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Effect of Alkyd Resin Concentration on the Flexural Strength of Recycled Coarse Aggregate Concrete

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Abstract
This work was aimed at examining the effect of alkyd resin concentration on the flexural strength of recycled coarse aggregate concrete. The work broadens the application of recycled coarse aggregate using alkyd resin treatment for the water absorption effect of the adhered mortar. Recycled coarse aggregates were immersed into the resin solution of varied concentration of 10%, 20%, 30%, 40% and 50% to obtain coated recycled aggregates of different thicknesses. The aggregate samples were subjected to impact value test to ascertain the resistance to impact load and also crushing value to ascertain the resistance to crushing load. The concrete samples were subjected to flexural strength test. It was observed that the aggregate impact and crushing value of the coated samples reduced with increase in concentration of alkyd resin. It was also observed that flexural resistance of coated recycled aggregate concrete increased with the concentration of alkyd resin. The flexural strength values for 10%, 20%, 30%, 40% and 50% concentration of alkyd resin were 2.95N/mm^2, 2.96N/mm^2, 3.07N/mm^2, 3.11N/mm^2 and 3.49N/mm^2 respectively. Strength improvements were observed for coated recycled aggregate concrete. The uncoated recycled aggregate concrete had the least flexural resistance to loading when compare to natural and coated recycled aggregate concrete. The increase in concentration of coating improved flexural strength of concrete.

Keywords: *Flexural strength, Alkyd resin coating, Recycled coarse aggregate*

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1. Introduction

Concrete made from recycled aggregates (RA) are called Recycled Aggregate Concrete (RAC). Recycled concrete aggregate (RCA) are aggregates obtained by recycling clean concrete waste. Utilizing recycled aggregate is certainly an important step towards sustainable development in the concrete industry. Crushing concrete to produce coarse aggregates for the production of new concrete is one of the common methods to achieve an environmentally friendly concrete. The composition of the aggregates can vary sustainability and their properties have a significant influence on the properties of the concrete (Chen et al., 2003; Khalaf and Devenny, 2005, 2004; Ryou, 2002; Hoffman et al., 2012.

The amount of mortar that adheres depends on the crushing process and the size of the recycled aggregate (Nagatak, 2000; Hansen and Narud, 1983; Hansen, 1945; Juan and Gutierrez, 2009; Tam et al., 2007). Because recycled aggregate contains porous cement mortar, one of the most important characteristics that sets it apart from raw/natural aggregate is its ability to absorb moisture. This property can affect the qualities of both freshly-poured and hardened concrete. Recycled concrete aggregate qualities are typically improved by removing the mortar from RCA that was previously attached and reducing the loss of these properties (Juan and Gutierrez, 2009; Akbarnezhad et al., 2011; Vivian et al., 2007).

Literature showed that the major problem of the reuse of aggregate is the reduction of mechanical properties of the resultant concrete (Orie and Orojo, 2014). This has been shown to be due to the adhered mortar (Matthew et al., 2009; Dimitriou et al., 2018). This has been mitigated by treating the recycled aggregate with chemicals (Igbinigie, 2017; Otoko, 2014; Omenaimen, 2019. This will enable utilization of concrete waste in an efficient manner. It is an effort to broaden the current application of

recycled aggregate that with alkyd resin treatment, standard and safer results can be achieve.

2. Materials and methods

2.1 Materials

Crushed granite was used as a natural aggregate, and reclaimed concrete was used as an aggregate. Sharp river sand made up the fine aggregate. The cement used in this study was regular Portland cement that was bought on the open market. Alkyd resin, a non-polar coating substance, was used for the coating. The process of submerging recycled aggregates in alkyd resin, water resistance has been achieved. Alkyd resin's remarkable structural plasticity makes them an essential component of coating binders. The concrete specimen was mixed and dried using portable water.

2.2 Coating of recycled coarse aggregate with alkyd resin concentration

Alkyd resin was used to coat the recycled coarse aggregate. The recycled aggregates were submerged in the resin solution to obtain coated recycled aggregates of different thicknesses. Five batches were used to vary the alkyd resin concentration on the recycled coarse aggregate. This variation was produced by altering the alkyd resin concentration as well as the immersion period. The coating process required the creation of five separate alkyd resin solutions with varying concentrations. Their concentrations ranged from 10% to 50%. For each of the corresponding concentrations, recycled coarse aggregates were submerged in the alkyd resin solution for periods of 1 hour, 2 hours, 3 hours, 4 hours, and 5 hours. So, 10% concentration takes an hour, and 20% concentration takes two hours and so on.

