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Effect of Crushed Waste Ceramic Tiles (CWCT) as Partial Replacement for Fine Aggregate in Concrete

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Abstract The reuse of crushed waste ceramic tiles as a substitute for fine aggregate in concrete has been investigated in this study. Waste ceramic tiles obtained from building demolition sites and left-overs from new building sites were used. The crushed waste ceramic tiles were substituted in place of fine aggregates in the following percentages (0%, 20%, 25%, 30% 35% and 40%) in the concrete mix. The water /cement ratio used was 0.6. The compressive strength of the concrete cast with the above partial replacement of fine aggregate were determined after, 7 and 28 days age of curing. The flexural strength was determined after 28 days. The results indicate that the maximum compressive and flexural strength is obtained at 40% replacement level of fine aggregate with crushed was ceramic tiles.

Keywords: *concrete, fine aggregate, waste ceramic tiles, compressive strength, flexural strength*

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1. Introduction

The earliest data of he application of ceramic waste materials in construction started in the 1920s in Holland, when the demolished rubble and slag were processed as aggregates in the so-called gravel concrete used for the residential building construction. At the end of World War II, Netherlands used the rubble as a base material and as an aggregate for concrete and asphalt [1].

Rapid industrial development causes serious problems all over the world such as depletion of natural aggregates and create enormous amount of waste material from new construction and demolition activities. One of the very effective ways to reduce this problem is to utilize the wastes from these construction and demolition activities. Ceramic materials contribute about 45% (the highest percentages) of wastes. Ceramic waste is durable, hard and highly resistant to biological, chemical and physical degradation forces [2].

Several waste materials such as stone dust, over burnt bricks, M-sand, glass powder, coconut shells, waste tires, slag, fly ash, broken glass pieces, rice husk ash, coconut shell ash have been used in concrete to partially replace the basic materials [2].

[1] investigated the partial replacement of fine aggregate with ceramic and demolition waste in rigid pavement. They concluded that by using ceramic and demolition waste 40% natural fine aggregate can be saved while making rigid pavement. It was also established that up to 20% demolition waste and 20% ceramic waste, the compressive strength is more than that of referral concrete.

[3] had found out experimentally that the use of ceramic waste powder in cement concrete 30% ceramic waste powder can replace fine aggregate in cement concrete without loss off compressive strength. They also concluded that only about 1% loss of split tensile strength is obtained compared to conventional concrete.

[4] also investigated the effect of waste ceramic tiles in partial replacement of coarse and fine aggregate of concrete. In the study waste crushed tiles were used to partially replace the fine and coarse aggregate (10% and 20%). They observed that the optimum percentage of coarse aggregate that can be replaced by crushed tiles is 10%.

[2] also studied the reuse of ceramic tiles waste (CWT) as aggregate in concrete. In their study, ceramic tile waste was used in the concrete as a replacement for natural coarse aggregate with (0%, 10%, 20%, and 30%) of the substitution and M20 grade concrete were used. The concrete moulds were cast and tested for compressive strength and split tensile strength after a curing period of 3, 7 and 28 days. The result indicate that the maximum compressive strength is obtained for 30% replacement of ceramic tile aggregate with natural coarse aggregate.

[5] studied the effect of replacing crushed tile as a coarse aggregate in concrete with partial replacement of (0%, 50%, and 100%) of natural aggregate. The mechanical and physical tests were carried out. The strength and unit weight of crushed tile aggregate concrete were decreased compared to control concrete. Absorption and capillary coefficients were increased compared to the control concrete.

[6], investigated the effect of ceramic waste as coarse aggregate on strength properties of concrete. The study concluded that ceramic waste could be used for both structural and non-structural works and recommends that

beyond 75% replacement level, ceramic waste material should not be used in concrete structures where high strength is the major consideration.

[7] also concluded that ceramic scrap can be partially used to replace conventional coarse aggregates (10% and 20%), without affecting its structural significance.

Properties of fresh and hardened concrete using ceramic waste as coarse aggregate and bottom ash as fine aggregate has been compared with the properties of conventional concrete [8]

Concrete with ceramic waste powder has a minor strength loss but possess increased durability performance because of its pozzolanic properties. As for the replacement traditional coarse aggregates by ceramic coarse aggregates, the results are promising but they underperform slightly in water absorption meaning that replacement of traditional sand by ceramic sand is better option. [9]

This work investigated the potential of partial replacement of fine aggregate with crushed waste ceramic tiles (CWCT) in the production of concrete. The major objective of re-using crushed waste CWCT in the production of concrete is to ensure that such products which normally should constitute environmental hazards are re-used in order to preserve the environment.

Previous works on the re-use of CWCT as fine aggregate considered replacement of coarse aggregate with CWCT up till 30%. This study focused on CWCT as a partial replacement of soley fine aggregate. In the concrete up till 40% replacement level.

