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PARTIAL REPLACEMENT OF COARSE AGGREGATE WITH CRUSHED CERAMIC TILES IN CONCRETE

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ABSTRACT

This paper investigated and reported the improvement of concrete properties by partial replacement of coarse aggregate with crushed waste ceramic tiles (CWCT). Compressive strength tests were conducted using 150x150x1250mm cube specimens. CWCT were used to replace coarse aggregate at 0%, 30%, 40% and 70% replacement levels in the concrete. Compressive strengths at 7, 14 and 28 days curing age was determined at all levels of replacement of coarse aggregate with CWCT. The compressive strength at 7, 14 and 28 days increased as the content of the CWCT was increased between 0%- 30%. At 40% waste ceramic tiles content, the values start to decrease. The optimum replacement value of crushed waste ceramic tile is 30%.

Key Words: crushed waste ceramic tiles, coarse aggregate, compressive strength, concrete.

INTRODUCTION

Solid waste generation is on the increase world-wide. Apart from defacing the landscape, they also constitute a major environmental hazard. In order to preserve the environment, there are several researches already concluded and there are also new ones being carried out to explore the reuse of solid wastes.

Most of these solid wastes have been found to improve concrete properties. Concrete is the world's second most utilized substance after water and it shapes the built environment. It is also recoverable as recycled aggregate.

An estimated 33 billion tonnes of concrete are manufactured globally each year. This means that over 1.7 billion truckloads each year, or about 6.4 million truckloads a day, or over 3.8 tonnes per person in the world each year.

Twice as much concrete is used in the construction around the world than the total of all building materials, including wood, steel, plastic and aluminium (Recycling Concrete Aggregate SOAS, University of Liverpool, (www.ecosmartconcrete.com/enviro statistic.cfm , 13/02/2018).

(Mojedu et al, 2014) investigated the suitability of broken tiles as coarse aggregates in concrete production, and observed that the compressive strength and density are maximum for concrete cubes with 100% crushed tiles and minimum when broken tiles content is 100%. It was also reported by (Mojedu et al, 2014) that replacement of crushed granite with 39% to 57% broken tiles content showed satisfactory result.

(Hemanth et al, 2015) investigated the effect of waste ceramic tiles as partial replacement of coarse and fine aggregate in concrete and concluded that the compressive strength increased for all mixes and the maximum compressive strength was obtained for the mix having 10% of crushed tiles and 20% of tiles powder. They concluded that the optimum percentage of coarse aggregate that can be replaced with crushed tiles is 10%.

(Tavakoli et al, 2013) studied the properties of concretes produced with waste ceramic tile aggregate and observed that the optimal replacement of ceramic tile aggregate for sand falls within 25% to 50% and 10% to 20% replacement levels was the best range for coarse aggregates. Further observation showed an increase in compressive strength and a decrease in unit weight due to the adverse effect of water absorption.

(Binici, 2007) used crushed ceramic tiles and pumice stone as partial substitute for fine aggregates in the production of mortar and concrete. The results showed that the resultant product had good compressive strength and abrasion resistance, as well as strong resistance to chloride attacks.

(Portella et al, 2006) carried out a noteworthy study involving the possibility of incorporating ceramic waste from electrical porcelain into concrete structures. The study demonstrated the viability or=f reuse of electrical porcelain, however, the damaging effect of certain by-products which generated an alkali-aggregated reaction made it necessary to use sulphate resisting cement.

(Gomes, 2009) also investigated the viability of incorporating coarse aggregate from concrete waste and ceramic block waste in the production of new concrete and concluded that with regards to durability, structural concrete can be made using recycled aggregates, but that the 4-32mm fraction of natural aggregates cannot be totally substituted.

(Ikponmwosa and Ehikhuenmen, 2017) investigated the effect of ceramic waste as coarse aggregate on strength properties of concrete. They applied replacement levels of 25%^, 50% and 75%. They concluded that ceramic waste tiles could be used for both structural and no structural works and recommended that beyond 75% replacement level, ceramic waste material should not be used in concrete structures. Where strength is the major consideration.

(Prasad et al, 2016) also studied the partial replacement of coarse aggregate by crushed tiles and fine aggregate by granite powder to improve concrete properties. The combustion of waste crushed tiles were replaced by coarse aggregate by 10%, 20%, 30% and 40% and granite powder were replaced in place of fine aggregate by 10%, 20%, 30% and 40% without changing the mix design. It was observed that there was increase in compressive strength, split tensile strength, flexural strength, bond strength and water absorption as the content of the ceramic powder was increased.

This study investigated the improvement of compressive strength by partial replacement of coarse aggregate with crushed waste ceramic tiles at replacement levels of 0%, 30%, 40% and 70%. Gaps in replacement levels of coarse aggregate with crushed waste ceramic tiles is the major objective of this study as against previous studies. These are primarily 30%, 40% and 70% replacement levels.

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MATERIALS AND METHOD

Cement

The cement used in the study was Portland Lime Cement (Plc) (Grade 42.5) produced at DANGOTE CEMENT INDUSTRIES Plc. It conformed to (BS B.S. EN 196-, 2006]

Fine Aggregate

Fine aggregate used was obtained from clean river sand at Oyigbo, a suburb of Port Harcourt. The maximum size was 4.75mm. Impurities were removed and it confirmed to the requirements of (BS 812-211,1992)

Crushed Waste Ceramic Tiles.

Ceramic tiles were obtained from off-cuts from building sites. They were crushed to about 20mm size manually with the aid of a hammer and sieved through 20mm sieve.

Coarse Aggregate

Coarse aggregate used is crushed angular and rough textured granite obtained from Ishiagu in Ebonyi State in South Eastern Nigeria. Maximum size was 20mm. It conformed to of (BS 812-211,1992)

Water.

