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Perceptible Investigation of Established Building to Endorse Repair Approaches

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Abstract

A perceptible investigation of established educational institution buildings—specifically those aged 18 years and above—serves as a critical process for identifying necessary repair approaches and endorsing appropriate rehabilitation strategies. Over nearly two decades of continuous use, institutional structures often encounter material degradation, environmental wear, compliance gaps with updated safety codes, and evolving functional requirements. Perceptible investigation involves a combination of visual assessments, non-destructive testing (NDT), damage diagnostics, and structural health monitoring to evaluate the current condition of key building components, including concrete, steel reinforcements, partitions, and service infrastructures. Findings from these methods pinpoint both immediate hazards and latent deficiencies, such as cracks, spalling, moisture ingress, reinforcement corrosion, and compromised joints. Based on these investigations, targeted repair approaches are recommended—such as crack sealing, cathodic protection, fiber-reinforced polymer (FRP) strengthening, and surface repair. The integration of self-healing concrete, cathodic protection systems, and advanced crack injection techniques further enhances long-term serviceability and resilience of institutional buildings. Effective endorsement of repair methodologies is underpinned by a meticulous understanding of the extent of deterioration and tailored interventions that ensure structural integrity, safety, and operational continuity. Emphasis is placed on proactive maintenance and sustainable rehabilitation, securing the building's role as a safe and functional educational facility. These abstract highlights the necessity for systematic and perceptible investigation as a foundation for implementing innovative and durable repair techniques in aging educational institution buildings.

Keywords: *Assessment, Corrosion, Deterioration, Rehabilitation, Repair.*

1. Introduction

The serviceability and structural integrity of reinforced concrete buildings progressively deteriorate over time due to environmental exposure, material aging, construction defects, and sustained loading. A systematic perceptible (visual) investigation plays a crucial role in identifying early signs of distress and formulating suitable repair and rehabilitation strategies. The present study focuses on the established building of Geethanjali Institution of Science and Technology, located in Nellore, which was constructed in 2008 and has been in continuous service for academic activities.[1] After more than fifteen years of exposure to varying climatic conditions, including high humidity and seasonal rainfall, the structure exhibits observable signs of deterioration such as surface cracks, plaster delamination, dampness, reinforcement corrosion indicators, and minor spalling in selected structural and non-structural components.[2] This research emphasizes a detailed perceptible investigation methodology involving systematic visual inspection, crack pattern assessment, measurement of crack width, identification of moisture ingress zones, and evaluation of surface distress symptoms. The primary objective is to correlate observed defects with possible underlying causes and to endorse technically feasible, durable, and cost-effective repair approaches. By establishing a structured condition assessment framework for the existing building, the study contributes to extending service life, ensuring occupant safety, and promoting sustainable maintenance practices in institutional infrastructure.

2. Literature Review

The assessment and rehabilitation of existing reinforced concrete (RC) buildings have gained significant attention in recent research due to the need for extending service life, ensuring occupant safety, and enhancing structural performance under environmental and loading deterioration. Initial condition assessments are often conducted through systematic visual inspections, which help identify observable defects such as cracking, spalling, corrosion staining, and moisture ingress. Visual inspection is widely accepted as a preliminary diagnostic tool, but researchers emphasize the limitations of relying solely on subjective observations without quantitative support (Results in Engineering, 2024). To overcome the limitations of conventional visual methods, modern studies strongly advocate the integration of non-destructive testing (NDT) techniques.[3] Techniques such as ultrasonic pulse velocity, rebound hammer testing, and half-cell potential measurements provide quantitative metrics of material condition and help detect hidden internal defects without causing damage to structural members. NDT improves the reliability of assessments by correlating field data with physical deterioration processes (RILEM, 2022; Salvador et al., 2021). Advanced condition assessment frameworks increasingly incorporate computational modelling and probabilistic analysis. Cho et al. (2025) proposed the use of adaptive neuro-fuzzy inference systems (ANFIS) combined with field assessment data to estimate the remaining service life (RSL) of RC members, indicating that hybrid data-driven and model-based techniques can provide actionable insights for maintenance planning. Such methodologies are particularly relevant for buildings constructed over a decade ago, where degradation patterns become more complex due to cumulative environmental exposures. In seismic regions, the need for performance-based evaluation and retrofit of existing RC buildings is imperative. Shendkar et al. (2025) explored seismic evaluation techniques and retrofit methods such as concrete jacketing and fiber-reinforced polymer (FRP) wraps to address deficiencies in strength and ductility. These retrofits not only improve seismic performance but also contribute to the overall durability of aging structures. Material-based strengthening innovations have also been widely investigated. Textile-reinforced mortar (TRM) and fabric-reinforced cementitious matrix (FRCM) systems have demonstrated improved compatibility with existing concrete substrates and enhanced performance in flexural and shear strengthening, compared to traditional FRP systems. Such systems provide robust retrofit options with better thermal stability and reduced brittleness, making them suitable for institutional buildings requiring minimal aesthetic disruptions (Results in Engineering, 2024). Corrosion mitigation strategies remain a key focus of deterioration control. Electrochemical techniques such as cathodic protection and chloride extraction, along with high-performance surface coatings and overlays, have exhibited significant effectiveness in arresting reinforcement corrosion — one of the principal causes of long-term deterioration in RC buildings exposed to moisture and chlorides (El-Reedy, 2024). Integrating corrosion protection measures within repair interventions enhances the durability of both new and existing materials. Overall, the literature underscores a multi-tiered approach: combining perceptible investigation, NDT, diagnostic modelling, and advanced repair technologies yields a more comprehensive condition assessment framework.[4] Future research trends emphasize automated inspection systems (e.g., digital imaging with AI), sensor-based structural health monitoring, and sustainability-oriented retrofit methods to support long-term performance and cost-effective maintenance strategies.