2.3 Aggregate Crushing Values Test (ACV)

This gives a relative measure of the resistance of an aggregate to crushing under a gradually applied compressive load. The test was carried out on the natural coarse aggregate and uncoated recycled coarse aggregate as control and also on the five groups of coated recycled aggregate with the five different thickness of coating. This test requires aggregates within the size range of 10 and 14 mm. Coarse recycled aggregate passing through the 14 mm sieve and retained on the 10 mm sieve was used for this test. The cylinder of the test was placed on a base plate and the test specimen (the aggregate) was placed in three layers of approximately equal depth, each layer being subjected to 25 strokes from the tamping rod. A crushing load was then applied on the aggregates. The aggregate crushing value was computed by obtaining the percentage of mass of crushed aggregates passing through the 2.36 mm sieve relative to the total mass examined. The ACV was expressed as a percentage for each test specimen given as:

$$ACV \quad \frac{M_2}{M_1} \times 100 \tag{1}$$

where M_1 is the total mass of test specimen, and M_2 is the Mass of the material passing 2.36 mm sieve.

2.4 Aggregate Impact Value Test (AIV)

This gives a relative measure of the resistance of an aggregate to sudden shock or impact. The impact value experiment was carried out on natural coarse aggregate, uncoated recycled coarse aggregate and the five groups of coated recycled aggregates with the three different thickness of coating. This test required aggregates within the size range of 10 mmm and 14 mm. This test was used for coarse recycled aggregates passing through the 14 mm sieve and retained on the 10 mm sieve. The procedure involved placing the test specimen in the cap of the impact machine and compacted by 25 strokes of a tamping rod. The impact machine hammer was then dropped from the top of the impact machine 15 times on the aggregates. The AIV was obtained as the percentage of crushed aggregates passing through the 2.36 mm sieve.

$$AIV = \frac{M_2}{M_1} \times 100 \tag{2}$$

where M_1 is the mass of test specimen in grams (g) and M_2 is the mass of the material passing 2.36 mm sieve in grams (g)

3. Results and discussion

3.1 Flexural strength of concrete samples

The results showed that the uncoated recycled aggregate concrete has the least flexural resistance to loading when compared to natural aggregate concrete with 37.8% reduction. It was observed that flexural resistance of coated recycled aggregate concrete increased with the concentration of alkyd resin. The flexural strength values for 10%, 20%, 30%, 40% and 50% concentration of alkyd resin were 2.95N/mm^2, 2.96N/mm^2, 3.07N/mm^2, 3.11N/mm^2 and 3.49N/mm^2 respectively. The flexural strength results of the natural aggregate concrete, uncoated recycled aggregate concrete and the coated recycled aggregate concrete samples are presented in Fig. 1.

