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Research article

A SOLUTION TO THE PROBLEM OF RECYCLED CONCRETE AGGREGATES.

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ABSTRACT.

There are a whole lot of construction and demolition waste being generated in Port Harcourt area of Nigeria due to rapid infrastructural development in the area. The recycling of the concrete, bricks and masonry rubble as concrete aggregates is an important way to contribute to a sustainable material flow; but this is not the case in Nigeria because of the various uncertainties limiting the widespread use of Recycled concrete Aggregate (RCA).

This paper proposes the use of an efficient silicon-based polymer treatment to reuse RCA easier. The treatments were carried out and were compared. It is concluded that this kind of treatment can improve the general properties of RCA, particular its rate of water absorption.

KEYWORDS: Sustainable material flow, Recycled concrete aggregate, Polymer, Treatment, Water absorption.

INTRODUCTION.

There are a whole lot of construction and demolition waste being generated in Port Harcourt area of Nigeria due to rapid infrastructural development in the area. Increasing problems with waste management and reducing natural sources of aggregates (sands and gravels) support the recycling of the accumulated waste materials. Therefore, recycling of the concrete, bricks and masonry rubble as concrete aggregates is an important way to contribute to a sustainable material flow. Unfortunately, the composition of these aggregates can vary substantially and consequently their properties have a significant influence on the properties of the concrete (Chen et al 2003; Khalaf and DeVenny 2005; Khalaf and DeVenny 2004, Ryu 2002; Hottmann et al 2012). In fact, the properties of concrete made with recycled concrete aggregates, are inferior to those made with natural aggregates.

Figure 1: Concrete Demolition Waste along Trans-Amadi, Port Harcourt, Nigeria.

The amount and quality of adhered mortar affect the physical properties of recycled aggregates, because the abhorred mortar is a porous material, and its porosity depends on the w/c ratio of the recycled concrete employed (Etxeberria et al 2007; Evangelista and De Brito 2010). The dimension of the recycled aggregate and the crushing procedure have an influence on the amount of adhered mortar (Nagataki 2000; Hansen and Narud 1983; Hansen 1986; Hasaba et al 1981; Mukai and Koizumi 1979).

The density and absorption capacity are some of the most significant properties of recycled aggregates that depend on adhered mortar, and which distinguishes recycled aggregates from natural aggregates. Also, porosity and cracks of the old cement mortar affects the bond between the RCA and cement paste when used in new concrete.

One way of improving RCA properties is to modify the mixing process in order to improve the behaviour of the concrete according to Otsuki et al (2003) and confirmed by Kong et al 2010. As for the mix design, most methods maintain use of fine natural mineral additives as partial replacement of cement and/or adding of reducing agent to water (Tam et al 2007; Kou et al 2011).

This paper presents the influence of an efficient polymer based treatment in RCA (4-20mm) with a view to improving its properties, such as its water absorption, the microstructure and toughness resistance, as to bring it closer to natural aggregates.

MATERIALS.

A. <u>Aggregates.</u>

Crushed granite was used as the natural aggregates, while two types of recycled concrete aggregates (RCA) were used. The first type of recycled concrete aggregates were crushed and obtained from the demolition of reinforced concrete buildings along Trans-Amadi, Port Harcourt, Nigeria (fig 1). The second type was made from conventional concrete, which were made to overcome the problem of heterogeneity due to the complexity of the mixtures of recycled aggregates. After 90 days curing, the homemade concrete was crushed into distinct granular fractions to form "conventional recycled aggregates" (CRA).

B. Set Of Silicon Based Emulsions.

A commercial silicon based emulsions which is a suitable water repellent polymer was used in different concentrations to treat RCA.

C. Polymer Treatment.

RCA were soaked in different concentrations of the polymer under a controlled laboratory environment. The optimal concentration of polymer based treatment required to improve the recycled aggregates were determined.

D. Water Absorption Measurement And Abrasion Resistance By Los Angeles.

The water absorption, porosity and toughness resistance were carried out on RCA treated by silicon polymer impregnation (SI - RCA) and on untreated recycled concrete aggregates.

RESULTS

A. Natural And Untreated RCA

Determination of water absorption for natural and untreated RCA was by total emulsion for 48 hours. Capillary water absorption coefficients were determined on different granular fraction before any treatment and are presented in fig 2. Natural aggregates did not absorb much water. As shown in fig 2, the water absorption coefficient is less than 1% for the natural aggregate, while for the recycled aggregates it is about 4% and about 5% for the RCA and CRA respectively. The presence of primary adhered mortar of recycled concrete aggregates is the main reason responsible for the increase of water absorption.

