

Structural Audit, Repair and Rehabilitation of Building

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ABSTRACT- Civil Engineering Industry is one of the oldest industries which provide a basic infrastructure to all the human beings. Structures can be any kind it can be Historical, Heritage Structure, Residential building, Commercial building or an Industrial building. Every structure has its own service life, and within this servicelife it should stand firmly on its position. Ex- ATajMahal in Agra in India which is one of the oldest structure and a Wonders of the World, and still stand on its position very efficiently. But this not a condition about the today's Structures. A collapsed mechanism has increased and today's Structures are getting collapsed before there service life is completed. Therefore, it is advisable to monitor it periodically by taking a professional opinion. Structural Audit is a preliminary technical survey of a building to assess its general health as a civil engineering structure. It is usually initiated as the first step for repair. In this Project a Root Cause of a faulty mechanism of structure and a preventive measures to overcome a failure of this structures. The construction material mainly reinforced concrete is being used extensively for various types of construction projects. However, the deterioration of Reinforced Concrete structures is recognized as a major problem worldwide. Apart from requiring regular maintenance, many structures require extensive Repair, Rehabilitation &Retrofitting. Over a period of time, as these structures become older, we find in them certain degradation or deterioration with resultant distress manifested in the form of cracking, splitting, delaminating, corrosion etc. Such deteriorated structures can be rehabilitated and retrofitted by using various types of admixtures & modern repair materials. The paper brings out the present state of concrete structures & the major areas where improvement is needed during its service life stage for sustainable development & also the method of carrying out Repair, Rehabilitation &Retrofitting. This has been brought in details in the paper along with Case studies, where the Author of the paper was directly involved in planning and execution of the jobs.

KEYWORDS- Structural audit, Structural Engineering, NDT method, Structural Evaluation Program, Rehabilitation, Retrofitting, Sustainable Development, Polymers, Admixtures

I. INTRODUCTION

The need of structural audit is for maintenance and repairs of existing structures whose life has exceeded the age of 30 years to avoid any mishaps and save valuable human life. The concrete is widely used as construction material being inexpensive, easy for construction, applications and because of it high strength-cost ratio. More than ever, the construction industry is concerned with improving the social, economic and environmental parameters of sustainability. In India, from 1980 onwards the infrastructure industry witnessed stepping up of public investment and growth in infrastructure industry which results in construction of new multi-storey concrete apartments which are now in the age of thirty plus years. There are many buildings during this period and earlier have reduced strength in due course of time because of structural deficiency, material deterioration, unexpected over loadings or physical damage. If, further use of such deteriorated structure is continued it may endanger the lives of occupants and surrounding habitation. There is demand of appropriate actions and measures for all such building structures to improve its performance and restore the

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desired functions of structures which may leads to increase its functional life. The periodical structural auditing and diagnosis for health of existing buildings is thus utmost important for finding the present serviceability and structural viability of structures. The structural audit must be carried out following auditing norms, methods of non-destructive testing and code provisions. The structural auditing will help to implement maintenance and repair work timely which leads to prolonged life of the building and safety of the occupants. In India there are many old buildings which have reduced strength in due course of time. If further use of such deteriorated structure is continued it may endanger the lives of the occupants and surrounding habitation. Appropriate actions should then be implemented to improve the performance of structures and restore the desired function of structures. Thus, it is utmost important to perform structural audit of existing buildings and to implement maintenance/ repair work timely which will lead to prolonged life of the building and safety of the occupant. To act more responsible and pre-emptive towards the dilapidated buildings, the municipal corporation must issue notices to the buildings and co-operative societies which are more than 30 years old to carry out mandatory structural audit and submit the audit report. Structural audit should highlight and investigate all critical areas and recommend immediate remedial and preventive measures. It should cover the structural analysis of existing frame and find critical elements for all types of loadings. It also helps in delivering a strong building structure with cost effective solutions and appropriate maintenance program. This paper deals with study of different parameter of structural audit including visual inspection, non-destructive testing, core sampling and testing. It also emphasizes on different repairs and retrofitting measures to be used for buildings after structural audit. Structural Audit is an overall health and performance check-up of a building like a doctor examines a patient. It ensures that the building and its premises are safe and have no risk. It analyses and suggests appropriate repairs and retrofitting measures required for the buildings to perform better in its service life. Structural audit is done by an experienced and licensed structural consultant.

