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'Assessment of structural integrity of G+2 storied old building for vertical expansion through Non Destructive and Semi Destructive testing and Design Analysis'

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Abstract - *This paper explores the critical process of assessing the structural stability of 46 years old G+2 educational building and performing design analysis to facilitate vertical expansion while preserving historical and architectural heritage. The study employs non-destructive and semi-destructive testing methods and utilizes STAAD.Pro software for structural analysis. The findings contribute to the knowledge of adopting old structures to meet contemporary space demands.*

***Key Words*: Non-destructive test (NDT), Rebound Hammer, UPV, Half-Cell, Carbonation, Profometer, Structural health Monitoring, Feasibility study, Strengthening RC structure**

1. INTRODUCTION

1.1 Background

Preserving historical and architectural heritage in urban areas is essential while addressing the growing need for space. To achieve this, it is imperative to assess the structural stability of old buildings before planning vertical expansion. Old buildings often possess historical and cultural significance, making their preservation a priority. However, as urban areas expand, the demand for space increases, necessitating innovative approaches to adapt and reuse these structures while ensuring their structural integrity.

1.2 Problem statement

Old buildings are constructed using traditional methods and materials, may not meet current design standards and can deteriorate over time due to various factors such as aging, environmental effects, or past modifications. This deterioration can compromise their load-carrying capacity. The challenge lies in accurately evaluating the structural condition of these buildings to determine their ability to support additional loads. This project focuses on a G+2 RC framed educational building approximately 46 years old, as a case study to address this challenge.

1.3. Physical observations

During the initial assessment of the building, several physical observations were made. These included the presence of dampness on walls at various locations, the growth of vegetation on exterior walls, masonry cracks in some areas, dampness on slab panels, and the presence of hairline cracks in beams. These observations provided valuable insights into the building's condition.

Fig. 1 General View of the Building

1.4 Objectives

The primary objectives of this project are as follows:

1. Conduct a comprehensive literature review to gain insights into existing research and techniques related to structural assessment, non-destructive testing, and design analysis for building expansions.

2. Develop a methodology that incorporates non-destructive and semi-destructive testing techniques to assess the condition of the old building.

3. Collect data through non-destructive and semi-destructive testing methods and analyze the results to evaluate the structural stability and identify potential weaknesses.

4. Perform design analysis and verification using Staad Pro connect edition software to assess the structural capacity of the existing building for vertical expansion.

5. Provide design recommendations, including reinforcement measures, modifications, and repairs, to ensure the structural integrity.

1.5 Methodology overview

The project methodology involves a comprehensive approach that combines non-destructive and semi-destructive testing techniques with structural analysis using Staad Pro Connect edition software. The initial steps include a literature review to gather relevant information and identify appropriate testing methods. The selected testing methods are then employed to assess the structural condition of the old building. The data collected from these tests is analyzed to evaluate the building's stability and identify any areas of concern. Finally, the Staad Pro Connect edition software is used to model and analyze the existing structure, considering the proposed vertical expansion. The analysis results guide the formulation of design recommendations to ensure the safe and effective expansion of the old building.

2.0 Methodology

2.1 Non-Destrctive tests

2.1.1 Ultrasonic Pulse Velocity Test

The ultrasonic pulse velocity test is widely used to measure the quality of concrete. It assesses concrete composition, checks for cracks, voids, and evaluates concrete wear. In this project, the test was conducted on R.C. Columns, beams, and slab panels using PUNDIT LAB, a portable Ultrasonic Non-Destructive Digital Indicator Tester. The results were categorized based on the reference quality grade chart in IS: 516 (Part 5/Sec 1) 2018 (Amended 2019).

Fig.2 UPV test on RC beam

Pulse Velocity (Km/sec)	Concrete Quality Grading
Below 3.75	Doubtful*
3.75 to 4.5	Good
Above 4.5	Excellent

2.1.2 Rebound Hammer Test

The Rebound Hammer Test assesses concrete quality based on surface hardness indicated by the rebound number. Higher rebound numbers correspond to higher concrete strength. The identified R.C. columns, beams, and slab panels were subjected to this test using a Schmidt Rebound Hammer. The results were compared to a reference strength chart to evaluate the surface hardness/quality of the concrete.

Fig.3 Rebound hammer test on RC beam

2.1.3 Carbonation Test

Carbonation of concrete occurs when atmospheric carbon dioxide reacts with calcium in the cement, reducing concrete alkalinity. This project conducted a carbonation test to estimate the depth of the carbonation front in building columns, beams, and slab panels. A phenolphthalein indicator in diluted alcohol was used to detect carbonation. The depth of color change indicated the carbonation level of the concrete.

