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UTILIZATION OF POWDERED CRUSHED TILE AS CONCRETE POZZOLAN

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ABSTRACT

The research emphasized on the effect of Powdered Crushed Tile (PCT) on workability level, soundness, setting time, strength development and strength optimization of PCT/OPC fresh paste. This was achieved by determining the physical properties of PCT. Properties such as specific gravity, bulk density, plastic limit and moisture content were investigated. Followed by this was the experimental programme carried out to examine the effect of PCT on the compressive strength of concrete at 14, 21 and 28 days of proper curing in ordinary water by partial substitution of OPC with PCT at varying level of 5, 10, 15, 20, 25 and 30 percent (%) respectively with the view to establish the % of PCT that would be appropriate for OPC/PCT design mix. The results obtained show that concrete produced with partial replacement of OPC for PCT has decrease in compressive strength with age. The highest compressive strength was observed in 5% replacement at 14 days. Densities of the specimens decrease with increase in % replacement of OPC for PCT. The research concluded that PCT cannot be used as partial replacement of OPC in concrete making and cannot be recommended as strength increase additive in concrete production.

Keywords *Powdered Crushed Tile, Compressive Strength, Setting Time, Workability and Soundness*

INTRODUCTION

Provision of housing in developing countries such as Nigeria is one of the most important basic needs of the low-income groups. It is a very difficult requirement to meet, however, because the cost of construction is usually beyond the means of both rural and urban poor people. In order to address this issue, the Nigerian Government for example, has come up with various housing policies such as the 1991 National Housing Policy with the aim of providing Nigerians with decent and affordable housing in the years to come (Sanusi, 1998). The classical or conventional building materials are imported and their prices are considerably beyond the reach of the average Nigerian.

In order to stem the over dependency on conventional building materials, it was realized that efforts have to be directed towards the local sourcing of alternative building materials. According to Neville and Brooks (2002), concrete and steel are the two most commonly used structural materials for construction proposes and they sometimes complement each other, concrete being relatively cheaper is the most widely used construction materials these days and as such, efforts have been made by many researchers to reduce the cost of its production. This is achieved by reducing the cost of cement which is one of the expensive constituent's parts of the concrete.

One of the ways to reduce cement cost is by partially replacing it with some cheaper or locally available materials. Numerous works have been conducted to study how possible construction materials can be developed from locally manufactured materials, agro-industrial waste or by-products which are abundantly available. Dashan and Kamang (1999) investigated the performance of Rice Husk Ash (RHA) as partial replacement of ordinary Portland Cement (OPC) in concrete production. Elinwa and Mahmood (2002) carried out an extensive work on the performance of concrete produced with Saw Dust Ash while Sa''ad (2005) compared the properties of concretes produced with different Powdered Burnt Brick (PBB) obtained from different locations in Nigeria. It is in the light of the ongoing research on how to utilize these wastes in a way that could be within the reach of the common and possibly every man for low cost construction development that effort is being made towards partial replacement of OPC with PCT.

The amount of tile waste on earth is enough for use as concrete additive. Tile is produced from natural materials sintered at high temperatures. There are no harmful chemicals in tile. However some parts of tile are used in cotto as flooring and also flooring in tennis courts, walkways, cycling paths and gardens as a ground material. Nevertheless, each year approximately 250,000 tons of tile are worn out, while 100 million tile are used for repairs with consequent waste broken pieces in every nook and cranny of the societies (Alduaij et. al, 1999). These broken pieces of tile serve as nothing but only cause the apparition of pollution, disfigure and contribute to the problem of wastes disposal to the society. This waste material can be recycled by converting it into powdered form and use as concrete additive.

The partial replacement of OPC with PCT in concrete production should be a welcome development in Nigeria considering the cost of production of PCT/OPC concrete in comparison to that of OPC. The study therefore, focused essentially on the compressive strength of concrete made with PCT as partial replacement of cement for concrete production since comprehensive strength is the most important property of hardening concrete that gives a clear indication of the quality of concrete, hence the study aimed at reducing the cost of construction by producing PCT/OPC cubes cured in ordinary water for 14, 21 and 28 days and tested at each hydration period.