II. OBJECTIVES

1. To recognize the types of structural defects
2. To identify any signs of material deterioration
3. To identify any signs of structural distress and deformation
4. To identify any alteration and addition in the structure, misuse which may result in overloading?

III. LITERATURE REVIEW

1. Patil S.R., Prof. Sayyed G.A” Structural Audit ”IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN : 2278-1684, p-ISSN : 2320–334X PP 60-64

From this Paper I Refer-

Civil Engineering Industry is one of the oldest industries which provide a basic infrastructure to all the human beings. Structures can be any kind it can be Historical, Heritage Structure, Residential building, Commercial building or an Industrial building. Every structure has its own service life, and within this service life it should stand firmly on its position. Ex- ATajMahal in Agra in India which is one of the oldest structure and a Wonders of the World, and still stand on its position very efficiently. But this not a condition about the today’s Structures. A collapsed mechanism has increased and today’s Structures are getting collapsed before there service life is completed. Therefore, it is advisable to monitor it periodically by taking a professional opinion. Structural Audit is a preliminary technical survey of a building to assess its general health as a civil engineering structure. It is usually initiated as the first step for repair. In this Project a Root Cause of a faulty mechanism of structure and a preventive measures to overcome a failure of this structures.

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2. **BHAVAR DADASAHEB “Retrofitting of Existing RCC Buildings by Method of Jacketing” Vol. 1, Issue: 5, June: 2013 (IJRMEET) ISSN: 2320-6586**

From this Paper I Refer-

Many parts of the country have suffered earthquake in last three decades. In costal part of South India faced Tsunami. In first three earthquakes it was found that many of damaged structures were build in non-engineered masonry techniques. Unreinforced masonry structures are the most vulnerable during an earthquake. Normally they are designed for vertical loads and since masonry has adequate compressive strength, the structures behave well as long as the loads are vertical. When such a masonry structure is subjected to lateral inertial loads during an earthquake, the walls develop shear and flexural stresses. The strength of masonry under these conditions often depends on the bond between brick and mortar (or stone and mortar), which is quite poor. This bond is also often very poor when lime mortars or mud mortars are used. A masonry wall can also undergo failure in-plane shear, if the inertial forces are in the plane of the wall. Shear failure in the form of diagonal cracks is observed due to this. However, catastrophic collapses take place when the wall experiences out-of-plane flexure. This can bring down a roof and cause more damage. Masonry buildings with light roofs such as tiled roofs are more vulnerable to out-of-plane vibrations since the top edge can undergo large deformations. It is always useful to investigate the behavior of masonry buildings after an earthquake, so as to identify any inadequacies in earthquake resistant design. Studying types of masonry construction, their performance and failure patterns helps in improving the design and detailing aspects.

3. **P. B. Oni “Performance Based Evaluation of Shear Walled RCC Building by Pushover Analysis” International Journal of Modern Engineering Research (IJMER)**

From this Paper I Refer-

As the world move towards the implementation of Performance Based Engineering philosophies in seismic design of Civil Engineering structures, new seismic design provisions require Structural Engineers to perform both linear and nonlinear analysis for the design of structures. In the present work three storey and six storey building models with plus shape Shear wall have been considered. Equivalent static and response spectrum methods are carried out as per IS:1893 (Part 1) -2002 using finite element analysis software ETABS v9.1.1. Seismic performance is assessed by pushover analysis as per ATC-40 guidelines for earthquake zone V in India. The paper also deals with the effect of the variation of the building height on the structural response of the shear wall. This paper highlights the accuracy of Push over analysis in comparison with the most commonly adopted Response Spectrum Analysis and Equivalent Static Analysis.

4. **Krish R. Villaitramani” PREFABRICATED CONSTRUCTION FOR MASS HOUSING IN MUMBAI” International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163 Volume 1 Issue 9 (October 2014)**

From this Paper I Refer-

Urbanization is the rapid influx of people migrating to cities. The UN has predicted that by 2050, 64.1% and 85.9% of the developing and developed world respectively will be urbanized. With limited resources of labour, time and finance, slums around the world continue to grow in size in uninhabitable conditions for humans. Prefabrication of houses, an innovation that has potential to address environmental and sustainability concerns at a rapid pace, mechanizes the construction process, enabling mass manufacture of affordable houses. This paper discusses the case of Mumbai, the city of maximum slum population density in the world, where prefabrication can be a promising solution to housing scarcity.

