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Review Paper on Seismic Assessment and Analysis of Typical RCC Structure for Retrofitting

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Abstract: ***An increasing number of reinforced concrete structures have reached the end of their service life, either due to deterioration of the concrete and reinforcements caused by environmental factors or due to an increase in applied loads. These deteriorated structures may be structurally deficient or functionally obsolete, and most are now in serious need of extensive rehabilitation or replacement. Strengthening can be used as a cost-effective alternative to the replacement of these structures and is often the only feasible solution.***
In this study, the main criteria is how to repair a reinforced concrete elements of structures and for this the skills, knowledge, and experience required to repair damaged or deteriorated structures are decidedly different from those required to build new structures.
The construction industry has embraced retrofitting techniques composites as a promising alternative for repairing and strengthening RCC structures. This study observes reinforced concrete structures that have been externally retrofitted. The goal of this research is to summarise the behaviour of RCC structure after they have been retrofitted with different methods. The main objective of the research is to repair structurally weak elements and make them useful in flexure and shear. This review paper has collected works on different retrofitting techniques to show the ways in which available retrofitting solutions may be judiciously used to improve load carrying capacity of the structures.
Keywords: Damaged RCC member, Retrofitting technics, Strengthening, Restoration.

I. INTRODUCTION

RCC (Reinforced Cement Concrete) is a construction technology which involved with the evolution of different structural materials during the Industrial Revolution. The standard life of R.C.C. framed structure is considered to be in the range of 50-60 years approximately depending upon the use and the importance of the structure. But it has been observed that many of the buildings completing just 50% of their life in some areas found to be in distressed condition and this needs the evaluation of the strength of the building so that appropriate remedial action can be taken to improve performance of the building depending upon the extent of deterioration of the structure. Recent earthquakes that occurred during last ten years have suggested that significant damage happened wasn't specifically on account of methods of earthquakes but on account of bad performance of construction during earthquake. The current building system, that were design and constructed according to first codal provisions, don't satisfy needs of present seismic design and code methods. It's realized that the best technique of lowering the danger of harmful structure is seismic retrofitting. In the recent past, there's a tremendous enhancement of retrofitting techniques. This analysis highlights the concepts of evaluating and also retrofitting of structure against seismic events.

A R.C.C structure is designed to have a capacity to carry combined loads (dead, live and seismic loads) at certain safety level and at certain degree of reliability. When this design is finally executed in construction process, the expected performance of the structural building should come into satisfaction. However, this ideal condition is not always realized. Almost all the structures are constructed of R.C.C and even though it is a wonderful construction material, but once set it is very difficult to increase its strength. The performance of building reduces in terms of safety level, strength or capacity due to the variety of causes or situations such as deterioration of concrete, unskilled work, alteration of building units, larger loads due to extension of structure etc. These structures behaves or performs normally during their entire life span but at the end of design period of structure, the structure may not be capable to take the existing loads and obviously it will not be possible to take the extra loads on it. This pose is a more difficult scenario for a structural engineer than designing and constructing a new building. Enhancement of the performance such a deficient building can be done by increasing the strength and the strength of building can be increased by the process of retrofitting. R.C.C Buildings can be made to undergo three different R's namely Repair, Rehabilitation and Retrofitting.

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II. ASSESSMENT PROCEDURE

A. Visual Inspection

1) *Collection of Information:* Building data with respect to structural and constructional drawings, vulnerability, number of stories, year of construction, seismicity and codes followed earlier etc.
2) *Condition of the Building:* Identification of structural damages such as cracking, spalling, quality of construction, lateral load resisting system, load path, maintenance, corrosion, recent retrofit measures and modifications

B. Detailed Investigation

In case construction drawings and structural details are not available, detailed investigations have to be conducted. Properties of materials like concrete and steel can be obtained by conducting non-destructive testing (NDT) in the field and laboratory. With the assessment analysis, safety of the building can be evaluated to recommend retrofitting/ strengthening measures.