2. Materials and Method

2.1. Materials

2.1.1. Cement

The cement used in the study was Portland Lime Cement (Plc) (Grade 42.5) produced at DANGOTE CEMENT INDUSTRIES Plc. It conformed to [10]

2.1.2. 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 [11]

2.1.3. Crushed Waste Ceramic Tiles

Ceramic tiles were obtained from off-cuts from building sites. They were crushed and sieved and subjected to Particle Size Distribution Test. The maximum size was 4.50mm.

2.1.4. 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 [11].

2.1.5. Water

Potable water used was obtained from the Civil Engineering Laboratory of the Rivers State University of Science & Technology. It conformed to [12].

2.2. Methodoloy

2.2.1. Preparation of the Waste Ceramic Tiles into Fine Aggregate

The (CWCT) was crushed and sieved to a size of 4.5mm. Physical tests on fine aggregate was carried out in order to determine their gradations and relative densities.

2.2.2. 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 0.6 was used. Fine aggregate was replaced with CWCT at 0%, 20%, 25%, 30%, 35% and 40% replacement levels. For each replacement level, three concrete cubes specimens were prepared for the compressive strength and another three beams for the flexural strength tests. The average values were obtained from the three tests specimens.

2.2.3. Sieve Analysis

Sieve analysis of the fine aggregate, coarse aggregate, CWCT aggregate was carried out to determine the particle size distribution. The sieve analysis was carried out in accordance with [13].

2.2.4. Specific Gravity

Test was performed in accordance with [14].

2.2.5. Compressive Strength

A total of 18 concrete cubes were prepared using 100% natural fine aggregate as well as a 0%, 20%, 25% 30%, 35% and 40% CWCT replacing fine aggregate. The concrete cubes were cured and crushed after 7 and 28 days and the compressive strengths were recorded as observed.

Test was performed in accordance with [15]

2.2.6. Flexural Strength

A total of 18 concrete beams were prepared using 100% natural fine aggregate as well as a 0%, 20%, 25% 30%, 35% and 40% CWCT replacing fine aggregate. The beams were subjected to flexural strength test after 28 days, in accordance with [16].

3. Result and Discussions

3.1. Chemical Composition Ceramic Tiles [17]

Table 1

Contentts	w/w %
SiO_2	55.24
CaO	28.70
Al_2O_3	13.25

Table 1 shows the chemical composition of the normal house hold ceramic tiles as obtained from the internet. Ceramic tiles from Table 1 above is larley composed of clay minerals, fedspar, Silica and Lime.

3.2. Specific Gravity

The specific gravities of the fine, coarse aggregate and crushed waste ceramic tiles is shown in Table 2.

Table 2. Physical properties of Aggregate

Property	Coarse Aggregate	Crushed Waste Ceramic Tiles	Fine
Specific Gravity	2.8	2.8	3.0

The specific gravity of the CWCT is very close to that of the fine aggregate (sand).

3.3. Compressive Strength

Figure 1 is the plot of the compressive strength against percentage replacement of fine aggregate with crushed waste ceramic tiles. The compressive strength of the concrete cubes decrease as the percentage CWCT increased between 0%-20% CWCT. The compressive strength increased between 25% - 30% CWCT.

The compressive strength decreased at 35% CWCT before peaking again at 40% CWCT. This result is in line with the result earlier obtained by [18]. The increase in compressive strength between (25%-30%) may be due to dense packing of voids by angular sized ceramic tiles. While the decrease in compressive strength may be due to less dense packing of the CWCT.

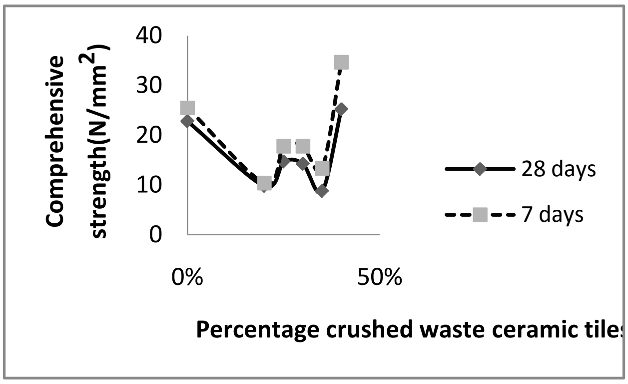

Figure 1. Plot of comprehensive strength versus crushed waste ceramic tile

3.4. Flexural Strength

Figure 2 is a plot of the flexural strength against the percentage replacement of fine aggregate with CWCT. The pattern observed for the compressive strength is repeated. The flexural strength of the concrete beams decreased as the percentage of the CWCT increased between (0%-20%) CWCT. Thereafter the flexural strength increased between 25-30% CWCT. The flexural strength decreased at 35% CWCT replacement before peaking at 40% CWCT replacement. Decrease in flexural strength with increase in CWCT is line with the observations of [7] and [19], less dense packing of the CWCT.