MATERIALS AND METHODS

The Research was carried out in Waziri Umaru Federal Polytechnic Birnin Kebbi Building Laboratory. The Tile Wastes used for the research were obtained from different nooks and cranny of the Town. Broken pieces of tiles were grinded by grinding machine and then sieved with 75μm BS sieve. Only those that passed through the sieve were used for the research work. Ordinary Portland Cement (Dangote brand), naturally occurring clean sharp river sand and coarse aggregate obtained from a small quarry sieved with 10mm and 20mm sieve sizes to get rid of the suspended and organic impurities were used for the research. The methods of preparation of the test specimens follow the procedure as outlined by appropriate British Standards especially BS 1881: 124 (1988) and BS 1881: 125 (1986). Before the casting of concrete specimens, physical properties test such as specific gravity, bulk density, moisture content, absorption capacity and plastic limit of the materials were first carried out. Also, soundness, workability and setting time test of the paste and fresh concrete were also carried out.

To assess the suitability of PCT as partial replacement of OPC in concrete production, absolute volume method of concrete design having mix ratio 1:2:4 of cement, sand and coarse aggregate was first carried out (trial mix) at varying replacement level of 5, 10, 15, 20, 25 and 30 % PCT for OPC at different water/cement (w/c) ratio ranging from 0.5 to 0.75. The essence of the varying w/c ratio was to determine the appropriate one that would give the highest strength which was finally adopted for the final design. For the purpose of the research, twelve concrete cubes were cast for each of the percentage replacement level of OPC for PCT and the control (0% replacement level) with w/c ratio of 0.65. Three cubes from each of the percentage replacement level and control were tested at 14 days curing in ordinary water to determine their compressive strengths. This was also repeated at 21 and 28 days respectively.

RESULTS AND DISCUSSION

Results of Particle Size Analysis of Aggregates

Table 1 and 2 show the results of the particles size analysis of the fine and coarse aggregate samples used for the research work. The result obtained in the tables comply with the grading limit of zone 1 and therefore make the aggregates suitable for construction work (BS 882, 1992).

Table 1: Particle Size Analysis of Fine Aggregate

B.S Sieve Sizes (mm)	Weight (g) Retained	Percentage Retained	Percentage Passing
4.75	8.96	0.90	99.10
2.36	110.80	11.08	88.02
1.18	214.37	21.44	66.59
600μm	387.47	38.75	27.84
300"	255.67	25.57	2.27
150"	19.01	1.90	0.37
75"	3.80	0.21	-
Pan	1.10	0.11	-

Table 2: Particle Size Analysis of Coarse Aggregate

B.S Sieve Sizes (mm)	Weight (g) Retained	Percentage Retained	Percentage Passing
20	0.00	0.00	100.00
14	324.69	16.23	83.77
10	1459.98	73.00	10.77
5	187.28	9.36	1.4
Pan	99.10	4.96	-

Results of Physical Properties of Materials

From table 3 the value of specific gravity obtained on PCT complied with BS 12:1991 which specified its range to be minimum of 2.20 and maximum of 2.80. The specific gravity of PCT is also similar to the values reported by Oyetola and Abdullahi (2006); Dashan and kamang (1999) on Acha Husk Ash (AHA) and RHA which was 2.13 for RHA and 2.12 for AHA. The specific gravity of the material is less than that of OPC (3.15 (Neville, 1981)) which means that PCT is a lightweight material. The specific gravity of the sand used for the research was found to be 2.65. The value obtained falls within the limit for natural aggregates which ranges from 2.6 to 2.7 (Neville and Brooks 2002).

The compacted bulk density of PCT was found to be 1008 kg/m³. The value obtained is close to 1115 k/m³ reported by Taylor (1991) on Powdered Burnt Bricks (PBB). The bulk density of PCT is less than the bulk density of OPC (1440kg/m³ (Neville, 1996)). The compacted bulk density of sand was found to be 1600kg/m³. This value obtained is close to the range given for bulk density before excavation of sandy soils which ranges from 1650 Kg/m³ to 1850kg/m³ as reported by Neville and Brooks (2002).

