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Structural Audit and Retrofitting of RCC Structure

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Abstract: ***Civil Engineering Industry is one of the oldest industries which provide a basic infrastructure toall 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- A Taj Mahal in Agra in India which is one of the oldest structures 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 measure 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 concretestructures & 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 job.***

I. INTRODUCTION

The concrete is widely used as construction material. Reinforced cementconcrete (RCC) as a construction material has come into use for the last one century. In India RCC has been used extensively in last five to six-decade year during these periods, we have created a large number of infrastructure assets in terms of building, bridge, towers and other structure. Decoration of RCC is a natural phenomenon and has started exhibiting in large number of structures a systematic approach is needed in dealing with such problem identification of the case of deterioration and consequent repair strategy of optimum cost need and evaluation. The first step in repair and rehabilitation is the proper diagnosis for successful repair work. It deals with non-destructive evaluation techniques. Details of commonly used test for non-destructive evaluation (NDT) like Rebound hammer test, ultra- sonic pulse velocityand core test. Retrofitting of structure like building which include retrofitting, maintenance andstrengthening of structure is not only a need in construction and management in Urban areabut also a problem which arises to structural engineering in property management disciplines. Retrofitting is defined as the process of modification of existing structure like building, bridge to make them more strengthen. Strength of the building is generated for the structural dimension, material, shape and no of structural element.



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1) *Structural Audit:* Structural Audit is nothing but the overall Health Performance, Checking up of Building like a Doctor examines the Patient. It ensures that the building and its premises are safe and have no risk. It gives analysis of structure and provides necessary suggestion for appropriate repairs and retrofitting measures for the building to provide better service life. This Audit should done by experienced and Licensed Structural Consultants.
2) *Retrofitting:* Retrofit in structures is done to increase the survivability functionality. The applications include different types of bridges, buildings, and industrial structures, transport structures in urban areas, earth retaining structures and marine structures. Retrofitting is the modification of strength of existing structures. Strengthening of members that do not meet safety requirements must be strengthened, however there is often an underlying mistake that the strengthening of whole structural system is neglected. Strengthening of connection between members is quite influential to structural integrity.The benefits of retrofit existing structure includes; cost saving in long run by reducingthe usage of energy and water by incorporating new technology, services or equipment; increasing the comfort level in a building by redesign the façade and interior to improve end users productivity and satisfaction through .
3) *Objective Of Project*

a) To understand the real condition of the Building.
b) Protect the life of human being and animal from structural failure.
c) To know the Current Health of building and to protect the future life.
d) Awareness of residents to under the seriousness of the problems and to suggest the remedial measures for strengthen or repairs, rehabilitation of the structure.
e) To identify any signs of material deterioration.

II. LITERATURE REVIEW

A. Charles R Farrar et.al.,(2007) "An introduction tostructural health monitoring". Phil. Trans. R. Soc. A 2007.

In this paper the process of implementing a damage identification strategy for civil engineering infrastructure is referred to as structural health monitoring (SHM). In the most general terms, damage can be defined as changes introduced into a system that adversely affects its current or future performance. Damage identification is carried out in conjunction with five closely related disciplines that include SHM, condition monitoring, non-destructive evaluation, statistical process control and damage prognosis.Significant future developments of this technology will come by multi-disciplinary researchefforts. Studying fields such as structural dynamics, signal processing, motion and environmental sensing and smart materials.

B. A.B.Mahadik et.al., Volume5,(2014) "Structural Audit OfBuilding".

This paper deals to create awareness among the civil engineers, resident at owners of building towards the health examination existing concrete building. To find out the strengthand durability of building so as to enhance its life duration or service life span. Structural audit generally done periodically by professional expert act immediately through recommendation provided in audits reports. The success of repair and retrofit is always based on types of problem, nature of problem and environmental conditions. The effectiverequirement of retrofitting is implemented on the auditing problem so enhance the propertyof structure.

