Pretreatment for the improvement of recycled aggregate concrete

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As sustainability is a pressing issue all over the world, the word "recycle" forms one of the most important keywords today. Recycling and resource saving have been advocated in the construction industry, but the effectiveness of these has been constrained because the conditions in applying these approaches were not provided (Tam et al, 2005). The main area where recycling can be developed is reusing construction and demolition (C&D) waste. While the environmental and economical benefits of using recycled aggregates from C&D waste are well accepted, some hypothetical problems related to durability aspects resulted in recycled aggregates being employed practically only as base filler for road construction. Concrete, however, is one of the high-grade applications where recycled aggregates can be used. Their use in concrete opens a whole new range of possibilities in the reuse of materials in the building industry (Kuman *et al*, 2013).

The utilization of recycled aggregates is a good solution to the problem of an excess of waste material, provided that the desired final product quality is reached. Accordingly, the performance characteristics of concrete incorporating commercially produced recycled aggregates, hereafter, referred to as recycled concrete; require reassessment in relation to natural aggregate concrete (Sagoe – Crentsil *et al*, 2000).

The construction industry is now putting greater emphasis than ever before, on increasing recycling and promoting more sustainable waste management practices. In keeping up with this approach, several studies have been conducted over the last years. However, while studies on the properties of laboratory – crushed concrete aggregate or demolished concrete aggregates are abound, only limited data are available on commercial – grade recycled aggregate including pretreatment of recycled aggregates, concrete mixture proportions, fresh concrete performance and durability aspects. Hence, this paper estimates the influence on the properties of fresh and hardened concrete produced by commercially crushed and graded recycled aggregates, focusing on the effect that pretreatment of recycled aggregates has on the properties of fresh concrete and the compressive strength of hardened concrete.

The recycled aggregates were derived from C&D waste, which had been processed by mechanized crushing and sieving at a C&D waste recycling plant. The origins of the C&D waste were unknown; resulting in an evidently heterogeneous composition, depending on the type, age, use and size of the structure it came from. The sample of C&D waste used as recycled aggregates contained: pieces of concrete, bricks, ceramic tiles, marble, asphalt and natural aggregates (sand, carved stones, gravel). Besides, it contained a small percentage of: mosaic, wood, plasterboard, plywood, pieces of plumbing parts, plastic parts, metal objects (wires, screws, etc.), cables, paper, dirt and other pollutants. Due to the storage conditions, adhesive material – impurities were attached to the outer surface of the recycled aggregates. Therefore, an investigation regarding the utility of a pretreatment of the recycled aggregates and its effect to the produced concrete was required.

The experimental procedure involved the preparation of three concrete mixes with a target compressive strength of 35 MPa. The first concrete mix consisted exclusively of crushed aggregates (substitution level 0% - reference concrete), the second one consisted exclusively of recycled aggregates without pretreatment (substitution level 100%) and the third one consisted exclusively of recycled aggregates being pretreated (substitution level 100%). Only coarse recycled aggregates were used in this study, since fine recycled aggregates were determined to be unsuitable for concrete production due to their low quality (Tsoumani et al, 2015).

Properties of fresh and hardened concrete were determined for all mixtures. Regarding the properties of fresh concrete; workability was measured through slump, using the standard slump test apparatus, according to ASTM specifications (ASTM C143), air content was determined according to ASTM specifications (ASTM C 231) and density of fresh concrete was determined according to EN specifications (EN 12350-6). In advance, for

each mixture, six cubic specimens of 150 mm in size were cast in steel moulds. After demoulding, the cubes were cured in water until the tests were conducted. Compression tests took place at the age of 7 and 28 days, according to the EN specifications (EN 12390-3).

Table 1. Experimental measurements.

Property	Substitution level		
	0%	100% (not pretreated)	100% (pretreated)
workability (cm)	22.00	20.10	19.50
air content (%)	1.80	1.90	2.00
density (Kg/m^3)	2420	2090	2220
compressive strength 7 days (MPa)	25.00	8.00	17.50
compressive strength 28 days (MPa)	32.50	11.50	22.00

All experimental measurements are presented in Table 1. The results reveal that regarding the properties of fresh concrete, no great deviation is observed. However, the workability and the density of the recycled aggregate concrete are lower compared to the reference concrete, while the air content is higher. Furthermore, using recycled aggregates leads to a reduction of the compressive strength, in both cases with and without pretreatment of recycled aggregates. However, it was observed that compressive strength's reduction was greater for the recycled aggregates that were not pretreated (up to 65%), almost twice as much as the strength reduction of the pretreated recycled aggregates (up to 32%).

The tests' results, led us to the conclusion that the use of recycled aggregate in concrete for structural use is generally not excluded, however their pretreatment is required. Furthermore, regarding the pretreated recycled aggregates concrete, despite its reduced strength, corresponds to C16/20 category concrete, that could be used in structures with reduced strength requirements. These results were more or less expected due to the physical and mechanical properties of the recycled aggregates (Tsoumani et al, 2015).

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