III. LITERATURE REVIEW

Pravin S Waghmare, In this paper, different jacketing methods are mentioned. Jacketing methods described for strengthening of column to improve the performance of R.C.C building. Jacketing is the most popularly used method for strengthening of building columns. The most common types of jackets are steel jacket, reinforced concrete jacket, fiber reinforced polymer, composite jacket, jacket with high tension materials carbon fibre, glass fiber. Construction technique for steel jacketing, R.C.C jacketing, FRP jacketing are studied. Construction technique detail for each jacketing is shown in the paper.

Dr.Gopal L. Rai, In this paper, different strengthening techniques for R.C columns are studied. Methods studied are concrete jacketing, steel jacketing, precast concrete jacketing, external pressurising and FRP wrapping. Concrete jacketing involves addition of thick layer of reinforced concrete in the form of a jacket, using longitudinal reinforcement and transverse ties. Additional concrete and reinforcement contributes to strength increase. Steel jacketing involves encasing the column with steel plates and filling the gap with a non-shrink grout. Precast concrete jacketing, in this technique new longitudinal r/f is set around the existing column and precast concrete segment are set around the new r/f. External pressurising involves pressurising the column by external strands.FRP involves wrapping of RC columns by fibber wraps.

Mahdi shariati, Nor Hafizahramli-sulong, Mohammad Mehdi Arabnejadk.h, Payamshafighand Hamid sinaei, “Assessing the strength of reinforced concrete structures through ultrasonic pulse velocity and Schmidt rebound hammer tests”, Scientific research and essays vol.6 (1)-2011. Experimental studies using ultrasonic pulse velocity and Schmidt rebound hammer as NDT tests were presented in the paper to establish a correlation between the compressive strength of compressive tests and NDT values. These two tests have been used to determine the concrete quality. The main members of an existing building including column, beam, and slab were included in the study. The test results show that the rebound no. method was more efficient in predicting the strength of concrete under certain conditions.

A.K.singh, Dr. R.S jangid,Dr. gopal l. rai, “Structural Retrofitting – a case study”, Municipal Corporation, Mumbai-2009.This paper describes the intensive retrofitting of an existing RCC framed structure. The building is a RCC framed structure owned by a nationalized bank and is more than 30 years old. The building was examined for its current structural condition and to suggest the remedial measures. The strategy adopted was aiming to recover the original performance, for which the damaged or deteriorated portion of the structure was to be repaired or replaced with new elements or new material.

Shailesh Agrawal and Ajay Chourasia (2003), performed the nonlinear static analysis of RC building using pushover approach before and after retrofitting. The comparison of strength parameters and pushover curve indicated that there was increase in ductility. As regards to stiffness of the building, it was seen that it remains more or less same up to linear stage, while in nonlinear stage every point increased both in capacity and the deformation after retrofitting. The strength of the building was correlated with base shear, the net enhancement in strength after retrofitting.

SachinRambhauShelke “Structural Health Monitoring and Audit, Repair and Rehabilitation of Building in Construction Industry”. Structures are assemblies of load carrying members capable of safely transferring the superimposed loads to the foundations. Their main and most looked after property is the strength of the material that they are made of. Concrete, as we all know, is an integral material used for construction purposes. Thus, strength of concrete used, is required to be ‘known’ before starting with any kind of analysis. In the recent past, various methods and techniques, called as Non-Destructive Evaluation (NDE) techniques, are being used for Structural Health Monitoring (SHM). The concept of nondestructive testing (NDT) is to obtain material properties of in place specimens without the destruction of the specimen nor the structure from which it is taken.

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However, one problem that has been prevalent within the concrete industry for years is that the true properties of an in-place specimen have never been tested without leaving a certain degree of damage on the structure. For most cast-in-place concrete structures, construction specifications require that test cylinders be cast for 28-day strength determination. Usually, representative test specimens are cast from the same concrete mix as the larger structural elements. Unfortunately, test specimens are not an exact representation of in-situ concrete, and may be affected by variations in specimen type, size, and curing procedures. The rebound hammer test is classified as a hardness test and is based on the principle that the rebound of an elastic mass depends on the hardness of the surface against which the mass impinges.

