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"A Comprehensive Investigation of Cracks on the Ground Floor of Kendriya Vihar 2"

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Abstract:. Cracks in buildings, particularly high-rise buildings, are a major problem due to environmental factors, soil structure failure, unsymmetrical design, and improper joints. These cracks can be controlled using proper materials, techniques, and safety measures. A comprehensive investigation of the ground floor cracks at Kendriya Vihar-2 in Jaipur aimed to determine the root cause and analyze their impact on the building's structural integrity. The investigation involved a thorough visual inspection and analysis of the building's construction materials and methods. Mortar splits can be avoided by using the best materials, construction techniques, and technical specifications. Addressing active cracking is crucial to prevent damage and ensure the longevity of the structure.

Index terms: Crack, Building materials, Building maintenance, Site inspection, Construction defects.

I.INTRODUCTION

The behaviors of structures, building services, and the many types of fractures that may develop, their causes, and how to cure them are all covered in this. Structural fractures can be caused by a few issues, including poor design, overstressing of structural components, overloading the site where a project is being built, and other related issues Non-structural Cracks: These are mostly caused by internally produced tensions in the building materials and are not a threat to a structure's safety, but they may be ugly, give the appearance that the work was poorly done, or give the idea that the structure is unstable. It's important to monitor non-structural cracks and assess their characteristics over time. Cracks can range in width significantly, from a hair-thin fracture that is hardly apparent to the human eye to a cavernous breach. This increases the cost of construction or encourages the development of cracks, which also has a long-term detrimental effect on the stability of the structure. Cracks are divided into three categories based on their width: (a) Thin Crack, which is less than 1 mm wide; (b) Medium Crack, which is between 1 and 2 mm wide; and (c) Wide Crack, which is greater than 2 mm wide.

Brittle materials are susceptible to dangerous fractures due to cracks, often occurring suddenly without warning. Linear Elastic Fracture Mechanics (LEFM) studies brittle fractures using a damage tolerance philosophy. The stress intensity factor (SIF) is a crucial parameter, determining the growth of pre-existing cracks under different loading conditions.

II.ABRAVIATION

MTS - Maximum tangential stress**,** LEFM - Linear elastic fracture mechanics**,** SIF - Stress intensity factor**,** NDT - Non-destructive test

III.LITERATURE REVIEW

Erdogan and Sih (1963) introduced the maximum tangential stress (MTS) criterion for predicting fracture conditions by studying crack growth in 0.12-inch-thick plexiglass specimens. They found that crack propagation follows the direction of maximum tangential stress near the tip, and extension occurs when the stress reaches a critical material-dependent parameter.

Kong et al. (1995) proposed a stress-based criterion stating that crack initiation coincides with maximum stress triaxiality ratio direction. They conducted mixed-mode experiments on steel FeE500 and found the criterion was in good agreement with experimental results.

Georgia-Lucia Coca researched in 2020. Over time, structural surface fissures form and influence resistance, quality, and aesthetics. Visual inspection by humans is risky, dubious, and time-consuming. The development of artificial intelligence may automate crack detection and enhance human performance.

P.L. Porcel (2020) investigated A semi-automatic tool for examining masonry cracks in a 16th-century Peruvian church using photogrammetry analysis, utilizing image processing to map fracture evolution. Accuracy verifies qualitative assessments and may benefit future crack monitoring research.

In this study, A.E Wojnarowski (2019) employ new photogrammetric techniques to monitor fractures and joints generating deflection in engineering works, requiring no specialized competencies, and utilizing two blocks of deformation markings, processing software, and a digital camera.

IV.THEORITICAL BACKGROUND

This chapter aims to provide a comprehensive understanding of the evolution and nature of cracks, as well as the analytical approach employed in the current study. Additionally, it delves into an exploration of the various types of cracks that can occur in structural elements and the different types of loading conditions that affect cracked bodies.