Potable water used was obtained from the Civil Engineering Laboratory of the Rivers State University of Science & Technology. It conformed to (BS 3148, 1980).

Preparation of the Waste Ceramic Tiles into Fine Aggregate.

The (CWCT) was crushed and sieved to a size of between (12.5 – 19.0 mm). Physical tests on fine aggregate, was carried out in order to determine their gradations and relative densities.

Concrete Mixture

The mix ratio used for the experiment is 1:2:4 by weight (cement: fine aggregate: coarse aggregate), while the water/cement ratio of 0.5 was used. Coarse aggregate was replaced with CWCT at 0%, 30%, 40%, and 70% replacement levels. For each replacement level, three concrete cubes specimens were prepared for the compressive strength tests. The average values were obtained from the three tests specimens.

Compressive Strength

A total of 12 concrete cubes were prepared using 100% coarse aggregate as well as, 30%, 40% and 70% CWCT replacing coarse aggregate. The concrete cubes were cured and crushed after 7, 14 and 28 days and the compressive strengths were recorded as observed. The average values of each set of here test cubes were taken as the representative value. Test was performed in accordance with (B.S.1881-116, 1983).

RESULT

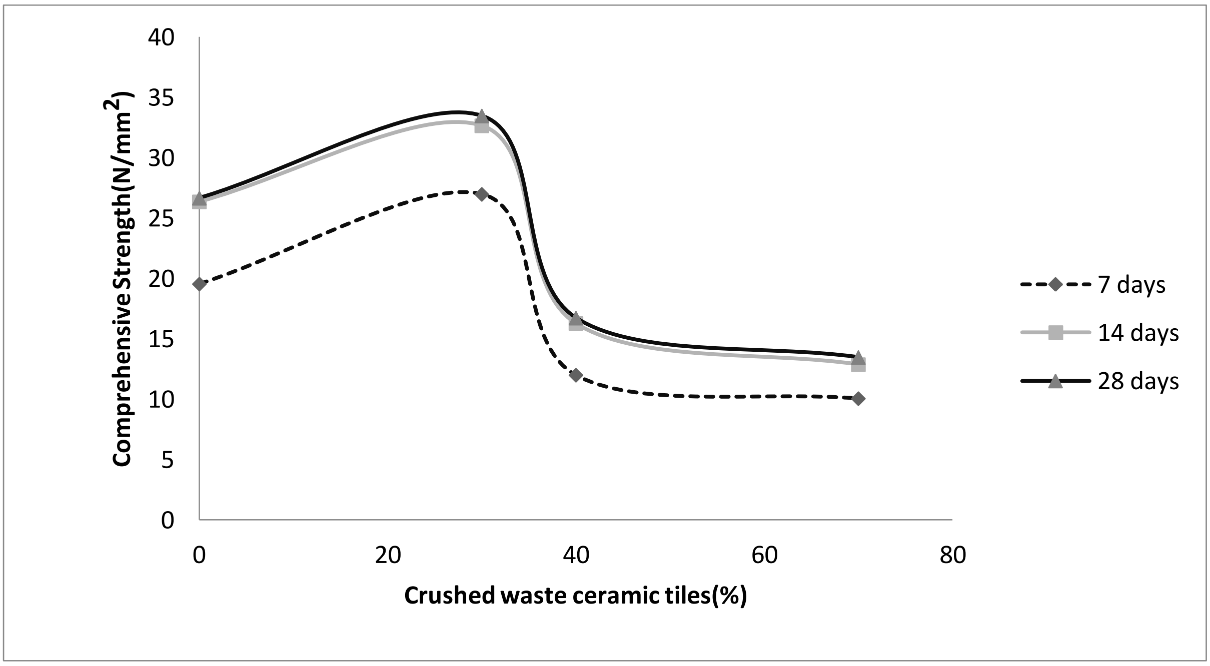

Figure 1 - Comprehensive strength versus percentage crushed waste ceramic tiles

DISCUSSIONS

Properties of ceramic coarse aggregate

used for the experiment

Specific gravity	2.40
Water absorption	0.18%
Impact Value	12.0%
Abrasion	20.5%

These compared favourably with values of normal coarse aggregate shown below.

Specific gravity	2.68
Water absorption	0,20%
Impact Value	10.5%
Abrasion	22.0%

Table 1 shows the properties of crushed waste ceramic tiles. The ceramic tiles above is largely composed of clay minerals, fedspar, Silica and Lime

Compressive Strength

Fig.1 is the plot of the compressive strength against percentage replacement of coarse aggregate with CWCT after 7, 14 and 28 days of curing. The compressive strength of the concrete cubes increases as the percentage CWCT increased. At all curing ages, the optimum crushed waste ceramic tile occurs at 30% replacement level. Thereafter the compressive strength starts tom decrease. The decrease of compressive strength beyond 30% replacement of coarse aggregate with CWCT may be due to the flaky nature and smooth surface texture of ceramic waste aggregate, these probably resulted in poor bonding properties of the matrix. (Ikponmwosa and Ehikhuenmen, 2017)

The following conclusions were drawn from the analysis of the result of the experiment.

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(a) The use of crushed waste ceramic tiles increases the compressive strength of concrete between (0%-30%) replacement level.
(b) The optimum compressive strength occurs at 30% CWCT replacement.
(c) The compressive strength starts to decrease after 30% CWCT replacement level.
(d) The use of CWCT resukts in cost reduction per cubic metre of concrete.

ABBREVIATIONS

BS = British Standards
CWCT = Crushed Waste Ceramic Tiles
PLC = Portland Limestone Cement

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