Vivek Kumar Yadav "Repairs And Rehabilitation of R.C.C. Structures by Fiber Reinforced Plastic- A Review" The purpose of the paper is to highlight the methods of repair and rehabilitation to be undertaken for structures with defects and deficiencies that necessitate rehabilitation. Repair and Rehabilitation methods currently used are reviewed on the basis of present knowledge and the merit of a holistic system approach. This paper focuses on visible symptoms of the problem rather than on visible and invisible problems as well as the possible causes behind them. This paper focuses about the repair materials and the techniques are essential for the satisfactory performance of the repaired structure.

Shubhangi Saxena, Case Study on Diagnosis and Repair of Failuers in RCC Building, The building material mainly reinforced concrete is being used comprehensively for innumerable forms of construction developments. However, the deterioration of Reinforced Concrete structures is acknowledged as a foremost problem. To one side, it requires regular maintenance and on other side many structures call for widespread repair, rehabilitation & retrofitting. With the passage of time, as these structures develop older, we discover in them certain dilapidation or weakening with subsequent distress revealed in the form of delamination, cracking, corrosion and splitting etc. Such worsened structures can be repaired, rehabilitated and retrofitted by means of several sorts of admixtures & new repair materials. The purpose of this paper is to suggest methods of repair, rehabilitation and retrofitting of RC framed structures with the help of a case study where the author was involved at every stage. In the case study of the structure involved the focus was made on the determination and correlation of the results of various non-destructive tests for the purpose of suggesting suitable sustainable measures for the rehabilitation of the structures.

Manish Kumar "Structural Rehabilitation, Retrofitting and Strengthening of Reinforced Concrete Structures" Reinforced cement concrete is getting extensively used for construction of different type of structures for the last one century. During this period, we have constructed many structures like buildings, bridges, industrial structures, pavement, water tanks etc. using this construction material. These structures have been created with huge investment of resources. It is essential to maintain those structures in functional condition. Since deterioration in RCC Structures is a common and natural phenomenon it is required to have a detailed plan, methodology for structural repair and rehabilitation shall be in place for dealing such issues. It is important to know exact reason of distress, type of distress and correct method of repair concrete structures. The different methods of repair are described in paper according to distress category which can be refereed for repair. Major finding of the study is that to protect our structure we need to have maintenance frequency and correct material to be chosen for repair. Also workmanship during repair needs to be taken utmost care for quality repair.

J. Bhattacharjee "Repair, Rehabilitation & Retrofitting of RCC for Sustainable Development with Case Studies" 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.

Prof. Dr. D. K. Kulkarni., Mr. Teke Sudhakar. S. Health Assessment Of Reinforced Concrete Structures - A Case Study, There are two distinct types of tests, and they are No-destructive and partially destructive. The authors have chosen two tests, from 7 as referred, (ND), viz. Schmidt "s Rebound Hammer test for assessing the concrete compressive strength, and Ultrasound pulse Velocity tests for establishing quality of concrete. They had the task of ascertaining strength of concrete. These help in assessing level of damages weaknesses, deterioration, corrosion, that has taken place in past life of the structure. On such assessment the apt method of strengthening, retrofitting can be proposed and future life of the structure can be estimated.

Health assessment of structures is essential to ascertain the strength which is indicating or for the durability in lieu of aging, weathering, corrosion, damage etc. effects.