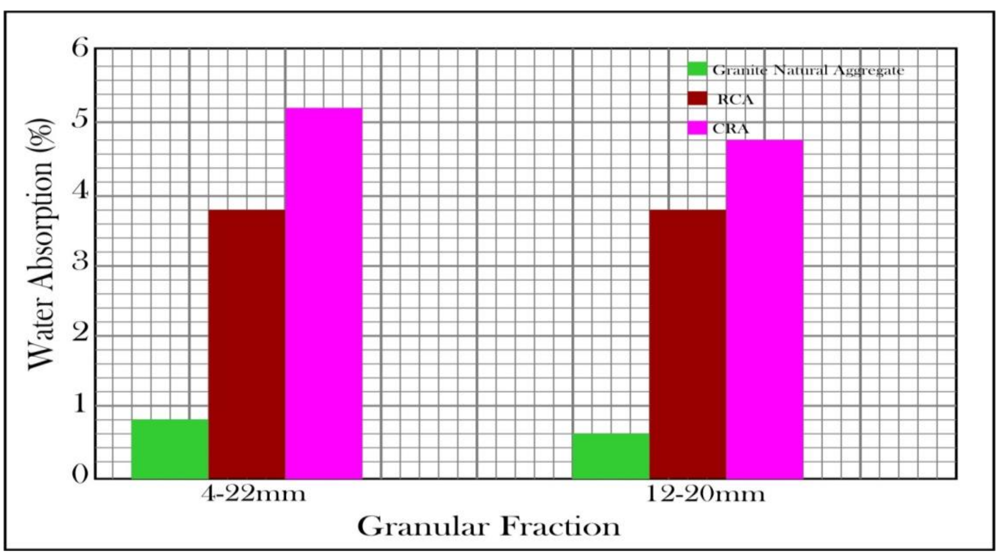

Figure 2: Variation Of Water Absorption Coefficient With Granular Fraction.

B. Treated RCA

Different batches of RCA were treated with different concentrations of the silicon based polymer emulsion with a view to determine its impact on water absorption capacity of RCA. The water absorption coefficient was determined after 48 hours of total water immersion. The ratios of initial water absorption to final water absorption were calculated for each composition.

Fig 3 shows the water absorption coefficient ratio between treated and untreated recycled concrete aggregates; which clearly shows that the water absorption coefficient ratio is directly proportional to the polymer concentration. At about 30% concentration, the water absorption is about seven times lower than that of untreated RCA and about nine times lower than untreated CRA. Having used the polymer based treatments on two kind of recycled concrete aggregates (RCA and CRA), the result obtained show the positive effect of polymer treatment on water absorption capacity of RCA. It appears that the polymer treatment is an appropriate treatment on RCA.

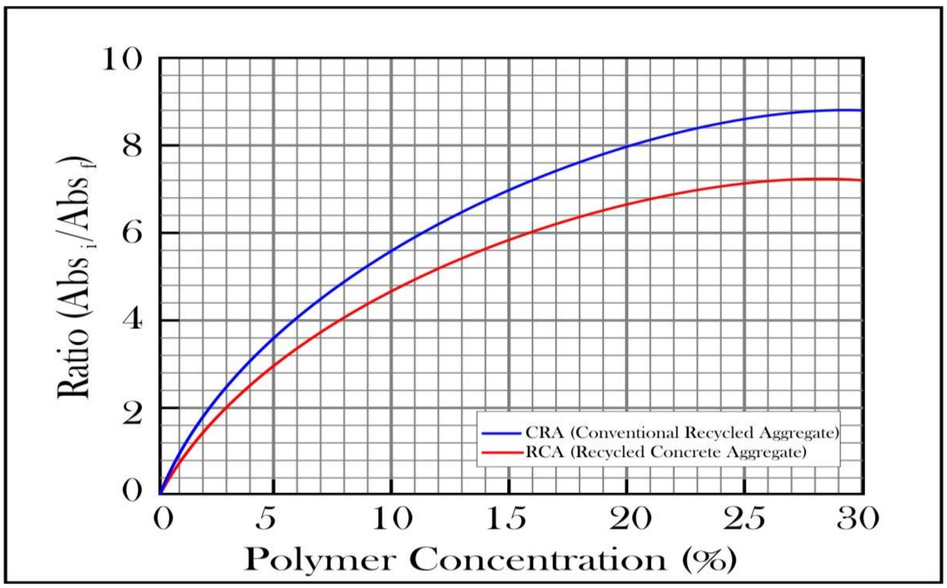

Figure 3: Variation of Water Absorption Coefficient Ratio with Polymer Concentration.

Impregnation of masonry with water repellent silicon based emulsion polymer appears to be the most successful method of protection from capillary water absorption. This kind of water repellent treatment are already being used as surface treatment for construction materials (Speath et al 2010; Zhao et al 2011). Both treated RCA type by polymer emulsion are efficient.

Table 1: LA Coefficients Of Natural Aggregates, Treated And Untreated RCA.

Aggregate Type	Los Angeles (LA) Coefficients (%)	
Natural aggregates	4-12mm	12-20mm
Granite	22-23	22-23
Recycled concrete aggregates	4-12mm	12-20mm
Untreated CRA	25±2	26±2
Treated CRA	24±2	21±2

The polymer treatment implies the formation of polymeric film, which should also provide an effect of consolidation on recycled concrete aggregates. It supplies water repellent qualities which decreases significantly water absorption and reinforced cement matrix of RCA, thus protecting recycled concrete aggregates, especially adhered mortars against mortar penetration.

Table 1 shows the results of the Los Angeles measurements and the impact of the polymer treatment on toughness resistance. The table shows that the polymer treatment slightly improves the Los Angeles coefficient.

CONCLUSION.

As a result of treatment of RCA with a silicon based polymer, there is improvement in the water absorption resistance. The polymeric film developed in the pore network allows the significant reduction of water adsorption capacity. Water repellent performance is achieved on treated RCA.

Priorities for further research include testing the polymer based treatment on other concrete aggregates and other granular fractions and studying other kinds of silicon based polymers. Physical and chemical interaction should be studied with a view to understanding better, the mechanism induced by the polymer treatment on RCA as well as its durability.

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