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Research Article

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Burnt Pulverized Chikoko (BPC) in Concrete Production: An Admixture and a Cement Replacement Investigation

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Abstract This work presents the investigation findings of Burnt pulverized chikoko (BPC) when used as admixture and partial Replacement of cement in the production of concrete. Chikoko Samples were collected from Okrika in Rivers in the Niger Delta region of Nigeria. Two prescribed mix ratios of 1:1.5:3 and 1:2:4 batched by weight was adopted. 150mm cube moulds were used to cast 108 concrete cubes, which were cured and tested for 7 days, 14 days and 28 days. Results from the investigation showed that when BPC was used as replacement for cement, a sharp and terrible decrease in strength of 24.91% and 30.58% when compared with the strength of the control at 28days for 20% cement replacement for 1:1.5:3 and 1:2:4 respectively. In contrast, while BPC was used as Admixture, results show an increase in strength of 18.412% and 18.82% from the control at 28days of 20% BPC Admixture for 1:1.5:3 and 1:2:4 respectively.

Keywords Burnt, Concrete, Pulverized, Chikoko, compressive, strength. Marine clay, Niger Delta

1. Introduction

The research work was carried out to study the use of Burnt Pulverized Chikoko (BPC) in Concrete Production as a Cement Replacement and as an Admixture with the aim of improving the compressive strength and other desired qualities of concrete. In carrying out the investigation the compressive strength, at different percentage content of BPC for different curing time 7, 14, 28 days were particularly studied. Chikoko is found in a relatively large quantity as a natural material in the transition zone of the Niger Delta Region of Nigeria. Deltaic lateritic soils are superficial soil deposits of varying thickness ranging from the top surface 0.5m to about 1.0m found in the Niger delta basin of southern Nigeria. Thus they are derived from overlying coastal plain sands of the Benin formation [1]. This soil group may be considerably and relatively immature and probably exists between stages 4 and 5 on the lateritic vertical profile postulated by Tuncer and Lohnes [2]. As a result of this relative immaturity, chikoko may also be much more sensitive to manipulations than other lateritic soils. It has plasticizing ability with very low permeability quality. This deltaic tropical marine soil is very soft. Hafez *et al* [3] carried out a Laboratory test. Table 1 below shows the full chemical composition of the chikoko soil.

Table 1: Chemical Composition of CHIKOKO Soil (Adapted from Hafez et al [3])

Chemical Constituents	Concentration Chikoko soil
Silicon Dioxide (Silica) SiO_2	62.96
AluminumTrioxide Al_2O_2	17.18
Calcium Oxides (lime) CaO	0.16
Magnesium Oxide (MgO)	1.05
Iron Oxide (Fe_2O_3)	35.7
Potassium Oxide(K_2O)	2.09
Sodium Oxide, (Na_2O)	0.22
Sulphate (SO_3)	0.76

Soft soils vary in thickness in coastal areas [4]. This also applies to the Chikoko soil of the Niger Delta, Nigeria [5]. The Chikoko soft soil is characterized with high moisture content in excess of 80% and like other soft soils can also be easily interrupted by activities on its surface [6]. It is also characterized with high compressibility, low bearing capacity, low strength and low permeability [7].

As such, the Chikoko soil is referred to as problematic when structures are constructed on it. They are not also suitable as subgrade material and therefore require stabilization with lime, cement, chemical and other additives or replacement with soil of better quality. The need to use local materials for sustainable civil infrastructure development gave the interest of using the chikoko in a modified form for the production of concrete.