4.1 Evolution of cracks in high-rise buildings

The evolution of cracks in high-rise buildings can be influenced by various factors, including:

4.1.1 Structural loads: High-rise buildings experience significant vertical and horizontal loads due to their height, weight, occupancy, and environmental conditions. These loads can exert stress on the building's structural elements, leading to the initiation and propagation of cracks over time.

4.1.2 Construction practices and materials: The methods and materials used during the construction of high-rise buildings can affect their long-term performance. Defects, such as inadequate reinforcement placement, poor concrete quality, or improper joint detailing, can contribute to the development of cracks in the building's structure.

4.1.3 Environmental factors: Environmental conditions, such as temperature variations, moisture levels, wind forces, and seismic activity, can impact the evolution of cracks in high-rise buildings. For instance, thermal expansion and contraction cycles, combined with moisture ingress, can lead to cracking in concrete and other materials.

4.1.4 Foundation movement: Settlement or uneven movement of the building's foundation can cause stress and strain on the structural elements, resulting in the formation and progression of cracks. Factors like soil conditions, groundwater levels, and nearby excavation work can influence foundation movements.

Age and deterioration: As high-rise buildings age, their structural components may experience deterioration due to factors such as corrosion, chemical exposure, or wear and tear. Deteriorated materials and weakened structural elements can be more prone to crack formation and propagation.

4.2 CAUSES OF CRACKS IN KENDRIYA VIHAR - 2

Cracks can occur in various materials and structures for a variety of reasons. The causes of cracks can be classified into several categories:

4.2.1 Structural Overload: Excessive loads or stress beyond the structural capacity of a material or structure can lead to cracks. For example, overloading a bridge beyond its weight-bearing capacity can cause cracks to develop.

"**Figure 1** Cracking due to Structural Overload"

4.2.2 Thermal Stress: Rapid or extreme temperature changes can result in thermal expansion or contraction, leading to cracks. This phenomenon is particularly common in materials with low thermal conductivity, such as concrete or ceramics.

"**Figure 2** Cracking due to Thermal Stress"

4.2.3 Moisture Changes: Moisture-related issues are a common cause of cracks. When materials absorb water, they can undergo expansion, and when they dry out, they may contract. These repeated cycles of expansion and contraction can result in cracking, particularly in materials like clay, soil, or concrete.

"**Figure 3** Cracking due to Moisture"

4.2.4 Shear Cracks: Shear cracks occur when forces push different parts of a structure in opposite directions, causing the material to shear and crack. These cracks often appear diagonally or at an angle.

"**Figure 4** Cracking due to Shear Stress"

4.2.5 Poor Construction Practices: Inadequate construction techniques or practices can contribute to cracks. Insufficient reinforcement, improper curing of concrete, inadequate mixing of materials, or poor compaction can result in structural weaknesses and cracks.

"**Figure 5** Cracking due to Poor Construction"

It is worth noting that the causes of cracks can often be interrelated. For example, poor construction practices combined with thermal stress and moisture changes can significantly increase the likelihood of cracking in a structure. Proper design, construction techniques, regular maintenance, and consideration of potential stressors are crucial in minimizing the occurrence and impact of cracks.

4.3 REPAIR OF CRACKS

The repair of cracks depends on the type, severity, and location of the crack, as well as the material or structure involved. Here are some general approaches to crack repair:

4.3.1 Surface Crack Repair in Concrete:

Small, hairline cracks can often be repaired by filling them with epoxy or polymer-based crack fillers. The filler is injected into the crack to bond and seal it. For wider or deeper cracks, a technique called crack stitching may be used. This involves embedding steel or carbon fiber reinforcement rods across the crack and securing them with epoxy or mortar. In cases where the crack is extensive or structural, professional assistance may be required. Structural engineers can evaluate the crack and recommend appropriate repair methods, such as epoxy injection, grouting, or even partial replacement of damaged sections.

4.3.2 Expansion Joint Repair in Concrete:

Damaged or deteriorated expansion joints should be replaced to allow for proper movement and accommodate thermal expansion and contraction. The old joint material is typically removed, and a new joint filler or sealant is installed.