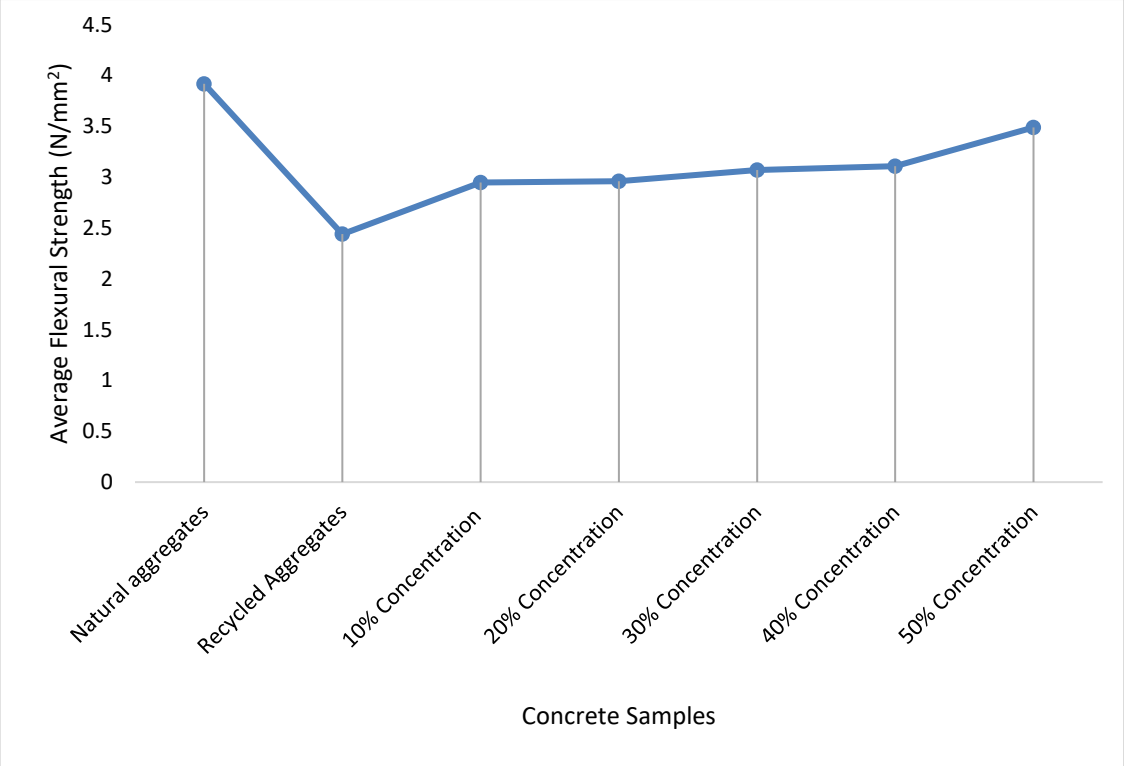

Fig 1: Flexural strength of concrete samples

3.2 Aggregate impact values of the samples

The aggregate impact values for natural and uncoated recycled aggregate were 20.23% and 31.13%. This indicates that the uncoated recycled aggregates were more subjected to lower resistance to impact load when compared with natural aggregated. The aggregate impact value of the coated recycled aggregate reduced with increase on concentration of alkyd resin. The aggregate impact value obtained for 10%, 20%, 30%, 40% and 50% concentration of alkyd resin were 25.89%, 25.58%, 25.10%, 24.37% and 23.14% respectively. The impact values of aggregate samples are presented in Fig. 2.

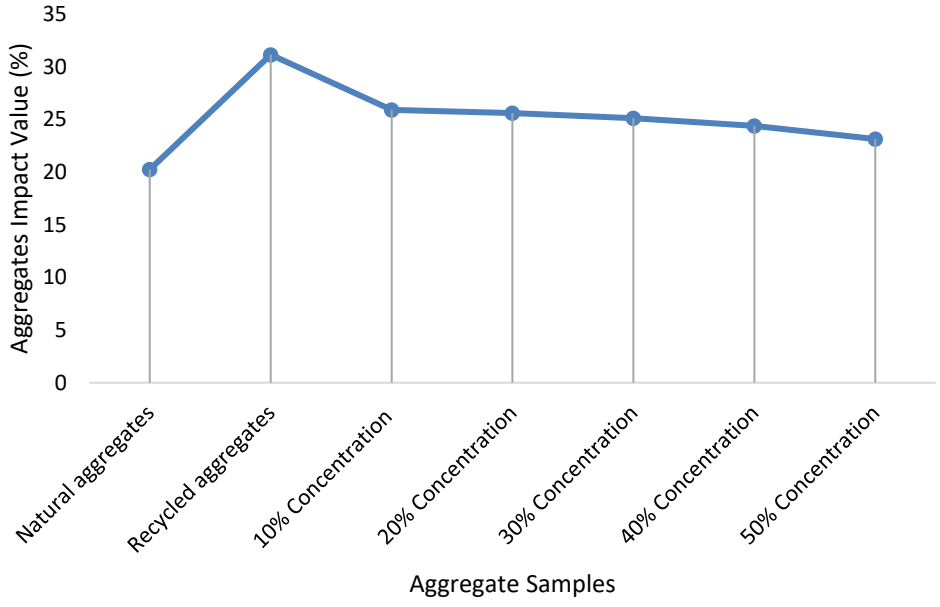

Fig 2: Aggregate impact values of the samples

3.3 Aggregate crushing value (ACV)

The results of the aggregate crushing value (ACV) test conducted on the aggregate samples are presented in Fig. 3. The aggregate crushing value for natural and uncoated recycled aggregate were 20.65% and 30.83%. It was observed that the aggregate crushing value of the coated recycled aggregate reduced with increased in concentration of alkyd resin. The aggregate crushing obtained for 10%, 20%, 30%, 40% and 50% concentration of alkyd resin were 27.76% 26.43%, 25.05%, 24.01% and 23.41%. The aggregate crush and break into smaller pieces which indicates the aggregate are of a lower quality.

