Characterization of concrete samples with different compressive strength using synchrotron X-ray microtomography

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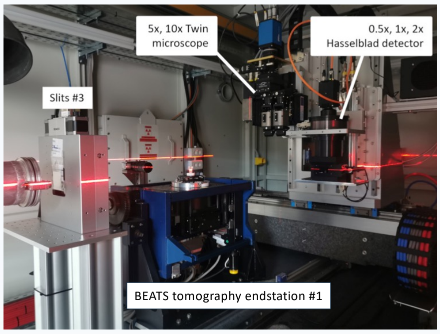
Abstract

The primary research objectives of this experiment are to characterize the microstructure of concrete samples and establish precise correlations between microstructural features and variations in compressive strength. To achieve these objectives, we prepared six types of concrete, each type with unique magnitude of cement, sand, water, aggregate1, and aggregate2. The composition of each type was adjusted to ensure a controlled variation in compressive strength. For each type of concrete, eight samples were prepared. Six samples were used to perform a standard compressive strength tests at ages of 7 and 28 days. Then, synchrotron X-ray microtomography was employed on the other two samples to non-destructively examine the internal microstructure of the samples, providing high-resolution 3D images.

Synchrotron-Light for Experimental Science and Applications in the Middle East (SESAME)

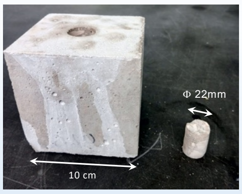
SESAME is a "3rd generation" synchrotron light source officially opened in Allan (Jordan) on 16 May 2017. It is the first synchrotron light source in the Middle East, and also the region's first major international center of excellence.

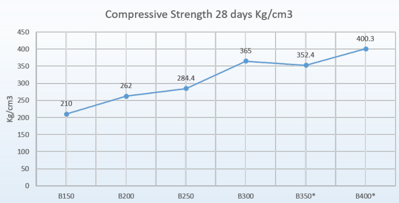
The BEATS beamline is located at port I10 of the SESAME storage ring and operates a hard X-ray full-field radiography and micro Computed Tomography (CT) station. Hard x-ray imaging can be applied in numerous scientific areas. BEATS is optimized for absorption and phase contrast X-ray radiography and tomography.



Samples and compressive strength tests

A total of 144 concrete cubes (10cmx10cmx10cm) were prepared. 36 cores (Φ 22mm) were scanned at BEATS beamline with low resolution (pixel size 6.5µm). Three smaller cores (Φ 6mm) were obtained and scanned with high resolution (pixel size 1.3µm).





Preliminary results (Scanned from 02/06 to 06/06 2024)

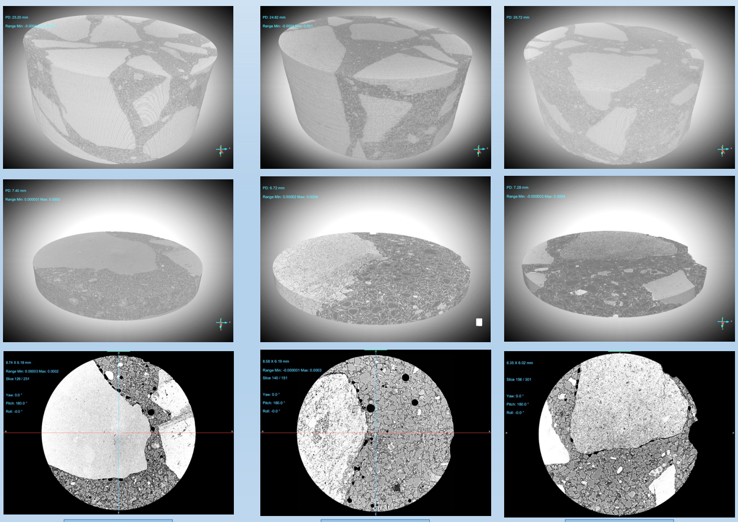
Adding Black Carbon to the B300 mix

Black Carbon 0% | Black Carbon 4% | Black Carbon 10%

Low resolution 3D volume

High resolution 3D volume

High resolution cross section



	Black Carbon 0%	Black Carbon 4%	Black Carbon 10%
Porosity + Black Carbon:	0.04139	0.05866	0.10409
Compressive Strength (28 days kg/cm^3):	331.5	361.9	329.0

Conclusions

Our research is driven by the hypothesis that compressive strength in concrete is primarily influenced by the microstructural characteristics, particularly porosity, pore size, and their distribution within the material.

As porosity increases, we expect a decrease in compressive strength due to reduced load-bearing material. Moreover, larger pores and irregularly shaped pores may act as stress concentrators, leading to reduced compressive strength.

We also expect to observe differences in the distribution of these features across the different compositions.

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