3. Objectives

The present study aims to evaluate the structural and durability condition of the established building constructed in 2008 at Geethanjali Institution of Science and Technology, Nellore, through a systematic perceptible (visual and preliminary technical) investigation. The specific objectives are:

- To conduct a comprehensive condition assessment of the building through detailed visual inspection and preliminary non-destructive testing to identify, measure, and classify defects such as cracks, spalling, corrosion & dampness to evaluate their severity and probable causes considering aging, environmental exposure, material degradation, and maintenance practices.

- To evaluate the structural stability, serviceability, and durability performance of the building in accordance with relevant IS codes and standard guidelines.

4. Methodology

The methodology integrates preliminary data review, detailed visual inspection, crack measurement, and selected non-destructive tests such as Rebound Hammer. Observed defects were mapped and classified based on severity and structural significance with micro structural analysis (SEM and EDS). Environmental exposure conditions specific to Nellore were also evaluated. Based on the findings, structural performance was assessed with reference to relevant IS codes, and suitable repair, rehabilitation, and maintenance strategies were proposed to enhance safety, durability, and service life.[5]

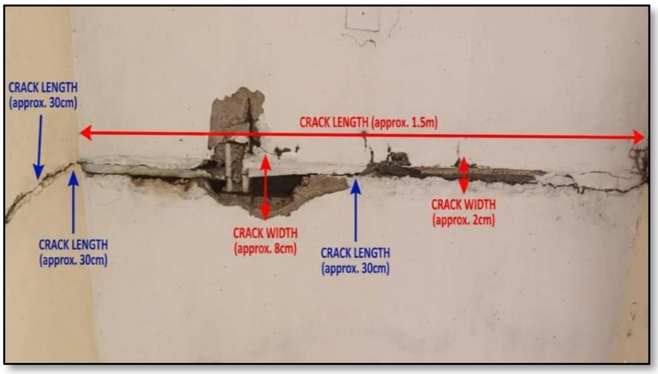
4.1 Study Of Existing Building

Figure 1 **Institutional Building and Plan**

The building has an approximate frontage of 80–90 m and a depth of about 25–30 m, forming a symmetrical academic block with a central administrative core and two extended wings. Each classroom (60 seating capacity) is assumed to measure roughly 8 m × 7 m (56 m²). The two digital halls (240 capacity each) are approximately 18 m × 14 m (250 m²), while the 700-capacity seminar hall may occupy around 30 m × 20 m (600 m²). The library (250 capacity) is estimated at 20 m × 15 m (300 m²). Laboratories are approximately 12 m × 8 m (96 m²) each. Administrative rooms (HOD, Principal, Director, etc.) may range from 12–25 m² depending on function. These dimensions are rough estimates for planning and documentation purposes only.

