Assessment of Institutional Library R.C.C Building in Ahmedabad

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Abstract: Population is rapidly growing in the developing country like India. Urbanization and demand of land is increasing. Increase in construction and material cost leads investor in trouble. About 30% of Construction industry creates pollution and dumping of construction waste materials are also a serious issue. Repair and Rehabilitation of structures is the only solution to conserve the structure. Buildings are designed according to standard codes but periodic monitoring & investigation are required for structure good health during service life. In the present case study, Reinforced concrete G+2 (including basement) an institutional R.C.C building is investigated. The distress in the building is seen in structural and non-structural elements. The major cause of distress was due to leakage of drainage and sewage pipelines.

Keywords: repair, retrofit, rehabilitation, residential building, structural failure, rejuvenation

I. INTRODUCTION

Concrete is a versatile material [1] It can be molded into any shape as per requirement [1] Concrete is the second most material widely used after water. The properties of fresh concrete and hardened concrete may differ due to aging of material. The regular inspection is required to maintain the functioning of building according to its use. The distress in the structure may be due to physical, chemical or environmental agencies. The defeats in the structure are crack, spalling, corrosion, peeling, dampness etc. In such situation evaluation of damages in structure is necessary and proper treatment should be adopted with good practices.

In Ahmedabad a premier institution LD College of Engineering library building was assessed in the year 2019. The distress observed in the building is classified into structural and non-structural elements. In structural element different types of cracks, spalling and corrosion and non-structural element distress like crack, dampness, staining and peeling of paints were observed. Some of the major reasons for distress in the structure are ageing, environmental effect, inadequate maintenance, change in load pattern and leakage of water and sewage lines.

II. OBJECTIVE OF THE STUDY

The primary objective of this study is to investigate and analyze the causes and extent of distress observed in a reinforced concrete (R.C.C) G+2 institutional building, including its basement. The study specifically aims to:

1. Identify the nature and extent of structural and non-structural distress in the building elements.
2. Examine the impact of leakage from drainage and sewage pipelines on the integrity of the structure.
3. Determine the root cause(s) of deterioration and damage to the concrete and reinforcement.
4. Assess the current condition and safety of the structure for continued usage.
5. Recommend appropriate remedial measures and strategies for repairing, strengthening, and preventing future damage.
6. Provide insights for improving construction practices and maintenance to avoid similar issues in future projects.

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III. LITERATURE REVIEW

Surresh Chandra Pattanaik et al (2011) Paper presented on institutional building located in south India. The G+1 and G+2 buildings experienced severe damage due to water leakage and environmental factors. The structure was safe under NDT test and minor repair and rehabilitation was done. The masonry walls of laterite stone was disintegrated, spalling of plaster, fungal growth and corrosion of reinforcement are observed. The steel jacketing was done on structural members for strengthening of building.

Varinder K. Singh (2012) Paper presented case study on repair and rehabilitation of G+8 multi-storeyed ONGC residential colony, Ahmedabad Gujarat. The building was severely affected after the Bhuj earthquake 2001. The distress seen in the buildings are cracks, spalls and corrosion of steel reinforcement. Several test were carried out like UPVT, Carbonation Test and Chloride Test. The structural member for 5 columns and 6 beams strength should be 20 N/mm2 but shows poor result estimated strength was 10 N/mm2 using UPV test. The corrosion in the structural elements was serve and deeply affected about 78mm in column and 35mm in beam using carbonation test. In the chlorine test, the permissible value of acid soluble chloride should be 0.25 gm/kg but during investigation it was found to be greater than 1.00 gm/kg. The severely affected columns and beams are jacked with PMM and cracks are repaired with epoxy grouting.

Prof. Y. R. Suryavanshi et al (2014) Paper discussed about RCC Frame building investigated for structural and non-structural members. The NDT tests were carried out such as Rebound hammer test, carbonation test, pH value, and UPV Test and found that structure need minor repair. The author had concluded that demolition of existing building cost more than repair and rehabilitation of building. And life of structure increase by 15 to 18 year by repair techniques.

