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Pretreatment for the improvement of recycled aggregate concrete

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Introduction

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. 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.

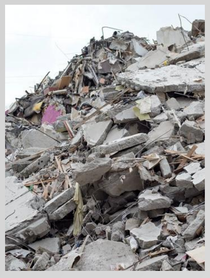

Figure1 : C & D waste

In keeping up with this approach, several studies have been conducted over the last years. However, 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 research estimates the influence on the properties of fresh and hardened concrete produced by commercially crushed and graded recycled aggregates, focusing on the effect that their pretreatment has on the properties of fresh concrete and the compressive strength of hardened concrete.

Experimental

The coarse aggregates used in this study included both natural and recycled aggregates. The natural aggregates were crushed limestone sourced from a local quarry, with nominal sizes of 9.5 mm (3/8”) and 25mm (1”). The recycled aggregates were derived from C&D wastes, which had been processed by mechanized crushing and sieving at a C&D waste recycling plant that is located in the industrial area of Thessaloniki, Greece. The origins of the C&D waste were unknown; therefore, the composition was evidently heterogeneous, depending on the type, age, use and size of the structure it came from. The material contained of: gravel, pieces of concrete / brick / tile / mosaic / marble, sand, carved stones, pieces of plumbing parts, plasterboard, plywood and asphalt. Besides, it contained a small percentage of: wood, plastic parts, metal objects (wire, screws, etc.), cables, paper, dirt and other pollutants.

The recycled aggregates were characterized in accordance with international standards (ASTM or EN specifications). In this study, only coarse recycled aggregates with the maximum nominal sizes of 11 mm and 25 mm were used, as the tests’ results, led us to the conclusion that the use of fine recycled aggregate in concrete for structural use is generally not recommended. The fine aggregates used were crushed limestone sand (nominal size: 4.75mm).

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 –M1), the second one consisted exclusively of recycled aggregates without pretreatment (substitution level 100%-M2) and the third one consisted exclusively of recycled aggregates being pretreated (substitution level 100%-M3).

Mix	Replacement Percentage (%)	Cement	Water	Superplasticizer	Fine aggregate	Coarse		Coarse	
						Natural	Recycled	Natural	Recycled
						nominal size (mm)			
						9,5	11	25	25
M1	0,0	280	191,00	2,00	913,00	287,00	0,00	662,00	0,00
M2	100,0	280	223,00	2,00	913,00	0,00	274,00	0,00	608,00
M3	100,0	280	280,00	2,00	913,00	0,00	274,00	0,00	608,00

Table 1: Details of concrete mixes (kg/m^3).

Results and Discussion

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).

Mix	Replacement Percentage (%)	Workability (cm)	Air content (%)	Density (kg/m3)	7-day Compressive Strenght (MPa)	28-day Compressive Strenght (MPa)
M1	0,0	22,00	1,8	2420,0	25,00	32,50
M2	100,0	20,10	1,9	2090,0	8,00	11,50
M3	100,0	19,50	2,0	2220,0	17,50	22,00

Table 2: Experimental measurements

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.

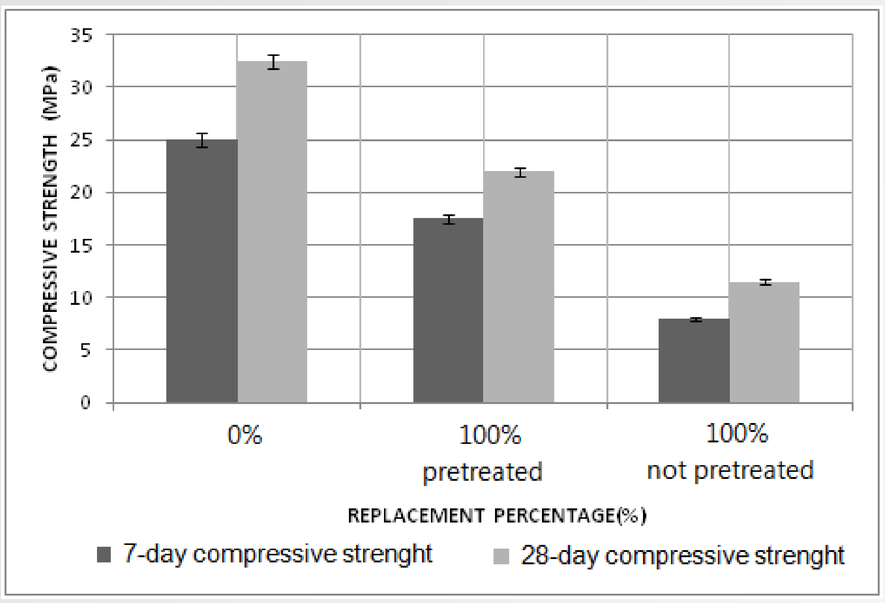

Figure 2: Compressive strength

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%).

Conclusion

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.

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References

1. Vivian W.Y. Tam,, X.F. Gao, C.M. Tam, “Microstructural analysis of recycled aggregate concrete produced from two-stage mixing approach”, Cement and Concrete Research 35, 1195– 1203, (2005).
2. Kuman, Suresh D. and Vikranth M.E., “Experimental Study on Strength and Durability Characteristics of Fibre Reinforced Recyled Aggregate Concrete”, Journal of Engineering Research and Applications, Vol. 3, Issue 6, pp.1883-1892 (2013)
3. K.K. Sagoe – Crentsil, T.Brown, A.H. Taylor, “Performance of concrete made with commercially produced coarse recycled concrete aggregate”, Cement and concrete research, (2000).