Fig.4 Carbonation test on RC beam

2.1.4 Half-cell Potential Difference Measurement Test

The Half-Cell Potential Difference Measurement Test is used to assess the likelihood of corrosion in steel reinforcement. It measures the potential of steel embedded in concrete using a copper sulfate half-cell. More negative potential values indicate increased corrosion activity. This test was performed on identified R.C. Columns, Beams, and Slab Panels to assess the probability of corrosion.

Sl. No.	Measured Potential Difference	Probability of Corrosion
1.	less negative than – 200 mV (> – 200 mV)	Low (there is a greater than 90 percent probability that no reinforcing steel corrosion is occurring in that area at the time of measurement)
2.	– 200 mV to – 350 mV	Corrosion activity of the reinforcing steel in that area is uncertain
3.	more negative than – 350 mV (< – 350 mV)	High (there is a greater than 90 percent probability that reinforcing steel corrosion is occurring in that area at the time of measurement)
4.	< – 500 mV	Severe corrosion

Fig.5 Half-Cell Potential difference test on RC beam

2.1.5 Profometer Studies

Profometer studies were conducted to measure the thickness of concrete cover and diameter, spacing of the reinforcing bars in accessible R.C. Columns, Beams, and Slab Panels. These studies helped to identify variations in the thickness of the concrete cover and existing reinforcement in RC members.

Fig.6 Profometer studies on RC beam

2.2 Semi-Destructive test on RC members

Semi-destructive test in the form of core sampling was used to evaluate the strength of in-situ concrete in RC sections. Core samples were randomly extracted from R.C. members for laboratory experiments. These core samples were then subjected to compressive strength testing according to IS: 516 – Part 4 (2018) guidelines. This test provided insights into the compressive strength of the concrete.

Fig.7 Concrete core compression test

2.3 Design Analysis

Design analysis plays a crucial role in assessing the structural capacity of the existing building for vertical expansion. In this project, STAAD Pro Connect edition software was used for structural analysis. STAAD, which stands for Structural Analysis and Design, is a certified major design software. It creates a 3D model of the existing structure, considering geometric representation, material properties, and boundary conditions. The model was used for structural analysis, including the calculation of shear forces and bending moments.

2.3.1 Loads considered for design analysis of old building

Dead Load: This refers to the permanent weight of the structure, including structural components, floor surfaces, ceilings, and stationary equipment. IS 875 (Part 1): 1987 guidelines were used to determine dead loads based on building materials and components.

Live Load: Live loads are variable and temporary loads caused by people, furniture, equipment, vehicles, or other transient factors. IS 875 (Part 2): 1987 specifies various types of live loads for different areas, such as residential, office, industrial, and public assembly spaces.

Seismic Load: Seismic load accounts for dynamic forces from earthquakes or seismic events. It considers ground movement characteristics, building response, and local seismic hazard. IS 875 (Part 3): 1987 guidelines were followed to determine seismic loads based on location and seismic zone.

DEAD LOAD (IS 875 PART 1 1987)	LOAD
Ground Floor	
Self Weight of Slab (150mm Thick)	3.75 KN/m2
Floor finishes	2.0 kN/m^2
First Floor	
Self Weight of Slab (150mm Thick)	3.75 KN/m2
Floor finishes	2.0 kN/m^2
Second Floor	
Self Weight of Slab (150mm Thick)	3.75 KN/m2
Floor finishes	2.0 kN/m^2
Third Floor	
Self Weight of Slab (150mm Thick)	3.75 KN/m2
Floor finishes	2.0 kN/m^2
Wall load excluding openings	
260mm thick and Wall height 3.4m	15.0 KN/m
Parapet wall (1.2m height 200 mm thk. Wall)	4.8 KN/m
Staircase load	
Self-weight of slab	3.75 KN/m2
Floor finishes	2.0 kN/m^2

LIVE LOAD (IS 875 PART 2 1987)	LOAD
Ground Floor	5.0 KN/m2
First Floor	5.0 KN/m2
Second Floor	5.0 KN/m2
Third Floor	5.0 KN/m2
Terrace	1.5 KN/m2
Stair case	3.0 KN/m2
Terrace	1.5 KN/m2

SESIMIC LOAD (IS 1893 PART 1 2002)	
ZONE	II
FZONE FACTOR	0.1
RESPONSE REDUCTION FACTOR	3.0
TYPE OF SOIL	MEDIUM
IMPORTANCE FACTOR	1.0
DAMPING PERCENTAGE	5%
HORIZONTAL SESIMIC LOAD	DL+50%LL

