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STRUCTURAL AUDIT OF EXISTING G3 BUILDING

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ABSTRACT

Structural auditing is a key method for determining the true condition of historic structures. The audit should identify and evaluate all risk and important areas, as well as if the building requires immediate maintenance. Itshould also include a structural study of current frame to identify weakstructural regions for static,wind, and seismic loads. If building's user has shifted fromresidential to commercial or industrial, thisshould highlight the significance of the transformation. It provides step-by-step instructions for doing a structural audit on a historic building. A specific format for collecting data from field was also supplied. Details on numerous non-destructive testing & other tests to be performed are also provided, as well as photographs of structural faults and correction procedures.

Keywords: Seismic evaluation, structural building, Audit, earthquake, cracks

INTRODUCTION

One of most criticaldifficulties in civil engineering applications is maintenance, rehabilitation, & upgrading of structural components. Strengthening has become an accepted method of increasing load bearing capacity & extending service life. Infrastructure decay caused by premature deterioration of buildings & structures has prompted study of different strategies for repairing or reinforcing. One of issues in concrete structure strengthening is selecting a strengthening technique that would improve structure's strength and serviceability while addressing constraints such as constructability, building operations, and budget. Many distinct scenarios may necessitate structural reinforcement. Strengthening is necessary to withstand wind and earthquake pressures, as well as to increase resistanceto blastloading. Additional strength may be required if structure is unable to bear initial design loads. Deficiencies can occur due to degradation (for example, corrosion of steel reinforcement and loss of concrete section), structural damage, or flaws in original design or construction. The bulk of structural strengthening includes enhancing structural element's capacity to safely withstand one or more of the following internal loading forces: flexure, shear, axial, & torsion.

Strengthening occurs by either decreasing amount ofthese pressures or increasing member's resistance tothem. To increase strength and serviceability, standard strengthening procedures such assection expansion, externally bonded reinforcing, post-tensioning, & extra supports may be applied. The selection of the best strengthening method necessitates careful consideration of several elements, including the following engineering issues:

- Increase in strength magnitude; Effect of changes in relative member stiffness;
- Size of the project (unique materials & processes may be less cost-effective for minor projects);
- Environmental circumstances (adhesive techniques may be problematic for high-temperature applications, while external steel methods may be unsuitable in corrosive environments);

Corresponding author **Lokesh Kumar and Monu Kumar**
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- Dimensional/clearance limits (section expansion may be restricted by extent to which it can intrude on surrounding clean space);
- Accessibility;
- Materials, equipment, & competent contractors are all available.

- Construction cost, maintenance costs,& life-cycle costs;&
- Load testing can be used to validate current capacityor to assess novel procedures and materials. To prevent issues caused by steel reinforcement corrosion in concrete buildings, research has shown that fiber reinforced polymer (FRP) reinforcement might be used in place of steel reinforcement. Steel reinforcement corrosion in reinforced concrete (RC) constructions reduces strength of both steel & concrete.

The strength of a corroding steel reinforcing bar is diminished due to a drop in steel bar's cross-sectional area. While the steel reinforcing bars corrode, the concrete's integrity is compromised due to cracking of concretecover produced by corrosion product expansion.

PURPOSE OFSTRUCTURAL AUDIT:
- To rescue both lives and property.
- Knowing the state of your building's health and projecting its estimated future life.
- Highlight the crucial areas that require quick attention.
- To actively help people and society in understanding the gravity of the challenges and the urgency with which they must be addressed.
- To meet municipal or other legislative obligations.

LITERATURE REVIEW

Rashid SMP and Bahrami A (2023) present a detailed study of fiber-reinforced polymer(FRP) & carbon fiber-reinforcedpolymer (CFRP) confinement techniques for SCTWCs. The behavior & development of FRP & CFRP wrappings ofSCTWCs are studied & described in this study. FRP's capacity to function as a confining material & reinforcement for columns has expanded its use in column applications. FRP may be used to strengthen structures from outside. When compared to un-strengthened columns, the CFRP strips improve load-carrying capacity of the columns by up to 30%. External bonding of CFRP strips provides external confinement pressure efficiently, reduces local buckling of steel tubes, & increases load-carrying capacity of SCTWCs. The major purpose is to help people comprehend SCTWCs. This article assists structural researchers & engineers in better understanding behavior of SCTWCs with FRP & CFRP composites used as external reinforcement. Future study directions are also recommended, based on existing research.

