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Research Article

The Effects of Iron-Ore Tailings on Setting Times of Some Commercial Cement

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Abstract: This work assessed three types of cement available commercially in terms of strength, porosity, setting and so on to prevent dangers waste of resources and to minimize cost of construction and if such similar commercial cements are mixed with iron-ore tailings. Burham, Dangote and Elephant cement were investigated to ascertain their setting times (both final and initial) using the Vicat apparatus. Iron-ores tailings which is amounting to several tonnes in piles which can in the future, lead to disposal problems was used as additives on these cements. The result shows that the tailings have positive effect on the setting times of the tested cements. Future work will address the contents of tailings which when added would provide the maximum benefit and also the effect on the compressive strength.
Keywords: Itakpe iron-ore, Tailings, cements, Initial Setting times, Initial Setting times, Vicat Apparatus.

INTRODUCTION

The tailings amount to several thousand tonnes in the pile. As the operation continues, a point would be reached when there would be any space to accommodate the tailing and this can lead to disposal problems[1-2]. This issue is now viewed from another perspective that since the tailings consists of almost the same constituents as the Portland cement;[7] the tailing could now be used to improve cement characteristics[3].

Itakpe iron-ore deposit is located near Okene in Kogi state, Nigeria The deposit as a proven iron ore reserve of about 200 million tonnes with an average of 36% Fe content. The estimated life of the mine is put conservatively at 25 years under average production rate of 8 million tonnes per year [4]. At this production rate, a lot of tailings are obtained as the waste products of beneficiated iron ore. Tables 1 and table 2 below show the composition for the tailings [4].

The Scope of this research work is to analyze Itakpe Iron-ore tailings which are the by-product from purification of iron-ore for its components[5] and to check its effect(s) on cement's setting time and compressive strengths when employed into usage, to assess three brands of cements as regards their setting times and compressive strengths and to recommend to the cement users the types and brands of cements that is/are suitable for different conditions and different constructions. A riffle slitter (box) was used to homogenize the sample in order to obtain a representative sample. A sample weighing 2000g was taken from the homogenized sample for test sieving. Sieves of sizes 2000mm, 1700mm,1180mm,850mm, 600mm, 212mm, 150mm and 75mm were used for the analysis. The result of the sieve analysis is shown in the table below.

Table 1: Composition of Itakpe Iron-Ore Tailings

Constituents	Percentage Composition (%)
SiO_2	71
Fe(total)	15
Al_2O_3	2.62
CaO	1.2
Total Alkali (Na_2O_3 + K_2O	1.2
MgO	0.3
TiO_2	0.2
P	0.08
S	0.03
Other Compounds and Elements	8.37

Table 2: Sieve Analysis

Sieve Size µm	Wt Retained (G)	% Wt Retained	Cummulative Wt % Finer
200	82.00	4.10	92.90
1700	60.00	3.00	89.90
1180	258.00	12.91	76.99
850	272.00	13.61	63.38
600	362.00	15.11	48.27
212	690.00	34.52	13.75
150	55.00	2.75	11.00
75	35.00	1.75	9.25
75	185.00	9.25	0

MATERIAL AND METHODS

Tests for initial and final setting times for the brands of cements under analysis

Materials and apparatus

300g of each three cement samples, clean water, Vicat apparatus, sensitive balance, 250ml graduate, non absorbent mixing plate (glass plate), trowel, spatulas, stop clock, lubricating oil, Itakpe iron ore tailings sample.

To determine the initial setting time of cement, which is the interval between the gauging and the partial loss of plasticity Vicat apparatus is used and the method is referred to as Vicat needle method.

The Vicat apparatus consists of a slender rod, square or round of 1mm square cross section with a flat end and the weight of the cap, rod and the needle being 300g.

Procedure

Initial setting time

These tests were carried out at room temperature (31^{o}c). 300g of a cement sample was weighed and poured on the mixing plate. Crater was formed in the centre and 25% of water, (75ml) was added and the material at the outer was turned into the Crater within 30 seconds by the aid of trowel. After about 30 seconds, it was thoroughly mixed and squeezed with hands for one minute. With the aid of hands, the paste was quickly formed into ball and tossed 6 times from one hands to the other keeping the hands about 15cm apart. With the ball resting on the palm of one hand, it was pressed into the mould through its larger end and the top of the paste was smoothened off.