2. Methodology

To achieve the objectives of this study, an experimental programming was planned to investigate the effect of burnt pulverized Chikoko (BPC) on compressive strength of concrete. Various tests were conducted on cement, fine aggregate, coarse aggregate, water, Chikoko and on the hardened concrete specimen (cubical) after suitable curing time 7, 14 and 28 days. The Chikoko samples were obtained from Okrika in Rivers State of the Niger Delta. The collected Chikoko was burnt in open air until it turned brilliant red. It was to be burnt in a furnace (controlled burning) but the facility intended to be used failed at the point of use. The red burnt chikoko was then pulverized using a Grinding Machine and sieved into fine (powder) sizes passing 200µm The Figure 1.1 shows the schematic representation of the chikoko powder production from the Deltaic marine clay (chikoko).

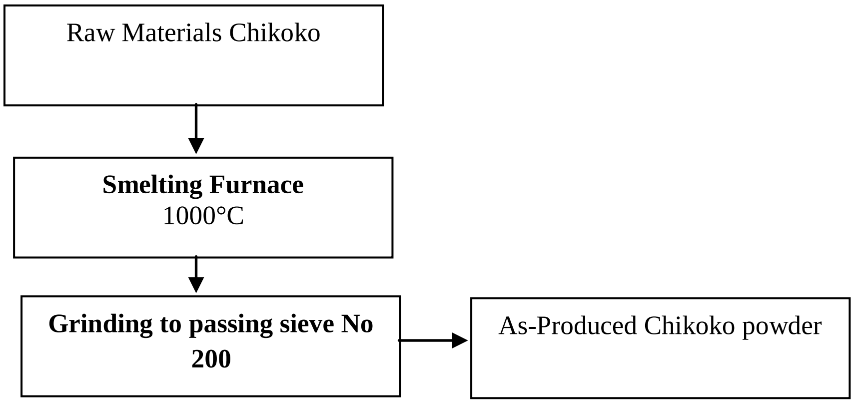

Figure 1.1: Production of Burnt Pulverized Chikoko

Crushed granite from Auchi in Niger Delta, with maximum size of 12.7mm was used. The grading and properties of the coarse aggregate conformed to BS EN 12620. This grade of coarse aggregate was adopted to allow for adequate and even compaction of concrete within the specimens. Fine aggregate conforming to BS EN 12620:2013 from Amassoma river sand was used. Grade 43 Dangote cement in 50kg bags and Portable water was used for the production of concrete samples. As specified by BS 1881-113:2011, six standard concrete cubes, were made for each set of percentage replacement and admixture The cubes were cast for concrete mixes (1:2:4 and 1:1.5:3) by weight with varying percentages (0%, 5%, 10%, 15% and 20%) of BPC as partial replacement of cement in one case and as admixture in another case. Details of the mix is shown in tables 2 After 24 hours the specimens were removed from the moulds and placed in clean fresh water at atmospheric temperature. The load was applied axially without shock till the specimen was crushed. Results of the compressive strength test on concrete with varying proportions replacement at the age of 7, 14 and 28 days are given in table below.

Table 2.1: Sieve Analysis of Coarse Aggregate (Granite)

Sieve size (mm)	Weight retained (g)	Weight retained (%)	Cumulative Weight retained (%)	Weight passing (%)
14	183	12.20	12.20	87.80
10	838	55.86	68.06	31.94
5	400	26.67	94.73	5.27
3.35	**75**	5.00	99.73	0.27
2.36	4	0.27	100.00	0

Table 2.2: Sieve Analysis of Fine Aggregate (Sharp Sand)

Sieve size (mm)	Weight retained (g)	Weight retained (%)	Cumulative Weight retained (%)	Weight passing (%)
2.36	4.67	3.11	3.11	96.89
2.0	1.89	1.26	4.37	95.63
1.18	10.99	7.33	11.70	88.30
600	36.80	24.53	36.23	63.77
425	43.17	28.78	65.01	34.99
300	29.60	19.73	84.74	15.26
212	15.81	10.54	95.28	4.72
150	4.20	2.81	98.09	1.91
75	2.00	1.33	99.42	0.58
Pan	0.87	0.58	100	0