Table 3: Physical Properties of PCT and Sand

S/NO	Properties	Sample Type and Description: PCT	Sand
1	Specific Gravity	2.60	2.65
2	Compacted Bulk Density (kg/m³)	1008	1650
3	Un compacted Bulk Density (kg/m³)	880	1490
4	Absorption Capacity (%)	27.55	22.45
5	Moisture Content (%)	7.10	2.04
7	Plastic Limit (%)	23.70	-

Results of Setting Time

As it can be observed in table 4 that the time required for PCT/OPC past to harden increased with increase in PCT replacement for both the initial and final setting times. This means that increase in PCT content in the past could lead to increase in both initial and final setting time of the paste. This shows that PCT has increase influence on setting time.

Table 4: Setting Time of PCT Pastes

PCT (%)	Cement (g)	TCP (g)	Water (ml)	Initial Setting Time (hrs.)	Final Setting Time (hrs.)
0	400	0	120	1.30	5.10
5	380	20	130	2.25	6.30
10	360	40	134	2.50	6.55
15	340	60	152	3.00	7.10
20	320	80	174	3.20	7.30
25	300	100	195	3.80	7.90
30	280	120	200	4.00	8.50

Results of Soundness Test

From the result of soundness test in figure 1, it is clear that increase in PCT content lead to increase in soundness of the paste. For OPC without PCT, the expansion was 0.2mm which is less than 10mm specified by BS 12:2: 1971. This confirmed that the cement used is of good quality. The moment PCT was introduced, increase in expansion was observed in all PCT pastes.

