American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-6, Issue-4, pp-158-163
www.ajer.org
Research Paper Open Access

Effect of Salt Water on the Compressive Strength of Ceramic Powder Concrete

[1]Ibrahim ASIWAJU-BELLO,[2]Oladimeji OLALUSI, [1]Festus OLUTOGE
[1]Civil Engineering Department, University of Ibadan, Ibadan Nigeria
[2]Department of Civil Engineering, Stellenbosch University, South Africa.

ABSTRACT:*The ceramic industry inevitably generates wastes, irrespective of the improvements introduced in manufacturing processes.This research examines the feasibility of using ceramic wastes in concrete and the effects of fresh and salt water environments on the compressive strength of the concrete. Inthis study the cement has been replaced with ceramic waste powder accordingly in the range of 0%,5%, 10%, 15%, 20%, and 30% by weight for concrete which was cured for 56 days in two liquid media (fresh and salt water).The findings revealed that use of waste ceramic enhances the properties of concrete cured both in fresh and salt water media, based on the results from the compressive test, higher compressive strength occurred in concrete cured in salt water than fresh water. The results demonstrate that the use of ceramic powder asactive replacement endows cement with positive characteristics like major mechanical strength and the economic advantages. The concrete also exhibited a high compressive strength in both water bodies. Reuse of this kind of waste has economic and environmental advantages (onshore and offshore structures). Indirectly, all the above contribute to a better quality of life for citizens, introduce the concept of sustainability and greenhouse in the construction sector*.

Keywords: *Concrete, Ceramic waste, fresh and salt water, Mechanical and Compressive*

I INTRODUCTION

Nowadays, as development strides increase, lots of engineering construction including high rise building, embankment walls, and bridges are going on along the coastal belt of many countries. In coastal areas, there has always been a deficiency of fresh water as the available water is contaminated by sea salts. But sea water contains large amount of sea salts, which may have adverse effects on the properties of concrete.

Portland cement concrete is one of the most widely used construction materials. As the demand for concrete as a construction material increases, so also the demand for Portland cement. It is estimated that the production of cement increased from about from 1.5 billion tons in 1995 to 2.2 billion tons in 2010 [1]. Unlike other materials which are delivered in a ready-to-use form, concrete often has to be manufactured just before use at or near the job site.

The effect of sea water on concrete has been a major problem associated with structures built in salty water or cast using salt as mixing or curing water. Sea water has a salinity property because of the quantity of chlorides in the water which tend to cause persistent dampness and efflorescence on concrete. Most sea waters are fairly uniform in chemical composition, which is characterized by the presence of about 3.5% soluble salts by weight. However, from the standpoint of aggressive action to cement hydration product, thepH of seawater varies between 7.4 and 8.4.At exceptional conditions, pH value lower than 7.5 may be encountered and this occurs due to a higher concentration of dissolved CO_2, which would make the seawater more aggressive to Portland cement concrete [2].

Portland Cement Concrete production is the second only to the automobiles as the major generator of CO_2, which pollutes the atmosphere. In addition to that large amount of energy is also consumed for the concrete production. With an increased global focus on environmental concerns such as global warming, sustainable development and recycling; alternatives to conventional concrete are being researched, such as Ceramic concrete.

Pozzolans are siliceous and aluminous material which possess little cementitious properties which will in finely form with the presence of water, react chemically with calcium hydroxide (Cement) at ordinary temperatures to form compounds possessing cementitious properties. Different types of pozzolans have been identified over years which include fly ash, rice husk, and ceramics which will be put in use in this project.

Ceramics are inorganic, non-metallic solid prepared by the action of heat and subsequent cooling. Supplementing cementing material such as fine-ground ceramicswhich belongs to Pozzolans materials has found the application in concrete production couple of decades ago because of their potential to replace a part of Portland cement in concrete. The measurements of properties of materials containing supplementary cementing materials are similar with many other cement based composites. Therefore, these materials or their combinations can be considered as environment friendly cement substitutes.

Previous studies have investigated the use of ceramics in concrete assand or coarse aggregate [3]. Lopez et al. [4] observed that this substitution process wouldincrease slightly the compressive strength. Besides, Torgal and Jalali [5] also concludedthat using ceramics as sand and coarse aggregate can slightly enhance compressivestrength and also durability of concrete. Medina et al. [6]also deal with the substitution ofceramic as a coarse aggregate and finally reported a positive effect for the process. Inanother study, the effect of ceramic electrical insulator as coarse aggregate in concrete wasstudied. In this study no negative effect was reported. Furthermore, the use of thesematerials in non- structural concretes was performed in a study in which the only problemreported was the high water absorption of the materials

This research is to investigate the sustainability of using ceramic powder as partial replacement of cement and also to produce a concrete with higher compressive strength to withstand the sulphate attack on concrete in sea water environment, thereby reducing the loss of strength effect of concrete in such marine environment The results are also compared with those obtained for reference concrete containing only Ordinary Portland Cement as binder.