Balamurali krishnan R et al (2016) Paper discussed about selection of repair materials and different repair techniques using a Beam. The selected materials for beam repair work are Polymer modified concrete, Glass Fiber Reinforced Polymer and Carbon Fiber Reinforced Polymer. Based on the results, CFRP increased the flexural strength by 18–20% with a single layer and by 40–45% with a double layer.

Yasir Shaikh et al (2019) Present paper studied an assessment and repair of institutional G+1 RCC building Dabhi, Gujarat. The building is showing signs of distress due to dampness, shrinkage, and environmental effects. The different types of cracks in non-structural elements are observed. The test results of NDT were carried out and found good and satisfies the criteria. The rebound hammer test shows average 35 N/mm2 strength of concrete shows good results. Carbonation, sulphate and chloride results show no corrosion in reinforcement bar. Paper concludes with providing treatment of cracks, dampness and termite.

IV. BACKGROUND STUDY

Institutional building of LDCE Ahmedabad was constructed in 1948; the design life period of building is 100 years. The buildup area of Library Building was 2845.85 sq. meter. A Reinforced concrete G+2 (including basement) is functional for library and reading room.

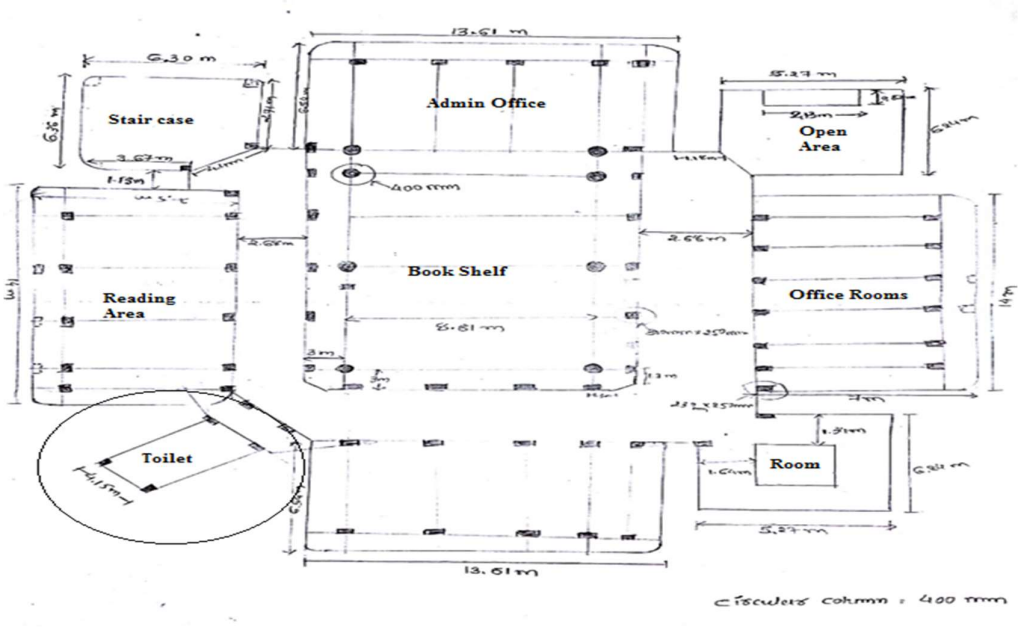

Fig.1. Plan of Library Building

The Plan of library building is shown in fig. 1. The major distress was observed in the toilet block area on the first floor (as shown in the highlighted circular area) and in the space directly below it on the ground floor, which was allotted as a store room. The highlighted zone had remained unused for several months.