Consuelo Beschi et al., "Beam-Column Joint Retrofitting with High Performance Fibre Reinforced Concrete Jacketing" investigated on retrofitting of beam-column joints using high-performance fibre reinforced concrete jacketing. They started testing specimen on a column with cross section of 300×300 mm in the upper part and 400×400 mm in the lower part, and a beam cross section of 300×600 mm. The beam was 5 metres long and the column was 3.55 metres high. A R.C. corbel was put at the beam column joint to replicate the presence of the transverse beam in the real construction. A static load is applied on this beam-column joint, followed by cyclic loading. The column is wrapped in FRP sheets that have been bent at a 90 degree angle. They were eventually wrapped in the HPFRC. During the test, a horizontal load was applied with increasing amplitude cycles till failure. The use of HPFRC jacketing improves the bearing capacity of the column, as well as its ductility and overall performance of the beam column junction. The results of the suggested technique can be used to strengthen existing RC structures with low concrete strength and low reinforcement ratios.

Stephen Pessiki et al., "Axial Behaviour of Reinforced Concrete Columns Confined with FRP Jackets" investigated the performance of circular and square RC column jacketing with FRP and found that FRP jacketed concrete members have better axial load-carrying and deformation capacities than unjacketed concrete members, as well as factors influencing the axial stress-strain behaviour of FRP confined concretes. The jackets provided to specimens with square cross sections were not as successful as those provided to specimens with circular cross sections, according to the comparative study between square and circular columns, because square cross sections contain zones of ineffectively confined concrete.

N. F. Grace et al., "Strengthening Reinforced Beam Using Fibre Reinforced Polymer (FRP) Laminates" presents the various types of Fibre reinforced polymer laminates are tested with the 14 simply supported cross section beams. All of the beams were the same size and had the same flexural and shear reinforcements. Firstly, each beam was cracked by delivering a 44.8kN midspan force. Each beam was strengthened with a FRP material after it had cracked. The beams were then subjected to a concentrated force at midspan until they failed completely. In this study, five different FRP strengthening systems were used. These systems consist of two types of CFRP sheets, two types of GFRP sheets and CFRP plates. In these systems, four different types of epoxies were used. Each beam was reinforced with FRP laminates that were originally loaded higher than the cracking load and then tested till failure. The authors discovered beam deflection, strain, and ductile behaviour. The author found that using the right combination of vertical and horizontal sheets, as well as the right epoxy, the ultimate load carrying capacity of the beam can be doubled. To summarise, the behaviour of beam strengthening is expressed in a greater design factor of safety.

T. P. Meikandaan, Dr. A. Ramachandra Murthy "Flexural Behaviour of RC Beam Wrapped with GFRP Sheets" conducted an investigation of the flexural behaviour of an RC beam wrapped in GFRP sheets, which included an experimental study using externally bonded GFRP sheets to the RC beam and testing under a two-point static loading system. They prepared six reinforced concrete beams for this, noted that all six are flexural weak and have the same reinforcement details. Three beams were isolated and used as control beams, while the other three were strengthened with GFRP in the tension zone. According to the findings, the bottom of GFRP sheet wrapping in a 70 percent preloaded beam can boost the beam's flexural capacity by 14 percent (on ultimate load) when compared to the control beam. According to the authors, strengthening the beam up to the neutral axis improves the beam's ultimate load carrying capacity. Since the earliest cracks generated by wrapping GFRP sheets on beams are not evident until they reach a higher load, this invisibility of initial cracks provides less warning than beams strengthened only at the soffit of the beam.