4.3.3 Settlement Crack Repair:

If settlement cracks are detected early and are not severe, they can often be repaired by injecting grout or epoxy beneath the affected area to stabilize and lift it. In cases of significant settlement, professional help is necessary to assess the underlying cause and implement appropriate remedial measures, such as soil stabilization or underpinning.

4.3.4 Repair of Cracks in Walls or Masonry:

Superficial cracks in walls can be repaired by filling them with patching compounds or sealants appropriate for the material.

For more severe cracks in masonry, a technique called crack stitching may be employed, like the method used in concrete crack repair. Reinforcement bars are installed across the crack and bonded with suitable materials.

4.3.5 Repair of Cracks in Asphalt:

Small cracks in asphalt surfaces can be filled with asphalt-based crack sealants or fillers. These materials help prevent water infiltration and further deterioration. For larger or extensive cracks, a technique called crack sealing may be performed. Hot rubberized asphalt or specialized crack sealing materials are applied to fill and seal the cracks.

Repair methods provided are general guidance; specific situations may require different approaches. Consult professionals like structural engineers or specialized services to accurately assess cracks and determine the most suitable repair method for your specific case.

V.RESEARCH METHODOLOGY

The research methodology employed in this study aimed to investigate the evolution of cracks in high-rise buildings. To achieve this objective, non-destructive testing (NDT) techniques were utilized during the experimental phase. Specifically, the two NDT methods employed were the Rebound Hammer and Ultrasonic Pulse Velocity tests.

The Rebound Hammer test is a widely used NDT technique for evaluating concrete structure quality and integrity. It measures hardness and potential cracks, providing a quick and convenient assessment of strength.

Ultrasonic Pulse Velocity (UPV) test assesses concrete quality and integrity by measuring ultrasonic waves' travel time, determining density, homogeneity, and potential cracks or voids. Analyzing velocity and attenuation provides valuable insights.

5.1 The research methodology involved the following steps:

5.1.1 Sample selection: High-rise buildings with suspected or documented cracks were selected as the research samples. The selection criteria ensured a diverse representation of building types, ages, and structural materials.

5.1.2 Preparation of test specimens: Concrete cores or sections containing the suspected cracks were extracted from the selected buildings to create test specimens. Care was taken to preserve the integrity and orientation of the cracks during the extraction process.

5.1.3 Rebound Hammer testing: The Rebound Hammer test was conducted on the test specimens to assess the concrete's hardness and potential presence of cracks. Measurements were taken at multiple locations along the cracked areas, as well as in non-cracked reference areas, to establish a comparative analysis.

5.1.4 Ultrasonic Pulse Velocity testing: The UPV test was performed on the test specimens to evaluate the concrete's density, homogeneity, and potential presence of cracks or voids. Ultrasonic transducers were placed at specific locations on the specimens, and the travel time of the ultrasonic waves through the concrete was recorded.

VI.RESULT & DISCUSSION

During the experiment, the non-destructive testing (NDT) techniques of Rebound Hammer and Ultrasonic Pulse Velocity (UPV) were used to analyse the growth of fractures in high-rise buildings. The results of these tests provide vital information about the state and features of the concrete, as well as the presence of cracks.