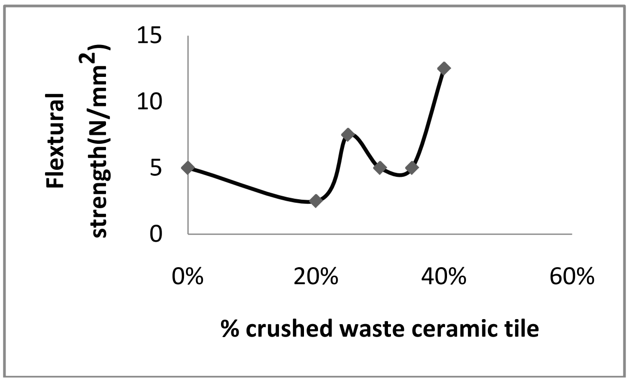

Figure 2. Plot of flexural srength versu crushed waste ceramic tile

4. Conclusion

The following conclusions were drawn from the result of the investigation.

(a) CWCT can be used to replace fine aggregate at between 25%-30% replacemet level and also at 40% replacement level.

(b) The reason fr the decrease in the compressive and flexural strength at between 30%-35% is still being investigated.

Abbreviations

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

References

[1] Saswat, H and Vikas, S.2016. Comprehensive Literature review on partial replacement of fine aggregate with ceramic and demolition waste in rigid pavement. International Journal of Innovative Research in Science Engineering and Technolgy, 5(8).

[2] Shruti, H.G., Gowtham, P.M.E. Samreen, T. and Syed, R.P. 2016. Reuse of ceramic waste as aggregate in concrete, International Research Journal of Engineering and Technology, 3(7), pp. 115-119.

[3] Hardil, P. and Arora, N.K. 2015. Use of ceramic waste powder in cement concrete. International Journal for Innovative Research in Science and Technology, 2(1).

[4] Hemanth, K.C., Ananda, R.K., Sateesh, B.K., Guraviaiah, T., Naveen, R.K. and Jami, S. 2015. Effect of waste ceramic tiles as partial replacement of coarse and fine aggregate of concrete. International Advanced Research Journal in Science, Engineering and Technology, 2(5), pp. 13-16.

[5] Topcu, I.B and Canbaz, M. 2007. Utilization of crushed tile as aggregate in concrete. Iranian Journal of Science and Technology. Transaction B. Engineering, 31, pp. 561-565.

[6] Ikponmwosa, E.E. and Ehikhuenmen. 2017. The effect of ceramic waste as coarse aggregate on strength properties of concrete. Nigerian Journal of Technology, 36(3), pp. 691-696.

[7] Reddy, M.V. and Reddy, C.N.V.S. 2007. An experimental study on use of Rock Flour and insulator ceramic scrap in concrete. Journal of Institution of Engineers, India, 88, pp. 47-50.

[8] Karthikkrishman, S. and Senthamarai, R.M. 2006. Strength characteristics of concrete with ceramic bottom ash. National Conference on recent developments in concrete technology, Government College of Technology, Coimbatore – 641013.

[9] Pacheco-Torgal, F and Jalali, S.2010. Reusing ceramic wastes in concrete. Construction and Building Materials, Vol. 24, pp 832-838.

[10] B.S. EN 196-0; 2016. Method of Testing Cement. Determination of fineness. British Standards Institute. London, United Kingdom.

[11] B.S. 882; 1992.Specification for Aggregates from natural sources for concrete. British Standards Institute. London, United Kingdom.

[12] BS 3148; 1980. Methods of test for water for making concrete. British Standards Institute. London, United Kingdom.

[13] BS 812-2 1995.Testing aggregates. Methods for determination of density. British Standards Institute, London, United Kingdom.

[14] BS. 410 1996. Specification for test sieves. British Standards Institute. London, United Kingdom.

[15] B.S.1881-116; 1983. Testing Concrete. Method for determination of Compressive Strength of Concrete cubes. British Standards Institute. London, United Kingdom.

[16] BS EN 12390-5; 2009. esting of Hardened Concrete. Flexural Strength of test Specimen. British Standards Institute. London, United Kingdom.

[17] MET-CHEM LABORATORIES, VODADARA

[18] Hitesh, K.M., Vikas, S. and Agarwal, V.C. Durability of concrete with ceramic waste as fine aggregate replacement. International Journal of Engineering and Technical Research (IJETP), Vol. 3, No.8, pp. 196-199, 2015.

[19] Siddesha, H. Experimental Studies on the effect of ceramic fine aggregate on the strength properties of concrete. International Journal of Engineering, Science and Technology. Vol. 1, No.1, pp. 71-76, 2011.