Reuse of Construction Waste as Coarse Aggregate in Concrete

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ABSTRACT: The recycling of construction waste as concrete aggregates is an important way to contribute to sustainable development. However, the use of recycled concrete aggregate (RCA) instead of natural aggregate influences the properties of concrete since it has high water absorption. Experimental studies were carried out on the improvement of RCA performance, especially to reduce water absorption. In this study, surface of RCA was coated with a mix of cement, rice husk ash (RHA) and water, so that its characteristics were improved. Concrete mixes were prepared using the treated recycled aggregates and physical properties of each concrete mix were studied.

1 INTRODUCTION

Crushed concrete is available nowadays in large quantities, which results from the demolition of old structures and waste concrete from new structures. Sometimes this waste is used for illegal landfills and makes leads to environmental and social problems. Depletion of natural resources increases the need of proper waste management methods such as recycling of the accumulated waste materials.

The recycling and reuse of construction and demolition waste seems to be a feasible solutions for the problem. It helps to promote sustainable development as it protects natural resources, and reduces the disposal of demolition waste from old concrete structures.

In recycled aggregates, water absorption is much higher than that of natural aggregates. (Silva et al, 2014) Higher water absorption leads to decrease the workability of the concrete. (Sérifou et al, 2013) The high water absorption capacity means more water is needed than for conventional concrete to obtain the same workability (Matias et al, 2012).

According to most research studies, compressive strength and slump reduce with the increase in RCA replacement (Sérifou et al, 2013).

Hence, it is necessary to reduce the water absorption of recycled aggregates prior to use.

Many research studies have been done on this topic. Pre-coated method is one of the methods that has been used to improve the properties of recycled aggregate. According to Zhihui et al (2012) surface-coated recycled aggregate with paste thickness of 0.035 mm resulted in a higher physical performance. According to his experiment water absorption could be reduced to 2.5% when the w/c ratio of the slurry equals to 0.8.

The main objective of this research project is to find a suitable method to reduce the water absorption of recycled aggregate.

The coating method is used in this experiment to treat recycled aggregates to reduce the water absorption. Slurry made with cement and rice husk ash is used for the treatment. Various slurries were checked by changing the proportion of cement: RHA.

Water absorption values of coated recycled aggregates obtained from the experimental study are presented in this paper.

Concrete mixes were prepared by using treated recycled aggregates. Two control tests were conducted by preparing concrete with recycled aggregate and natural aggregate with the same mix proposition to compare the test results. The target strength of concrete mix design was 30 N/mm^2.

2 METHODOLOGY

2.1 *Collection and preparation of samples*

Recycled coarse aggregate is obtained from Construction Waste Management Centre located at Walauwatta, Dadalla, Galle. Concrete waste in the Galle municipal area is collected and crushed at this center.

2.2 *Experimental program*

- Water absorption and particle density of recycled and natural aggregates were tested according to the BS 812: Part 2: 1995.

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- Coating was prepared with cement, rice husk ash and water for improving the recycled aggregates. Various types of coatings were prepared by changing RHA: Cement ratio and by changing water solid ratio. Properties of each slurry is given in Table 1 below.

Table 1 Composition of slurry scenarios

Water/solid ratio	RHA: cement ratio			
	0:100	20:80	40:60	50:50
0.625	√	√	√	√
0.750	√	√	√	√
0.875	√	√	√	√
1.000	√	√	√	√
1.250	√	√	√	
1.500	√	√		
1.750	√			
2.000	√			

