

A Review on Structural Audit, Repair and Rehabilitation Techniques

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Abstract - Structural Audit is a technical survey of an engineering structure to assess its health. Evaluation of current vague practices of Structural Audit paved way to understand the drawbacks of those processes and modify the same for methodical implementation of Structural Audit. This research aims at understanding the drawbacks if any in the current procedure, recast the structural auditing process and propose some improvement measures to the governing body. Structural audit is the technical survey of the building in order to check its strength and stability. Structural audit is the first step in repairing procedure of the building. Structural audit is generally recommended for older buildings. Structural audit was first introduced by Indian society of structural engineers. Structural audit helps in improving the safety, efficiency and gives idea about the strength of the structure by detailed technical inspection. In present study attempt have been made to carry out structural audit of the old RCC building by carrying out site inspection, performing NDT on the structure. Building is modelled and analyzed using ETABS and Demand to capacity ratio is determined. After checking strength and stability of the structural members suitable recommendations are given in order to retrofit unsafe structural component. Finally structural audit report is prepared for the building. This paper also deals with the repair rehabilitation measures that are to be enacted after the Audit and prepare an advanced operating procedure for Structural Audits.

Key Words: Structural Audit, Non-Destructive Test, Repair, Rehabilitation.

1. 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 its 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. 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 auditing will help to implement maintenance and repair work timely which leads to prolonged life of the building and safety of the occupants.

1.1 Research Objectives

- Performing a Structural Audit of the building.
- Evaluating various retrofitting options, materials, feasibility and economy.
- Performing structural calculations and capacity demand ratio for structural members.
- Suggesting retrofitting/construction system and getting the rehabilitation of the building done.
- Post retrofitting tests on the building.

2. STRUCTURAL AUDIT OUTCOMES



Fig -1 Slab Reinforcement Corrosion



Fig -2 Plaster cracks on external wall



Fig -3 Seepage due to cracks



Fig -4 Leakage in Slab

- j. External Drain down take Plumbing.
- k. Terrace waterproofing by using non-destructive method.



Fig -5 Waterproofing



Fig -6 Wall plastering to avoid seepage

2.2 Recommendations

- a. 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.
- b. 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.
- c. To bring the RCC components to their near original strength the same have to be repaired by polymer modified mortar method.
- d. The RCC members originally deteriorated due to ingress of water and to prevent it happening again all sources of leakages must be stopped completely.
- e. 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.
- f. To stop the ingress of water the following steps have to be taken.
- g. Structural Repairs (Wherever Necessary).
- h. External Plaster (Patch)
- i. Crack Filling/Joint Filling.



Fig -7 Column and beam jacketing

3. LITERATURE REVIEW

Guney OZCEBE (2004) Intensive experimental research carried out for decades showed that strengthening of reinforced concrete (R/C) frames by introducing R/C infill 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 no-load 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 infill.

S. Sorace and G. Terenzi (2013) 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.

Ms. Shradha Chandrakant Deshmukh (2013) 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.

Bhavar Dadasaheb (2013) 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 behaviour of masonry buildings after an earthquake, so as to identify any inadequacies in earthquake resistant design. Studying types of masonry.

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Dong Hyup Kim (2013) Software development has been applied with various atomized 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.

A.B. Mahadik and M.H. Jaiswal (2014) 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 its 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.

Krish R. Villaitramani (2014) 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.

S. B. Halbhavi (2015) 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 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.

J. Bhattacharjee (2016) 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.

Swapnil U Biraris (2017) 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 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.

4. CONCLUSION

The overall conclusion of all above reviews is 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. 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. 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. We suggest the Micro Concrete for Repairing the R.C.C. Column and Beam. Therefore Rehabilitation of the RCC members and will constitute the following steps

- Propping the structure wherever necessary.
- Removing loose/disintegrated concrete.
- Cleaning the affected steel.
- Adding steel wherever necessary.
- Applying Passivator coat to the steel.
- Applying Bond Coat and doing Polymer /Micro.
- Waterproofing (Wherever Necessary).
- Application of plaster for controlling seepage.

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