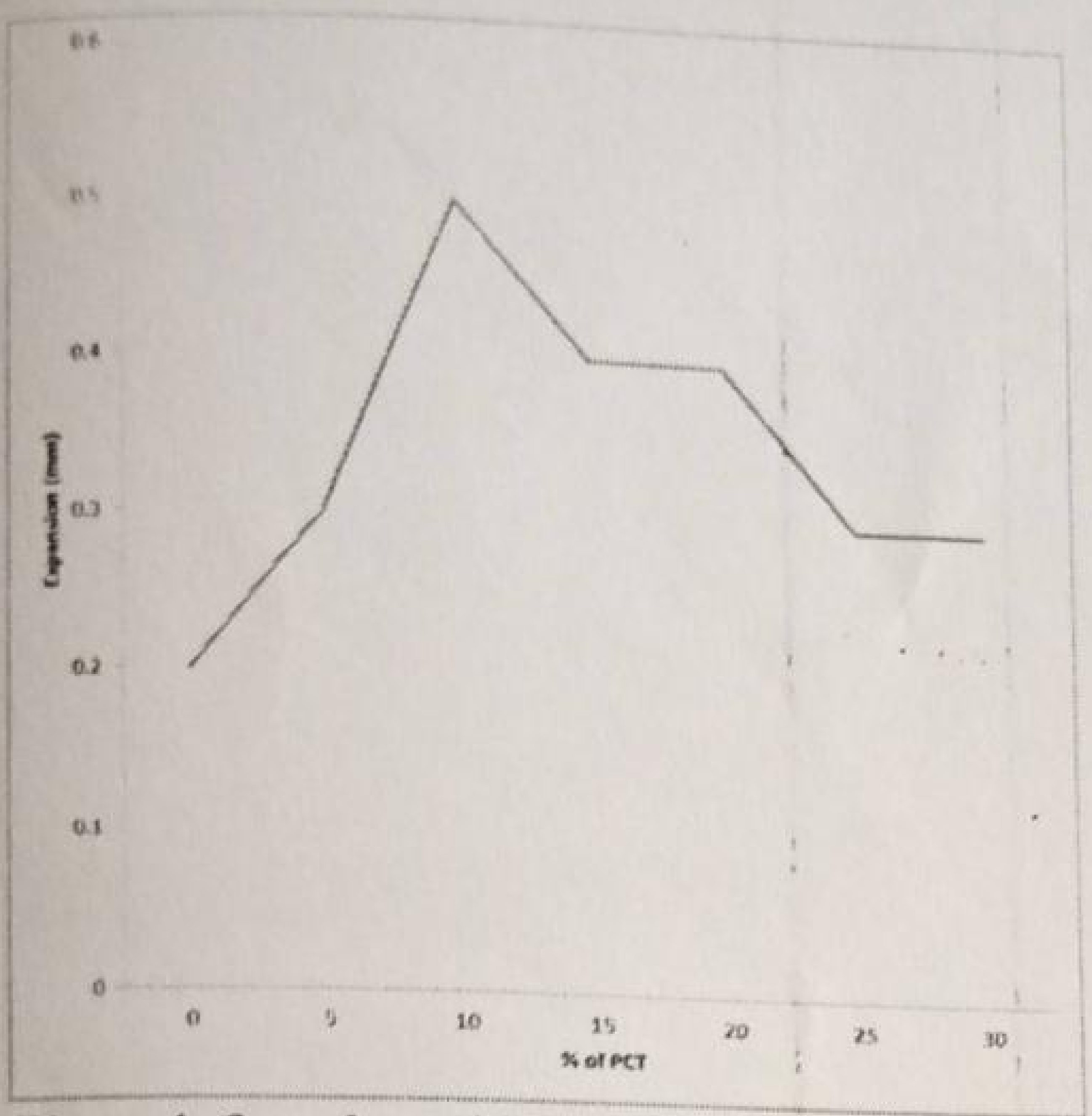

Figure 1: Soundness Test of PCT Pastes

Results of Workability Test

The results of workability test using slump and compacting factor methods in table 6 show that specimens slumps were in the range of 4 to 8mm which indicates low workability. The compacting factor test for each specimen was also in the range of 0.82 to 0.85 which also indicate low workability (Orchard 1979). The result of compacting factor test compared favorably with the slump test. The low slump and compacting factor simply implies that there was proper coating of the aggregate by PCT/OPC paste in the research work.

Table 5: Workability Test of PCT/OPC Fresh Concrete

% of PCT	W/c Ratio	Degree of Workability			
		Slump (mm)		Compacting Factor	
0	0.65	8	Low	0.84	Low
5	0.65	8	Low	0.85	Low
10	0.65	6	Low	0.84	Low
15	0.65	6	Low	0.84	Low
20	0.65	4	Low	0.83	Low
25	0.65	4	Low	0.83	Low
30	0.65	4	Low	0.82	Low

Results of the Compressive Strength Test

From figure 2, it can be observed that the longer the ages of curing of PCT/OPC concretes in ordinary water the more the reduction in compressive strengths. For instance, the compressive strength of specimen with 10% partial replacement was observed to be 14.40 at 14 days, 11.85 at 21 days and 9.50 at 28 days with % strength reduction of 61.69 at 28 days. The results of the compressive strength of concrete cubes with partial replacement of OPC for PCT does not comply with BS 8110 (1985) recommendation which recommends that the minimum compressive strength required for concrete to be used for structural purpose at 28 days should be between 20 to 40N/mm.^{2} The more the addition of PCT up to 30% replacement, the more the reduction in compressive strength at all ages. The reduction in strength may be due to the sintered high temperatures which tile is subjected to during production. This high temperature may lead to low reactivity of some or all the particles which tile contains, hence, the reduction in PCT/OPC concrete strength in water.