- Rice husk ash was ground by using a grinder for 5 minutes. Required amounts of cement, RHA and water were measured and mixed in the mixer for 2 minutes.
- Recycled aggregate used for coating was in the dry condition and sieved by a 5mm sieve. The RCA were added into evenly stirred slurry and soaked for 10 min, then allowed to dry naturally in wind for 24h.
- Coated recycled aggregate was spread on a net and allowed to dry for 24h. Then treated recycle aggregate was placed in a curing tank for 28 days.
- 50x50x50mm^3 mortar cubes were prepared for each slurry. Their strengths were tested according to the BS 4551: Part 1: 1970.
- Water absorption of recycled aggregates were tested at 7 days (see Fig. 1)
- Best three slurries were selected according to the lowest water absorption values.
- Three different concrete mixes were prepared by using recycled aggregates after treating using above slurries.(100% treated coarse recycled aggregates used)
- Concrete mixes were prepared using untreated recycled aggregates and using natural aggregates.
- Properties of concrete made with treated recycled aggregate were compared with the properties of concrete made with recycled aggregates and natural aggregates.

3 RESULTS

3.1 *Properties of recycled aggregate*

Table 2 shows the properties of NCA,RCA

Table 2. Properties of recycled aggregate and natural aggregate

Property	Natural aggregate	Recycled aggregate
Density(Oven dried basis) (kg/m^3)	2720	2370
Density(Saturate and surface dry basis) (kg/m^3)	2720	2480
Apparent particle density (kg/m^3)	2740	2670
Water absorption (%)	0.29	6.01

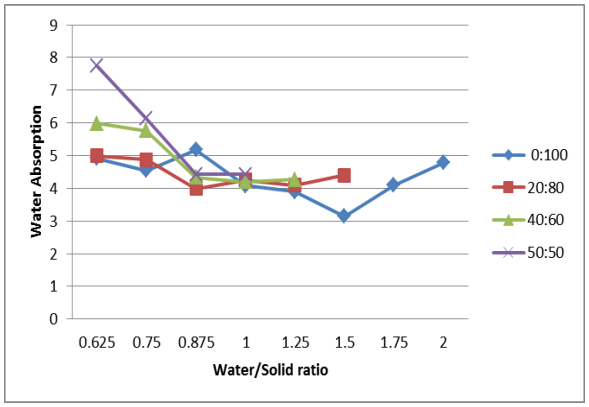

Fig. 1 Water absorption of treated aggregates after 7 days curing

Water absorption values of recycled aggregates, treated with various slurries were determined. Slurry ratio that gives the least water absorption value in recycled aggregate is selected as the best slurry for a given RHA: cement proportion.

Three best slurry ratios were selected. These three slurry ratios and water absorption values in each case are given in Table 3

Table 3. Best three slurry ratios and their water absorption values

Aggregate Type	Slurry Ratio	RHA: Cement	Water absorption value(% of dry mass)
TRCA 1	1.5	0:100	3.14
TRCA 2	0.875	20:80	3.99
TRCA 3	0.875	40:60	4.33

4 DISCUSSION

The density, slump of fresh concrete, compressive strength of concrete specimens and water absorption values of treated recycled coarse aggregates used were determined to investigate the influence of recycled aggregate on concrete properties. See Table 3

Table 4 Concrete cube strength and slump values

Type of Aggregate used	Avg. Compressive Strength (N/mm^2)	Average Density (kg/m^3)	Slump value (mm)
NCA	31.44	2430.88	100
RCA	29.22	2346.03	15
TRCA 1	36.55	2345.16	70
TRCA 2	35.51	2323.5	75
TRCA 3	33.50	2286.85	70

NCA- Natural Coarse Aggregate
RCA- Recycle Coarse Aggregate
TRCA 1- Recycle aggregate Coated with slurry type 1 (Water solid ratio = 1.5, RHA: Cement = 0:100)
TRCA 2- Recycle aggregate Coated with slurry type 2 (Water solid ratio = 0.875, RHA: Cement=20:80)
TRCA 3- Recycle aggregate Coated with slurry type 3 (Water solid ratio = 0.875, RHA: Cement=40:60

4.1 *Water absorption values of treated recycled aggregate*

According to Fig. 1 the lowest water absorption value (3.14%) was obtained when the RCA was treated with the slurry with 1.5 water/solid ratio and 0:100 RHA: Cement content.