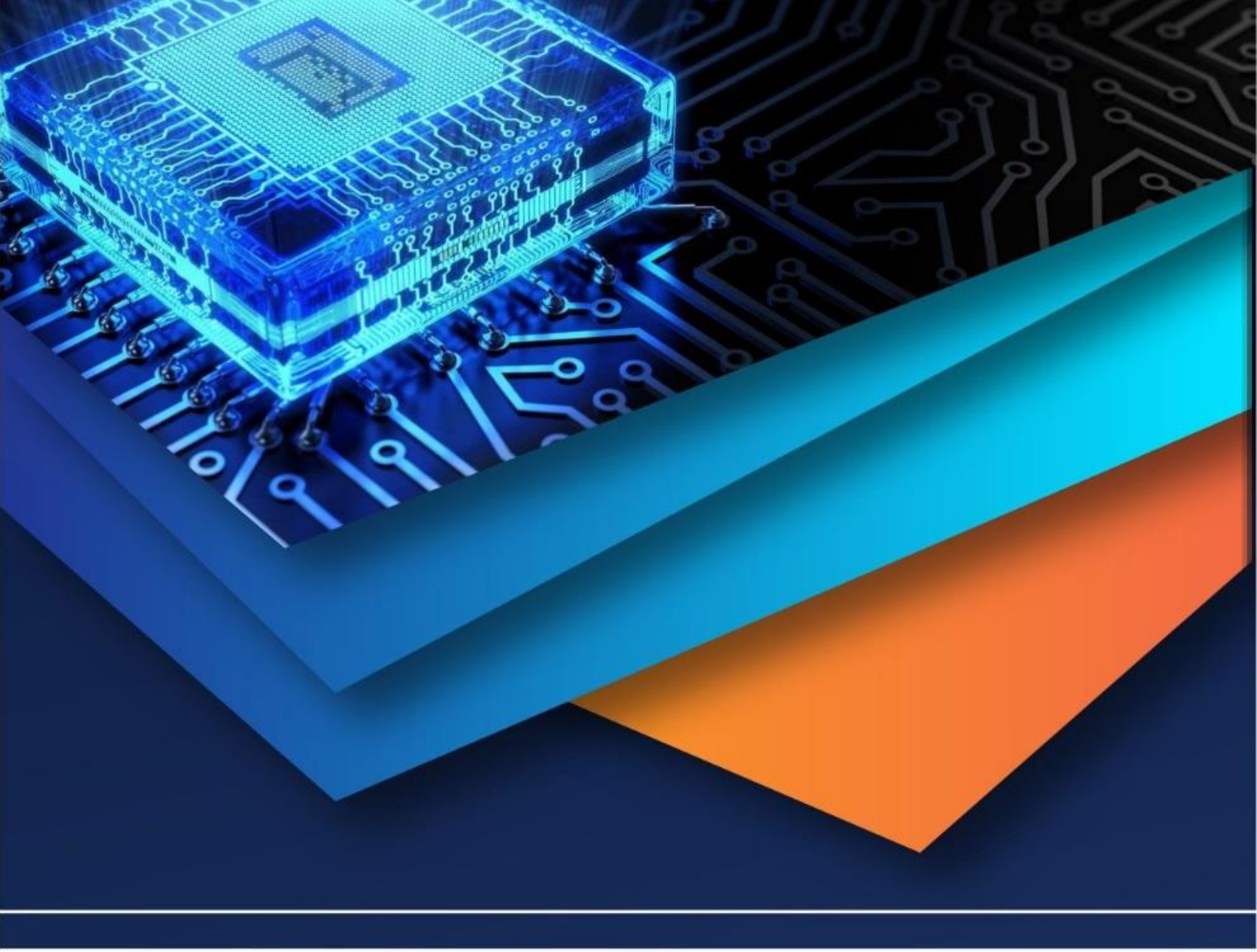
IV. LITERATURE REVIEW CONCLUSION

As reviewed above, seismic strengthening can effectively upgrade the performance of existing structures; nonetheless, the majority of published papers were research-oriented and there is a lack of practical aspects that would directly benefit practitioners. It is, hence, worthwhile to elaborate on where current practices are originated, how prescribed standards synergistically apply, and how research is translated into practice. In so doing, design professionals are informed adequately and will be better guided to successfully complete assigned engineering tasks. This paper discusses a synthesis of procedural details concerning the analysis, design, and retrofit of building structures situated in a seismic region with a focus on specification articles, the background of design criteria, and technical requirements that are implemented in globally. Furthermore, case studies are required to studied the disseminate cost-efficient technologies for enhancing the earthquake-resistance of aged buildings that were built before the enactment of modern seismic codes and related regulations.

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