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5. **Guney OZCEBE “REHABILITATION OF EXISTING REINFORCED CONCRETE STRUCTURES USING CFRP FABRICS” 13th World Conference on Earthquake Engineering Vancouver, B.C., Canada August 1-6, 2004 Paper No. 1393**

From this Paper I Refer-

Intensive experimental research carried out for decades showed that strengthening of reinforced concrete (R/C) frames by introducing R/C infills to the selected bays in both directions is an effective method for the rehabilitation of damaged structures. However, this procedure requires evacuation of the building for several months; therefore its applicability in the rehabilitation of the existing structures, which are currently in use, is neither feasible nor practical. Observations of poor building performance after the recent earthquakes in Turkey and elsewhere and the enormous existing building stocks necessitate urgent development of innovative strengthening techniques, which would not interrupt the use of the building during rehabilitation. An experimental study was initiated at the METU Structural Mechanics Laboratory, which aimed to develop such strengthening techniques. In this study, it was intended to convert the nonload bearing existing masonry walls and partitions into structural elements which would form a new lateral load resisting system by strengthening them with CFRP fabrics and integrating them with the existing structural system. In this context, 1/3 scaled 2-story 1-bay reinforced concrete frames were tested. The frame of the test specimens was detailed to include the common deficiencies of the structures in Turkey. All together seven specimens were tested. The arrangement of the CFRP layers, the amount of CFRP used, the anchorage of CFRP fabric to the wall and the frame elements were the major parameters investigated. This paper summarizes the tests carried out to develop an efficient strengthening method for existing structures by the application of CFRP fabrics to the hollow clay tile infills.

6. **J. Bhattacharjee “REPAIR, REHABILITATION & RETROFITTING OF RCC FOR SUSTAINABLE DEVELOPMENT WITH CASE STUDIES” Civil Engineering and Urban Planning: An International Journal (CiVEJ) Vol.3, No.2, June 2016**

From this Paper I Refer-

The construction material mainly reinforced concrete is being used extensively for various types of construction projects. However, the deterioration of Reinforced Concrete structures is recognized as a major problem worldwide. Apart from requiring regular maintenance, many structures require extensive Repair, Rehabilitation & Retrofitting. Over a period of time, as these structures become older, we find in them certain degradation or deterioration with resultant distress manifested in the form of cracking, splitting, delaminating, corrosion etc. Such deteriorated structures can be rehabilitated and retrofitted by using various types of admixtures & modern repair materials. The paper brings out the present state of concrete structures & the major areas where improvement is needed during its service life stage for sustainable development & also the method of carrying out Repair, Rehabilitation & Retrofitting. This has been brought in details in the paper along with Case studies, where the Author of the paper was directly involved in planning and execution of the jobs.

7. **S. B. Halbhavi “Energy Auditing: A Walk through Survey of Library Building of Institute to Reduce the Lighting Cost” INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING Vol. 3, Issue 8, August 2015**

From this Paper I Refer-

This paper presents simple walk through energy audit for the lighting load of library section of educational institution. Lighting is a major load in case of educational institution particularly in library section. Lighting is an area which provides a major scope for achieving energy efficiency at the design stage by using the modern energy efficient lamps. Innovation and continuous improvements in lighting design has given big energy saving options. Implementation of energy audit can reduce the wastage of energy and gives good practice of energy conservation. In this paper library

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loads have been surveyed tabulate, energy saving measures is analyzed involves the replacement of low efficient lighting by high efficient lighting. The outcome of evaluation namely annual consumption reduction, greenhouse gas reduction and payback period is presented.

8. S. Sorace and G. Terenzi “Advanced Seismic Retrofit of a Low-Rise R/C Building” IACSIT International Journal of Engineering and Technology, Vol. 5, No. 3, June 2013

From this Paper I Refer-

The paper offers a synthesis of the design study of an advanced seismic retrofit solution of a low-rise reinforced concrete building, consisting in the installation of a dissipative bracing system incorporating pressurized fluid viscous spring-dampers as passive protective devices. This demonstrative application represents the last stage of the research activities carried out by the authors on this protection technology, also within several international Research Projects. The structural characteristics of the case study building make it representative of a large stock of similar edifices designed with earlier Technical Standards editions, in Italy and other European seismic-prone countries. The mechanical parameters, dimensions, layouts and locations selected for the constituting elements of the system, and the performance assessment analyses in original and rehabilitated conditions carried out according to a full non-linear dynamic approach, are presented. The results of the analyses show a remarkable enhancement of the seismic response capacities of the structure, which allows reaching the high performance levels postulated in the retrofit design.