Table 2.3: Specific Gravity of Granite

Sample	M_1	M_2	M_3	M_4	W_w	Specific Gravity (G_s)
1	695	1395	2375	1945	270	2.59
2	693	1389	2292	1875	279	2.49
3	696	1392	2351	1907	252	2.76
					Average	2.61

Gas jar method, Ref; BS 1377; 1995 Test 6 (A)

Table 2.4: Loose and Compacted Bulk Densities of Granite

Sample	Wee (kg)	Wel (kg)	Wec (kg)	Bulk loose (kg/m^3)	Bulk Compacted (kg/m^3)
1	4.600	5.851	5.973	1256.33	1378.85
2	4.600	5.793	5.969	1198.08	1374.83
3	4.600	5.896	5.984	1301.52	1389.89
			Average	1251.98	1381.19

($Vc = 9.9576 \times 10^{-4}\ m^3$)

Table 2.5: Mix Proportions Containing Different Levels of BPC

Location Sample	Bayelsa				
Mix - 1:1.5:3	**Admixture**				
Mix components	0%	5%	10%	15%	20%
Cement (kg)	9.00	9.00	9.00	9.00	9.00
BPC (kg)	_	0.450	0.900	1.350	1.800
Sand (kg)	13.5	13.5	13.5	13.5	13.5
Water (kg)	4.25	4.25	4.25	4.25	4.25
Coarse Agg. (kg)	28	28	28	28	28
Slump (cm)	4.00	0.50	0.00	0.50	0.50

Table 2.6: Mix Proportions Containing Different Levels of BPC

Location Sample	Okrika									
Mix - 1:1.5:3	**Admixture**					**Replacement**				
Mix components	0%	5%	10%	15%	20%	0%	5%	10%	15%	20%
Cement (kg)	9.0	9.00	9.00	9.00	9.00	9.00	8.55	8.10	7.65	7.20
BPC (kg)	_	0.45	0.900	1.350	1.80	_	0.45	0.90	1.35	1.80
Sand (kg)	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
Water (kg)	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25
Coarse Agg. (kg)	28	28	28	28	28	28	28	28	28	28
Slump (cm)	4.00	1.70	0.50	0.50	0.50	4.00	1.70	0.50	0.50	0.00

Table 2.7: Mix Proportions Containing Different Levels of BPC

Location Sample						**Okrika**				
Mix - 1:2:4			**Admixture**					**Replacement**		
Mix components	0%	5%	10%	15%	20%	0%	5%	10%	15%	20%
Cement (kg)	7.50	7.50	7.50	7.50	7.50	750	7.125	6.750	6.375	6.000
BPC (kg)	_	0.375	0.750	1.125	1.50	_	0.375	0.75	1.125	1.50
Sand (kg)	15	15	15	15	15	15	15	15	15	15
Water (kg)	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75
Coarse Agg (kg)	30	30	30	30	30	30	30	30	30	30
Slump (cm)	1.0	0.50	1.00	0.50	0.50	1.00	0.50	0.50	0.00	0.50

3. Result and Discussion

Table 3.1 showing results of equivalent Compressive stresses from compression test of 150mm cube specimens at different age with BPC as cement replacement and admixture (sample location – Okrika).