C. Saiesh.L.Naik et.al., Volume: 04 Issue: 05, May(2017) "Structural Audit of RCC Building".

This paper concludes that structural audit is generally recommended for older building. Structural audit help to improving the safety, efficiency and gives the idea about strength and durability of building. Structural audit is used to find out appropriate remedial measures can be recommended forall structure defect and damages so that to find out the damages non –destructive test is required. This method of testing's allows to test the material or component is without losing its usefulness. NDT method helps is testing integrity of concrete or structural member through outs its lifespan. The main cause of damage of the structural member is due to corrosion. Corrosion inthe structural member is seen due to dampness and linkage from the slabs, crack in the wall.

D. John T.Petro et.al., (sep2011), "Detection of Delamination in Concrete Using Ultrasonic Pulse Velocity Test".

In this test experimental study was perform to evaluate delamination in concrete using ultrasonic pulse velocity test. For this two slabs specimen are used having size 150mmand 300mm thickness consist delamination of varying size. For the test direct and indirect transmission methods were carried out to determine the characteristics of concrete. The indirect method was used to determine the properties like dynamic young's modulus and dynamic Poisson's ratio and direct method has been used to estimate the compressive strength of concrete.

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E. Mostafa Kazemi et.al. "Compressive strength assessment of recycledaggregate concrete rebound hammer test".

In this study estimate the compressive strength of recycled aggregate concrete by using rebound hammer test. Rebound hammer test helps to identify relative surface weakness in cover concrete and to determine relative compressive strength of concrete. Casting cubes were tested under the controlled condition.

F. K.-S. Youm, H.-E. Lee, and S. Choi "Seismic performance of repairedRC columns" Magazine of Concrete Research, vol. 58, no. 5, pp. 267– 276, 2006.

Steel or fiber-reinforced polymer (FRP) composite jackets have been utilized in retrofitting reinforced concrete (RC) bridge columns and have shown to be effective in enhancing seismic performance of the structures. However, to date, only a few researches have been conducted on the behavioral characteristics of the repaired RC columns using steel or FRP jackets. In the present paper, the comparative performance of repaired RC columns using steel and CFRP jackets is presented.

Also, the effect of transverse reinforcement ratio on the behavior of the steel and the CFRP repairing is investigated. Monotonic and cyclic load tests are conducted on nine RC column specimens with different repairing strategies and transverse reinforcement ratios to compare the ultimate and the hysteretic behaviors.

From the tests, it is observed that both steel and CFRP jacket repairing can significantly increase the ductility and the ultimate capacity of damaged columns.

Notably, the steel jacket repaired columns show better energy dissipation capacity than the CFRP jacket repaired columns for columns with lower transverse reinforcement ratio. It is also observed that the location of plastic hinge region goes up as the transverse reinforcement ratio of RCcolumns increases.

G. Soumya Gorai P.R. Maiti "Advanced Retrofitting Techniques for Reinforced Concrete Structures" Research Scholar, Department of CivilEngineering, Indian Institute of Technology, Kharagpur, India

Any technology or material has its limitations and to meet the new requirements, new technologies have been invented and used over the ages. A large number of reinforced concrete structures located at seismic prone areas are not capable of withstanding earthquakes according to the current coal provisions.

Furthermore, the seismic behaviors of the existing buildings are affected due to design deficiency, construction deficiency, additional loads, additional performance demand, etc.

Recent earthquakes have clearly demonstrated an urgent need to upgrade and strengthen these seismically deficientstructures. The retrofitting is one of the best options to make an existing inadequate building safe against future probable earthquake or other environmental forces.

Retrofitting reducesthe vulnerability of damage of an existing structure during a near future seismic activity. Itaims to strengthen a structure to satisfy the requirements of the current codes for seismic design. A significant amount of research work has been carried out in recent years to develop various strengthening and rehabilitation techniques to improve the seismic performance of structures.

This paper aims to present an overview on different innovative and cost effective techniques of retrofitting for strengthening the damaged structures.