9. A.B. Mahadik and M.H. Jaiswal ” International Journal of Civil Engineering Research. ISSN 2278-3652 Volume 5, Number 4 (2014), pp. 411-416”

From this Paper I Refer-

This paper deals to create awareness amongst the civil engineers, residents and owners of building towards the health examination of existing concrete buildings called as Structural Audit. The need of structural audit is for maintenance and repairs of existing structures whose life has exceeded the age of 30 years to avoid any mishaps and save valuable human life. The concrete is widely used as construction material being inexpensive, easy for construction, applications and because of it high strength-cost ratio. More than ever, the construction industry is concerned with improving the social, economic and environmental parameters of sustainability. In India, from 1980 onwards the infrastructure industry witnessed stepping up of public investment and growth in infrastructure industry which results in construction of new multistory concrete apartments which are now in the age of thirty plus years. There are many buildings during this period and earlier have reduced strength in due course of time because of structural deficiency, material deterioration, unexpected over loadings or physical damage. If, further use of such deteriorated structure is continued it may endanger the lives of occupants and surrounding habitation. There is demand of appropriate actions and measures for all such building structures to improve its performance and restore the desired functions of structures which may leads to increase its functional life.

10. Ms.ShradhaChandrakantDeshmukh “Energy Conservation and Audit” International Journal of Scientific and Research Publications, Volume 3, Issue 8, August 2013 1 ISSN 2250-3153

From this Paper I Refer-

Energy is one of the major inputs for the economic development of any country. In the case of the developing countries, the energy sector assumes a critical importance in view of the ever-increasing energy needs requiring huge investments to meet them. For reducing cost and increasing efficiency, then use energy conservation, management and audit. The objective of Energy Management is to achieve and maintain optimum energy procurement and utilization, throughout the organization as To minimize energy costs / waste without affecting production and quality. To minimize environmental effects. Energy Audit is the key to a systematic approach for decision-making in the area of energy management. It attempts to balance the total energy inputs with its use, and serves to identify all the energy streams in a facility.

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11. Swapnil U Biraris “Structural Audit of Old Structures” International Journal of Engineering Trends and Technology (IJETT) – Volume-43 Number-3 -January 2017

From this Paper I Refer-

Structural audit is an overall health and performance check-up of buildings .It is important to the building to check their safety and they have no risk. It is process of analyses of building And this process suggest a appropriate repairs and retrofitting measures required for the buildings to perform better in its service life structural audit is an important tool for knowing the real health status of the old buildings.

12. Dong Hyup Kim “An Information System Audit Model for Project Quality Improvement by the Agile Methodology” International Journal of Information and Education Technology, Vol. 3, No. 3, June 2013

From this Paper I Refer-

Software development has been applied with various automatized tools and techniques to increase the productivity in order to supply the requested products on time with the highest quality to customers. As a result, numerous software development methodologies have been tried continuously during the practical work. As a consequence of this effort, an agile methodology has recently been utilized in many projects in order to promptly deal with changing demands of customers. In the case of South Korea, project-applicable methodologies have been established and applied to different fields, and this tends to expand further. Information system audit evaluated product suitability throughout the whole development process including the previous step and contributed greatly to the quality enhancement. However, there are several differences between recently growing agile project and the previous one, such as management methods, construction phases, and key products. As a result, information system audit should understand the character of agile and review the comprehensive development process. This paper proposes an audit model that is suitable to the agile project by comparative analysis between the current audit model and agile methodology. Agile methodology audit model will be advantageous to the Agile applied project audit. The model should be verified and supplemented by applying to the practice, and various Agile practical items should be applied continuously and studied further.

13. Rogério Cabral “ A Review of Risk Management in Construction: Opportunities for Improvement” Modern Economy, 2014, 5, 367-383 Published Online April 2014 in SciRes. <http://www.scirp.org/journal/mehttp://dx.doi.org/10.4236/me.2014.54036>

From this Paper I Refer-

To expand knowledge of a search on a particular topic or to gather a significant sample of information that allows the researcher to identify and analyze the current state of knowledge on a topic, this paper presents a structured process for the selection of academic papers, evidence of papers’ relevance through bibliometric analysis, and analysis of the papers’ contents to identify gaps in the knowledge related to the theme under consideration and the objectives of the researcher. Starting from an interest in identifying and analyzing valuation models and risk management applied to the construction industry and using the Knowledge Development Process-Constructivist (ProKnow-C), this research identified 12,032 articles in thirteen academic databases. In its subsequent steps, the ProKnow-C allowed, in a process of continuous selection, the choice of the 23 articles that presented quantitative or qualitative risk management models developed for the construction industry. The relevance of this set of papers was demonstrated by bibliometric analysis.

