

Assessment of the Qualities of Dangote and Elephant (Portland) Cement Brands commonly used in the Nigerian Construction Industry

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ABSTRACT: Lack of choice and branding has made EPC and DC brands the most commonly used Portland cements in the Nigerian Construction Industry and generally especially in the South-West zone where this study was carried out. This study appraised the engineering properties of the two cement brands, Dangote and Elephant using a sampling fraction of 0.1 to ensure equal representation of the two samples. The study finds that both conform to ASTM150-92, BS&EN197-1:2000, SON standards, all relating to the minimum allowable engineering qualities of Portland cement. Also, the study shows that EPC has an average finesse of 7.02% compared with DC of 12.08%. Variation in 10mm diameter plunger penetration for EPC is; 28%-26.8% while that of DC is; 25%-25.4%. The setting times for both brands of cement shows that EPC has a higher setting time of 3hrs compared to DC with 2hrs, 40mins, indicating that EPC sets better than DC. In terms of CS, EPC has an average CS of 22.931N/mm² compared to DC of 21.852N/mm² for the 7days curing period; 25.631N/mm² and 23.372N/mm² for the 21 days; 36.178 N/mm² and 30.163 N/mm² for 28 days curing period respectively. These results compare favourably with ASTM 150-92 for minimum strength requirements for 7-28 days curing period of 20N/mm² -28N/mm². BS&EN 197-1:2000 specifies a range of 32.5-42.5N/mm² for 28 days curing period, a standard met by only EPC. This study finds that the two cement brands meet the standards set by ASTM 150-92, while only EPC conforms to BS EN 197-1:2000 regarding minimum and maximum range for CS for Portland cements. The SG for EPC ranges from 2.73-2.83 while DC has a range of 3.20-3.00. Finally, a small increase in the density of mortar cube is observed during curing for both brands of cement. The density of EPC mortar was noticed to be slightly higher than DC. In conclusion, this study finds that EPC exhibits high concrete strength than DC.

KEYWORDS: ASTM (American Society for Testing and Materials), BS (British Standard & Cement Composition Specifications), BDT (Bulk Density Test), CT (Consistency Test), CS (Compressive Strength), DC (Dangote cement brand of Portland cement imported as bulk cement and re-bagged in Nigeria), EPC (Elephant Portland cement brand of Portland cement manufactured in Nigeria), EN (European standards), SGT (Specific gravity test), FT (Fineness Test), SON (Standard Organization of Nigeria).

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I. INTRODUCTION

This study sets out to assess the engineering qualities of EPC and DC, assess the compliance of the brands of cements to various local and international standards and compare the results obtained.

According to the European Standard EN 197-1 [10], cement is a hydraulic binder, a finely ground inorganic material which, when mixed with water, forms a paste which sets and hardens by means of hydration reactions and processes and which after hardening, retains its strength and stability even under water. Lea [12] states, when a material increases in strength even when stored under water after setting, the material is said to be hydraulic. Cements may also be defined as adhesive substances capable of uniting fragments or masses of solid matter to a compact whole [11]. The major components of Portland cement that forms a clinker are tricalcium silicate ($3\text{CaO} \cdot \text{SiO}_2$), dicalcium silicate ($2\text{CaO} \cdot \text{SiO}_2$), tri-calcium aluminate ($3\text{CaO} \cdot \text{Al}_2\text{O}_3$) and tetracalcium aluminoferrite ($4\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{Fe}_2\text{O}_3$), these notations for the above compounds are shortened for use in cement industry as C3S, C2S, C3A and C4AF respectively; C3S and C2S are responsible for strength development, while C3A and C4AF control setting and heat evolution during hydration [14]. There are several brands of Portland cement available in the market but their chemical compositions are the same but under different brand names. Variations in physical properties occur due to the variation in the amount of chemical constituents during manufacturing [14].

Although there are other cement brands in the Nigerian markets like Ibeto cement, Unicem cement and Bua cement brands, this study assesses the qualities of Dangote and Elephant cement brands as the two major brands used in the Nigerian construction industry especially in the South-West zone where the study was carried out. The key physical parameters used in classifying and comparing the two identified Portland cements include bulk density, relative density (specific gravity), fineness, setting time, compressive strength and consistency test.

Other parameters such as soundness, heat of hydration, loss on ignition and chemical composition were not considered due to the fact that other authors have worked extensively on these parameters. The non-availability of manufacturers' data that may enable the end users of branded Portland cements to make the best choice prompts this study, bearing in mind that collapsed buildings are often traced to the quality of cement used in the construction process. In highlighting some qualities of the two chosen brands of Portland cements, this study will in a long way help to alleviate some of the identified problems inherent in the choice and to a larger extent eliminate the use of inferior quality cements that abound in the Nigerian Economy.

II. METHODOLOGY

A probability sampling method is any method of sampling that utilizes some form of random selection. In order to have a random selection method, we need to set up some process or procedure that assures that the different units in the population have equal probabilities of being chosen.