H. Hamid Eskandari-Naddaf, M.Lezgy-Nazargah, And Hossein Bakhshi,(2016) "Optimal Methods For Retrofitting Corrosion-DamagedReinforced Concrete Columns".

The author has been developing two software. ETABS and MATLAB software were applied to develop and optimal plan that involved minimal repair costs and maximum safty.it has been used two methods for corrosion damaged reinforced concrete column retrofitting.

The main objectives of the present work as follows To optimize the reinforcement process considering the cost of concrete and reinforcement.

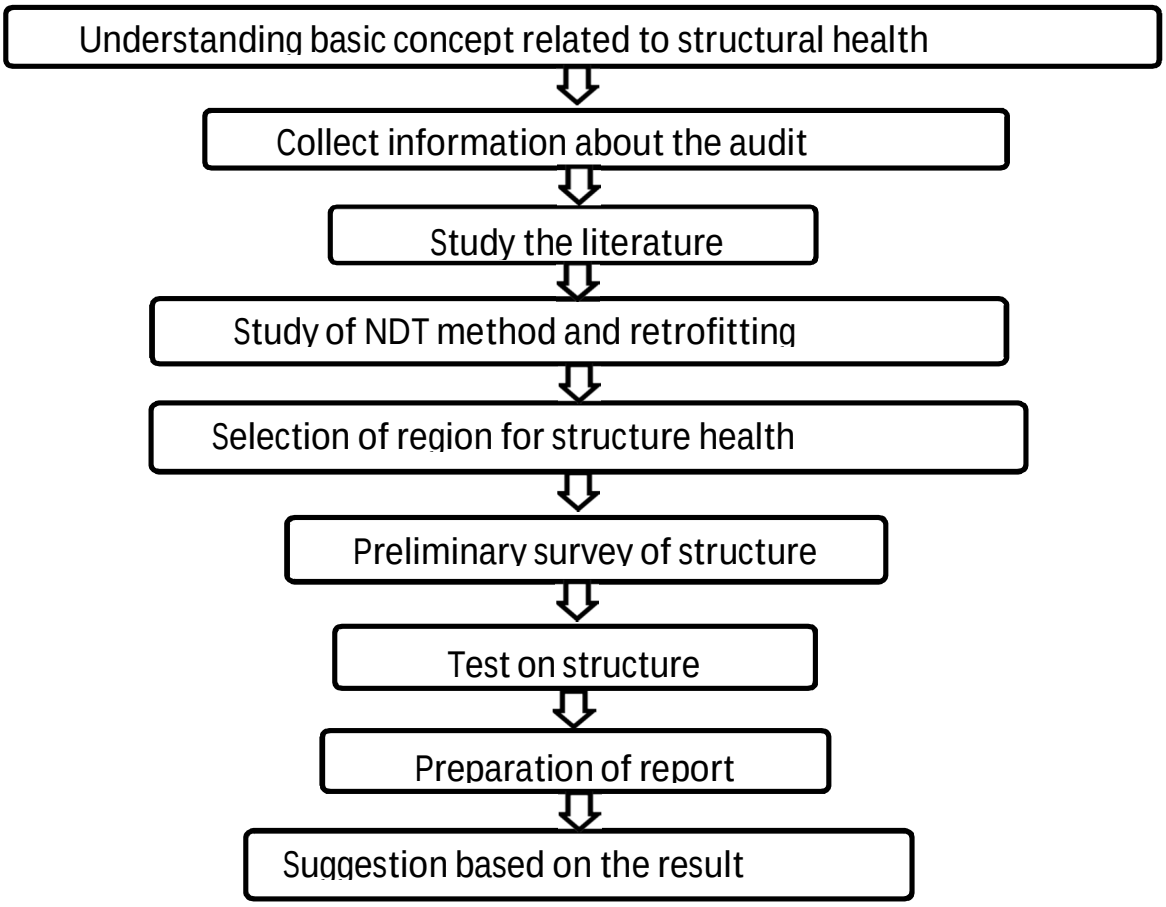
To compare the column cost for various concrete strength (fc) as well as type of retrofitting methods. In case study two type of retrofitting methods are applied to 20 %critically corroded column the results are follows Considering safety factors, applying externally –bonded still plate yields about 40%growth in comparison to concrete jacketing retrofitting which means implementing steel plate are safer than used concrete jacketing retrofitting. Considering all parameter's, the concrete jacketing retrofitting shows approximately 70%decreassing total cost which makes the more economicalcompare to other methods.