Table 3.1: Results of Compressive Strength from Compression Test

		(1:1.5:3)			**(1:2:4)**		
		7days N/mm^2	**14days N/mm^2**	**28days N/mm^2**	**7days N/mm^2**	**14days N/mm^2**	**28days N/mm^2**
1	Control	20.89	23.56	26.67	20.89	17.78	26.67
2	Control	20.00	22.22	28.89	17.78	21.33	24.44
	average	20.44	22.89	27.78	19.33	19.56	25.56
3	5% R	23.33	23.11	29.78	20.00	19.56	19.11
4	5% R	25.56	23.11	31.11	20.44	19.11	19.56
	average	24.44	23.11	30.44	20.22	19.33	19.33
5	10% R	20.00	25.78	29.78	20.89	21.33	20.00
6	10% R	22.22	26.22	28.44	21.33	19.56	23.11
	average	21.11	26.00	29.11	21.11	20.44	21.56
7	15% R	25.56	18.67	26.67	20.89	20.00	19.11
8	15% R	20.00	18.67	26.22	20.00	20.00	17.78
	average	22.78	18.67	26.44	20.44	20.00	18.44
9	20% R	19.56	19.56	19.11	19.56	20.44	19.56
10	20% R	19.56	20.44	20.89	19.56	20.89	19.11
	average	19.56	20.00	20.00	19.56	20.67	19.33
11	5% Admix	21.33	23.11	28.89	20.89	20.44	26.22
12	5% Admix	30.22	27.56	27.56	21.33	25.78	29.33
	average	25.78	25.33	28.22	21.11	23.11	27.78
13	10%Admix	26.00	29.33	32.89	24.00	24.00	25.33
14	10% Admix	24.00	28.89	32.00	21.33	24.44	22.67
	average	25.00	29.11	32.44	22.67	24.22	24.00
15	15% Admix	28.89	31.56	32.44	20.00	22.67	26.22
16	15% Admix	29.78	31.11	33.33	21.33	22.67	26.22
	average	29.33	31.33	32.89	20.67	22.67	26.22
17	20% Admix	24.89	27.11	32.44	21.33	25.78	30.22
18	20% Admix	22.67	28.44	33.33	22.22	24.44	30.22
	average	23.78	27.78	32.89	21.78	25.11	30.22