V. CODAL PROVISION FOR REPAIR & REHABILIATION OF BUILDINGS

A. Handbook on repair and rehabilitation of RCC Buildings

The main objective of condition survey is to identify the causes and sources of distress and select the plan for effective remedial measures [6] The flow chart of condition survey decides that Testing stage is required or not is shown in figure: 2[

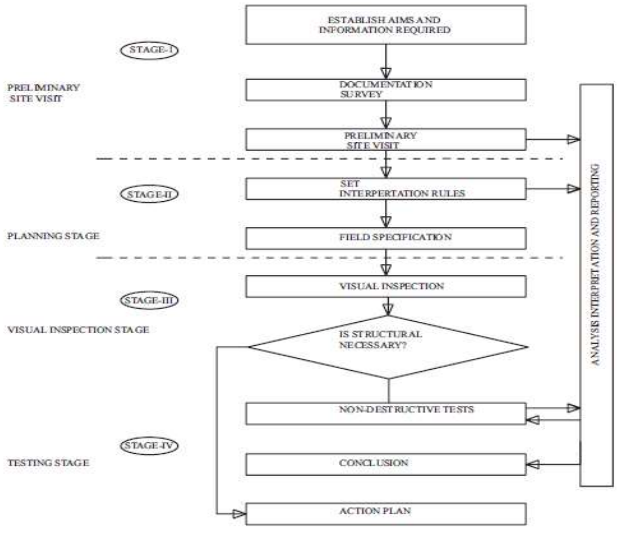

Fig.2. Flow chart showing condition survey [6]

This above flowchart outlines a systematic approach for investigating structural distress in a building, divided into four stages**:**

Stage I: Preliminary Site Visit

- Establish Aims and Information Required: Define the purpose and scope of the investigation.
- Documentation Survey: Review drawings, previous reports, and records.
- Preliminary Site Visit: Conduct an initial visual check to understand the condition.

Stage II: Planning Stage

- Set Interpretation Rules: Define criteria for assessing damage and deciding further action.
- Field Specification: Plan resources, team, equipment, and testing locations.

Stage III: Visual Inspection Stage

- Visual Inspection: Detailed inspection of the site to identify distress signs.
- Decision Point: Assess whether structural testing is necessary based on visual findings.

Stage IV: Testing Stage

- Non-Destructive Tests (NDTs): If needed, conduct tests like rebound hammer, ultrasonic pulse velocity, etc.
- Conclusion: Analyze all findings to determine the causes and severity of distress.
- Action Plan: Propose remedial measures, repair strategies, and preventive recommendations.

TABLE I:
TESTS TO DETERMINE THE QUALITY OF CONCRETE

Sr. No	Test Name	Test Value
1.	Rebound Hammer Test	>40 Very good Quality
2.	Ultra-Pulse Velocity Test	>4.0 km/s Very good Quality
3.	pH Value	>11.5 No corrosion
4.	Half-cell potential	<5% probability of corrosion is less

A. IS 456 2000 Code of Practice Plain and Reinforced Concrete

The stakeholder uses this code for concrete structure. The code talks about limit state method using safety serviceability, workability, durability and aspects. The special design requirements for structural elements such as beams, columns, and slabs are defined.

B. IS 15988: 2013 Seismic Evaluation & Strengthening of Existing Reinforced Concrete Buildings

The code discuss about the preliminary investigation and detailed investigation of concrete members. Strengthen of structural members using column jacking; fiber jacking beam, steel bracing at joints and reducing of structural irregularity are also covered.

C. IS 13935: 2009 Seismic Evaluation, Repair & Strengthening of Masonry Buildings

Selection of repair materials for strengthening of masonry damaged due to earthquake like shotcrete, epoxy resin, quick setting cement mortar, mechanical anchors, fiber reinforced plastics are covered. The suitable techniques for repairs are repair of minor to major cracks, horizontal seismic belts; vertical seismic belts at corners, strengthening with wire mesh are studied.