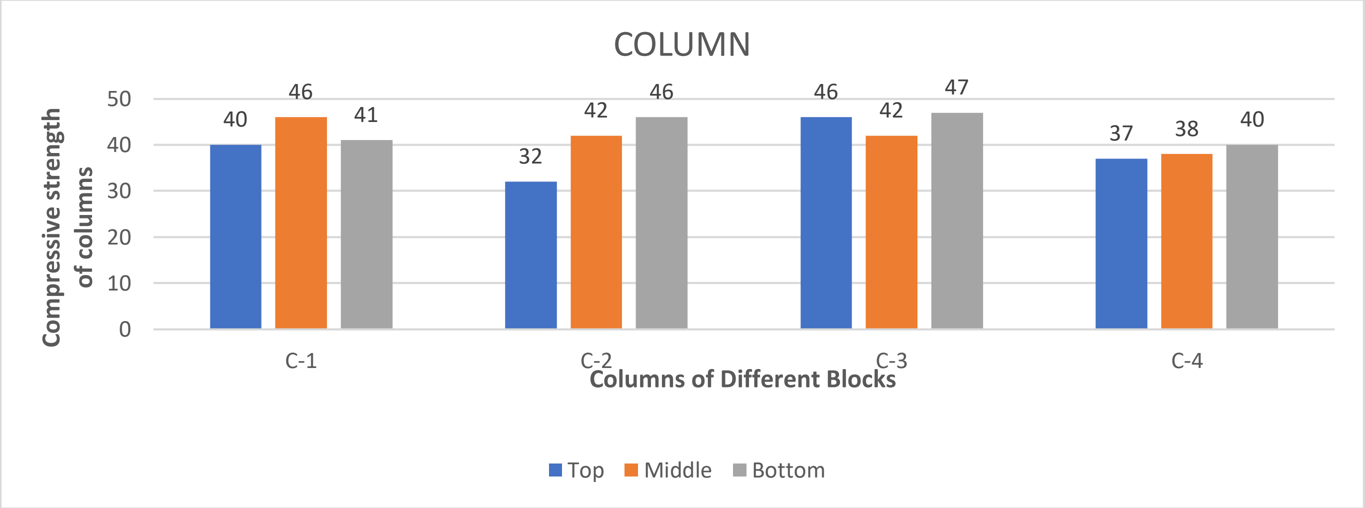
6.1 Rebound Hammer Test Results:

The Rebound Hammer test was performed on the test specimens at several sites along the cracked sections as well as in non-cracked reference areas. The rebound values obtained were analysed to determine the compressive strength of the concrete and the presence of cracks.

The investigation discovered differences in rebound values between cracked and non-cracked sections. Lower rebound values were reported in cracked locations, indicating that the concrete compressive strength was lowered.

S. No.	**Rebound No.**			**Comp. Strength**			**Description**
	Top	Mid.	Bott.	Top	Mid.	Bott.	
C-1	42	45	40	40	46	41	Lower column section's strength is weaker, but still in good shape.
C-2	35	43	45	32	42	46	Column's upper part is in good condition, slightly weaker than rest.
C-3	45	43	46	46	42	47	Columns in this block are in good condition.
C-4	38	39	42	37	38	40	Columns in this block are in good condition.

Table – 1 Rebound Hammer Results of Columns



Graph 1: Point of Test on Columns v/s Compressive Strength of Columns

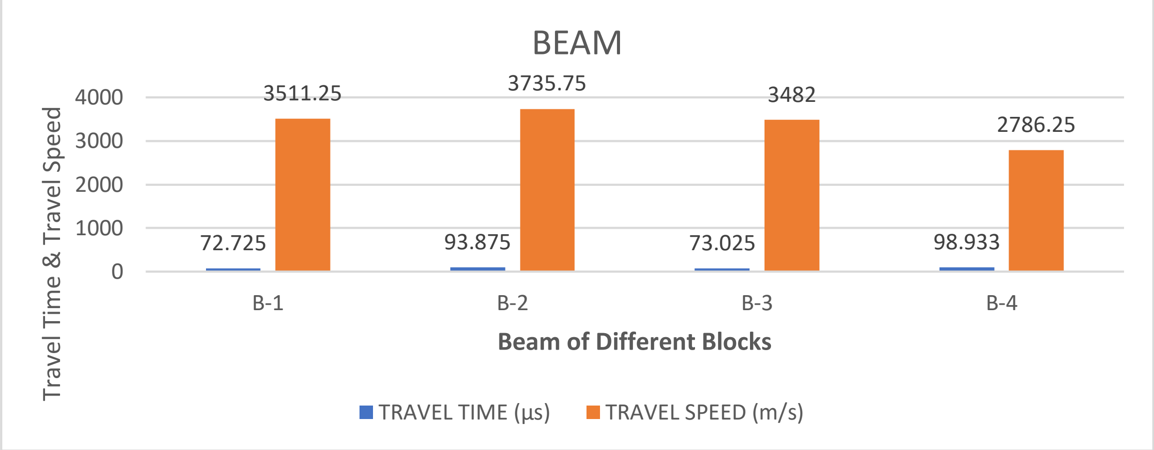
6.2 Ultrasonic Pulse Velocity Test Results:

