EFFECT OF RECYCLED CONCRETE AGGREGATE IMPROVED BY CARBONATION TECHNOLOGY ON ALKALI SILICA REACTION IN RECYCLED AGGREGATE CONCRETE.

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1. INTRODUCTION

Due to depletion of natural aggregates in many parts of the world as a result of environmental exploitation and availability of concrete waste in large quantities resulting from the demolition of old concrete structures, recycled concrete aggregate (RCA) becomes very vitals as an alternative to natural aggregate for concrete sustainability. However, structural designers are generally reluctant to use recycled aggregate concrete CRAC) ascribing to the generally perception that RAC may not possess the required structural strength and durability as natural aggregate concrete (NAC) because of the porous nature of the attached mortar of RCA with high water absorption. These affect the RAC by low strength, high shrinkage and Alkali Silica Reaction (ASR), In particular if the RCA is produced from the concrete that was removed from service due to ASR.

In Japan, effort has been made to categorize the RCA into Low (L), Medium (M) and High (H) and the categorization is based on the water absorption and the density of RCA. Carbonation technology has been developed to enhance the properties of the RCA. This technology has been used to improve the strength and reduce the shrinkage of the RAC as reported by Iyoda (2014) and poon (2015), the carbonation technology is less expensive and environmental friendly. In this study, the carbonation technology was used to investigate the ASR of RAC.

2. METHODS

The effect of carbonation on ASR expansion of RAC was assessed by selecting two different aggregates considered to be reactive aggregates namely aggregate A and aggregate B in other to identify the reactive aggregate that can initiate the ASR in concrete. The reactiveness of the aggregates was Identify by mortar bar method (both JIS and ASTM). The A and B aggregates exceeded the threshold of 0.1% set by ASTM as shown in Figure 1. Reactive aggregates (A and B) were selected to cast a concrete in which ASR was initiated by increasing the alkali content of cement to 2.12% (7kg/m^3 of concrete). The initiation of ASR of the concrete was verified by measuring the expansion of the concrete curing under the condition prescribe by Rilem (AAR3) and laboratory condition (water at 40^{o}c). The concrete cast with A aggregate exceeded the expansion thresholds of 0.05% set by Rilem and cracks emancipated to confirm the presence of ASR in the concrete. The ASR concrete was recycled into low (L) and high (H) category of RCA. Some portion of Low (L) RCA was put into a carbonation chamber at the temp. of 20^{o}C and the relative humidity of 60%, the chamber was vacuumed at 1 bar of environmental pressure. CO_2 was injected into the chamber and the pressure of the chamber was kept at a constant level. RCA (L) was carbonated for 7 days in the chamber with a CO_2 concentration of 5%. The density and the water absorption carbonated RCA (LC) were shown in Figure 2. It shown that the Low class of recycled aggregate has enhanced to medium M Class of RCA after carbonation due to the $CaCO_3$ formed around the attached mortar. Two batches of the RAC (with additions of alkali (7kg/m^3) and without addition of alkali) were cast from the three categories of RCA (RAL, RALC RAH, RBL, RBLC and RBH) from each aggregates (A and B) with water cement ratio of 50% and unite water of 165kg/m^3 and ASR test was conducted

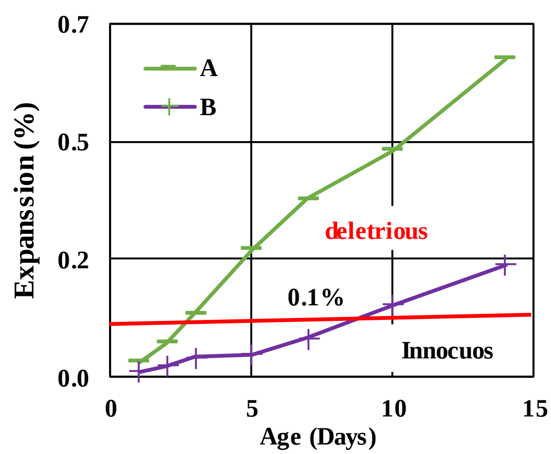

Figure 1. ASR Expansion of mortar bar (ASTM)

