Materials Today: Proceedings xxx (xxxx) xxx

Contents lists available at ScienceDirect

Materials Today: Proceedings

journal homepage: www.elsevier.com/locate/matpr

Effect of elevated temperature on mechanical properties of normal strength concrete: An overview

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ARTICLE INFO

Keywords:
Fire damage concrete
Mechanical properties
Porosity
Permeability
High temperature

ABSTRACT

Concrete is frequently used in construction owing to its advantageous mechanical characteristics, including its high compressive strength, durability, workability, and fire resistance. Nevertheless, sustained exposure to fire can result in these qualities deteriorating, which poses a serious risk to concrete buildings. As a result, it is critical that researchers investigate how exposure to fire affects the mechanical characteristics of concrete in order to address this problem. Temperature, environmental conditions, the composition of the concrete mixture, and other factors all have an impact on the thermal and mechanical characteristics of concrete. This work seeks to give an overview of how exposure to fire affects the mechanical characteristics of concrete and to highlight areas that require further research. According to the study, there are three main stages that normal concrete strength goes through. The first stage sees a slight increase in strength between 20 and 300°Celsius, followed by a sharp decrease between 300 and 800°Celsius, and finally a complete loss of strength above 800°. Moreover, the fire response of concrete is strongly influenced by factors including the kind of aggregate, moisture content, concrete grade, additives, heating rate, and heating time. By making optimal use of admixtures, the fire behavior can be significantly improved.

1. Introduction

Due to the rapid development of the population in recent decades, concrete has become an increasingly common building material. This is owing to its advantageous properties including compressive strength, durability, hardness, workability, and fire resistance. Concrete is also a versatile material, as it can be moulded into any shape for a range of architectural and structural applications. Owing to its low thermal conductivity and incombustibility, concrete is often a more inert material than other materials such as wood and steel [1]. Although concrete is widely utilized in construction because it is a fire-resistant material, high temperatures significantly alter its chemical composition and physical properties [2]. Elevated temperatures have a particularly adverse impact on the micro and macroscale of concrete, leading to overall mechanical deterioration and even structural degradation [3]. As a result, several research on cementitious composites under high heat have also been undertaken lately, and the primary influencing factors have been discovered and explored.

High temperatures lead concrete to undergo both physical and chemical changes, which significantly reduce its strength. In particular, the bound and free water in the concrete evaporates at temperatures of about 100–110 °C [4]. Because of the elevated temperature and the water evaporation, the cement hydration is accelerated by internal autoclaving when the temperature elevate up to 300 °C [5]. The calcium hydroxide, which is necessary for the hardening and strength of the cement, break-up into calcium oxide and water at temperatures above 400 °C and then begins to decompose at about 600 °C [6,7]. At temperatures between 600 °C and 800 °C, the calcium carbonate decomposes into calcareous aggregate [8]. However, the composition of concrete, i.e., the type and quantity of constituents used, has remarkable consequences on the fire response of concrete [9].

As a result of the above-mentioned change in the mechanical properties of concrete, the exposure of building components to high temperatures has catastrophic effects on the building in the event of a fire disaster. Therefore, several researchers have studied the effects of high temperatures on the structural properties of concrete[10–12] In general, it can be observed that the structural properties (shear, flexure, bond, etc.) of structural element deteriorate as the temperature increases. A good bond between the steel bars and the concrete is critical to the structural integrity of the element RC. The lower bond strength at high

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https://doi.org/10.1016/j.matpr.2023.09.053
Received 15 December 2022; Received in revised form 27 August 2023; Accepted 7 September 2023