II MATERIALS AND METHOD

2.1 Materials

Ordinary Portland Cement

Type-I Portland cement (Elephant Cement Grade 32.5 N/mm^2) conforming to ASTM C-150 was used as binding material. Its physical properties include Fineness of % passing through #200 sieve, Density of 3.15(g/cm^3), Specific Surface Area of 3310(cm^2/g)

Ceramic Powder (Broken Plates)

Plates made from ceramic were obtained at Dugbe and Aleshinloye markets in Ibadan, Oyo State. They were grinded and a fineness of percentage passing through 150µmm sieve wasused as the partial replacement entity.Approximate chemical composition of the ceramic powder is given in Table 1 below. Figure 1 shows the ceramic powder at sieving stage.

Table 1. Chemical Composition of Ceramic Powder

Constituents	% by Mass
Silicon dioxide (SiO_2)	66.57
Aluminium Oxide (Al_2O_3)	21.60
Iron Oxide(Fe_2O_3)	1.41
Calcium Oxide(CaO)	2.41
Sodium Oxide (Na_2O)	1.41
Potassium Oxide(K_2O)	2.79
Zirconium Oxide (ZrO_2)	1.49

Figure 1. Ceramic powder at sieving stage

Fine Aggregates

Normally fine aggregate was used for preparing concrete. These sand grains are between coarse aggregate (2mm to 64mm) and silt (0.004mm to 0.0625mm). Aggregates that passed 4.75mm IS sieve wasused, which was obtained from Ibadan.

Coarse Aggregates

The coarse aggregate used was crushed stone with a maximum nominal size of 25.5 mm, obtained from Ibadan

Water

Salt water was obtained from Lekki Beach in Lagos State. The Ocean water was used in curing of the concrete. Fresh water was obtained from a well source was used for the concrete mix.

2.2 Methods

Mix Design

A mix design of 1:1.14:2.66 and a water/cement ratio of 0.35 were used in the production of the ceramic powder concrete. After approximately 24 hours, the specimens were removed from the moulds. The ceramic powder mixture proportion is presented in Table 2.

Table 2: Ceramic powder mixture proportion

% of Ceramic powder	Cement (Kg)	Ceramic Powder (Kg)
0	33	0
5	31.4	1.6
10	29.4	3.4
15	27.5	5.5
20	26.4	6.6
30	23.1	9.9

Concrete Specimens

The cube sizes of 150mm x 150mm x 150mm were casted to conduct the compressive strength test. Concrete cubes were produced with partial replacement of cement with ceramic powder in 0%, 5%, 10%, 15%, 20% and 30% respectively.The concrete cubes were cured and tested for compressive strength for 7, 14, 28 and 56 days respectively.

Testing of Sample

Sieve analysis was conducted to determine the gradation of aggregate particle sizes,Slump test was carried out to determine the workability of the fresh concrete and compressive strength tests on the concrete cubes were carried out with the Compressive test machine at Labiran and Associates Ibadan, Nigeria.

III RESULTS AND DISCUSSIONS

3.1 Results

Physical Observations

After casting the cubes, they were cured in both fresh and salt waters.It was observed that the salt water cubes have whiter surfaces than the reference concrete which was cured in fresh water. A deposit of salt was formed on the cube specimens, with whitish appearance at the edges. This is shown in Figure 2.

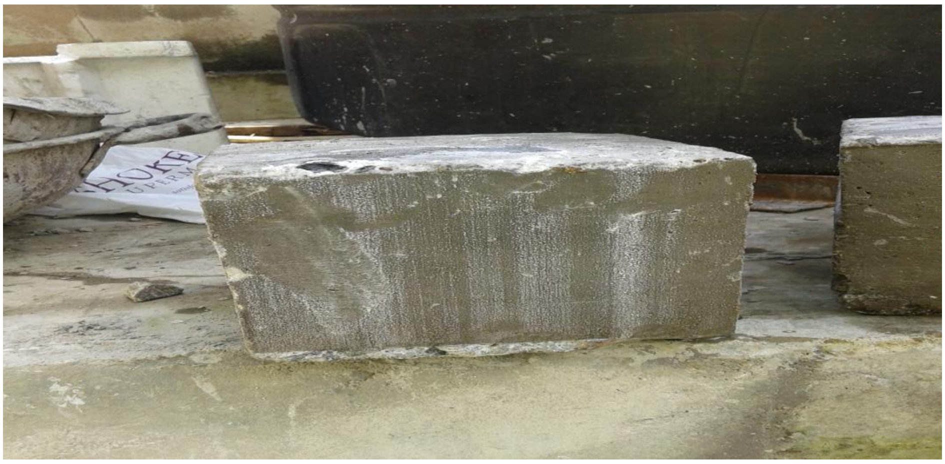

Figure 2. The cube specimen cured in salt water

Figure 3. The cube specimen cured in fresh water

Sieve Analysis
The particle size gradation conducted is shown in the graph representation in Figure 4