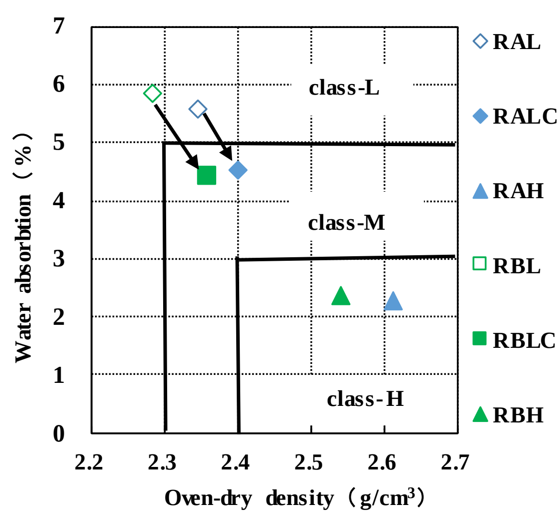

Figure 2. Density and Water Absorption ratio of RCA

3. ASR EXPANSION

The results of f ASR of RAC are shown in the following. Figure 3. shows the ASR expansion of RAC with high content of alkali. The RALC show significant reduction despite exceeding the limits of 0.05% when compared to RAL and RAH. This effect on RALC is as result of carbonation, because the calcium carbonate in the attached mortar had prevented the diffusion of silica ions from the original aggregate of RCA into the new mortar RAC that possess high alkali. But in the case of RAL and RAH such phenomenon does not occur which prompted high expansion of ASR. Figure 4. shows the ASR expansion of RAC of RCA (B) with high content of alkali. RBLC shows a low level of ASR expansion when compared with RBL and RBH. The carbonation RBL has significant influence in reducing the ASR expansion of the RBLC. Figure 5. shows the ASR expansion of RAC of RCA (A) without high content of alkali, it shows that RALC show the tendency of reduction in ASR expansion as the expansion reaction continue. This indicates that application of carbonation technology to cure the RCA can reduce the effect of ASR in RAC. The Figure 6. shows the mechanism of the ASR of RAC made with carbonated RCA. In the case of concrete made with high RCA (RAH and RAB) the ASR expansion is very high because high RCA possess no attached mortar and silica would diffuse easily from the original aggregate into the new mortar thereby accelerating the ASR reaction. For un-carbonated RCA (RAL and RBL) the silica would diffuse into the new mortar but not as quickly as High RCA. For carbonated RCA (RALC and RBLC), the calcium carbonated formed in the attached mortar ($Ca(OH)_2 + CO_2 = CaCO_3 + H_2O$) has prevented the diffusion of the silica ion from the original aggregate into the new mortar thereby slowing down the ASR reaction that lead to low expansion of the ASR.

4. CONCLUSION

With the aim of reducing the effect of ASR in RAC, the following were concluded:

1. Carbonation of RCA can reduce the effect of ASR in the RAC as the carbonation in the attached mortar has prevented the diffusion of silica from original aggregate into the new mortar of RAC.
2. The High class of RCA of ASR effected concrete can increase the ASR expansion of the RAC because of easily diffusion of silica ion from the original aggregate into the new mortar of RAC

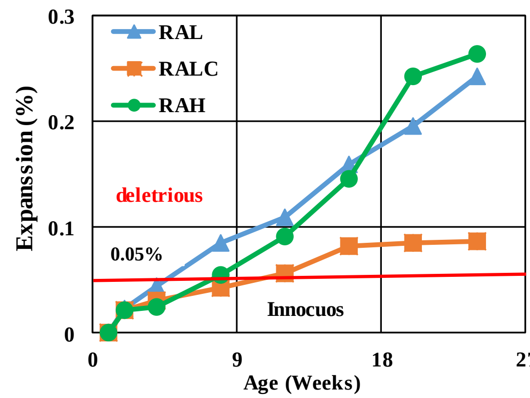

Figure 3. ASR Expansion of RAC with Alkali

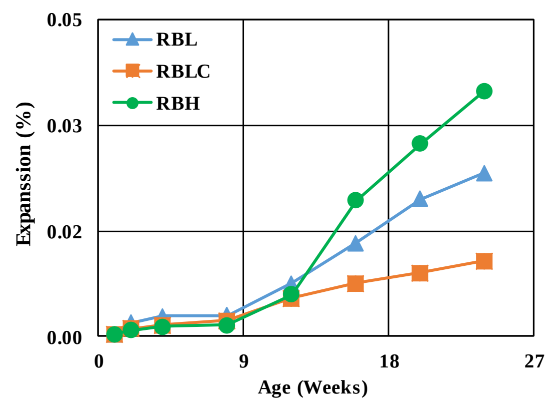

Figure 4. ASR Expansion of RAC with Alkali

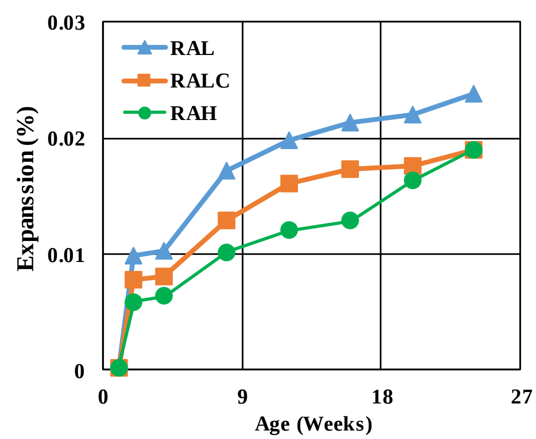

Figure 5. ASR Expansion of RAC without Alkali

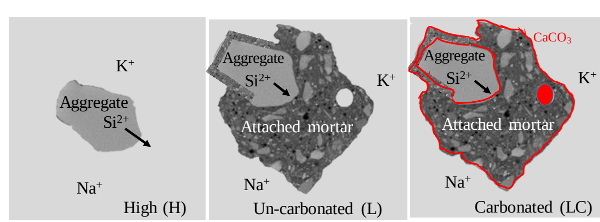

Figure 6. The Mechanism of the ASR of RAC made with Carbonated RCA

REFERENCE

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