HIGH-TEMPERATURE MICROSTRUCTURAL EVALUATION OF FIBRED CONCRETE USING X-RAY TOMOGRAPHY AND DIGITAL IMAGE ANALYSIS

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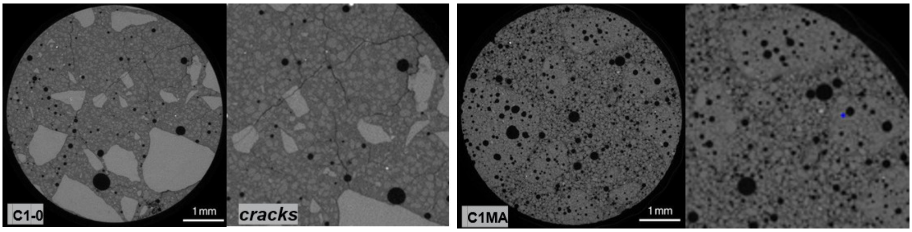
Abstract

The performance of concrete when exposed to elevated temperatures, such as during a fire, is governed by complex thermo-hydric interactions, often resulting in internal damage such as micro-cracking, increased porosity, and explosive spalling in extreme cases. This study explores the influence of aggregate types and the presence of polypropylene (PP) fibers on the microstructural evolution of concrete exposed to high temperatures, using X-ray computed tomography (CT) as a non-destructive diagnostic tool. Four concrete formulations were tested, incorporating either calcareous or mortar-based aggregates, with and without PP fibers. Samples were subjected to controlled heating at 80°C, 150°C, 200°C, 300°C, and 450°C. CT scans were conducted after each heating stage to capture internal transformations. Advanced image analysis techniques were applied, including manual alignment, image registration, and subtraction, to isolate and visualize the effects of temperature on the concrete microstructure. Post-processing steps such as segmentation and intensity mapping enabled quantification of pore connectivity, crack propagation, and fiber-induced vapor pathways. Findings reveal a strong correlation between aggregate type and thermal mismatch-induced cracking. Mortar aggregates exhibited reduced micro-cracking due to better thermal compatibility with the cement matrix, while PP fibers formed vapor channels that alleviated internal pressure build-up due to its melting around 170°C.The result of permeability measurements on these four concrete formulations further supported these findings, offering a comprehensive understanding of thermo-hydrodynamic behaviour under fire-like conditions. This study demonstrates the efficiency of advanced tomographic imaging methods in evaluating thermally induced damage in concrete and paves the way for more resilient fire-safe structural designs.

Keywords: X-ray tomography, Image subtraction, segmentation, thermal mismatch, polypropylene fibers, mortar aggregate, micro-cracking

Table 1. Heating protocol

Samples	C1-0	C1-18/32(0.5)	C1MA	C1MA-18/32(0.5)
Heating/cooling temperature	80°C, 150°C, 200°C, 300°C and 450°C			
Heating/cooling rate	2°/minute			
Dwelling	3 hours			



C1-0 sample after 450°C heating ***C1MA sample after 450°C heating***

Figure 1. X-ray Tomography Images after heating to 450°C

References

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