M. Karabini, T. Rousakis, E. Golias, and C. Karayannis (2023) evaluate seismic performance of inadequately reinforced large-scale T beam-column connections with big and substantially reinforced beams. Externally bonded NSM X-shaped composite ropes with improved flexible continuous detailing are used in joints. The experimental research concludes that cyclic loading is harmful to joint performance. The absence of an internal steel stirrup causes the joint to deteriorate sooner. The unstrengthened specimens disintegrateat 2 percent drift,which corresponds to 34 mm beam-end displacement & 30 10-4 rad shear deformation of the joint. The composite strengthening improves joint's structural performance by up to 4% drift,

Corresponding author Lokesh Kumar and Monu Kumar
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which equates to 68 mm of beam-end displacement & shear deformation of 10 10-4 rad. The scenarios of inadequate existing transverse reinforcement in joint & modest externalFRP strengthening explored give a unique view into needed retrofits to achieve varied degrees of post-yielding displacement ductility under seismic loading at 2 percent, 3 percent, and 4percent drift. It enables further analytical enhancements leading to dependable redesign analytical models.

Del Zoppo M, Di Ludovico M, Balsamo A, & Prota A. (2018) investigated the behavior of existing columns made of RC with border line flexure and shear behavior in case of poor quality concrete and light FRP reinforcement with local jacketing, as well as moderately good concrete and strong FRP reinforcement with local jacketing, to highlight effect of concrete strength on efficacy of retrofit intervention. As an alternative to FRP jacketing, efficacy of Fiber Reinforce Cementitious Composite (FRCC) jacketing for seismic fortification of columns with considerably deterioratedconcrete coverings or columns previously damaged by anearthquake is being investigated. Under cyclic loads, six full-scale RC columns were tested: one as a control specimen, four with carbon FRP (CFRP) reinforcement in the probable plastic hinge area, and one totally jacketed with FRCC. When bad & medium grade concrete columns were compared, CFRP local jacketing shown to be more effective in event of low quality concrete. In event of poor quality,FRCC jacketing appears to be a suitable repair procedure & an acceptable alternative to FRP jacketing; nevertheless, further experimental research is needed to optimize this refit process.

The mechanical characteristics of hybrid steel-FRP-reinforced flexural members were examined by Yuan F, Chen L, Chen M, & Xu K. (2018). Only a few studies on components subjected to mixed flexural & compression loads, such as columns, have been reported due to poor compressive behavior of FRP bars. We propose and test a new hybrid steel-FRP-reinforced concrete-engineered cementitious composite (ECC)composite column with ECC in its plastic hinge area. A hybridsteel-FRP-reinforced concrete column was also studied forcomparison. The influence ofmatrix type on failure mechanism, fracture pattern, ultimate strength, ductility, & energy dissipation capacity of columns was thoroughly examined. We observed that substituting concrete in the plastic hinge zone with ECC successfully inhibits local buckling of FRP bars, greatly enhancing column strength and ductility.

Kang Seok Lee and colleagues (2016) investigated traditional seismic retrofitting methods for concrete columns, such as strengthening using steel plates or steelframe bracing, as well as cross-sectional increments & infilled walls. However, these approaches have inherent drawbacks, such as increased bulk and requirement for exact fabrication. The structural & material characteristics related with a new technique for seismic reinforcement of concrete columns using FRP were investigated in this work. This paper describes the seismic resilience of reinforced concrete columns controlled by shear strengthening using a sprayed FRP system. When compared to the control column, the shear strength and deformation capabilities of shear columns augmented with sprayed FRP rose dramatically. The spraying FRP method suggested in this study has the potential to be used to seismically strengthen existing concrete columns in a cost-effective and practical manner.

Soumya Gorai and P.R. Maiti (2016) offer an overview of many creative and cost-effective retrofitting strategies for reinforcing damaged structures. This study's result was Seismic retrofitting is increasingly a critical concern. Recent earthquakes in many regions of the world have clearly proven the importance of fixing seismically inadequate constructions. The present state of the art evaluation includes a variety of experimental

Corresponding author Lokesh Kumar and Monu Kumar
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and analytical studies focused on novel seismic retrofitting approaches. To promote more quick and successful use of various strengthening approaches, design guidelines and suggestions should be made more widely available.