14. Sophiya Sunny Pulickal “A Study on Safety Audit Management System in Kuwait” International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Index Copernicus Value (2013): 6.14 | Impact Factor (2015): 6.391

From this Paper I Refer-

A construction site is one of the most risky, perilous and accident prone working environment. Everyday construction personnel are exposed to a lot of site perils that could result in injury or even fatality.A complete eradication of these

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construction site dangers are close to impossibility but, it can be reduced to a considerable extent. The safety audit management system is one step to achieve a better, safe and accident-free working environment. A safety audit was prepared on MS Excel and 19 major elements were selected for the study. The audit was implemented in SSH International, Kuwait. For the collection of data for the audit, physical checks/inspections were done. Safety engineers, safety officers and others involved in addressing the safety at the workplace were contacted. Safety records, safety logs, safety registers, minutes of safety meetings, etc. were assessed. The factors that could affect the health and safety of the workers at the site were then ranked based on their criticality. The audit score for the consultancy was 79%. Out of the 19 audits elements, 6 elements were ranked as the primary and secondary causes of accidents. The improper usage of the following 6 elements could affect the Health and the safety of the construction personnel at the aforementioned construction site. The six elements were the following: Amenities/Sanitation, Electrical Works, Excavations, Tools and equipment, Fire protection and hot works, and Personal Protective Equipment's (PPE's). The practical implication of the audit is that the actual work-site conditions could be taken into account through the audit, and based on the happenings at the work-site, suggestive measures could be given.

V. DEVELOPMENT MODEL

A Norm According to the model bye-law no. 77 for co-operative housing societies, it is mandatory that if the age of a building is 15 to 30 years, a structural audit must be carried out once in five years and for buildings older than 30 years it should be carried out once in three years. One may, however, go for it even earlier if one suspects the condition of the building to be bad. Perhaps monsoon/ post monsoon is the best time to commission a structural audit since the seepage is more evident at that time. The certificate, issued by a structural engineer registered with BMC, will have to be submitted within a year after a building completes 30 years. For any corrective repairs suggested by the commissioner, the owner or occupants will be asked to submit the structural stability certificates again after a specific period suggested by him. If found unsafe, he has been given the authority to issue a notice to the owner to submit a structural stability certificate within 30 days from the date of notice. It will be binding on owners to carry out corrective repairs to the satisfaction of the commissioner. The certificate, issued by a structural engineer registered with BMC, will have to be submitted within a year after a building completes 30 years. For any corrective repairs suggested by the commissioner, the owner or occupants will be asked to submit the structural stability certificates again after a specific period suggested by him. If found unsafe, he has been given the authority to issue a notice to the owner to submit a structural stability certificate within 30 days from the date of notice. It will be binding on owners to carry out corrective repairs to the satisfaction of the commissioner.

Phases of Model development-

a. Methodology and Investigation

1. Condition survey-

Conditional survey is an examination of concrete for the purpose of identifying and defining area of distress. The objective of condition surveys of a building structure is:

A) To identify:-

1. Causes of distress
2. Their sources.

B) To assess:-

1. The extent of distress occurred due to corrosion, fire, earthquake or any other reason.

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2. The residual strength of the structure.

C) To priorities the distressed elements according to seriousness of repairs

D) To select and plan the effective remedy.

2. Stages for Condition Survey:-The condition survey has following stages.

1. Preliminary inspection.

2. Planning

3. Visual inspection

4. Field and laboratory testing.

b. Structural Audit Report

A] Case Study of R.C.C. Building

Basic Information	
Type of Structure -	RCC Building of G+4 floors
Address -	Pune
Type of Structure	RCC
-	

No of wings & stories - 4 storied (4 flats from 1st to 4th floor each and having two flats at ground floors) No & type of apartments - 18 flats

Description of Building

Year of construction-Aug 1987

Age- 27 years

Effects of monsoon - Yes

1. Visual observations

The building was investigated flat by flat for observation and external area of the building. Some of the column, beams & slab within the section were observed for a range of defects such as cracks, spells, crazing, seepage etc. All the defects were marked on the observation sheets with approximate repair area which formed the total data of the structure.