4.2 Visual Inspection

A comprehensive visual inspection was carried out to assess the condition of both structural and non-structural elements, including beams, columns, slabs, walls, and staircases. Various distress indicators such as flexural, shear, and shrinkage cracks, spalling of concrete, exposed reinforcement, corrosion staining, damp patches, efflorescence, and plaster detachment were systematically documented. Crack widths were measured using a calibrated crack width gauge to ensure accuracy, and their exact locations were marked on structural layout drawings for reference and monitoring. Each observed defect was classified into minor, moderate, or severe categories based on its extent and potential impact on structural integrity, durability, and serviceability.[6] This categorization enabled prioritization of repair measures and provided a clear understanding of the building's overall condition and maintenance requirements. As shown as figure 2.



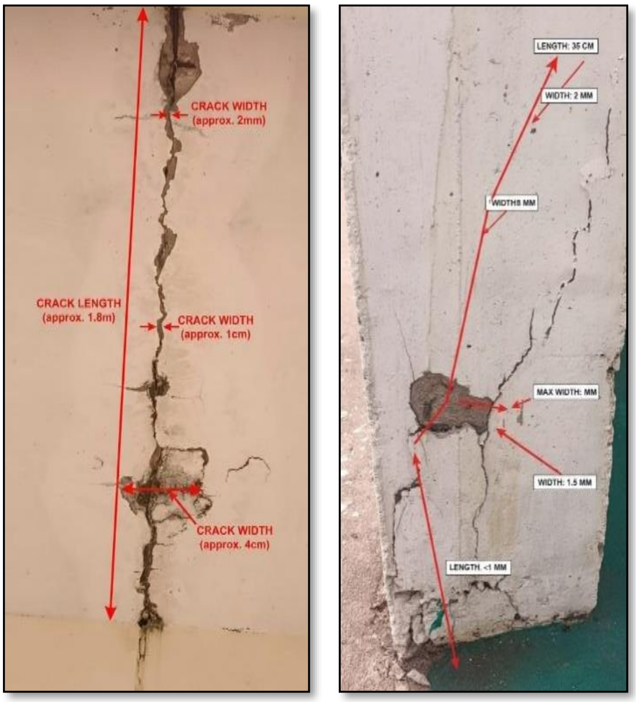


Figure 2 **Visual Inspection Of Cracks Detailing In Top Floor (3rd Floor) Building**

4.3 NDT

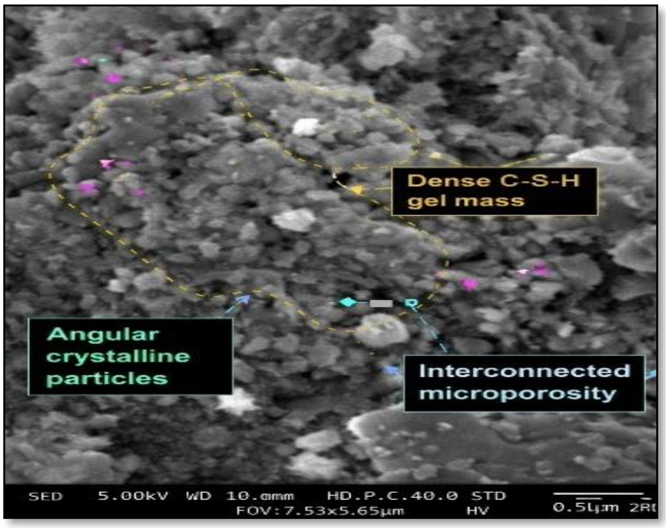
The Rebound Hammer test (Schmidt Hammer) was conducted to evaluate the in-situ surface hardness and estimate the approximate compressive strength of concrete. As shown as Figure 3.

Figure 3 **Rebound Hammer Test**

Test locations were carefully selected in both sound and visibly distressed areas to enable comparative assessment of concrete quality. Prior to testing, the surface was cleaned and made smooth to ensure reliable readings. At each test point, multiple impacts were applied, and the corresponding rebound numbers were recorded. The average rebound value for each location was calculated to minimize the influence of surface irregularities and random errors. These average values were then correlated with standard calibration charts to estimate the equivalent compressive strength of concrete.The results helped identify potential zones of weakened or deteriorated concrete and provided a rapid, non-destructive means of assessing structural condition and uniformity.