Note: R means replacement and Admix means Admixture

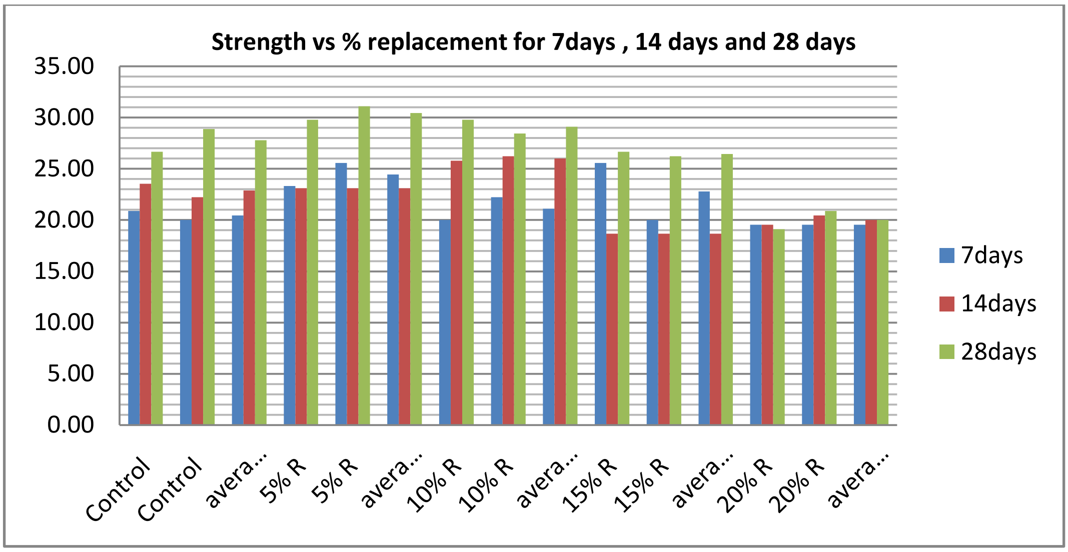

Figure 3.1: BPC used as Cement Replacement for 1:1.5:3 Mix

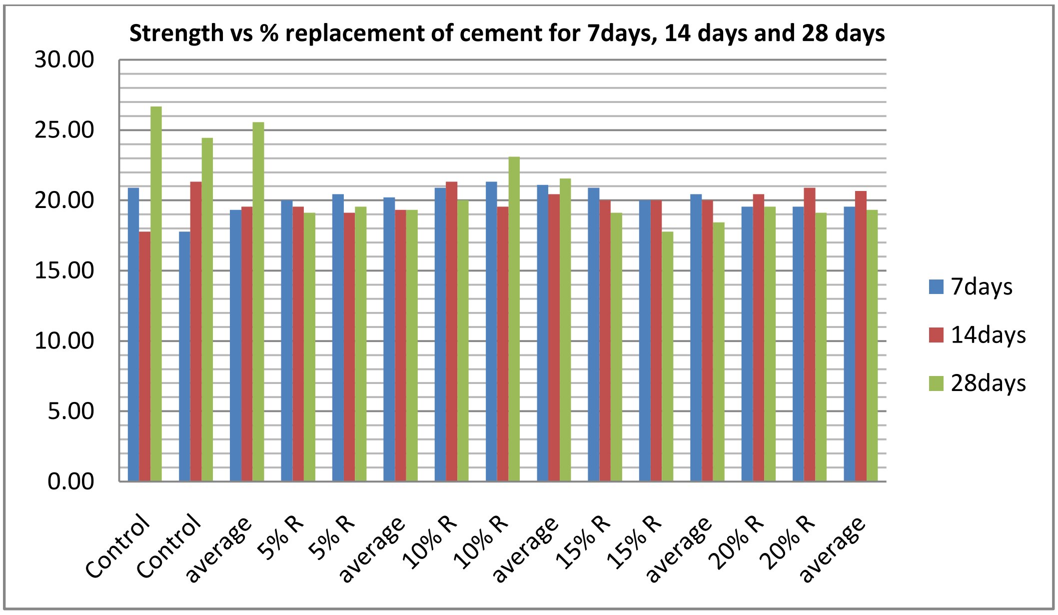

Figure 3.2: BPC used as Cement Replacement for 1:2:4 Mix

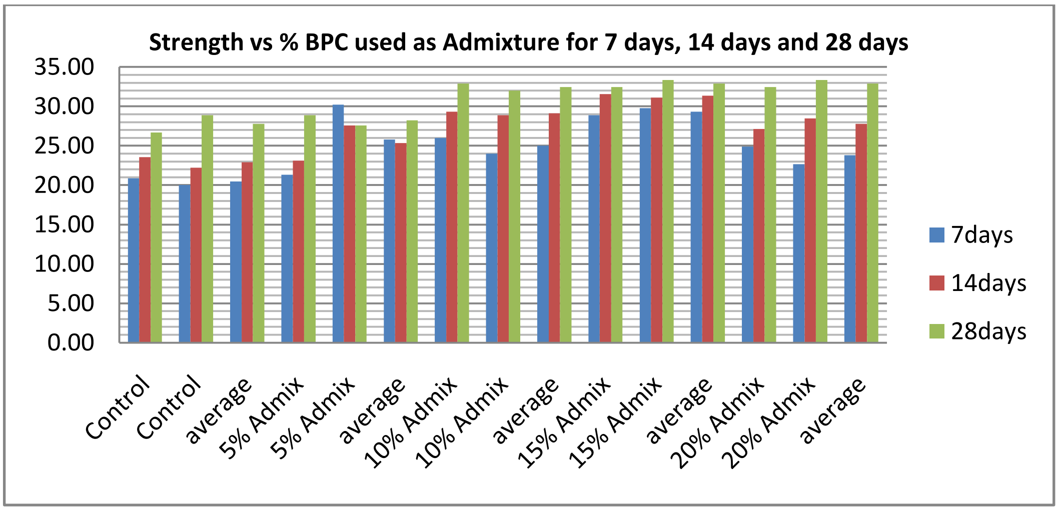