The UPV test was performed on the test specimens to evaluate the concrete's density, homogeneity, and potential presence of cracks or voids. The travel time of ultrasonic waves through the concrete was measured, and the results were analyzed to identify any anomalies associated with cracks.

UPV test results reveal cracks in cracked areas, causing increased travel time and reduced wave velocity, indicating disruption of ultrasonic wave transmission and changes in concrete density and homogeneity.

S. NO.	**TRAVEL TIME (μs)**	**TRAVEL SPEED (m/s)**	**DESCRIPTION**
B-1	72.725	3511.25	The velocity is below 3750 m/s so the concrete quality is doubtful.
B-2	93.875	3735.75	The velocity is below 3750 m/s so the concrete quality is doubtful.
B-3	73.025	3482	The velocity is below 3750 m/s so the concrete quality is doubtful.
B-4	98.93333	2786.25	The velocity is below 3000 m/s so the concrete quality is poor.

Table: -2 Result of Ultra Sonic Pulse Velocity Meter for Beam



Graph 2: Point of test on Beam v/s Travel Time or Travel Speed of Ultrasonic Pulse for Beam.

6.3 DISCUSSION:

The Rebound Hammer and UPV tests reveal cracks and potential structural deficiencies in high-rise buildings. Lower rebound values indicate reduced concrete hardness, while increased travel time and reduced wave velocity indicate changes in density and homogeneity. These findings emphasize the need for identifying and addressing cracks to ensure structural integrity and long-term performance. Further investigation, such as visual inspections and additional testing methods, may be necessary to accurately assess the extent and implications of identified cracks.

VII.CONCLUSION

The research emphasizes routine building maintenance, comprehensive fracture management, stricter regulations, advanced technologies, and stakeholder collaboration for effective building fracture management. These conclusions emphasize the following key takeaways:

1) **Routine maintenance and inspection:** Regular maintenance and thorough inspections are essential in identifying cracks early and taking prompt corrective actions. By implementing preventative measures, the risk of catastrophic events that pose a threat to public safety can be significantly reduced.

2) **Comprehensive approach to dealing with fractures:** Given the multitude of factors contributing to high-rise building cracks, a comprehensive strategy is necessary. This approach should consider all relevant variables, including the building's structure, surrounding environment, and potential stressors, to effectively address and prevent fractures.

3) **Stricter standards and regulations:** The study highlights the need for more rigorous building codes and regulations. These standards should incorporate the latest scientific findings in materials and structural engineering to minimize the occurrence of cracks and structural failures.

4) **Utilization of advanced technologies:** Cutting-edge technologies such as drones and sensors can play a crucial role in inspecting high-rise structures and identifying potential fractures. Real-time data from these technologies can enable proactive measures to address issues before they escalate.

5) **Collaboration among stakeholders:** Repairing fractures in high-rise buildings requires collaborative efforts among building owners, designers, engineers, and regulators. By working together, sharing knowledge, and leveraging their expertise, the construction industry can create safer and more resilient high-rise structures for the future.

Overall, these conclusions emphasize the importance of proactive measures, the integration of advanced technologies, adherence to stricter regulations, and the significance of collaboration to ensure the safety and integrity of high-rise buildings. In order to maintain the safety and integrity of high-rise structures, these findings emphasize the need of proactive measures, the integration of cutting-edge technology, adherence to tougher rules, and the value of teamwork.

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