4.4 Micro Structure Analysis

Concrete samples were extracted from cracked and visibly deteriorated regions for detailed microstructural investigation using Scanning Electron Microscopy (SEM). The SEM analysis was performed to examine the internal morphology of the concrete, including the presence of microcracks, pore distribution, and the characteristics of hydration products such as calcium silicate hydrate (C–S–H) and calcium hydroxide. Special attention was given to identifying signs of chemical deterioration, including carbonation effects, sulfate attack, and microstructural disintegration. The high-resolution imaging enabled a clear understanding of crack propagation patterns and the interaction between aggregates and the cement matrix. These microstructural observations provided valuable insights into the internal damage mechanisms and helped validate the probable causes of distress identified during the preliminary visual inspection. As shown as Figure 4.



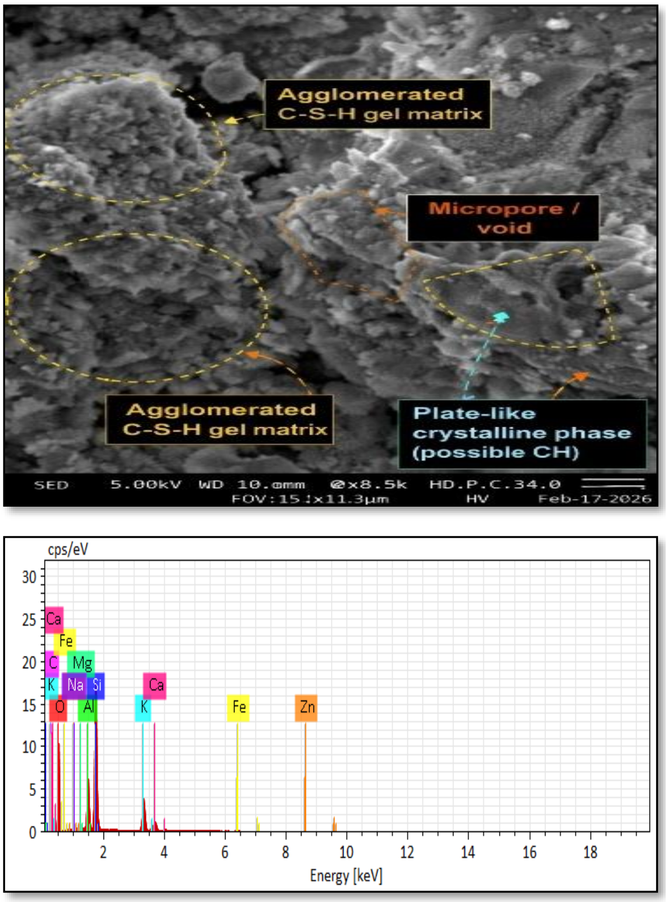


Figure 4 Sem & Eds of Deteriorated Concrete

5. Results

The rebound hammer test was conducted on a concrete wall surface using an N-type Schmidt hammer. Twelve readings were recorded, giving an average rebound number of 29.2.Based on standard calibration charts, the estimated compressive strength of concrete is approximately 22 MPa. The quality of concrete is assessed as fair to good.[7]

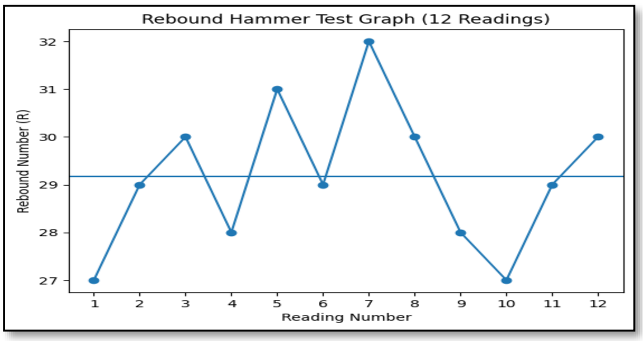


Figure 5 Rebound Hammer Test Graph

SEM micrographs reveal a dense, agglomerated C–S–H gel matrix with embedded plate-like CH crystals. The compact morphology and limited microporosity (100–400 nm) indicate advanced hydration and low permeability. Absence of microcracks or ettringite formations suggests minimal expansive reactions. Overall, the well-developed hydration products and controlled pore structure reflect enhanced mechanical strength and durability, supporting long-term structural performance in health monitoring applications. As shown as Table 1.

