Reducing the environmental impact of construction wastes by their use in the preparation of construction mixtures

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Abstract

This paper is focused on the utilization of Recycled concrete aggregate (RCA) as a substitute for natural aggregate. Concrete produced in this way is characterized by worse properties than standard concrete, mainly due to the properties of the RCA. One option is to modify the surface of the RCA and thereby to improve the properties of the concrete as a whole. By the method described in this paper, we have succeeded in reducing the total water absorption of concrete by 50%, while the compressive strengths on the tested cubes with the edge 100 mm were 55 MPa.

Keywords: C&D waste, recycling, concrete, water absorption, compressive strength

1. Introduction

The main problem of Recycled concrete aggregate (RCA) is higher absorption than natural aggregates (NA) (Poon 2004, Silva 2014). This phenomenon is mainly caused by residual (old) mortar. There are many ways to remove the old mortar or strengthen the bond between the mortar-old mortar-aggregate phases (Al-Bayati 2016). Many studies have shown that RCA can be fully used as a filler in the preparation of concrete mixtures. However, it is necessary to properly modify its surface (Tam 2005, Torgala 2012).

Our research about RCA was intended to reduce its water absorption and verify the behavior of waste with modified properties in fresh and hardened concrete mixtures. As a RCA was used Construction and demolition waste (C&DW), namely used concrete roofing tiles.

2. Material and Methods

In order to determine the behavior of RCA in the fresh and hardened concrete mixture, a total of 7 mixtures were designed, while mixture B0 was control mixture. This experiment was based on a two-fraction concrete mixture, the natural aggregate fractions 4/8 mm or 0/4 mm with RCA were replaced, in mixture B6 both fractions. In all tested mixtures only 100% weight replacement of natural aggregate was realized. In the B1 (4/8 mm) and B4 (0/4 mm) mixtures, the natural aggregate with the original untreated RCA was replaced. Mixtures B2 (4/8 mm) and B5 contained RCA, the surface of which during the mixing of the respective concrete mixtures was modified. In the mixture B5, the surface of the entire RCA fraction 0/4 mm was not modified. The cause of the activation of only a selected fraction, 1/4 mm was the fear of a possible significant reduction in strength characteristics. Mixture B3 with a RCA fraction 4/8 mm was prepared, the surface of which prior the mixing the samples was modified (Junak 2017, Junak 2018). Table 1 shows details about experimental mixtures.

Table 1. Details of tested mixtures

Mixture	0/4 mm		4/8 mm		Surface modification	
	NA	RCA	NA	RCA	Before mixing	Prior mixing
B0	●	-	●	-	-	-
B1	●	-	-	●	-	-
B2	●	-	-	●	-	●
B3	●	-	-	●	●	-
B4	-	●	●	-	-	-
B5	-	●	●	-	-	●
B6	-	●	-	●	-	-

To increase the cohesion bonds between the old mortar and aggregates, RCA was coated (before/prior mixing) with a geopolymer suspension (coal fly ash, liquid glass, NaOH, water).

Concrete cubes with the edge 100 mm were used to monitor the water absorption and compression strength after 28 days and one year of hardening.

3. Results and Discussion

Overview of reached values of compressive strengths and water absorption of experimental concrete samples after 28 and 365 days of hardening is given in the Figure 1.

Looking at Figure 1, both methods of surface modification (before/prior mixing) appear to be acceptable in terms of RCA water absorption reduction. However, it should be noted, that this was only fully confirmed by the 4/8 mm fraction, since the efficiency of the surface modification of RCA is dependent on the size of the aggregates, inter alia.

The highest compressive strength reached mixture B2, 56.9 MPa after 365 days of hardening. This value is 5% higher than the control mixture BO. Modifying the surface of the RCA during mixing will seems to be more advantageous in terms of reached compressive strengths. The RCA surface is coated with a suspension of pozzolanic material, to fill the pores and cavities of the old cementitious mortar to form C-S-H gels, important in the development of strengths.

4. Conclusion

The absorption capacity of RCA can be several times higher than that of natural aggregate due to the high residual cementitious content. By choosing a suitable method of reinforcing the aggregate/old cement matrix, it will have a positive effect on the absorption of RCA, but also on the absorption of the hardened concrete mixture itself. In our experiment, the absorption of RCA by 50% due to the aggregate coating by geopolymer suspension was reduced. In addition, the compressive strengths in the range of 10 - 55 MPa were achieved.

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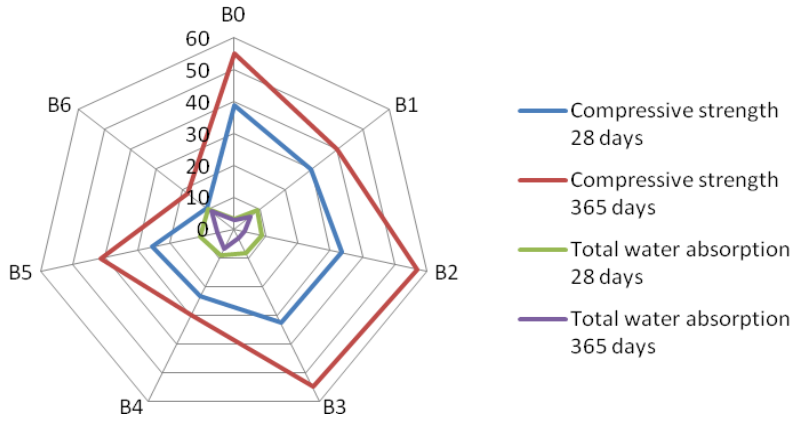

Figure 1. Reached values of compressive strengths and water absorption of tested samples after 28 and 365 days of hardening

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