Fig.8 Rendered view

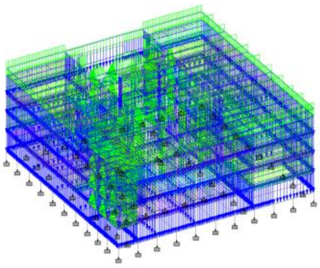

Fig.9 Loads acting on building

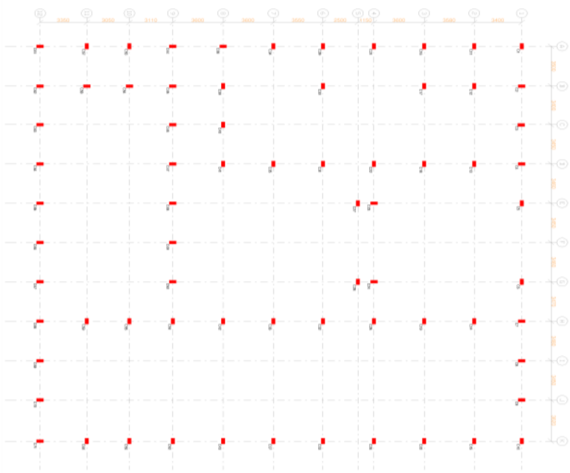

Fig. 10Structural Layout

3. Results and recommendations

3.1 Inferences

Based on the test results and data analysis, the following inferences were drawn:

Ultrasonic Pulse Velocity Test: The quality of in-situ concrete in the tested R.C. Columns, Beams & Slab Panels of the structure was found to be **"Good at many locations & Doubtful at few locations"** as per IS: 516 (Part 5/Sec 1) 2018 (Amendment in 2019).

Rebound Hammer Test: The strength of the cover concrete in the tested R.C. Columns, Beams & Slab Panels was estimated to be more than **30 N/mm2**.

Carbonation Test: Carbonation of cover concrete in the tested locations of R.C. members was observed to be **moderate** condition.

Half-Cell Potential Difference Measurement Test: The probability of corrosion in tested locations of R.C. members was **uncertain** (moderate) at many locations.

Profometer Studies: Cover concrete thickness in the tested locations of R.C. members varying from **25mm to 50mm** and **8mm,10mm, 16mm, 20mm, 25mm** dia. Reinforcement bars were provided in existing rc members.

Semi-Destructive Test (Compressive Strength): Compressive strength of concrete core samples in tested locations was observed to be **35.0 N/mm2** and **30.5 N/mm2**.

From the results of STADD Pro design analysis of existing building for proposed one additional floor load, it is inferred that few columns are under reinforced, RC beams and footings are safe.

3.2 Recommendations

Based on the findings from the structural stability assessment and design analysis, the following recommendations have been formulated:

1. Strengthen columns through jacketing from footing level to 2nd floor level to ensure the structural integrity and capacity for vertical expansion.

Columns(C5,C6,C16,C18,C19,C20,C29,C31,C33,C40,C42,C43, C46,C48,C54,C58).