The mould was then placed resting on the glass plate under the plunger in the Vicat apparatus. The 1mm square needle was fixed at the lower end of the Vicat apparatus and was brought in contact with the surface of the paste. The scale on the Vicat apparatus was then set to Zero and then released, the down penetration (mm) was noted. At 5 minutes interval, the just explained step was repeated until the paste stiffened sufficiently for the needle to penetrate no further than a point approximately 5mm from the bottom of the mould. These steps were repeated for the remaining Cement samples. The tailing was sieved and mixed with each cement samples in ratio 1:29 (3.33% tailings) and the above steps were repeated for this mixture and the initial setting time was recorded.

Final setting time

The 1mm needle used for the initial setting time was replaced by 5mm diameter attachment needle. The process of penetration continued as above until the needle made an impression on the paste but the circular cutting edge failed to do so. The final setting time was reckoned with from the moment when mixing water was added to the cement. Final setting time is the time required for gauged cement to acquire sufficient firmness to resist a certain definite pressure.

Precaution

- All the movable parts of the apparatus were lubricated before the experiment.
- All the readings were taken at eye level.
- The sequences of the experiment were in order of normal consistency, initial and final setting time.
- All the readings were taken thrice and the mean values were recorded.

RESULTS AND DISCUSSION

Table 3: Initial Setting Times of Cements

Time (Min)	MEAN PENETRATION (mm)					
	Burham only	Burham + Tailings	Elephant only	Elephant + tailings	Dangote only	Dangote + Tailings
0	28	31	20	22	17	13
5	29	32	21	23	19	17
10	31	34	22	25	19	***** 18
15	32	36*****	22	26	20	20
20	33*****	40	23	26	21*****	20
25	38	41	24	27*****	23	24
30	44	41	25*****	31	29	30
35	46	44	28	35	33	36
40	46	46	33	38	41	42
45	48	47	34	40	43	45
50	49	47	37	43	43	46
55	49	48	42	47	45	49
60	49	48	46	49	48	49

* Point at which the initial setting time is reached.

Table 4: Final Setting Times of Cement

Time (Min)	MEAN PENETRATION (mm)					
	Burham only	Burham + Tailings	Elephant only	Elephant + tailings	Dangote only	Dangote + Tailings
0	38	46	35	33	38	34
5	35	35	32	32	35	30
10	30	25	26	28	32	29
15	24	21	21	22	28	28
20	18	16	15	13	13	11
25	17	12	13	13	11	10
30	12	10	12	10	8	7
35	6	5*****	10	8	7	6
40	4*****	3	8	7	7	4*****
45	3	3	6	4*****	6	3
50	3	2	6	3	5*****	3
55	1	2	5*****	1	3	1
60	1	1	1	0	3	1

* Point at which the final setting time is reached.

Table 5: Summary of the Setting Times of the analysed Cements.

Cement Types	**Initial Setting Time (Min)**	**Final Setting Time (Min)**
Burham only	20	40
Burham + Tailings	15	35
Elephant only	30	55
Elephant + Tailings	25	45
Dangote only	20	50
Dangote + Tailings	10	40

