Performance, Degradation and Failure Mechanism of Normal and Lightweight Concrete Exposed to Elevated Temperature

Rami Hawileh,* Hind Alharmoodi, Abdallah Hajjaj, Abdulaziz Aljarwan, Sumit Sahoo and Jamal Abdalla

Civil Engineering Department, American University of Sharjah, Sharjah, 26666, United Arab Emirates

**Email:* rhaweeleh@aus.edu (R. Hawileh)

Received: 12 September 2025; Revised: 25 October 2025; Accepted: 04 December 2025

Type: Research article.

Abstract

This paper investigates the performance of normal-weight concrete (NWC) and lightweight concrete (LWC) when exposed to higher temperatures. A total of 42 NWC and LWC cylinders are exposed to different steady-state temperatures (room temperature, 100 °C, 200 °C, 400 °C, 600 °C, and 800 °C) and also under ISO-834 standard fire curve. Parameters like compressive strength, mass loss, and modulus of elasticity are evaluated. Additionally, the failure patterns are observed, and SEM analysis is performed to investigate the internal microstructure. The experimental results are compared with the Eurocode (EC) 2 model of the degradation of concrete's compressive strength degradation with an increase in temperature exposure. Analytical models are also developed to predict the degradation of compressive strength and modulus of elasticity with respect to increases in temperature. The findings indicate that LWC performs better under fire than NWC maintaining a normalized compressive strength factor of approximately 0.25 at 800 °C, compared to 0.227 for NWC. Significant decreases in residual strength of NWC and LWC specimens are reported starting at 400 °C. Initially, LWC samples exhibited higher mass loss than the NWC samples. However, at higher temperatures, starting from 800 °C, this trend reversed, with NWC showing a higher rate of mass loss. Further, the ductility of both types of concrete increases at high temperatures. On the contrary, the modulus of elasticity decreases with an increase in temperature. Microstructural analysis of the concrete specimens confirmed these results showcasing cracks in the aggregates and in cement materials at elevated temperatures. The findings indicate that LWC is a viable alternative to NWC in fire-prone regions, offering enhanced thermal performance and environmental benefits.

Table of Contents