Figure 3.3: BPC from Okrika used as Admixture for 1:1.5:3 Mix

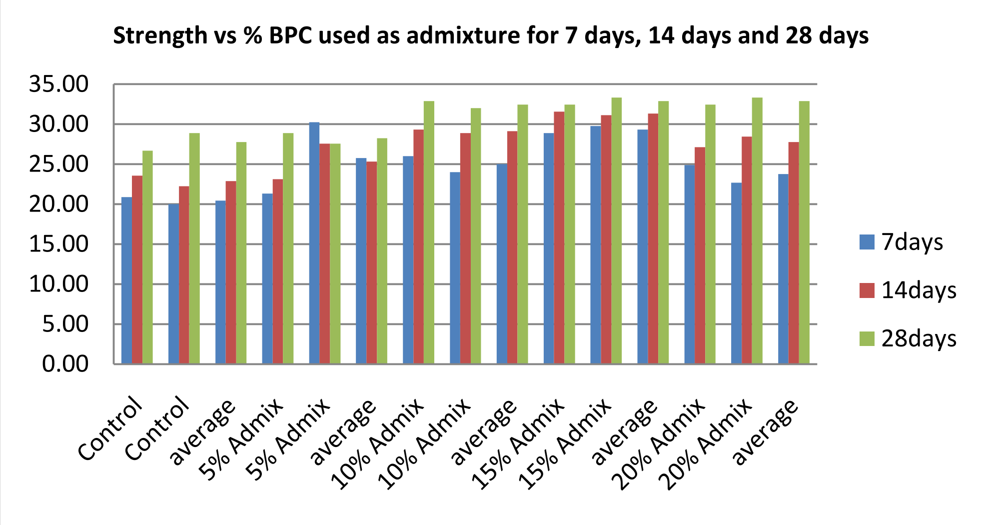

Figure 3.4: BPC used as Admixture for 1:2:4 Mix

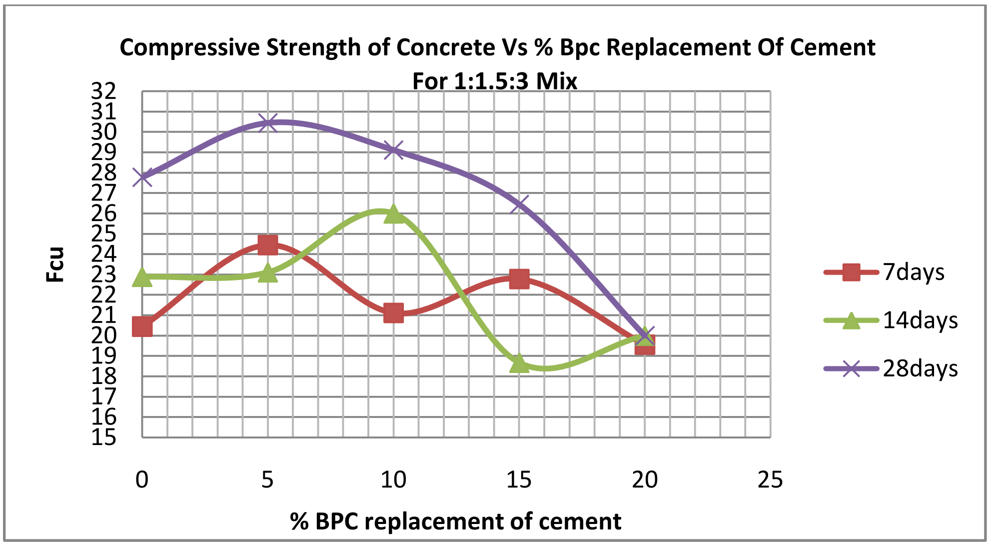

Figure 3.5: Compressive Strength of Concrete Vs % BPC Replacement of Cement for 1:1.5:3 Mix