VI. PRELIMINARY INVESTIGATION

Visual inspection for Library building was carried out. If a building has given about 25 to 30 years of service without much maintenance or repair then it is reasonable to expect that it would need some repair sooner or later. The different types of crack observed in the structure are bonding cracks, shrinkage cracks, diagonal cracks and longitudinal cracks. The

measured crack wide was >2mm.

Fig.3 Different Cracks (a) bonding crack (b) longitudinal crack (c) shrinkage crack (d) diagonal crack

The improper bonding between structural and non-structural element leads to bonding cracks in figure: 3 (a). The longitudinal cracks may be observed in structural element due to insufficient cover of the member in figure: 3 (b). The improper curing and weathering effect the shrinkage cracks develops in figure: 3 (c). Due to varying temperature shrinkage crack occurs which increase in crack leads to diagonal crack in masonry walls figure: 3 (d). Due to ageing the crack in the structure lead to widen up and enlarge if not proper repair treatment are done. The external agencies like physical, chemical or environmental aspects would enter into the cracks and make the distress worse. It also leads to other distress like spalling, staining, corrosion etc.

The spalling is observed in slab, reinforcement are observed. Over time, corrosion of the reinforcement begins. The major causes of spalling are insufficient cover, cracks, shrinkage, weathering effects in figure: 4.

Fig.4 Spalling & Corrosion of reinforcement in structural element

The staining effects are observed in the structure due to leakage of pipelines. The improper sealants in joints leakage of water leads to growth of plants in figure: 5

Fig.5 Staining effects

Due to leakage of water and drainage pipelines dampness and peeling of paints in the structure are also observed in figure:6

Fig. 6 Peeling of paints and dampness effects

VII. REPAIR STRATEGY

The following strategies for the rehabilitation of concrete and masonry structure are:

1. Cleaning of damaged concrete and plasters.
2. Cleaning of corroded steel reinforcement in slab by manual or mechanical means and applies corrosion inhibitor [FAIRCRETE C].
3. Jacketing of slab can be done to steel reinforcement in slab for strengthening.
4. Application of Polymer Modified Mortar (Synthetic Butadiene Polymer Latex with 43 Grade OPC cement) in 15-20 mm thick layers in each old concrete/plaster with new layers.
5. Epoxy grouting in masonry and structural members like slab and beams to repair cracks.
6. Polymer Modified Mortar in masonry and structural members to crack sealants.
7. Replacement of leakage water lines drainage and sewage pipelines.
8. Sealants of joints pipelines.
9. Re-plastering and Painting with Acrylic paints.

VIII. REPAIR MATERIALS

The selection of material is chosen based on hand book on repair and rehabilitation published by Director General Works CPWD, Government of India [6]

Grout Material

The injection of epoxy grout material (low viscosity) into structural and non-structural member by using pneumatic grouting technique for restoration of the structural integrity of cracked concrete. The Pidilite Dr. Fixit epoxy material

cost approx. 575 per liters.

Polymer Modified Mortar (PMM)
Styrene-butadiene latex-modified mortars and concrete are suitable for a multiple applications. Due to the properties like bond to substrate and low permeability are most important. SBR Latex @ 20% by weight of OPC in PMM. The mix proportion 1:3 with water/binder ratio of 0.35 (1 - 43 Grade OPC meeting specification of IS 8112 Cement: 3 - Coarse Sand meeting the requirements of Zone II sand of IS 383) used in RCC repair. The Styrene-butadiene latex Polymer material cost approx. 120 per liters.

Asian Paints Smart Care Damp Block
Asian Paints Smart Care Damp Block is a polymer modified, flexible cementations waterproof coating. It is a high performance cementations material formulated with elastic waterproofing polymers, nano technology based additives and crystalline technology. The Asian Paints Smart Care Damp Block material cost approx. 190 per liters.