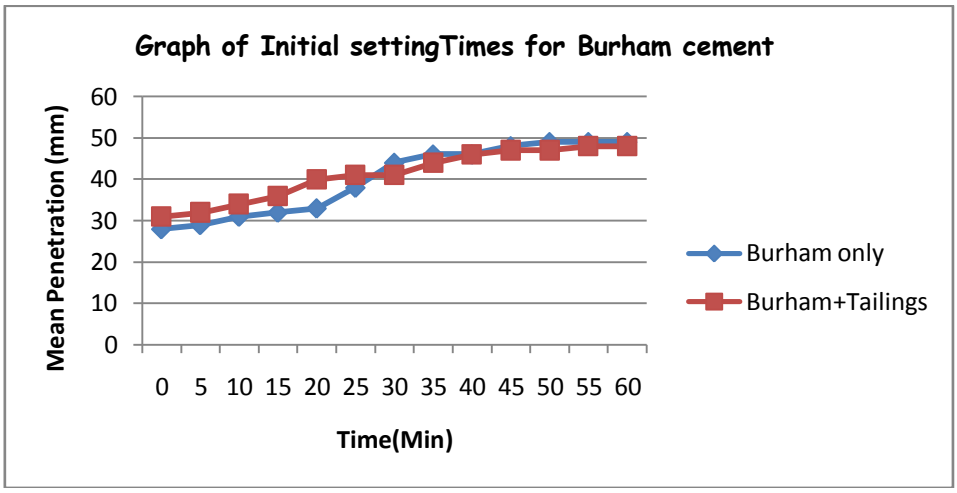

Fig 1: Initial Setting Times for Burham cement

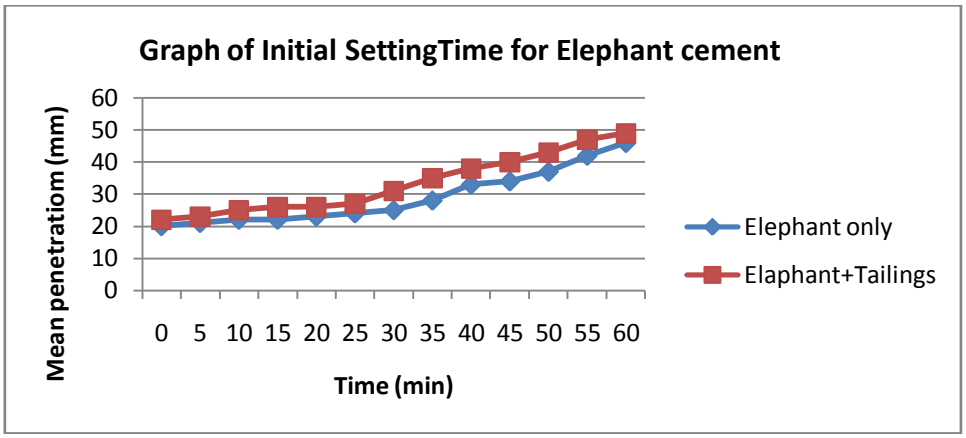

Fig. 2: Initial SettingTimes for Elephant cement

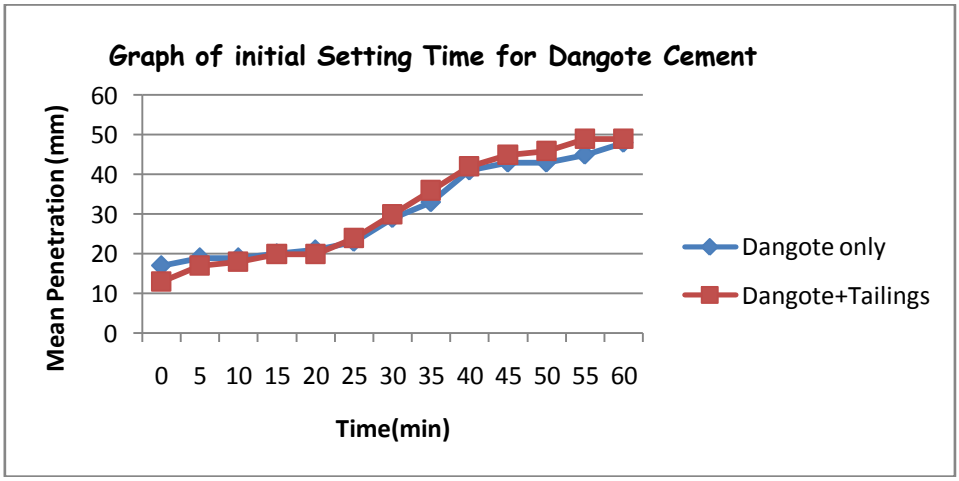

Fig.3: Initial Setting Time for Dangote Cement

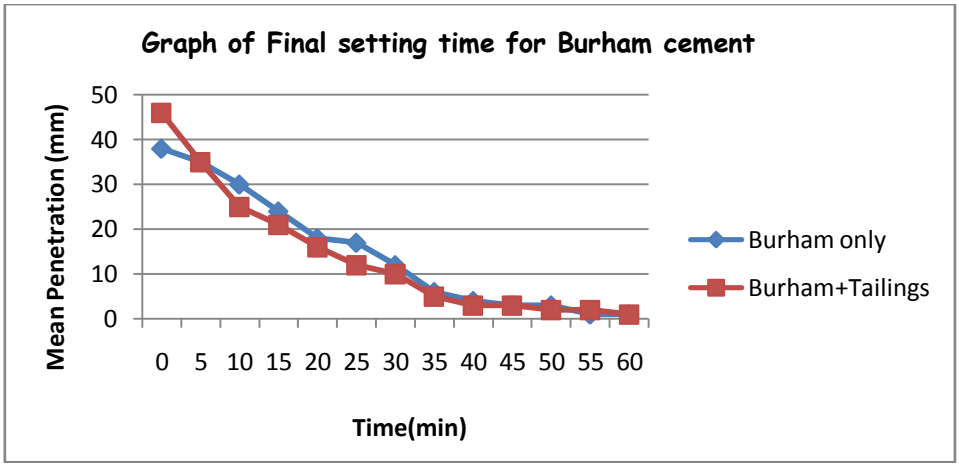

Fig.4: Final Setting Time for Burham Cement

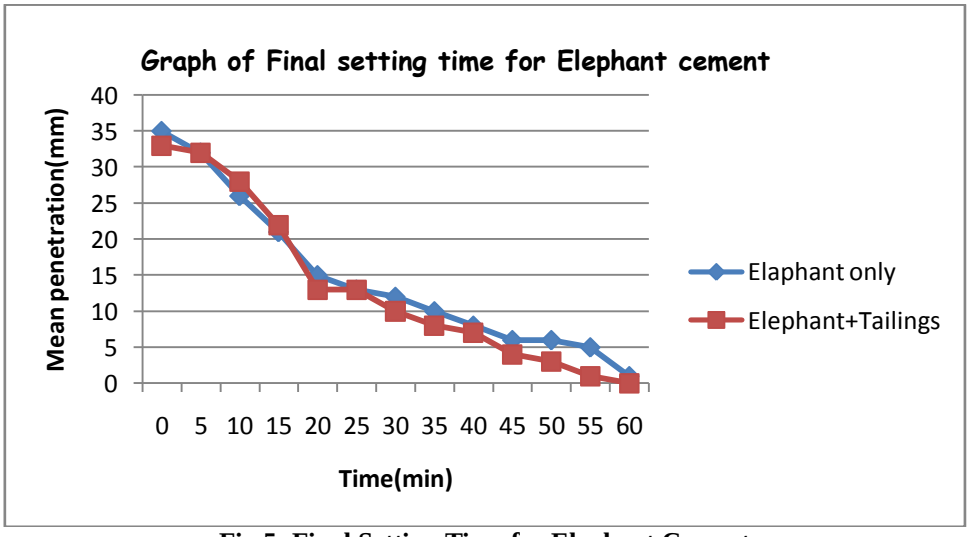

Fig.5: Final Setting Time for Elephant Cement

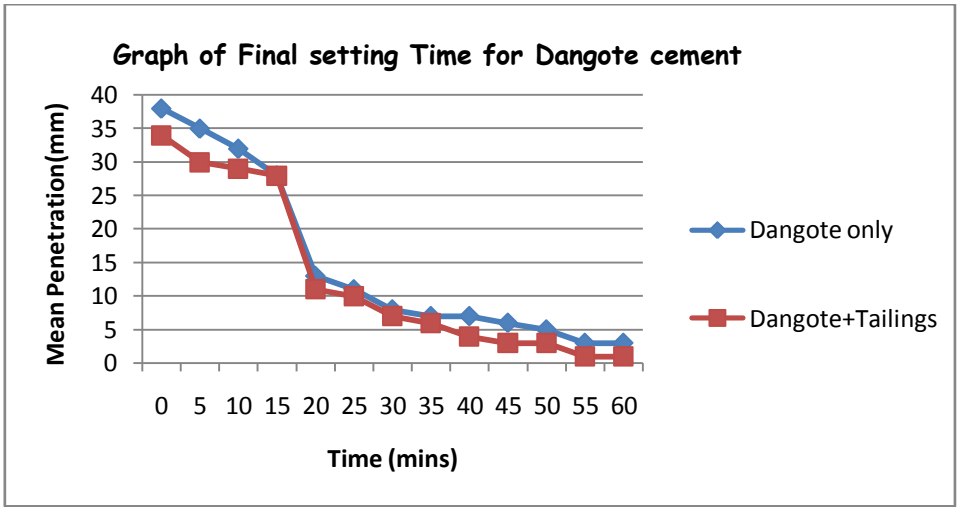

Fig.6: Final setting Time for Dangote cement

DISCUSSION

Burham Only

The initial setting time for this cement can be divided into three regions ,The time intervals between 0 and 20 minutes, 20 to 35 minutes and 35 to 60 minutes. The time of 20 minutes when this increment in rate of penetration begins signifies the setting time for Burham cement. After 35mins, the materials have almost hardened. Figure 4 shows the graph of the mean penetration versus the time and the rate of penetration reduced again. The graph has negative slopes because the mean penetration reduces with in time. Between 0 and 20 minutes, there is a linear relationship between the time and the mean penetration but from 20 - 25 mins, the penetration is almost constant reducing at 5mm depth which signifies the final setting time to be 40mins. Beyond 40 minutes, the mean penetration reduces to almost zero with increase in time depicting complete solidification.

