Available online www.jsaer.com

Journal of Scientific and Engineering Research, **2016, 3(3):457-461**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Effects of Water-Cement Ratio on Compressive Strength of Chikoko Pozzolana Blended Cement Concrete

DO Onwuka[1], S Sule[2], US Onwuka[3], TU Anyanwu[1]

[1]Department of Civil Engineering, Federal University of Technology, Owerri
[2]Department of Civil and Environmental Engineering, University of Port Harcourt P.M.B. 5323, Rivers State
[3]Department of project management, Federal University of Technology, Owerri

Abstract Chikoko mud is very soft organic marine clay. It is a natural pozzolana which can be used as partial replacement for cement to achieve economy in concrete production. In this paper, the effect of water-cement ratio on the compressive strength of chikoko pozzolana concrete is reported. Thirty (30) trial batches of chikoko pozozlana blended cement concrete mixes predicted by Scheffe's simplex lattice theory were produced using varying water-cement ratios. A total of ninety (90) concrete cubes were produced from the thirty trial batches, implying that three concrete cubes were produced per trial batch for compressive strength test after 28 days of curing. The results obtained showed that the compressive strength of chikoko pozozlana concrete decreased with increasing water-cement ratio; decreased with increasing water/cement-chikoko ratio and increased with increasing water-chikoko ratio. The trends are reflections of the expected properties of concrete and as a result, can serve as a useful tool for estimation of water-cement ratio, water-chikoko ratio and water/cement-chikoko ratio for any given value of compressive strength of chikoko pozzolana concrete and vice-versa.

Keywords Marine clay, fine sediments, mangrove swamp, chikoko pozzolana, partial replacement, compressive strength, water-cement ratio, effect

Introduction

The most basic necessity of man is shelter. The provision of decent shelters to low income earners at an affordable rate; has not materialized over the years due to high cost of building material such as cement [1-2]. A large number of housing units in Nigeria are made of concrete, and cement is its major component. The high cost of cement has made it difficult for most citizens of Nigeria to afford their own shelters. Concrete is the most universal building and construction material in the world. According to Gahlot and Sanjay (2006) [3], concrete is a composite material which comprised essentially of a binding medium in which is embedded particles or fragments of relatively inert material filler. In portland cement concrete, the binder is a mixture of portland cement and water; the filler may be any of the wide variety of natural or man-made aggregates. Concrete as a structural material, finds application in roads and high way construction, bridges, dams, buildings, tunnels and a host of other civil and structural engineering facilities [4]. According to Mehta and Montero (1997) [5], concrete has the following advantages: flexible in design, economical both in terms of construction and maintenance cost, durable, fire resistant, it can be cast in-situ or precast, raw materials are available, high compressive strength value, corrosion resistant, resistant to biological attack and can be formed into any shape.

The worldwide demand for cement as the most important component of concrete, is growing on daily basis and there is need to search for materials that can replace cement partially without producing any adverse effects on the strength properties of concrete [6-9]. According to Otoko and Chinwa (1991) [10], the advantage of using these supplementary materials, is slow hydration, which implies low rate of heat development which is of great importance in tropical construction works. Their reaction with cement also reduces the porosity of the paste and thereby reduces the permeability of concrete [11].

In the long term, chikoko pozzolana concrete structures may show signs of structural failure due to lack or insufficient knowledge of the designers of the chikoko pozzolana concrete mixes, of the optimum value of water-cement ratio, water- chikoko ratio and water-cement-chikoko ratio required to optimize the compressive strength, which is the most important property of concrete.

This paper aims at investigating the effect of water-cement ratio, water-chikoko ratio and water/cement-chikoko ratio on the compressive strength of chikoko pozzolana concrete. The derived curves would serve as simple tools for the determination of optimum value of compressive strength of chikoko pozzolana blended cement concrete for any given value of water-cement ratio, water-chikoko ratio and water/cement-chikoko ratio.

Materials and Methods

The materials used for this study include cement, sand, granite, water and chikoko mud.

Cement: The cement used as binding agent is ordinary portland cement with properties conforming to BS 12:1978. The properties of cement are as shown in Table 1.

Water: The water used in this study is portable, colourless, odourless, tasteless, fresh and free from organic matters.

Fine Aggregates: The sand used as fine aggregate used in this study was obtained from Imo River in Oyigbo Local Government Area of Rivers State. It was washed and air-dried for a period of two weeks before it was used for concrete work. The particle size distribution and other properties were determined in accordance to the requirements of BS 812: 103 [12]. The maximum size of the fine aggregate was 5mm.

