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Characterisation of Recycled Aggregate Concrete Through X-Ray Mapping

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Every year, urban development generates large volumes of solid waste due to the construction and demolition. Most of the waste from construction becomes landfilled; however, as the population grows continuously, land demand soon becomes a shortage. Therefore landfill is no longer a suitable option to deal with construction waste. Over the last decades, many researches have been carried out on the usage of recycled coarse aggregate. These researchers are primarily focused on the possibility of using recycled concrete aggregate (RCA) as a replacement for natural aggregate [1, 2]. RCA is produced by the crushing of original concrete, it is usually either fully or partially used in the recycled aggregate concrete (RAC) [3]. The use of recycled aggregate in concrete opens a whole new range of possibilities in the reuse of the waste materials.

RCA is different from the natural aggregate, because its surface is attached with old cement mortars. The attached mortar on the RCA can lead to low strength and high absorption. These are the main reasons it has not been widely used in the constructions. The interfacial transition zone (ITZ) is the interface between the aggregate and hydrated cement past, and it refers to as the ‘weak link’ in concrete [4, 5]. The quality of RAC depends on the thickness of the ITZ. A JEOL 8600 EM Probe with a Moran X-Ray mapping (XRM) software/hardware system was used to analyse the ITZ. The samples were 50% RCA replacement concrete with 0.5 % cement dye (iron oxide pigment). It is used to distinguish the old and new cement matrix. Furthermore, the 0.35, 0.45 and 0.55 water to cement ratios (w/c) were used.

The specimens were cured under room temperature and relative humidity of laboratory conditions for 28 days until the day of testing. The RAC specimens were first cut into 20 mm thick slices with a diamond blade table saw, and then further cut into 20 x 20 mm cross section with a small diamond blade saw. The samples were embedded into epoxy resin to prevent microstructural damage. The samples were grounded and polished to provide a smooth and flat surface to provide accurate analysis and to minimise the disturbance of edge effects [6]. Prepared samples were coated with a 30nm layer of carbon and then analysed by EM Probe. Full spectrum X-ray maps were collected on a 1024 x 1024 pixel image at 50 ms per point and processed to produce chemical maps and pseudo colour maps.

From the pseudo colour XRM as illustrated in Figure 1 of iron dyed 50% RCA replacement samples, the ITZ is getting thicker as the w/c ratio increases. The thickness of the ITZ range is approximately 4 to 10 µm for the 0.35 w/c ratio, 6 to 11 µm for the 0.45 w/c ratio and 7 to 15 µm for the 0.55 w/c ratio. The average is 8 µm for the 0.35 w/c ratio, 10 µm for the 0.45 w/c ratio and 12 µm for the 0.55 w/c ratio. The thickness of the ITZ is measured between the edges of the old cement matrix to new cement matrix. It is well known that the strength of concrete is influenced by the w/c ratio. In addition, the thickness of the ITZ is also related with the w/c ratio. From Ca/Si ratio mapping (see Figure 1d, 1e and 1f) it can be seen that Ca rich area (boundary) is becoming thicker with increasing w/c ratio, and often it is the region with high calcium hydroxide ($Ca(OH)_2$) [7]. It provides less bonding to the surrounding materials.

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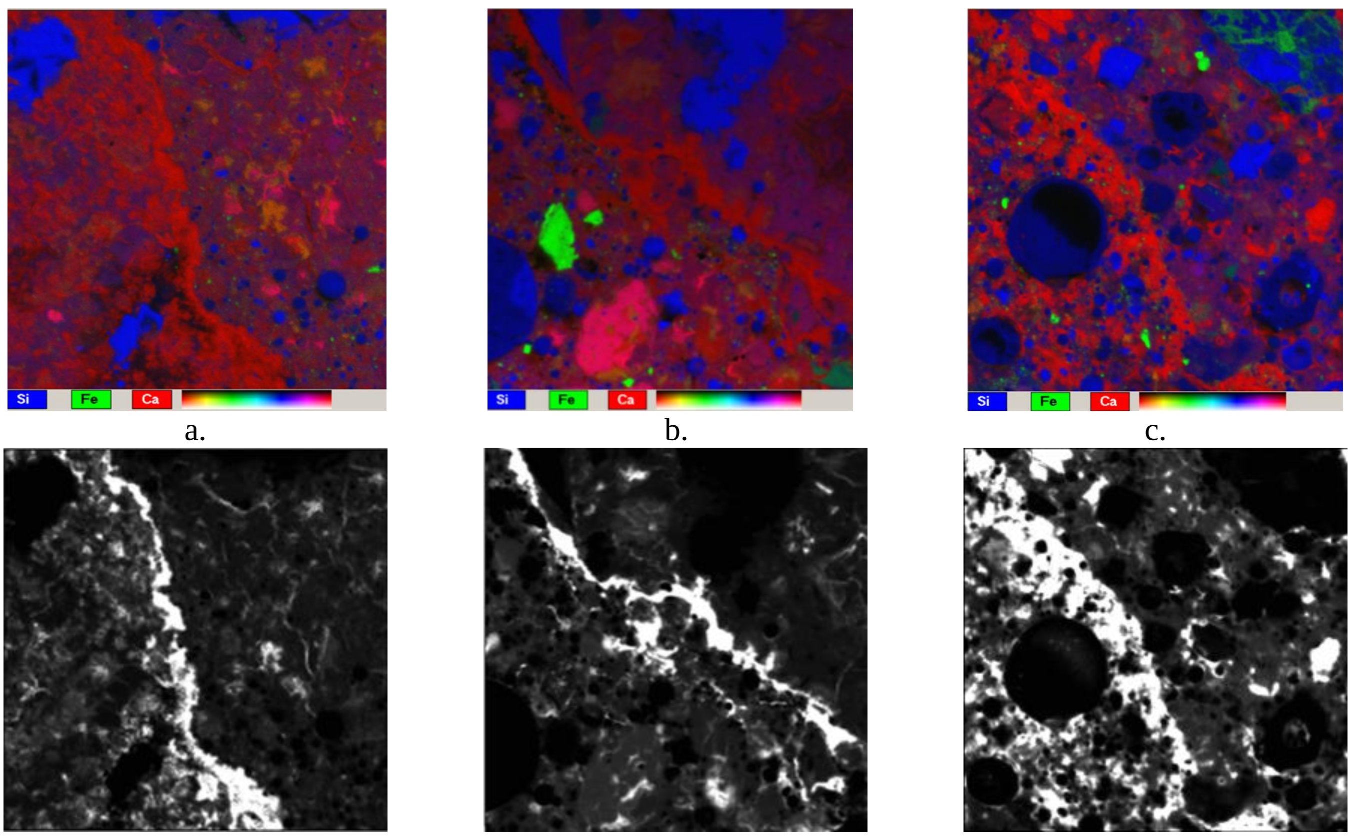

d. e. f.

Figure 1. Quantitative XRM of iron dyed 50% RCA replacement sample with a) Pseudo colour map of 0.35 w/c ratio, b) Pseudo colour map of 0.45 w/c ratio, c) Pseudo colour map of 0.55 w/c ratio, d) Ca/Si ratio map of 0.35 w/c ratio, e) Ca/Si ratio map of 0.45 w/c ratio, and f) Ca/Si ratio map of 0.55 w/c ratio.

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