Table 1 Sem Microstructural Observations

Parameter	Observation	Structural Implication
Dominant Phase	Dense gel-like matrix	Primary strength-giving phase
Secondary Phase	Plate-like crystals	Normal hydration product
Particle Morphology	Fine angular crystals in gel mass	Improved bonding
Porosity	Limited micropores (100–400 nm)	Reduced permeability
Microcracks/Ettringite	Not observed	Good durability condition

The EDS spectrum reveals dominant Ca, O, and Si peaks confirming the presence of calcium silicate hydrate (C–S–H) as the primary hydration product. The significant Ca peak also indicates the presence of calcium hydroxide. Minor Al and Fe peaks correspond to aluminate and ferrite phases.[8] Alkali elements (Na and K) are present in trace amounts. The detection of Zn suggests either admixture incorporation or external contamination. No significant sulfur peak was observed, indicating limited ettringite formation. As shown as Table 2.

Table 2 **Detected Elements (From Labeled Peaks)**

Element	Approx. Energy (keV)	Source in Cementitious System
C	~0.27	Carbon tape / carbonation
O	~0.52	Oxides / hydration products
Na	~1.04	Alkali component
Mg	~1.25	Minor phase / SCM impurity
Al	~1.49	C_3A / alumina phases
Si	~1.74	Silicates / C–S–H
K	~3.31	Alkali
Ca	~0.34 & 3.69	C–S–H / CH
Fe	~0.7 & 6.4	C_4AF / ferrite phase
Zn	~8.6–9.6	Possible additive / contamination

Conclusions

The perceptible investigation of the 18-year-old institutional building, comprising visual inspection, rebound hammer testing, and SEM–EDS microstructural evaluation, provides a comprehensive understanding of its current structural condition.

- The rebound hammer results indicated an average rebound number of 29.2, corresponding to an estimated compressive strength of approximately 22 MPa, which classifies the concrete quality as fair to good.[9] This suggests that the primary structural elements retain adequate load-carrying capacity.
- Microstructural analysis revealed a dense and well-developed C–S–H gel matrix with limited microporosity and absence of deleterious products such as ettringite, indicating minimal chemical deterioration and satisfactory durability performance. The EDS results further confirmed stable hydration phases without significant sulfate-related distress.
- Overall, the building exhibits localized surface-level deterioration rather than systemic structural degradation.[10] Therefore, preventive maintenance measures—including crack sealing, surface patch repair, corrosion protection treatment, waterproofing, and protective coating application—are recommended to enhance durability and extend service life.
- Major structural rehabilitation is not presently required; however, periodic monitoring is advised to ensure long-term performance and safety.

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References

[1]. Cho, H.-C., Lee, S.-H., Park, M., & Kim, K. S. (2025). Remaining service life evaluation of reinforced concrete buildings considering failure probability of members. International Journal of Concrete Structures and Materials, 19(1), 17. https://doi.org/10.1186/s40069-024-00749-x

[2]. Cho, H.-C., Lee, S.-H., Choi, S.-H., Yi, S.-T., Kang, W.-H., & Kim, K. S. (2023). Structural safety inspection of reinforced concrete structures considering failure probabilities of structural members. International Journal of Concrete Structures and Materials, 17(1), 12. https://doi.org/10.1186/s40069-022-00571-3

[3]. Tefera, B. B., & Tarekegn, A. G. (2025). Non-destructive testing techniques for condition assessment of concrete structures: A review. American Journal of Civil Engineering, 13(1), 10–31. https://doi.org/10.11648/j.ajce.20251301.12

[4]. Kim, T.-H., Kim, S.-I., Sun, C.-H., Kim, I.-H., & Shin, H. M. (2025). Seismic performance assessment of solid RC columns deteriorated by chloride-induced corrosion. International Journal of Concrete Structures and Materials, 19, 109. https://doi.org/10.1186/s40069-025-00858-1.

[5]. El-Reedy, M.A. (2024). Steel-Reinforced Concrete Structures: Assessment and Repair of Corrosion (3rd ed.). Routledge.

[6]. Results in Engineering. (2024). Comprehensive review and comparative analysis of building condition assessment models, 100, 106739.

[7]. RILEM Technical Committee. (2022). Non-Destructive Testing and Assessment of Concrete Structures. Springer.

[8]. Bureau of Indian Standards. (1992). IS 13311 (Part 2): 1992 – Non-destructive testing of concrete: Methods of test, Part 2: Rebound hammer. New Delhi, India: BIS.

[9]. ASTM International. (2019). ASTM C1723-10 (2019): Standard guide for examination of hardened concrete using scanning electron microscopy. West Conshohocken, PA: ASTM International.

[10]. ASTM International. (2017). ASTM E1508-12a (2017): Standard guide for quantitative analysis by energy-dispersive spectroscopy. West Conshohocken, PA: ASTM International.