# THE EFFECT OF WATER-CEMENT RATIO OF CONCRETE ON PROERTIES OF CARBONATED RECYCLE CONCRETE AGGREGATE

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## 1. INTRODUCTION

In last decade, the construction industry has developed a potential solution for both sustainability in demolition of structure and increase service life of the demolished structure is repurposing concrete that is taken out of service as recycled concrete aggregate (RCA). This material allows for a more economical aggregate source for towns that are located far from any virgin aggregate sources. The utilization of RCA has increased in recent years as a result of significant scientific researched. Several methods have been proffered in enhancing the properties of RCA in literature and can be categorized into two categories: (1) Enhancing the quality of the adhered mortar, for instance, surface coating with pozzalanic materials (2) Detaching the adhered mortar by ultrasonic cleaning method, and presoaking the RCAs with $H_2SO_4$, $H_3PO_4$. Nevertheless, these methods possess some defects either on the environment or on the material. This research adopted carbon dioxide ($CO_2$) to treat RCA made from different water cement ratio for enhancing the properties of RCA and investigate the effect of different water cement ratio of the parental concrete of 100 % OPC and 50 % replacement blast furnace slag (BFS) on the properties recycled aggregate. The prime of this concept is that $CO_2$ can react with calcium hydroxide (CaOH) in the adhered mortar of the RCA to form calcium carbonate $CaCO_3$. the adhered mortar is densified after carbonation, which increased the density and reduced the porosity of RCA.

## 2. METHOD

The effect of different water cement ratio of the parental concrete of 100% OPC and 50% BFS on the properties of carbonated RCA were examined. Firstly, concrete was made from different mix proportions as shown in Table 1 and Table 2. The targeted slump was 10 ± 2 .5 cm and the targeted air volume was 4.5 ± 1.5%. The concrete was cured in water and for 28 days. The compressive strength was determined in compliance with JIS A 1108:2006, as shown in in Figure 1. Thereafter, the concrete was recycled into RCA in accordance with JIS 5022 and JIS 5023. The RCA was carbonation with the method prescribe by JIS A1153. The absolute density, and absorption capacity of the RCAs were carried out in accordance with the test method describe in JIS A 1110 2006, the porosity of the RCA was also examined through the method of Archimedes' principle, all the recycled are prefix with R and the carbonation are suffix with C as indicated in the graph with respective water cement ratio.

Table 1. The mix proportions of the 100% OPC

| W/C (%) | s/a (%) | Units weight (kg/m$^3$) W | C | S | G |
|---|---|---|---|---|---|
| 35 | 45 | 165 | 471 | 756 | 952 |
| 45 | 47 | | 367 | 830 | 964 |
| 55 | 49 | | 300 | 892 | 957 |
| 65 | 51 | | 254 | 948 | 939 |

Table 2. The mix proportions of 50% of BSF

| W/C (%) | s/a (%) | Units weight (kg/m$^3$) W | C OPC 50% | C BFS 50% | S | G |
|---|---|---|---|---|---|---|
| 35 | 45 | 165 | 236 | 236 | 748 | 942 |
| 45 | 47 | | 183 | 183 | 824 | 957 |
| 55 | 49 | | 150 | 150 | 887 | 951 |
| 65 | 51 | | 127 | 127 | 944 | 934 |

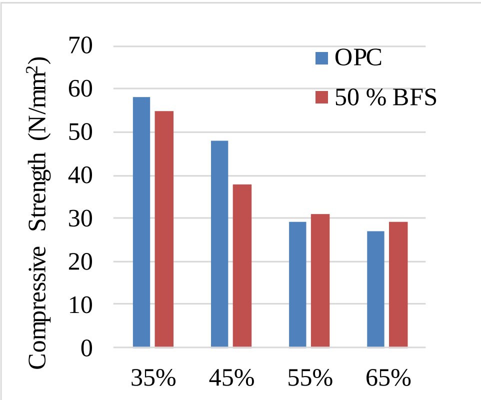


Figure 1. The 28 days' compressive strengths of original concrete.

Key Words: Recycled Concrete Aggregate, carbonation, water-cement ratio, OPC and BFS.