Cetin Sahin (2014) shows how to model a structure in software & evaluate its seismic resistance using linear methodologies, as well as propose concentrically braced frame rehabilitation to increase drift capacity. It also illustrates how a linear analysis might be followed by a pushover study to estimate a retrofitted structure's seismic resistance. As a consequence of the study, seismic resilience of a seven-story steel moment frame building was investigated. The 3-dimensional evaluations "Equivalent Static Analysis-ESA", "Response Spectrum Analysis-RSA", & "Time History Analysis-THA" were carried out. The fundamental period, dominant mode forms, & base shear were determined using 3D ESA and RSA.

To conduct out seismic evaluation, Dinesh J.Sabu & Dr. P.S. Pajgade (2012) developed a streamlined technique for evaluation, which is critical for a nation like India, which is prone to earthquakes. Estimating the reaction of structures to earthquakes is critical for life preservation & risk management. The Response Spectrum analysis approach is used to evaluate current reinforced concrete bare frame, frame with infill, and frame with infill and soil impact designs. The Response Spectrum analysis for seismic evaluation of existing structures is used to evaluate performance of these models. Following the study, the amount of reinforcement necessary in each format is established, and retrofitting is recommended appropriately. This paper investigates several retrofitting methods. It is also found that the influence of infill is quite important in seismic evaluation of existing RC structures. The research's conclusion was that whole study is focused on seismic evaluation & retrofitting of existing RC buildings. Existing reinforced concrete buildings are subjected to seismic examination.

PROCESS

Building architectural and structural designs are necessary. We would benefit from having complete structural calculations, including structural design assumptions. The permissible liveloads, whether building is planned for residential,commercial, light industrial, or heavy industrial use, & if any future provision for adding more floors is addressed are all examples of assumptions. What kind of seismic loads are taken into account? Which I.S. Code requirements have been met?

If Architectural & Structural plans are notavailable, any Engineer can create them by measuring size of building and determining position of columns, beams, & other structural sections. A careful inspection of structure can reveal following:

- There are any foundation settlements.
- Cracks seen in columns, beams, & slabs.
- Photographs of concrete deterioration & exposed steel reinforcements might be useful.
- A quick tap with a hammer might indicate concrete damage.
- Corrosion extent in reinforcement.
- Balcony condition - sagging, deflection,cracks?
- Status ofarchitectural elements such as chhajjas, fins,canopies, and so on.
- Wall cracks indicate swelling in R.C.C. members, strain, deflection, or corrosion.
- Leaks from the patio and toilet blocks.
- Leaks and humidity in walls cause fractures and corrosion.
- Structure-altering changes were made.
- Added or changed toilet blocks?

Corresponding author Lokesh Kumar and Monu Kumar

Submitted: 27May 2023, Revised: 09 June 2023, Accepted: 18 June2023, Published: July 2023

- User switch from residential tocommercial to industrial?Partition Wall Replacement?
- Status of lift and lift machineroom - Type of Maintenance Contract, renewal of license.
- The state of the electrical wiring from the mete room to all of apartments. Is there an explosion in meter room or substation?
- Capacity of overhead and subsurface water tanks. Leaks, cracks, and frequency of cleaning, as well as pump condition.
- Plinth protection throughout the property, including the condition of drainage, water pipelines, and pumps.
- How much water flooded ground during the recent monsoons?

- External paint - When was it last painted & what sort ofpaint was used?
- Repair status and latest repair.
- What was fixed?
- What was the name of the Agency?
- How much money was spent on repairs?
- Are there any building plans available? When will it be approved? Is there a certificate of occupation available? Are there any structural plans available? Is a certificate of structural stability available? Are any structural calculations available?
- When was the last time a structural audit was completed?

It is critical that certain examinations be performed in ancient building. This will offer an understanding of level of corrosion, distress, & strength loss in concrete and steel.

NDTTESTS

1. The followingNDT tests must be performed onstructural components. Itis critical, however, that testing scheme is created basedon a preliminary examination of building/structure:
2. Core tests are used to assess equivalent in situ compressive strength and toestablish a relationship b/w the rebound hammer test and the in situ strength ofconcrete.
3. **Rebound Hammer test** to estimate in situ compressivestrength of cover concrete.
4. **USPV test** to assess integrity of concrete.
5. **Carbonation test** to assess depth of carbonated concrete.
6. **Cover test** to assess cover provided to RCC structural members.
7. **Half-cell potentiometer test** to determine probability ofactive corrosion.