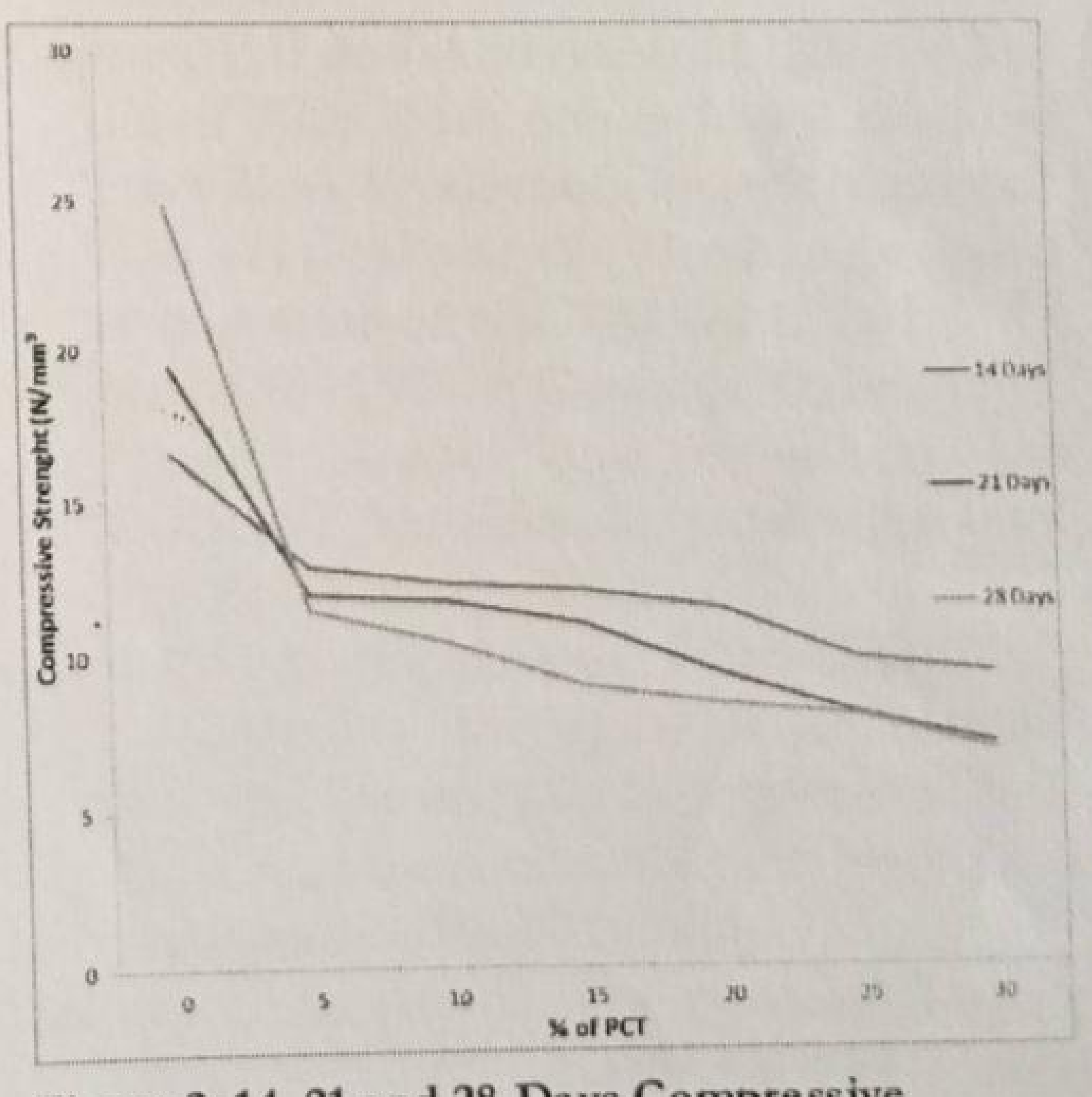

Figure 2: 14, 21 and 28 Days Compressive Strengths of PCT/OPC Concretes

Results of the Density Test

The densities of the specimens decrease with increase in % of PCT as observed in figure 3. The densities of the specimens are within the range recommended for normal weight concrete which is between 2355 to 2560kg/m^3

(Everett, 1990).