When RHA was added with cement, the least water absorption value was obtained when the water/solid ratio becomes 0.875.

The water absorption of RCA was 6.01%. By using the coating method, the water absorption values were reduced considerably.

4.2 *Properties of concrete*

4.2.1 *Compressive strength*

According to the test results in Table 4, the highest compressive strength was achieved when type 1 treated recycled aggregates were used. Least compressive strength is achieved when recycled aggregates were used without any treatment.

By contrast, the concrete specimen prepared with treated RCA performed better than the specimen prepared with untreated RCA. On the 28th day of concrete curing, most of the concrete mixes with treated coarse RCA exhibited higher strengths than those of the corresponding control specimens and achieved the target design strength.

According to the findings from the compressive strength analysis, all three types of RCA have significantly enhanced the compressive strength of concrete.

4.2.2 *Density*

Highest density was achieved when natural aggregates were used. All concrete mixes with RCA have lower density than that of with natural aggregate. Treated recycled aggregate resulted in lower density than that of untreated recycled aggregates. Improvement of RCA was done by coating RA with slurry made by cement and RHA. When the RHA content increases in the slurry, the density decreases and decreases the RA density.

4.2.3 *Workability*

Slump values obtained from each type of concrete mix are presented in Table 4. It shows that highest slump value obtained when NCA was used. Least slump obtained when Untreated RCA was used. By using treatments for RCA, slump values could be considerably increased.

5 CONCLUSION

- Density of recycled coarse aggregate is 2370 kg/m^3. Density of natural aggregate is approximately 2720 kg/m^3.
- Water absorption of natural aggregate is 0.29%. Water absorption of recycled coarse aggregate is 6.01%. Water absorption of recycled coarse aggregates can be reduced to 3.14% by using coating methods.
- The workability of concrete mix made with recycled coarse aggregate concrete mix is lower than that of natural aggregate. However, workability can be enhanced by using treated recycled aggregates.
- Compressive strength of concrete made of untreated recycled coarse aggregates has lower values than that made of natural aggregates. However, compressive strength can be increased by using treated recycled coarse aggregates.

REFERENCES

British Standard BS 812: Part 2: 1995, “Testing aggregates: methods for determination density”, The British Standards Institution, London.

British Standard 4551: Part 1-1970, “Methods of testing mortars, screeds and plasters: physical testing”, The British Standards Institution, London.

Hansen, T.C. and Narud, H. “Strength of recycled concrete made from crushed concrete coarse aggregate”. Concr Int 1983;5(1):79–83.

Matias, D., Brito, J. de, Rosa, A. and Pedro, D. (2012), “Mechanical properties of concrete produced with recycled

coarse aggregates – Influence of the use of super plasticizers".

Sérifou, M., Sbarta, Z. M. Yotte, S., Boffoué, M. O., Emeruwa, E. and Bos1, F. (2013), "A Study of Concrete Made with Fine and Coarse Aggregates Recycled from Fresh Concrete Waste".

Silva, R.V., Brito, J. de, Dhir, R.K. (2014), "Properties and composition of recycled aggregates from construction and demolition waste suitable for concrete production", Civil Engineering, Instituto Superior Técnico, Av. Rovisco Pais, 1049-001 Lisbon, Portugal.

Zaharieva, R., Buyle-Bodin, F., Skoczylas, F. and Wirquin, E. (2003), "Assessment of the surface permeation properties of recycled aggregate concrete", Cement and Concrete Composites, vol. 25, no. 2, pp. 223–232, 2003.

Zhihui, Z., Shoude, W., Lingchao, L. and Chenchen, G., (2012), "Evaluation of pre-coated recycled aggregate for concrete and mortar" Shandong Provincial Key Lab. of Preparation and Measurement of Building Materials, University of Jinan, Jinan 250022, China.