1. CORE TEST:

To prevent cutting reinforcement, the reinforcement is identified at the planned place using a Rebar Locator called a Photometer.

- The core cutting equipment is placed in place and the core is removed.
- The cores are transferred to laboratory, where visual observations of the cores are made for interpretation. Reinforcement bars are removed if they are encountered.
- The cores are extracted fromwater by cutting them exactly perpendicular to the longitudinal axis to the appropriate L/D ratio of 2.
- Both endsare prepared by grinding up to tolerance limit for flatness and parallelism defined by Clause 4:8 of BS 188: Part 120: 1983.

Corresponding author Lokesh Kumar and Monu Kumar
Submitted: 27May 2023, Revised: 09 June 2023, Accepted: 18 June2023, Published: July 2023

2. REBOUND HAMMER TEST:

The test is carried out in accordance with IS: 1331 (Part 2): 1992 and BS 1881:Part 202: 1986 recommendations to determine in situ strength of concrete based on correlationestablished b/w in-situ strengthat specific site and reboundnumbers.

- At test sites, plaster is removed.
- A smooth, clean, dry surface free of defects such as honeycombing cracks and hollow sound is chosen for testing.
- A 300 mm by 300mm area is scraped with carborandum stone to remove weakly adhering scales and any remaining plaster mortar.
- In this location, grids of 12 points spaced around 30 mm apart are chosen.

- 12 readings are obtained at chosen sites while holding rebound hammer at rightangles to surface of concrete part. The unusually high and abnormally low values are discarded, and the average of the balance measurements is calculated.
- The adjusted rebound number is calculated by taking into account the elements impacting the hardness of the concrete surface, such as surface moisture, carbonation, test position inside the member, test direction, and so on.
- The compressive strength of concrete is calculated against each rebound number using a graph based on the correlation established between the rebound numbers atcore test locations and the equivalent cubestrength values.
- This collection of compressive strength data produced by the aforesaid procedure is statistically analyzed.

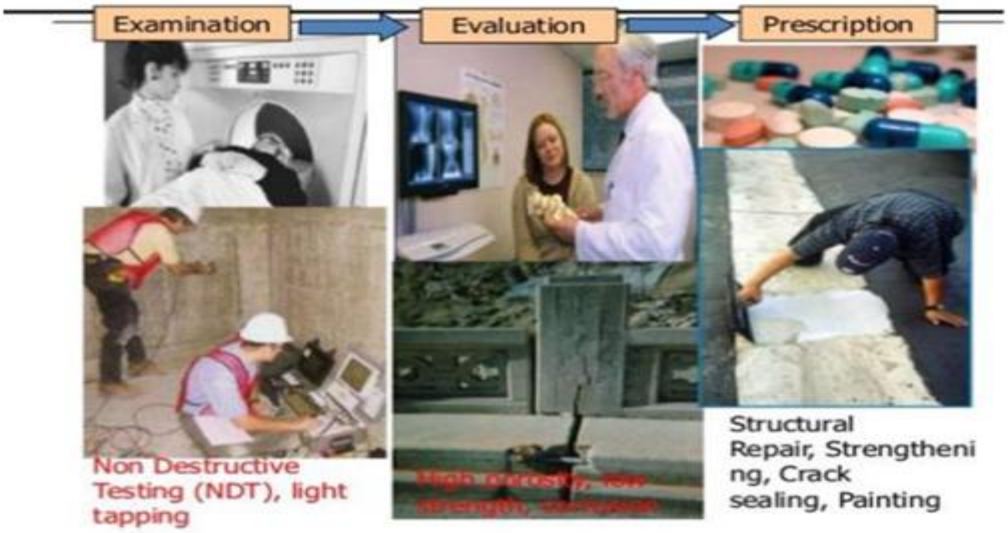

Fig. 1 Structural auditing

Table 1 quality of concrete

AverageRebound	Quality ofConcrete
>40	VeryGood
30-40	Good
20-30	Fair
<20	Poor
0	VeryPoor

Corresponding author Lokesh Kumar and Monu Kumar
Submitted: 27May 2023, Revised: 09 June 2023, Accepted: 18 June2023, Published: July 2023

3. USPVTEST:

- The plaster is removed attest places as needed.
- A smooth, clean, dry surface free of defects such as honeycombing, fractures, and hollow sound is chosen for testing.
- A 300 mm × 300mm area is scraped with carbonated stone toremove any loosely adhering scales orplaster mortar remnants.
- On opposing faces of the concrete members, two points are marked. (In completely opposite directions for direct transmission of ultrasonic pulses).
- Grease is used as a coupling medium to guarantee that the transducers make appropriate contact with the concretesurface and that the ultrasonic pulse is transferred through medium with little disruption.
- Both transducers are now kept in place at the right test sites using continuous pressure, and ultrasonic pulses are sent through concrete.
- In microseconds, machine displays time it takes to travel known path.
- The velocity is computed by comparing measurement to eachknown route.
- IS 13311(Part- I): 1992 specifies the velocity requirement for concretequality assessment.