Granite: The granite used as coarse aggregates was obtained from crushed rock mill in Rivers State. The aggregates were thoroughly washed and air-dried for a period of two weeks to remove dirt, and later surface dried before usage. The granite has a maximum size of 20mm.

Chikoko mud: The chikoko mud used in this study was obtained from chikoko deposit within the creek of Eagle's Island, Port Harcourt, Rivers State. It was air-dried for a period of four (4) weeks after which it was ground and sieved with a 212 μ m sieve to obtain particles fine enough to facilitate easy reaction with cement. The grading was carried out to the requirements of BS 12 (1975). The physical and chemical properties of chikoko pozzolana are presented in Table 1.

Preparation of Test Specimens for Trial Mixes

In this study, the concrete specimens were produced using 150mmx150mmx150mm concrete steel moulds. Initially, five mix proportions of water/cement, cement/chikoko mud, fine aggregate and coarse aggregate (i.e **0.5:0.95:0.05:2:4, 0.55:0.90:0.10:1.75:3.5, 0.60:0.85:0.15:2.1:4.2, 0.45:0.80:0.20:1.5:3.0** and **0.65:0.75:0.25:2.5:5.0),** were used as trial mixes [1-2]. Thereafter, a total of thirty (30) trial mixes was generated using Scheffe's theory. In all, a total of ninety (90) concrete cubes, were produced from trial mixes implying that three samples were produced per trial mix. In the manufacture of concrete cubes, hand mixing was used and the materials were turned over a number of times until uniform colour and consistency were obtained. Water was then added to cause hydration of cement. It was later compacted into steel moulds in three layers using a tamping rod. The cubes were demoulded after 24 hours of casting and cured in a curing tank for 28 days. The compressive strength test was then carried out on the cubes. The trial mixes used in this study are shown in Table 2.

Table 1: Chemical and Physical Properties of Chikoko

S/N	Component	Content (%)	S	Physical Property	Value
1	CaO	9.85	1	Fineness modulus	$320m^2/kg$
2	SiO_2	41.21	2	Free swell	4.55cc/g
3	Al_2O_3	10.15	3	pH value	7.5
4	Fe_2O_3	2.31	4	Bulk unit weight	$10.95KN/m^3$
5	MgO	5.02	5	Loss on Ignition	6.51
6	Na_2O	1.97			
7	K_2O	8.17			
8	So_3	0.08			
9	TiO_2	0.72			
10	ZnO	0.09			

Source: Authors experiment

Table 2: Thirty (30) Trial Mixes of Chikoko Pozzolana Blended Cement Concrete

S/No	Actual Mix Ratios					Pseudo Mix Ratios				
	Water	Cement	Chikoko	Sand	Granite	Water	Cement	Chikoko	Sand	Granite
1	0.50	0.95	0.05	2.00	4.00	1.00	0.00	0.00	0.00	0.00
2	0.55	0.90	0.10	1.75	3.50	0.00	1.00	0.00	0.00	0.00
3	0.60	0.85	0.15	2.10	4.20	0.00	0.00	1.00	0.00	0.00
4	0.45	0.80	0.20	1.50	3.00	0.00	0.00	0.00	1.00	0.00
5	0.65	0.75	0.25	2.50	5.00	0.00	0.00	0.00	0.00	1.00
6	0.525	0.925	0.075	1.875	3.75	0.50	0.50	0.00	0.00	0.00
7	0.550	0.900	0.100	2.05	4.10	0.50	0.00	0.50	0.00	0.00
8	0.475	0.875	0.125	1.75	3.50	0.50	0.00	0.00	0.50	0.00
9	0.575	0.850	0.150	2.25	4.50	0.50	0.00	0.00	0.00	0.50
10	0.575	0.875	0.125	1.925	3.85	0.00	0.50	0.50	0.00	0.00
11	0.500	0.850	0.150	1.625	3.25	0.00	0.50	0.00	0.50	0.00
12	0.600	0.825	0.175	2.125	4.25	0.00	0.50	0.00	0.00	0.50
13	0.525	0.825	0.175	1.800	3.60	0.00	0.00	0.50	0.50	0.00
14	0.625	0.800	0.200	2.300	4.60	0.00	0.00	0.50	0.00	0.50
15	0.550	0.775	0.225	2.00	4.00	0.00	0.00	0.00	0.50	0.50
16	0.5495	0.8991	0.0999	1.9481	3.8962	0.333	0.333	0.333	0.00	0.00
17	0.5162	0.8658	0.1332	1.8648	3.7296	0.333	0.00	0.333	0.333	0.00
18	0.5328	0.8325	0.1665	1.998	3.996	0.333	0.00	0.00	0.333	0.333
19	0.525	0.875	0.125	1.8375	3.675	0.25	0.25	0.25	0.25	0.00
20	0.550	0.8375	0.1625	2.025	4.05	0.25	0.00	0.25	0.25	0.25
21	0.575	0.8625	0.1375	2.0875	4.175	0.25	0.25	0.25	0.25	0.25
22	0.5375	0.9125	0.0875	1.9625	3.925	0.50	0.25	0.25	0.00	0.25
23	0.600	0.825	0.175	1.825	3.650	0.25	0.00	0.25	0.00	0.50
24	0.520	0.8900	0.1100	1.870	3.740	0.40	0.20	0.20	0.20	0.00
25	0.550	0.850	0.150	1.970	3.940	0.20	0.20	0.20	0.20	0.20
26	0.545	0.8550	0.1450	1.995	3.990	0.30	0.10	0.20	0.20	0.20
27	0.545	0.835	0.1650	1.920	3.840	0.10	0.20	0.20	0.30	0.20
28	0.570	0.8425	0.1575	2.1125	4.225	0.35	0.15	0.25	0.00	0.25
29	0.545	0.8550	0.145	1.965	3.930	0.25	0.20	0.15	0.20	0.20
30	0.5375	0.8575	0.1425	2.0375	4.075	0.45	0.05	0.00	0.20	0.30