Burham And Tailings

When Iron-ore tailings are added to Burham cement, the mean penetration as a function of time is shown in figure 1. It is obvious from this figure that the initial setting time is reduced from 20 to 15 minutes and the solidification occurs faster. The tailings appeared to have blocked some of the pores in the solidifying paste thereby increasing the rapid solidification of the paste. In addition, the final setting has dropped from 40 to 35minutes as shown in figure 1,following similar reasoning.

Elephant Only

This brand of cement was found to have the highest initial setting time (30 minutes) as shown in table 3; this is possibly because it has the finest particles among the three brands assessed. It was observed that water poured on this brand of cement did not sink immediately as expected, rather stays on before reaction due to the strong bond between the particles. Hence delayed the settings time to 30 minutes. In fact beyond 30 minutes, there is rapid solidification even though such solidification is longer for the same reason. Indeed the final setting time shown in figure 4 is equally higher (55 mins) depicted by the penetration reaching 5mm of the solidification paste. It is interesting to note that from figure 4. and figure 5 that the mean penetration versus the time curve for the two cement (Burham and Elephant) show similar trend in their final setting times.

Elephant And Tailings

Table 3 shows the reduction in the initial setting time (30-25) on this type of cement when the Iron-ore tailings was added which implies that the setting time can be controlled using Iron-ore tailings as an additive. Figure 2 which is Ogive-like in nature can be viewed from 2 stages and these stages have almost linear relationships. At 25 minutes, the initial setting time was reached and after this, the mean penetration increased proportionally with increase in time. On the final setting time as shown of fig 5, between 0 and 10 minutes, the relationship seems the fifteenth minutes, there is a very sudden drop penetration which signifies that the paste hardened up very fast and is almost constant from 20 to 25 minutes but after this, there is almost linear relationship between the mean penetrations and the time until the penetration reduce to zero which means, total solidification.

Dangote Only

Dangote cement was found to have initial setting time of 20 minutes as shown in the Table 3, that is, similar to that of the Burham figure 3 could also be viewed in three stages. Between 10 and 15 minutes when the initial setting has not been reached, there is a linear relationship but at the twentieth minutes, the setting time was reached. The remaining two stages are also linear but with increase in penetration. As for the final setting time from the fifteenth minute to the twentieth minutes there is a sudden drop in penetration as shown on figure 6. The setting time was reached at the fiftieth minute when the mean penetration dropped to 5mm.

Dangote And Tailings

The effect of tailings on this cement as regards the setting time is the decrease in setting time. The graph of this Dangote tailings as shown on fig 3 which has an ogive -like shape after the initial setting time has been reached at the tenth minute, the cement paste begins to solidify with time and from the 55^{th} minutes, the penetration remained almost constant. Moreover, the final setting time for this mixture which is shown on figure 6, it be seen that between 0 - 15 minutes, there is almost linear relationship but between 15 - 20 minutes, there is a pronounced drop in penetration which implies a very fast hardening rate and the paste later solidifies linearly with time.

CONCLUSION

It could be observed from the results of test and the analyses that both the initial and the final setting times for Burham cement are the lowest of the three branches (Elephants, Dangote and Burham). This is followed by Dangote while Elephant has the highest value. The effect of tailing decreased the setting times which ultimately increase the hardening rate.

REFERENCES

1. Yun CHEN; Utilization of Mine Tailings in China. Shanghai Land & Resources, 2012; 4:21.
2. Hudson-Edwards KA, Jamieson HE, Lottermoser BG; Mine wastes: Past, present, future. Elements, 2011; 7(6):375-380.
3. Benzaazoua M, Fall M, Belem T; A contribution to understanding the hardening process of cemented pastefill. Minerals Engineering, 2004; 17(2):141-152.

4. Audu DA, Zakari YI, IGE I; Radiological Effects of Iron-Ore Mining and Processing at Itakpe, Kogi State. Journal of Natural Sciences Research, 2003;3(15):92-98.
5. Ajaka EO; Recovering fine iron minerals from itakpe iron ore process tailing. ARPN Journal of Engineering and Applied Sciences, 2009; 4(9):17-28.
6. Adepoju SO, Olaleye BM; Gravity Concentration of Silica Sands from Itakpe iron-ore Tailings by Tabling Operation. Department of Mining Engineering, Federal University of Technology, Akure, Nigeria, Nigeria Journals of Engineering Management, 2001; 2(2):51 – 55.