Table 2 USPC Test (Part-I)1992

PulseVelocity	ConcreteQuality	Concrete Grade
>4.0km/s	Very good to excellent	I
3.5-4.0km/s	Good to very good	II
3.0-3.5km/s	Satisfactory but loss of integrity is suspected	III
<3.0km/s	Poor & loss of integrity exist	IV

4. CARBONATIONTEST PROCEDURE:

Concrete powder is obtained by drilling through concrete at a specific place. The gathered powder is then moistened and a phenolphthalein indicator is put on it to see whether there is any color change. If color shifts to pink, it indicatesthat carbonation has not damaged the concrete, and if no color change is detected, it implies that carbonation has affected the concrete.

5. COVER METERTEST PROCEDURE:.

The instrument used is PROFOMETER -4, RebarLocator Model S, manufactured by M/s. PROCEQSA, Switzerland, which is able to perform following functions:

- To locate bar accurately.
- To assess clear cover tobar.
- To calculate bardiameter of selected bar.

The gadget operates on a magnetic basis and includes spacing constraints in order to detect the bars separately.

The restriction of the rebar finder instrument for identifying bars is that the depth of the rebar from the concrete surface should be less than 70 mm and the spacing of the bars should be greater than 150 mm.

Corresponding author Lokesh Kumar and Monu Kumar
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6. HALF-CELL POTENTIOMETER TEST PROCEDURE:

The half-cell potentiometer is made out of a stiff tube with a copper rod immersed in a copper sulphate solution within. This is linked to a voltmeter, then another live wire connection is sent via the voltmeter to connect it to the rebar. To begin experiment, live wire is attached to a rebar of test specimen, and the rigid tube is placed on surface of concrete, & voltmeter reading is obtained. The potential difference b/w electrodes is determined by reading. The corrosion condition within the concrete may be anticipated based on the value of potential difference. The potential of active corrosion is determined using following guidelines:

Table 3 Half-cellpotential(mV)test

Sr. no.	Potential mV(mili volts	Corrosion in stee
1	<-0.200	No corrosion of steel
2	-0.200 to -0.350	Uncertain corrosion activity
3	>-0.350	Corrosion occurring in steel

Table 4 Summary report of all tests

Members	Core test	Rebound Hammer test	UPSV Test	Carbonation test	Cover Meter Test	Half-cell Potentiometer Test
All Exterior column up to second floor (25 mm bars used)	Flatness is 0.6mm wide & Parallelism is 1.5 mm wide	poor	Grade IV	carbonation	Cover found 35 mm	Corrosion
All Beams at top floor (16-20 mm bars used)	Flatness is 0.7 mm wide & Parallelism is 1.75 mm wide	Fair	Grade III	carbonation	Cover found 28 mm	Corrosion

4.4SAMPLE VISUALOBSERVATIONS:

- Corrosion has a significant impact on chajjas.
- Columns suffer severe corrosion cracks.
- The top level slab is extensively corroded, the concrete cover has broken down, and steel is visible.
- the front side Corrosion has severely harmed Chajja over its entire length.
- Corrosion affects top-level beams.
- Almost all of the columns on the upper floor have corroded.

Corresponding author Lokesh Kumar and Monu Kumar
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Fig. 2 Actual Photographs of Building No.4, Labor Camp, Matunga road, Mumbai Date: 2-2-16

CONCLUSIONS

The goal of this work was to evaluate structural audit analysis of an existing RC structure. Consider that building is 60 years old, with a G+3 R.C.C. structure. The building is subjected to a structural audit. Slabs & footings aresafe in audit, but beams & columns are not. It is best to get a professional assessment on building's health on a regular basis. If structures are determined to have deteriorated and been damaged over time, non-destructive testing should be performed.

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Corresponding author Lokesh Kumar and Monu Kumar
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