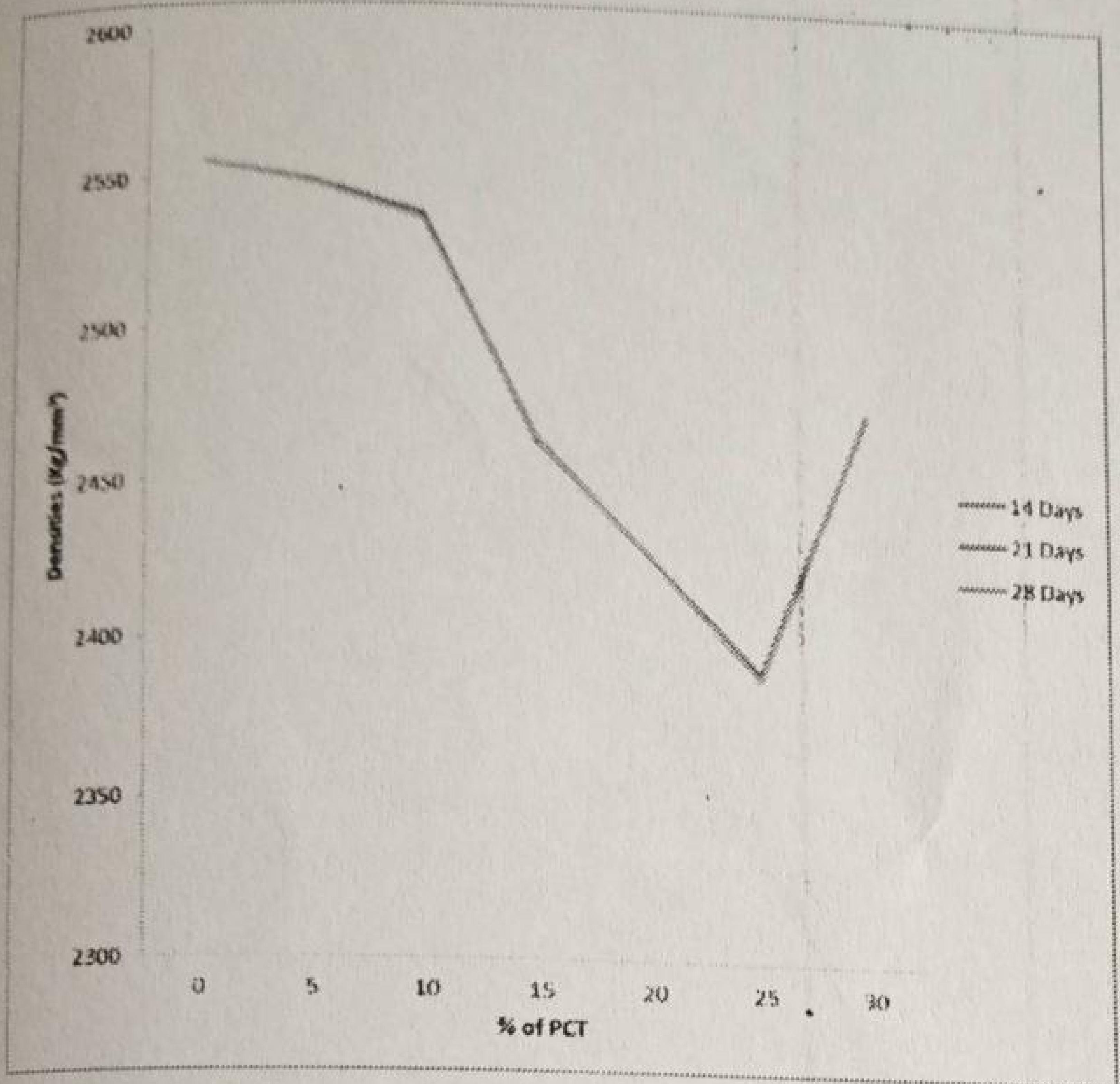

Figure 3: 14, 21 and 28 Days Densities of PCT/OPC Concretes

CONCLUSIONS

i PCT has increase influence on setting times and soundness of cement paste.

ii PCT performs poorly as partial replacement of OPC and cannot be recommended as strength increase additive in concrete production.

iii) The Density of concrete produced with partial replacement of PCT decreases as % of PCT increase.

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