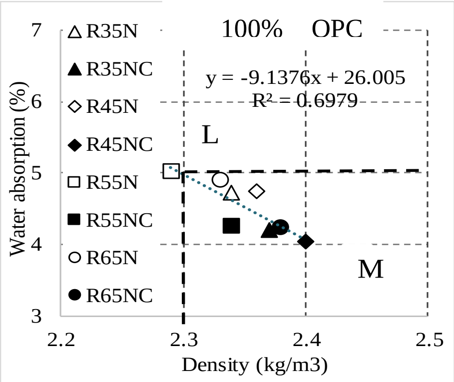

Figure 2. absolute dry density and water absorption ratio of carbonated and un-carbonated RCA

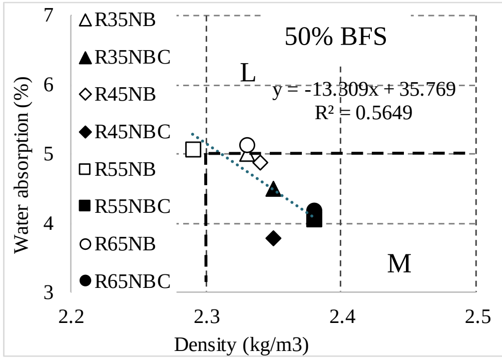

Figure 3. absolute dry density and water absorption ratio of carbonated and un-carbonated RCA

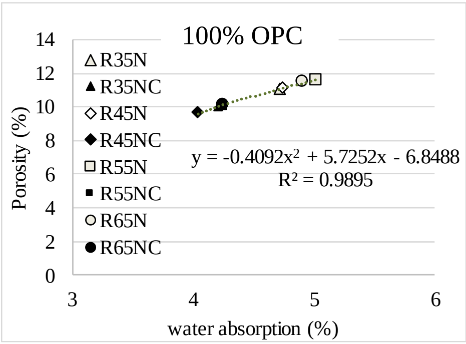

Figure 4. Porosity against water absorption

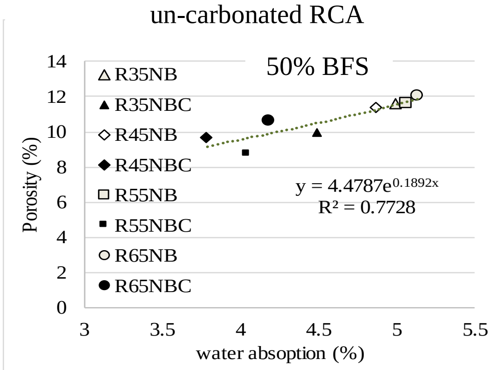

Figure 5. Porosity against water absorption

## 3. DISCUSSION OF RESULTS

All the carbonated RCA increase in absolute density and decrease in water absorption almost at the same rate in both 100% OPC and 50% replacement of BFS as shown in Figure 2 and Figure 3 respectively. This shows that different water-cement ratio has no significant effect on the properties, but the carbonation improve more when blast- furnace slag cement is used. This might depend on the volume of $Ca(OH)_2$ and C-S-H in the adhere mortar. in the case OPC of lower water-cement ratio, the amount of $Ca(OH)_2$ is high in the adhered mortar and the carbonation of the adhered mortar would be less than the BFS because C-S-H in the Slag hydration can easily react with $CO_2$ which can easily produce large volume of $CaCO_3$ that would filled up the pore in the adhered mortar thereby densified the adhered mortar by increasing the density and reducing the pore that prevent water penetration which lead to low water absorption. Figure 4 and Figure 5 show the porosity and water absorption of 100% OPC and 50% BFS replacement respectively. It shows linear relationship between the porosity and water absorption.

## 4. CONCLUSION

A comprehensive research was conducted on the effect of the different water cement ratio and on the properties of carbonated RCA. It was found that water cement ratio has no significant effects on the properties of carbonated RCA. It was also found that BFS can easily carbonated than OPC. Also the lower the water-cement ratio the less carbonation.

## REFERENCE


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2. Takeshi Iyoda, Study of concrete modification effect with Recycled aggregate treated by carbonation, II International conference on concrete sustainability. ICCS16.


Key Words: Recycled Concrete Aggregate, carbonation, water-cement ratio, OPC and BFS.