Results

After curing the ninety cubic specimen of chikoko pozzolana blended cement concrete for 28 days, they were tested to failure in compression in a universal testing machine. The average loads were recorded and used to determine the compressive strength used in plotting the graphs shown in Figures 1, 2 and 3 respectively.

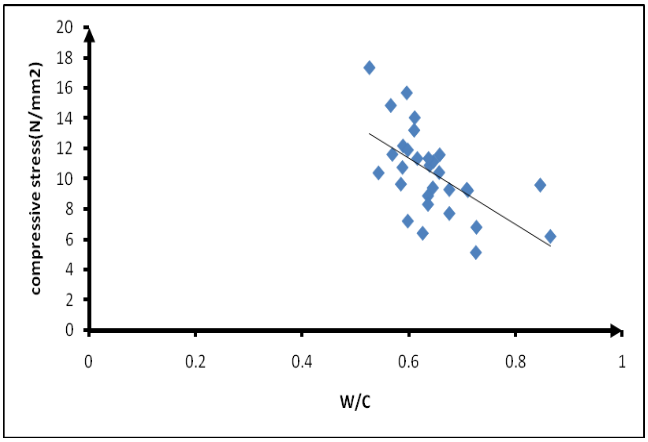

Figure 1: Relationship between compressive strength

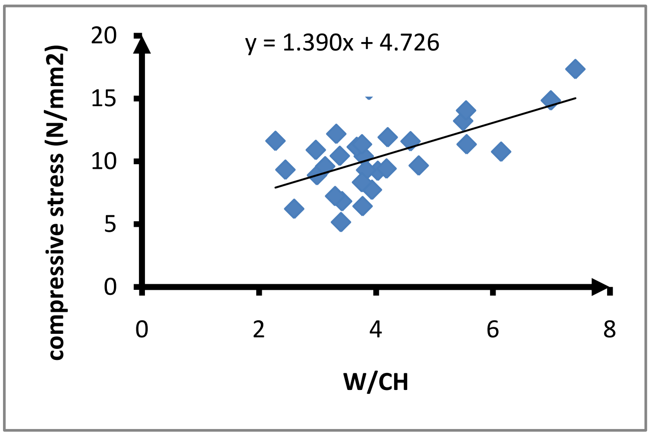

Figure 2: Relationship between compressive strength and water-cement ratioand water-chikoko ratio

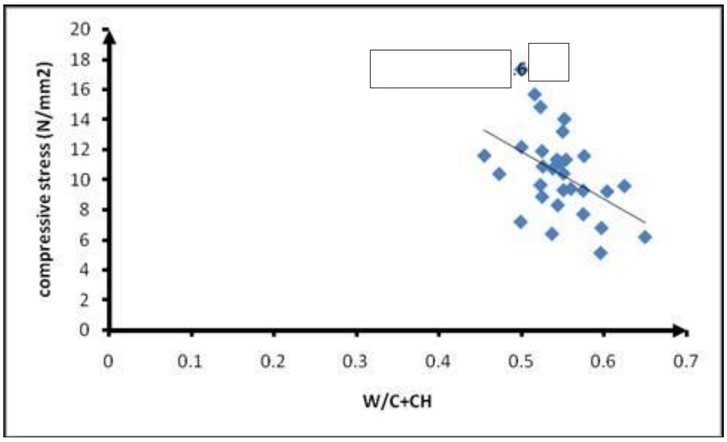

Figure 3: Relationship between compressive strength and Water/cement-chikoko ratio