2. Repair the destressed portions of the building by using proper retrofitting techniques.

3. Utilize lightweight flooring and Aerocon Blocks for masonry walls to reduce structural load and enhance stability.

Fig. 11 Column jacketing

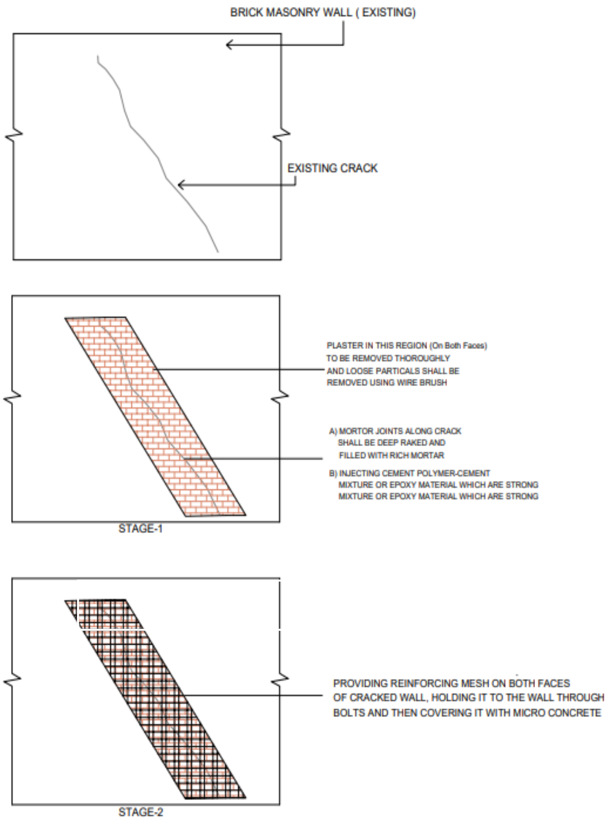

Fig. 12 Repair steps for masonry

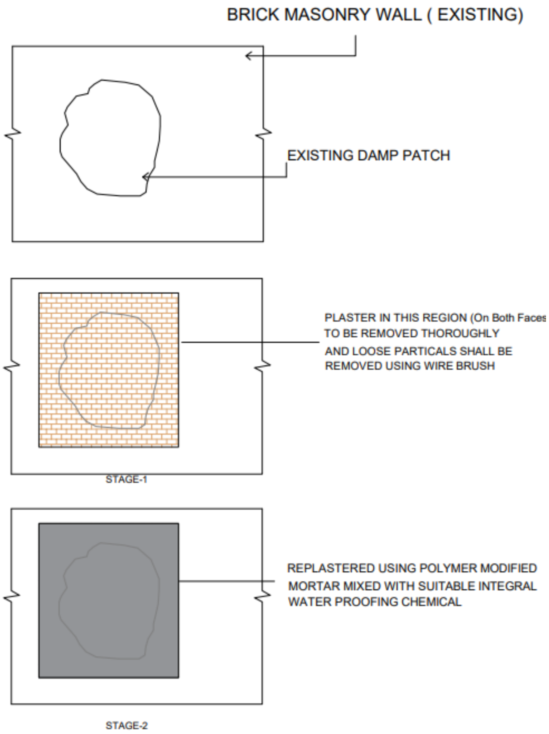

Fig. 13 Repair steps for dampness on walls

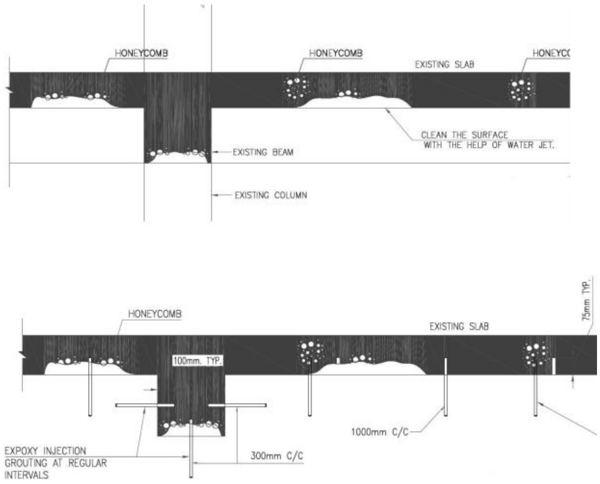

Fig. 14 Repair steps for distressed RC members using Injection grouting

3.3 Limitations

It is essential to acknowledge the limitations of this project:

The assessment and analysis heavily rely on the availability and quality of data obtained through non-destructive and semi-destructive testing methods.

The project focused on a specific old building, and the results may not be directly applicable to other structures.

Long-term performance considerations, such as durability and maintenance, were not extensively addressed in this study.

4. Conclusion

This paper has outlined a comprehensive approach to assessing the structural stability of aging buildings and conducting design analysis for vertical expansion. It emphasizes the significance of preserving historical and architectural heritage while adapting to contemporary space demands. The project's methodology, including non-destructive testing, semi-destructive testing, and Staad Pro analysis, provides a holistic understanding of the structural condition and capacity of an old building.

The project's recommendations for reinforcement and design modifications contribute to the safe and efficient vertical expansion of old buildings. While acknowledging project limitations, this paper underscores the importance of continued research in preserving and adapting old structures to meet the evolving needs of urban areas. The findings from this study can serve as a valuable resource for professionals involved in the restoration and expansion of historic buildings

References

[1] IS 456-2000 code book for design of beams, columns and slabs.

[2] IS 875 for design of loads

[3] SP 16 for desihn of columns

[4] ACI 562 for repair & rehabilitation of concrete structures

[5] IS 516 Part 4 for sample preparing and testing of concrete cores

[6] IS 516 Part 5 for Non Destructive testing of concrete

[7] IS 1893 criteria for earthquake resistant design of structures

[8] Assessing the strength of reinforced concrete structures through ultrasonic pulse velocity and Schmidt rebound hammer tests, Vol.6(1), pp. 213-220 , January 2011, https://doi.org/10.5897/SRE10.879

[9] Structural audit of an old building doi:10.1088/1757-899X/1197/1/012054

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