 4.75 lit water in 25 kg powder bag and pour it where required

CONCLUDING REMARKS

The paper suggests that

REFERENCES

1. Varinder . K. Singh “Structural Repair and Rehabilitation of 3 no. (+8) Multi-Storeyed residential
2. Building, at ONGC colony at Chandkheda, Ahmedabad, Gujrat.”
3. Anand S. Arya , Ankush Agarwal Guidelines “Condition Assessment of Building For Repair and Upgrading.”
4. Jen-Chei Liu, Mou-Lin Sue and Chang-Huan Kou “Estimating the Strength of Concrete Using Surface Rebound Value and Design Parameters of Concrete Material” Tamlang Journal of Science and Engineering Vol. 12, No. 1, pp. 1-7 (2009)
5. Swapnil U Biraris, Aishwarya G Gujrathi, Abhishek D Pakhare, Anjali N Satbhai, Pournima K Vispute “Stractural Audit of Old Structures” International Journal of Engineering Trends and Technology (IJETT) – Volume- 43 Number-3 – January 2017.
6. Nikhil L.Jagtap, Prof. P. R. Mehetre “Study on Retrofitted R.C.C. Building by Different NDT Methods”
7. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) (May – Jun 2015)
8. Tony C. Liu , Leonard Millstein, Ashok K. Dhingra “GUIDE FOR EVALUATION OF CONCRETE STRUCTURES PRIOR TO REHABILITATION” ACI 364.1 R-94
9. M. ElGawady, P. Lestuzzi, M. Badoux, “A REVIEW OF CONVENTIONAL SEISMIC RETROFITTING TECHNIQUES FOR URM”, 13th International Brick and Block Masonry Conference Amsterdam, July 4-7, 2004
10. Dr. Durgesh C. Rai , “SEISMIC EVALUATION AND STRENGTHENING OF BUILDINGS”, IITK- GSDMA GUIDELINES. 2005
11. BRUCE M. IRON S, “GUIDE FOR THE DESIGN AND CONSTRUCTION OF EXTERNALLY BONDED FRP SYSTEMS FOR STRENGTHENING CONCRETE STRUCTURES”, American Concrete Institute ,2008
12. Saptarshi Sasmal, K. Ramanjaneyulu, Balthasar Novák, “SEISMIC RETROFITTING OF NON DUCTILE BEAM-COLUMN SUB-ASSEMBLAGE USING FRP WRAPPING AND STEEL PLATE
13. JACKETING”, Construction and Building Materials 25 (2011) 175–182
14. Giovanni Matrinola, Alberto Meda, “ Strengthening and repair of RC Beam”
15. FIBER REINFORCED CONCRETE” Cement & Concrete Composites 32 (2010) 731–739, 2010
16. Pravin B. Waghmare, “MATERIALS AND JACKETING TECHNIQUE FOR RETROFITTING OF STRUCTURES “International Journal of Advanced Engineering Research and Studies, 2011