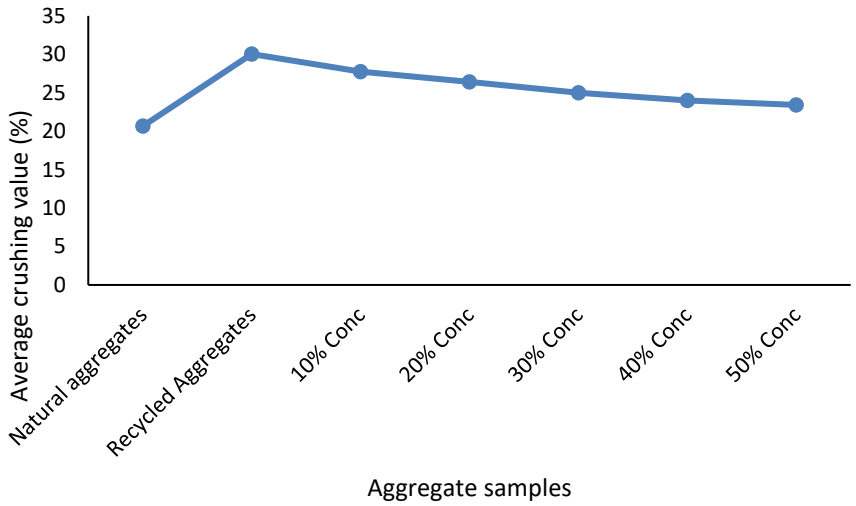

Fig 3: Aggregate crushing values of samples

3.4 Slump values of the aggregate samples

It was observed that the uncoated recycled aggregate concrete has the least workable concrete with a slump value of 18 mm. This was as a result of the high water absorption of the uncoated recycled aggregates. The natural aggregate concrete has a slump value of 38 mm. The values for slump for recycled aggregate coated with 10%, 20%, 30%, 40% and 50% concentration of alkyd resin were 26 mm, 29 mm, 31 mm, 34 mm and 37 mm respectively. The increased in concentration of alkyd resin coating of the recycled aggregate reduces water absorption and improves workability. The Slump values of the aggregate samples are presented in Fig. 4.

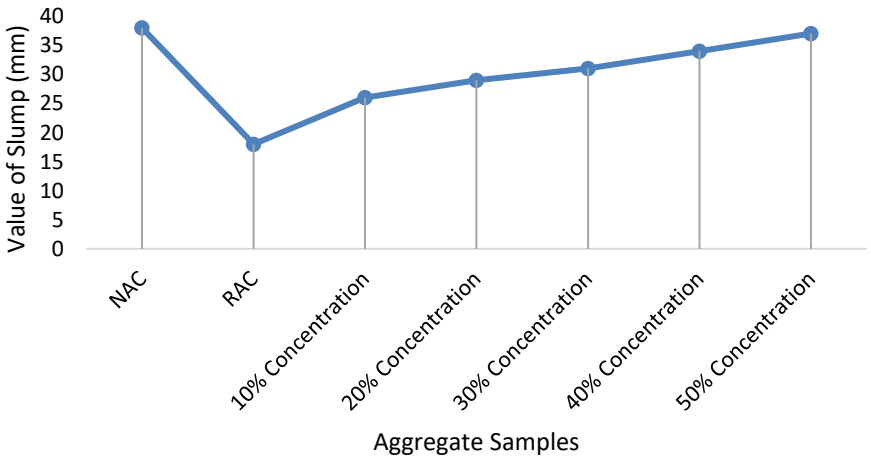

Fig 4: Slump values of the aggregate's samples

4. Conclusion

The performance of natural aggregate concrete, recycled aggregate concrete and alkyd resin coated recycled aggregate were determined. Based on the experimental study conducted, the following conclusions were made. The flexural resistance of coated recycled aggregate concrete increased with increase in concentration of alkyd resin. The uncoated recycled aggregate concrete has the least flexural resistance to loading when compared to natural aggregate. The aggregate crushing value test which gives a relative measure of the resistance of an aggregate to crushing under a gradual applied compressive load, showed that recycled aggregate has a crushing value of 30.83% when compared with natural aggregates with a crushing value of 20.65%. The crushing value of the coated recycled aggregate reduced with increase in concentration of alkyd resin. Aggregate impact value test which gives a relative measure of the resistance of an aggregate, showed that recycled aggregates have a lower resistance to impact load when compared with natural aggregates and coated recycled aggregates.

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