2. Tapping observations

Some of the column & beams inside the flat were subjected to tapping by hammer. The hollow sound was recorded in the observation sheets as follow, which was evaluated for remedial measures.

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3. Non-Destructive Observations

Some of the column & beams inside the rooms and the passage areas were subjected to Tests by Ultrasonic Pulse Velocity. The readings were recorded which were evaluated further for remedial measures.

c. Report on Non Destructive Testing Of R.C.C. Members

1] Inspection & testing: - The aim of testing was to arrive at the general quality of concrete, rather than evaluating each RCC Members in detail. Hence, a few RCC members at random were tested. Ultra Sonic Pulse Velocity (UPV) measurements were taken for Columns, Beams.

2] Corrosion: - Rusting of Iron and steel is the most commonly process of corrosion.

Any corrosion of reinforcement results in the formation of rust, which occupies a volume of about 2.2 times that of iron from which it is formed. This corrosion product has literally no place to go so that it produces large internal pressure as high as 1 ton /square inch around the concrete resulting in longitudinal cracks parallel to reinforcement and cracks in the concrete.

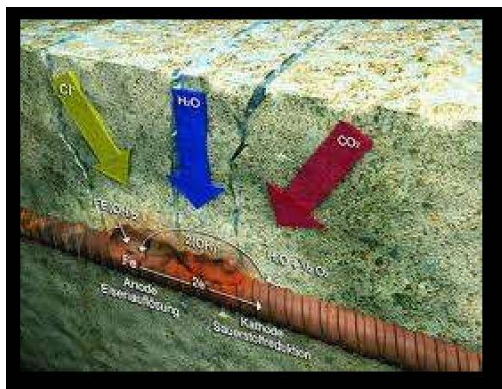


Fig No -3. Corrosion of Reinforcement



Fig.No-4 Spalled cover concrete & exposed cover Reinforcement

d. Observations

1. External

Structurally the building appears to be unsound and few structural members show major distress signs at external face & internal area of the building,

The Building is of RCC frame and brickwork / block masonry. RCC Columns and Beams show corrosion based cracks at many places.

The exterior face of the building shows cracks, crazing, and delamination in plaster.

I. Beam & column adjoining to wall delamination is noticed at various places on the facade of the building.

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II. All these defects propagate to seepage and leakages. Seepage near any R.C.C. members leads to further propagation of defects like rebar corrosion, etc.

III. Other important problem in the building appears to be the seepages from the dead walls & entire exteriors, more prominent on the south & west sides of the building. The level of damage is more on the account of the south west sides due to atmospheric direction of monsoon.

IV. Due to these problems, the condition of the building appears to be quite leaky and structural distress is observed in most of the corner columns & beams.

2. Plaster

1. External plaster acts as a skin on the RCC frame and the brick / block work, the most vulnerable part is the joints between the RCC and brick work
2. Major cracks observed accelerating the passage of water through the wall resulting in seepages inside flats.
3. The building is crack filled but not painted; which has to be attended periodically to avoid further distress in the building.
4. At many places joints between RCC members and brick / block work have separated and water is found to be seeping inside.
5. Most of the plaster in the building sides which are not exposed to monsoons directly, the extent of seepage is lesser than the side's facing monsoon.
6. Due to forces of weather and carbonation in some places, plaster has deteriorated.

e. Recommendations

1. Looking into all aspects of the building maintenance and as per our detailed survey, we suggest that the building needs to be thoroughly repaired and painted in a planned manner.
2. For any RCC framed structure the RCC components are like the bones in a body and hold the entire load of the body and any damage to the same has to be rectified immediately and cannot be left unattended for long period of time.
3. To bring the RCC components to their near original strength the same have to be repaired by polymer modified mortar method.
4. The RCC members originally deteriorated due to ingress of water and to prevent it happening **again** all sources of leakages must be stopped completely.
5. Plaster acts like a skin to the bones in a RCC structure, but the skin also needs to have a raincoat and the same is provided by a good quality resin based coating.
6. To stop the ingress of water the following steps have to be taken.
7. Structural Repairs (Wherever Necessary).

