ORIGINAL RESEARCH PAPER

Engineering

A REVIEW ON POST FIRE ASSESSMENT TECHNIQUES OF CONCRETE STRUCTURES

KEY WORDS: Post-fire, Concrete, Non-destructive test, Destructive test, Strength, Residual strength.

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ABSTRACT

It is necessary to evaluate the state of the concrete following a fire because reinforced concrete constructions typically withstand high temperatures well and are not destroyed. Through an examination of the concepts and viability of these approaches, this review offers thorough insights into the use of the various strategies for evaluating fire exposed concrete (FEC). The purpose of examination is to increase the efficacy of the evaluation and the results in terms of repairing the safety and integrity of concrete structures destroyed by fire. Overall, this review adds to the body of literature by assessment techniques and offering insightful information that helps practitioners, engineers, and academics choose appropriate approaches and support well-informed repair strategy decision-making.

INTRODUCTION

One of the most common building materials used worldwide, concrete is susceptible to high temperatures or fire hazards when in use. Although concrete is more fire resistant than other building materials like steel and wood, it nevertheless deteriorates in the presence of fire and extreme heat. Concrete has physical and chemical alterations in response to high temperatures, which deteriorates the material's qualities. Since the autoclaving condition was caused by the water evaporating at temperatures below 300°C, it was usually assumed that the strength of concrete did not diminish or even slightly enhanced when exposed to these temperatures. The residual strength of concrete clearly declined at 400°C. When subjected to 600°C, the residual strength was typically around 50% of the initial strength, and after 800°C, it was typically less than 30%. When temperatures surpassed 1000°C, concrete lost nearly all its strength. Unlike compressive strength, which fell linearly with rising temperature, the elastic modulus began to decrease once the exposed temperature surpassed 200°C. Permeability, another measure of durability, also declined quickly following exposure (Rao, 2023; Kumar, 2019).

The following are the most significant structural damages to concrete structures damaged by fire:

- The mechanical qualities of steel reinforcement and concrete deteriorate. Determining their residual mechanical properties is essential for this to assess the impacted structure's structural sufficiency.
- A structural element or a collection of structural element's geometrical modifications brought on by a fire's high temperature. The structural system may change because of these modifications, intensifying the typically negligible second-order effects. For instance, based on measured deviations, the sufficiency assessment of walls and columns with a persistent loss of verticality should incorporate the additional P-Δ. This requires a detailed survey of the damaged structure (Kog, 2021).

Post-Fire Assessment Methods:

A thorough assessment of concrete structures damaged due to fire exposure is required to assess the quality and safety. Preliminary assessment techniques include visual inspection, non-destructive, semi-destructive and destructive test. Some of the important field techniques are discussed.

Visual Inspection And Hammer Tapping:

When evaluating fire damage to concrete structures, it is crucial to start with a thorough visual examination to find important damage signs including cracking, spalling, delamination, and deformations. This first stage offers a fundamental mapping tool for estimating the degree and scope of the fire's impact. In addition to the visual inspection, a hammer and chisel are used in auditory methods to identify regions that have been severely damaged by fire by identifying changes in the concrete's sound quality. This method permits a focused damage analysis and improves the accuracy of the assessment (Rao, 2023).

Ultrasonic Pulse Velocity:

UPV assesses the damage and structural soundness of concrete structures. When it comes to finding interior cracks, voids, and regions of deteriorated concrete, UPV is especially useful. It functions best in dry environments where precise wave propagation is made possible by the material's density and uniformity. Moisture, on the other hand, reduces its efficiency because it changes the velocity measurements, which could cause misunderstandings. Furthermore, UPV may encounter difficulties with extremely heterogenous materials, where changes in aggregate distribution and density compromise measurement accuracy (Rao, 2023; Kumar, 2019).

Ground Penetration Radar:

GPR is frequently used to evaluate the deterioration of concrete, particularly on bridge decks. By sending out radio waves and examining the properties of their reflections, this technique assesses the state of the concrete over time and intensity. Changes in these parameters might reveal possible problems such as corrosion, cavities, and cracks. Clear signal transmission is made possible by dry circumstances and homogenous materials, which are ideal for GPR performance. However, under saturated or wet conditions, when high conductivity hinders signal penetration, its performance is limited. Because overlapping reflections might make it more difficult to understand data, GPR also has trouble with resolution issues in heavily reinforced or heterogeneous structures (Deep, 2024; Guidebook, 2002).

Impact Echo:

Using a spherical object to tap a concrete surface, the impact

Echo method measures the acoustic response to ascertain the depth of the slab. The existence of flaws like delamination, cavities, and cracks is shown by differences between the calculated and real depths. To obtain a comprehensive evaluation, its implementation necessitates traffic delays and rigorous testing across multiple places. Data analysis is further complicated by the need for specialised tools and knowledge to analyse the collected data (Deep, 2024; Guidebook, 2002).

Core Sampling:

Concrete sample microstructural examination, chemical analysis, and core sampling and testing provide direct proof of material qualities following fire exposure. Although they are intrusive, they are thought to be the most accurate assessment tool. Concrete core samples from both impacted and unaffected sections are analysed to look for colour and texture changes as well as to measure the modulus of elasticity, compressive strength, and depth of fire impact. By using this technique, engineers can ascertain the degree of damage and deterioration brought on by fire exposure because it offers concrete's mechanical qualities as direct proof (Wroblewska, 2020; Jovanovic, 2023).

Carbonation Tests:

Concrete's carbonation depth, which indicates the degree of damage from high temperatures, can be accurately estimated using the carbonation test. Concrete's pH decreases as a result of calcium hydroxide (portlandite) dehydroxylating when heated to 450 – 500°C. The depth of exposure to these temperatures can be ascertained using this pH shift; this measurement is frequently referred to as the carbonation depth (Guidebook, 2002).

Crack Measurement Technique:

After a fire, the heat differential between the outer and interior layers of concrete, along with internal vapour pressure building, can cause cracks. Usually, a camera or other image capturing equipment is used to take pictures of FEC specimens while they are being viewed under light filtration at a particular magnification. This method can help with restoration efforts by estimating made with different grades of cement and aggregate can be measured for crack density (Deep, 2024).

CONCLUSIONS

There is a critical need in the construction field for a revie of the body of knowledge regarding the evaluation of concrete structures damaged by fire. By incorporating cutting-edge methodologies and techniques, such as visual monitoring, non-destructive and destructive techniques, a framework for assessment process is to be streamlined. The presence of a framework guarantees that post-fire damage assessments are less time-consuming and safer for engineering teams, while also improving their efficiency and accuracy. The post-fire evaluation work technique gives a practical way to accurately assess the safety and operational preparedness of fire-damaged concrete structures by offering a methodical framework that includes necessary information areas.

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