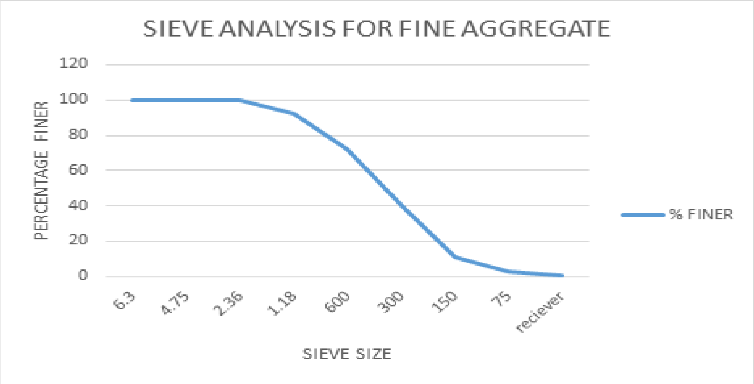

Figure 4. Sieve Analysis for Aggregate

Salt Water pH Value
The pH value of the saltwater was tested for and the results are shown in Table 3

Table 3. Salt Water pH Value

S/N	First reading	Second reading	Third reading	Average
pH meter reading	7.85	7.60	7.59	7.59

Slump Test
The slump test result conducted for the degrees of contamination are given as in Table 4 below.

Table 4: Computed Slump Test Result

% contamination	slump(mm)
0	32mm
5	29mm
10	25mm
15	21mm
20	18mm
30	12mm

Compressive Strength Test
Compressive strength tests were performed with the compression testing machine using cube samples. Three samples per batch were tested with the average strength values were reported Table 5.

Table 5. The Compressive strength of cubes cured in fresh water

Ceramic Powder	Average Compressive Strength (N/mm^2)			
%	7days	14days	28days	56days
0	18.22	27.70	38.96	39.70
5	23.70	31.85	42.22	44.44
10	22.22	29.48	41.48	43.70
15	21.93	28.15	40.44	42.96
20	19.70	27.85	40.00	42.67
30	17.04	26.67	39.56	40.30

Table 5. The Compressive strength of cubes cured in salt water

Ceramic Powder	Average Compressive Strength (N/mm²)			
%	7days	14days	28days	56days
0	22.52	31.11	38.52	39.26
5	25.19	36.30	45.78	48.89
10	24.44	34.81	42.67	46.67
15	23.85	33.78	42.22	45.19
20	22.96	32.59	39.26	42.96
30	20.30	31.70	38.52	39.26

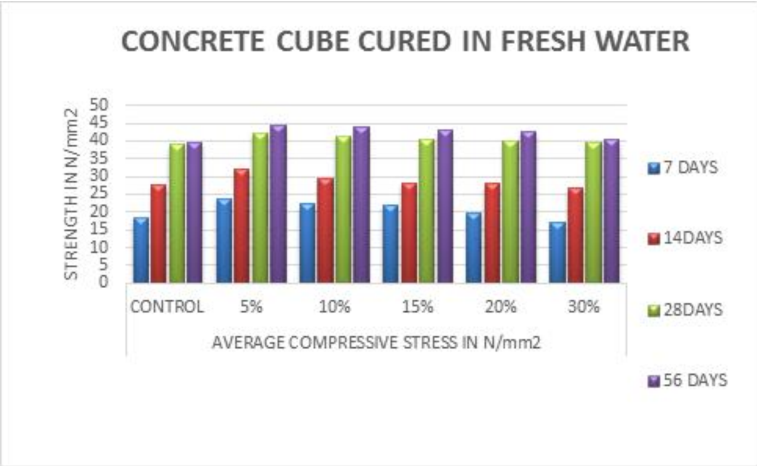

Figure 5. Comparison of compressive strength cured in fresh water

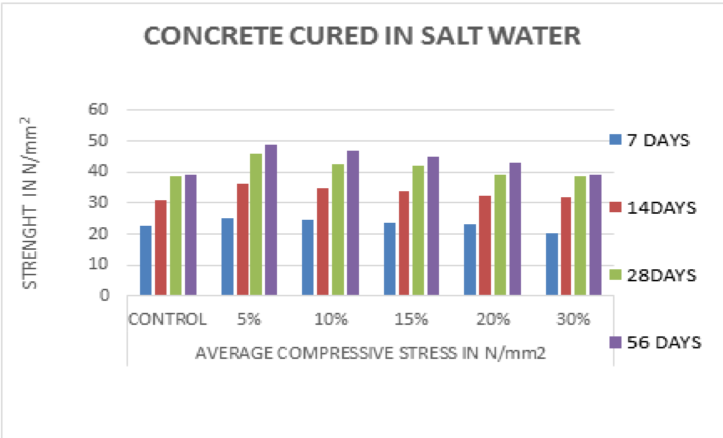

Figure 6. Comparison of compressive strength cured in salt water

3.2 Discussion

Slump Test

The slump conducted for all the batches shows that the slump is in the range10-32mm, the control mix exhibits a slump with 32mm. The angular shape of the ceramic powder tend to reduce workability. The 5% mix shows the highest workability and the 15% mix fall at the optimised workability whereby the 30% mix shows the smallest/weakest workability.