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8. External Plaster(Patch)
9. Crack Filling/Joint Filling.
10. External Drain down take Plumbing (Wherever Necessary).
11. Terrace waterproofing by using nondestructive method.
12. Dead wall / Internal Terrace parapet wall plaster repairs.

III. RESULT AND DISSCUSSION

Case Study-1: Repair/Rehabilitation of Tathawade at Pune, India

The author has successfully used various admixtures for major rehabilitation of wharves along with other repair works of caissons, dry dock etc. costing Rs.50 million (App.) at Pune (Pune), India. The two wharves (Contiguous to each other) having width of 16.45 m and total length of 500 m, was constructed during 1957 and 1967 (one having length of 350 m and other of 150 m). The damages observed were excessive spalling of concrete, formation of wide cracks, excessive corrosion, falling of fenders and shearing off of piles etc. In general, it was observed that various structural elements after these have been exposed/chipped off showed much more deterioration than was observed at the time of the site survey.

E. Structural Audit Report:

Name of the Building: Sai Apartment
Description: Row House
Address: Tathawade Pune. 411033
MH, INDIA.
Society Name: Sai Apartment
Age of Building: 52 years
Contact Person: Mr. Shailesh Jagtap
Tel No: +91 9579670950
Inspection Date: 24 Nov 2016
Inspected by: Mr. Sanjay Shelar

The two wharves were composed of fender portals, bollard portals, curtain wall (on one side of wharf only), wailings (connecting piles at the bottom of the bracing level), Deck slab (37.5 cm thick) and wearing coat (17.5 cm thick) over deck slab. Apart from a visual and dimensional survey, various other tests were carried out to diagnose distresses. Cover meter test, half-cell potential survey, ultrasonic pulse velocity test, petrography test, core test, water permeability test, chloride sulphate test and porosity test were carried out. In addition, analytical assessment of residual strength was also made. The structure being very old, design calculation/details were not available. Using a computer, a structural analysis was carried out that showed that all structural members were adequately designed based on earlier codal provisions. Because of the extent of deterioration repairs were required to wharf portals frames, curtain wall, wailings, deck slab, wearing coat and fenders. The repair methodology adopted for different types of defects are as follows:-

1. Square cutting the boundary of damaged concrete.
2. Chipping the spalled surface by pneumatic chipper.
3. Removing rust from existing reinforcement by wire brushing.
4. Welding of additional reinforcement after carrying out anti-corrosive treatment and an epoxy coating.
5. Removing dust from surface of concrete and reinforcement by compressed air, drying of the surface before applying coating of epoxy.
6. Applying an epoxy coat within an interval of 15 to 30 mins after mixing of resin & hardener and quartz sand, in the proportion of 100, 50 & 800 by weight. Air curing, for 48 hrs.

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SITE PHOTOS



Fig No 01 Closer View of Rehalilitaion Building



Fig No 02 RUST Sign in RCC Coloumn

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Fig No 03 Huney Combed Coloumns Beam- Junction



Fig No 04 Expansion Joint Location

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Fig No 05 Repair Material RCC Beam.



Fig No 06 Recasting RCC Slab

IV. CONCLUSION

From the consideration of all the above points we conclude that the defects of structural members are due to combined effects of carbonation, corrosion & effect of continuous drying and wetting. The result of visual survey prompt us to conclude the distress is wide spread and is an ongoing process and so needs to be stopped at this stage so as to avoid complete collapse of the structure. There for Rehabilitation of the RCC members and will constitute the following steps

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1. *Propping the structure wherever necessary*
2. *Removing loose/disintegrated concrete*
3. *Cleaning the affected steel*
4. *Adding steel wherever necessary*
5. *Applying Passivator coat to the steel*
6. *Applying Bond Coat and doing Polymer /Micro*
7. *Concrete treatment depending on the requirements*
8. *Finishing with new plaster*

The condition of the building appears to be quite bad and major structural distress is observed in some of the columns and beams of the external walls. Micro Concrete Repairs to R.C.C. Column, Beam, etc.: In terms of to restoration of extensive damages in R.C.C. micro concrete: micro concrete is a very high strength mix design concrete, its factory made product. its dry powder in grey color more like cement constitutes cement as a one component & other's graded fine aggregate, additive in powder form & free flowing agent, because of this micro concrete can placed in less thickness & mix. Material can travel in narrow gape & having self-leveling properties, so that it provides very smooth & uniform finish. Strength equivalent to 35 m concrete can be achieved in only three day setting / placing time.

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