Discussion of Results

The relationship between the compressive strength and water-cement ratio, water/chikoko ratio and water/cement-chikoko ratio are as shown in Figures 1 to 3 respectively. From Figures 1 and 3, it can be observed that the compressive strength decreases with increase in water-cement ratio and water-cement-chikoko ratio respectively. This decrease in compressive strength may be attributed to the fact that partial replacement of cement with chikoko mud caused a reduction in the quantity of cement in the mix, which was required to undergo a hydration reaction leading to the reduction in the formation of strength producing cementitious compound in concrete. Also, it can be observed from Figure 2 that the compressive strength of chikoko pozzolana blended cement concrete at age 28 days increases with increase in water-chikoko ratio. This trend may be due to the reaction of lime (CaO) present in cement with silica (S_iO_2) contained in chikoko mud. Consequently, more calcium silicate hydrate, which was a binder, was slowly and gradually formed to fill up the voids in the concrete leading to increase in strength. Besides, the various curves generated from the trial mixes, shows that homogeneous mixes were obtained.

Conclusion

From the study the following conclusions are drawn.

1. The hardened chikoko pozzolana concrete cubes gave low strength values at the age of 28 days, with the maximum value being 17.33N/mm^2. This shows that, it can only be used for mass concrete and non load bearing structures.
2. The compressive strength of chikoko pozzolana concrete decreased with increase in water-cement ratio and water/cement-chikoko ratio, but increased with increase in water-chikoko ratio.
3. The trends observed from the curves agreed favourably with those of normal concrete mixes, showing that the generated curves can be used effectively in the prediction of compressive strength of chikoko pozzolana concrete for any given value of water-cement ratio, water/cement-chikoko ratio and water-chikoko ratio.

References

[1]. Onwuka, D.O., Anyaogu, L., Chijioke, C., and Okoye, P.C., (2013). Prediction and Optimization of Compressive Strength of Sawdust Ash-Cement Concrete Using Scheffe's Simplex Design, *International Journal of Scientific And Research Publications,* Vol. 3, pp.1-8.

[2]. Anyaogu, L. and Ezeh, J.C. (2013). Optimization of Compressive Strength of Fly Ash Blended Cement Concrete using Scheffe's Simplex Theory. *Natural and Applied Sciences, Vol. 4, No.2, pp. 177-186.*

[3]. Gahlot P.S and Sanjay S., (2006). Building Repair and Maintenance Management. CBS Publishers and Distributors, New Delhi.

[4]. Neville, A.M., (1996). Properties of Concrete. Longman Ltd., England.

[5]. Mehta, P.K. and Montero, P.J.M. (1997). Microstructure, Properties and Materials, Indian edition, Indian Concrete Institute, Chennai.

[6]. Ndefo, O. (2013). Properties of Cement-Groundnut Shell Ash Concrete. *International Journal of Innovative Research in Engineering & Science.* Issue 2, Vol.8, 16 -25.

[7]. Otoko, G.R. (2014). On the Economic Use of Cement in Soil Stabilization. *International Journal of Engineering and Technology Research,* Vol 2. No.1, pp. 01-07.

[8]. Buari, T. A., Ademola S. A. and Ayegbokiki S.T., (2013). Characteristic Strength of Groundnut Shell Ash (GSA) and Ordinary Portland Cement (OPC) Blended Concrete in Nigeria. *IOSR Journal of Engineering (IOSRJEN)*, Vol.3, Issue 7, 01-07.

[9]. Emesiobi, F.C. (2004). Further Use of Chikoko Mud Pozzolana for Economical Sandcrete Blocks Production. *NSE Technical Transaction, 39(3).*

[10]. Otoko, G.R. and Chinwah, J.G. (1991). The Use of "Garri" as Admixture in Hot Weather Concreting. *The Journal of Nigerian Institute of Structural Engineers*, Vol.1, No.4, pp. 13-18.

[11]. Kovacs, R. (1975). Effect of Hydration Products on the Properties of Fly-Ash Contents. *Cement and Concrete Research*, 5, No.1, pp. 73-82.

[12]. BS 812: Part 1 (1975). Methods of Determination of Particle Size and Shape. British Standards Institution, London.