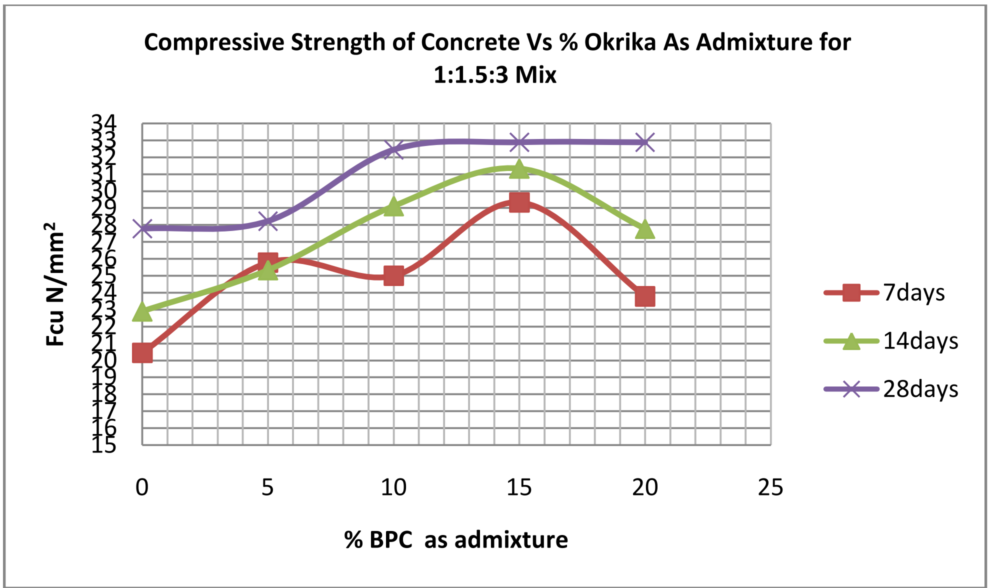

Figure 3.6: Compressive Strength of Concrete VS % Okrika as Admixture for 1:1.5:3 Mix

3.1. Effect of BPC as Cement Replacement on Compressive Strength of Chikoko Concrete

The following were observed that the difference in compressive strength between the control mix and 5, 10, 15 and 20 % replacement at 7 days were slightly higher than the compressive strength of the control mix >19.33 Nmm^2 however, 10 % replacement at 7 days gave the highest while in 14 days 5% replacement only was below the control mix and in 28 days recorded all samples below the control mix compressive strength.

3.2. Effect of Admixture on Compressive Strength of Chikoko Concrete

The effects of admixtures at 7, 14 and 28 days shown in with respect to different percentage 5, 10, 15 and 20%. Admixture.

Higher mean compressive strengths compared to the control (0% chikoko Admixture) were obtained at 7, 14, and 28 day age. Except 20% admixture at 28day fell less than that of the control, all other percentage admixture maintained a steady rise mean compressive strength exceeded that of control. However, 20% showed more consistency in rising and gave optimum compressive strength at 28 day i.e. from 21.78 to 25.11 and to 30.22Nmm^2 at 7, 14 and 28days respectively.

4. Conclusion

The strength and durability characteristics of concrete mixtures have been computed in the present work by replacing 5%, 10%,15% and 20% cement with BPC and also as admixture with same percentage ratio and tested at 7, 14, and 28 days. On the basis of present study, following conclusions are drawn:

a. At 5% admixture BPC in the mix, there is an increase in the strength of cube after 7 days was compared to concrete without replacement. And after 14 days and 28 days there is enormous increase in strength as compared to the control mix
b. Optimum compressive stress was achieved at 20% BPC admixture which showed more consistency in rising and gave optimum compressive strength at 28 days i.e. from 21.78 to 25.11 and to 30.22 Nmm^2 at 7, 14 and 28 days respectively.
c. In comparison of the compressive stress attained between percentage Replacement and percentage Admixture on both location. Optimum compressive stress was obtainable at 15% Okrika admixture at 28day = 30.22Nmm^2

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