Compressive Test

The compressive strength was obtained at 7-days and 28 days of different samples of concrete, the results show that differences were wider in early age than after 28 days strength (56 days).
As shown in Figure 5 and 6, the average 28 days compressive strength for different proportions of concrete results show that strength of concrete increased as ceramic powder quantity increased up to 20 %. Beyond 20 % mix, it was reduced relatively. The 7-day compressive strength of ceramic concrete gains higher strength with respect to control concrete mix. However, 28 day strength had a significant change. Therefore, less early age strength in ceramic waste concrete is beneficial in construction.

There was an appreciable increase and early strength gain in the salt water concrete cubes to fresh water cubes as compared to the control cubes that show a lower strength at the early stage. The rate of strength gain in fresh water ceramic concrete cube is slow, as compared to the salt water ceramic concrete cubes, which at 7 days has attained almost 65% of its final compressive strength. At 14 days, all the cubes specimen still recorded an increase in strength. The rate of increase in salt water cubes is higher than that of fresh water cubes specimen. At 28 days, the rate of strength gained still shows an increase for all cubes. The fresh water ceramic concrete cubes also recorded a high strength at 28 days. However, the comprehensive strength of the salt cube was higher than that of the fresh water cubes specimen at 28 days.

Another point worthy of note is the rateof strength gained in the Salt water cubes and fresh water cubes had an increase in strength beyond 28days. It shows an additional gain of strength at 56days. There are clearly some complex chemical mechanisms involved here.The required strength was achieved by using 280 Kg/m^3 for the given 20% ceramic powder in place of 350 Kg/m^3 extra cement than required, which gives rise to increased CO emission and leads to shrinkage cracks. Therefore, using 280 Kg/m^3 for ceramic powder mix concrete to achieve a good characteristic strength is a good savings.

IV CONCLUSION

Based on experimental research carried out the following conclusions can be made:

- Ceramic powder is a pozollanic material which can be used as a cementituos material in concrete.
- There was an increase in the strength of concrete cured in salt water and fresh water when ceramic powder is added to the concrete mix, which makes it more durable than ordinary concrete.
- Utilization of ceramic waste and its application can be used for the production ofconcrete, which can be the possible alternative solution of safe disposal of ceramic waste.
- Concrete cured with salt water increases in its 28 days compressive strength than the compressive strength obtained in the fresh water concrete cubes.

REFERENCES

[1]. Malhotra, V. M. (1999). Making concrete 'greener' with fly ash. *ACI Concrete International*, 21, pp. 61-66.
[2]. Mehta, P. K. and Monteiro, P. J. M. (1985). Concrete Structure, Properties and Materials, 2nd Edition, Prentice Hall, Englewood, Clifs.
[3]. Bensted, J. and Munn, J. (2001). A discussion of the paper "The use of waste ceramic tile in cement production" by N. Ay and M. Unal. *Cement and Concrete Research*, 31, 161-162.
[4]. Lopez, V., Llamas, B., Juan, A., Moran, J. M. and Guerra, I. (2007). Eco-efficient concretes: Impact of the use of white ceramic powder on the mechanical properties of concrete. *Biosystems Engineering*, 96, 559-564
[5]. Torgal, F. and Jalali, S. 2010. "Reusing ceramic wastes in concrete", *Construction and Building Materials* 24, 5: 832 - 838
[6]. Medina. C, Frías. M and Sánchez .M.I Microstructure and properties of recycled concretes using ceramic sanitary ware industry waste as coarse aggregate, *Construction and Building Materials*, Volume 31, June 2012, pp: 112-118.
[7]. American Concrete Institute (ACI 211): Concrete Mixture for both Normal- and High-Strength Concretes.
[8]. British Standard Code of Practice.1980.BS12, Portland cement (ordinary and rapid hardening). British Standard Institution, London.
[9]. British Standard Code of Practice.1980.BS 3148, Test for Water for making concrete. British Standard Institution, London.
[10]. British Standard Code of Practice.1983.BS 1881: Part 1, Method for determination of Slump, British Standard Institution, London.
[11]. British Standard Code of Practice, (1992).Aggregates from Natural Source for Concrete. British Standard Institution, London.