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III. METHODOLOGY

1) *Visual Inspection:* The building was investigated by Floor by Floor for observation and external area of the building some of the column, beam and slab within the structure were observed for a range of defects such as spalls, seepage cracks and crazing….etc. All the defects were marked on the observation sheets with approximate repairs which formed the total data of the structure.



2) *Tapping Observation:* Some of the column and beams inside the flats were subjected to Tapping by hammer. The hollow sound was recorded. This was evaluated for remedial measures.
3) *Non Destructive Testing [NDT]:* In addition to Visual Inspection and Tapping Observation the quality and strength of structural components can be determined by the use of various Non-Destructive Test. There are various NDT instrument used in concrete members which determines the present Strength and quality of concrete. The result of these is useful in finding out the treatment to be given to the structural members and various types of the test available in the market those are as below.

a) *Rebound Hammer Test:* To measure the surface Hardness of Concrete.
b) *Half Cell Potential Method:* To assess probability of corrosion in the embedded steel.
c) *Ultra Sonic Pulse Velocity:* Test To assess homogeneity of the concrete to assess strength of concrete qualitatively to determine structural integrity.
d) *Repairs:* The repairs should be as per Standard Procedure given in respective code. The maintenance work should carried out as per mentioned.
e) *Identification Of Distress Area Of Structure:* Based on the above inspection analysis and test results the report concluded the critical areas that need immediate repairs and maintenance, retrofitting, rehabilitation. The report is prepared on the maintenance required.

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4) The retrofit process is a general term that may consist of a various method of retrofitting.

a) *Cocrete Jacketing:* Concrete jacketing involves placing an additional layer of concrete covering the existing column, together with additional longitudinal bars and ties to enhance the flexural and/or shear capacities. The retrofitting of columns by concrete jacketing is not sufficiently documented.

b) *Steel Jacketing:* Steel jacketing refers to encasing the section with steel plates and filling the gap with non-shrink grout. It is a very effective method to recover the deficiencies such as inadequate shear strength and inadequate splices of longitudinal bars at critical locations. But it may be costly and its fire resistance has to be addressed.

c) *Fiber Reinforced Polymer Composite (FRPC) Jacketing:* A Fiber Reinforced Polymer (FRP) typically consists of high tensile continuous fibers oriented in a desired direction in a specialty resin matrix. These continuous fibers are bonded to the external surface of the member to be strengthened in the direction of tensile force or as confining reinforcement normal to its axis. FRP can enhance shear, flexural, compression capacity and ductility of the deficient member Glass fibers are the most common types of fibers used in the majority of commercially available FRPs. FRP systems, commonly used for structural applications. FRP strengthening is a quick, neat, effective, and aesthetically pleasing technique to rehabilitate reinforced

IV. RESULT

A. By the above investigation survey we have come to result that the structure health condition is fair.

B. According to study of NDT test & UPV test we have concluded that structural member or components are suffering from class 3 damage. Principal repair works should be started early as possible and to avoid further deterioration of structure.

V. CONCLUSION

A. According to the Visual inspection building condition is fair and NDT tests it is concluded that repairs are required to the buildings.

B. During performing NDT testing it is observed that various columns, beams & slab whose quality and strength is doubtful as shown in table no 6 and 9 for such beams and columns it is concluded that Jacketing should be done.