Asian Paints Smart Care Vitalia
Asian Paints Smart Care Vitalia is an integral liquid waterproofing compound with advanced formulation and superior plasticizing additives for cement concrete, mortar and plasters. The product is formulated with selected surface active plasticizing agents, chemicals & additives which make the cement concrete/plaster mix cohesive and upon curing, reduces water permeability. The Asian Paints Smart Care Vitalia material cost approx. 235 per liters.

IX. REPAIR METHODOLOGY

Repair Methodology is an important feature for any project. The correct adoption of technique results in good practice. The following sequences are to be followed for any structural repair and rehabilitation projects:

1. Identify the location and documents of Project
2. Study Environmental Aspects
3. Visual inspection of distress
4. **Preliminary investigation**
   - Finding the location of distress
   - Identifying the cause of distress
5. Detail investigation (if required)
   Using methods like NDT SDT and DT
   - NDT - Rebound Hammer test, Ultrasonic Pulse Velocity test, Carbonation Test, Radiography test etc.
   - SDT - Penetration test, Pull off – Pull out Test, Core Test etc.
   - DT - Tensile strength test, Compressive strength test, hardness test etc.
6. Possible diagnosis techniques
7. Applying good practice

TABLE II:
REPAIR TECHNIQUES FOR THE CURRENT PROJECT

Crack Repair Techniques	**Spalling & Corrosion Repair Techniques**
1. Preparation of surface. 2. Installation of injection 3. Mixing of epoxy 4. Injection of epoxy 5. Sealants of surface	1. Preparation of surface. 2. Installation of steel reinforcement jackets / corrosion incubation. 3. Application of PMM 4. Sealants of surface 5. Plastering of surface 6. Painting of surface
Staining Removal Techniques	**Peeling & Dampness Removal Techniques**
1. Preparation of surface. 2. Removal of plants and green marks. 3. Clean the cracks	1. Preparation of surface. 2. Remove the plastered surface 3. Apply PMM

4. Installation of injection 5. Mixing of epoxy 6. Injection of epoxy 7. Sealants of surface	4. Sealants of surface 5. Plastering of surface 6. Painting of surface

X. COST OF REPAIR

After per the investigation of Toilet and Store Room Region covering approx 26.4 m² Area the repair cost is tabulated below

TABLE III:
MARKET AVERAGES COST OF REPAIR (CPWD 2023)

Sr. No	Item Description	Unit	Rate (INR)	Qty	Amount (INR)
1	Surface preparation (plaster/tiles)	m²	100	26.4	2,640
2	Crack repair (epoxy injection / sealant)	m	250	10	2,500
3	RCC spalling repair + reinforcement treatment	m²	1,000	5	5,000
4	Waterproofing (toilet floor + walls up to 1.2 m)	m²	450	15	6,750
5	Plumbing (pipe replacement + fittings)	Lump sum	—	—	6,000
6	Floor & wall tile replacement	²	750	20	15,000
7	Replastering (internal/external walls)	m²	250	20	5,000
8	Painting (anti-fungal emulsion)	m²	100	25	2,500
9	Door/Window repairs or replacement	Lump sum	—	—	4,000
10	Miscellaneous & contingencies (10%)	—	—	—	4,940
	Total Estimated Cost				**₹54,330**

XI. CONCLUSION

The detail investigation was not required due to less damage in the structural and non-structural members. The overall cost of repair was approx. Rs 54,330 /-. The major reason of the distress was leakage in pipe networks. So some of the conclusions are as follows:

- Proper fitting of Drainage Pipes and sealing around the pipes at regular time period.
- Cleaning of interior and exterior structure at regular time period.
- Regular Maintenance & Repairing work like crack grouting plastering, painting etc. required.
- Proper Terrace Drain of water is essential.
- The life of structure is increased to 10 – 12 years.

Recommendation

During the service life of any structure, inspection and maintenance is required at a regular interval of 3 - 5 years. Research should be carried out for new innovative materials to bond between new and old concrete / masonry or other materials and restore its parameters.

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