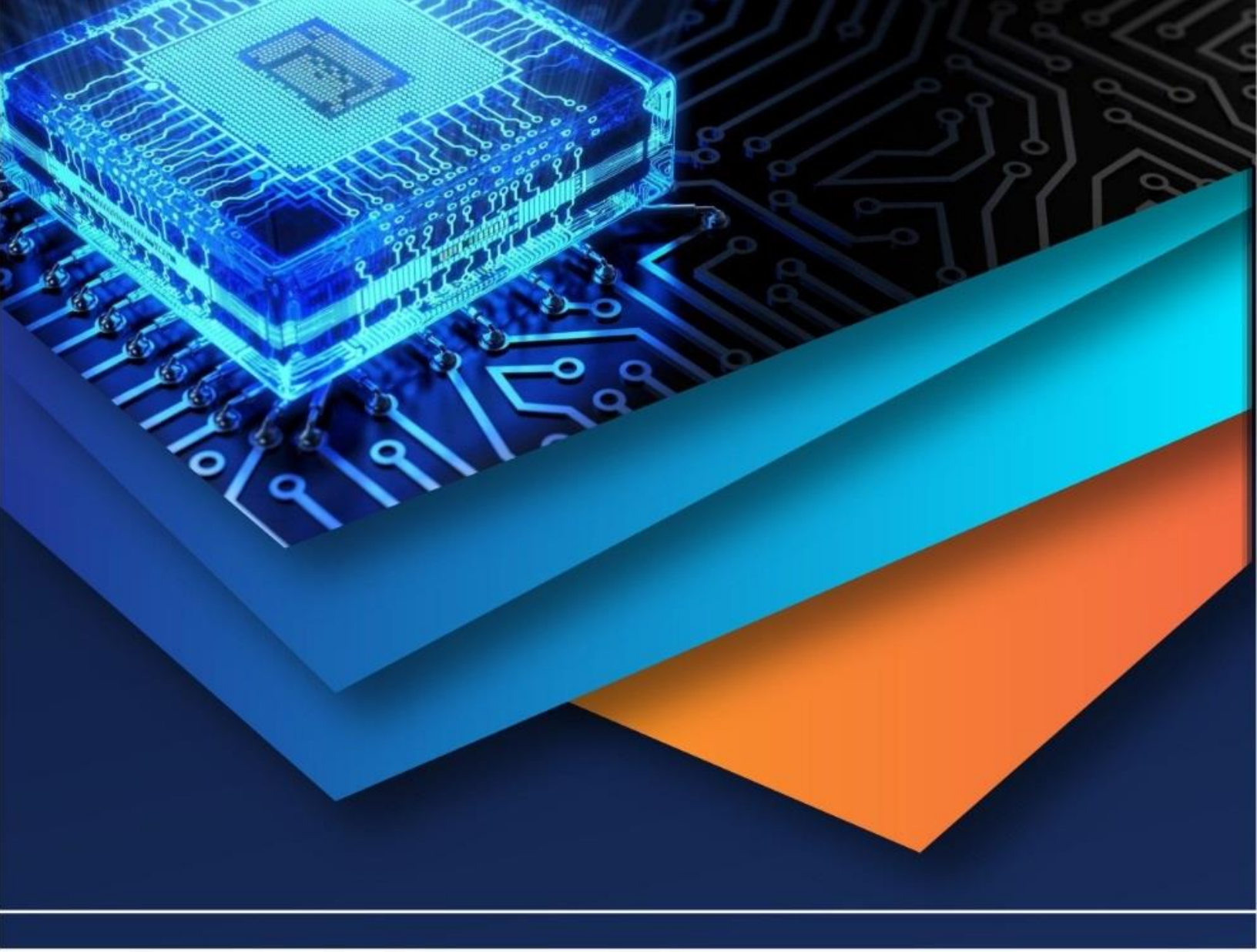
C. According to UPV test it is concluded that repair work are required to the doubtful columns, beam & slab as shown in table.

D. As per specifications proper repairs and retrofitting should be done, to maintain building in good condition.

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