The basic terms are:

N = the number of cases in the sampling frame

n = the number of cases in the sample

${}^N C_n$ = the number of combinations (subsets) of n from N

$f = \frac{n}{N}$ = the sampling fraction

In this study, 100 bags each of Elephant cement and Dangote cement were considered in which 10 bags were randomly selected from each type of cement. of the 10 bags, 1 Kobiowu (divided into 10 equal parts), for laboratory tests and analyses.

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Thus,

Population size $N = 100$

Sample size $n = 10$

Test sample $m = 0.1$

Laboratory sample, k

Where,

$$k = 0.01$$

$$f = \frac{0.01}{0.1} = 0.1$$

This implies that the sampling fraction of cement is 0.1 and the interval size is 10. This shows that different units in the population have equal probabilities of being chosen and the sample size is relatively large enough for representation.

This study used EPC (grade 32.5) and DC (grade 42.5) purchased at Oke-Baale, Osogbo, Osun State, Nigeria. A population of 100 bags of each brand of cement was selected from which 10 bags of cement samples were randomly picked for sampling. From each bag of Cement for EPC & DC, a local pan called 'Kobiowu' was employed in taking samples from each bag for laboratory tests. The tests carried out include; CS test, ST test, FT, BDT, SGT, CT.

All tests carried out covers the 7, 14, 21 & 28 days curing period for concrete setting with Portland cement. All laboratory tests were carried out under scrutiny and using International Standard format for such tests under laboratory environment.

III. RESULTS AND DISCUSSION

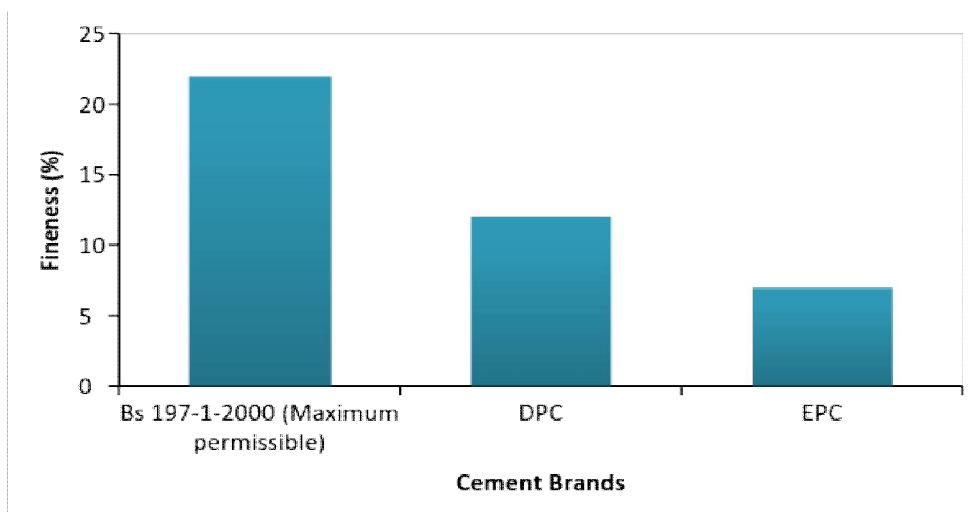


Fig. 1 Graph depicting the finess result between EPC,DC and Standard

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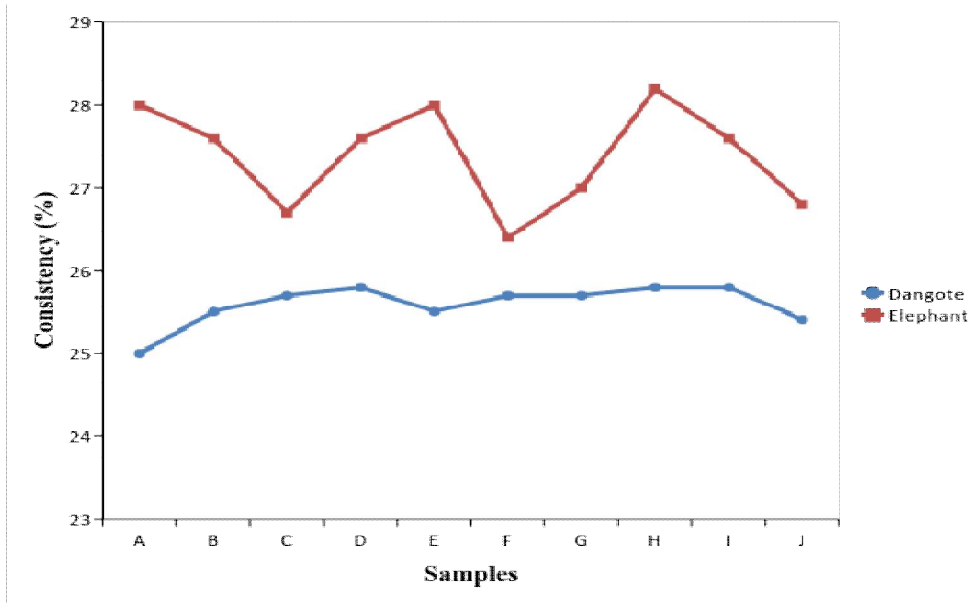


Fig. 2 Graph showing the consistency variation of the 10 tested samples of EPC and DC

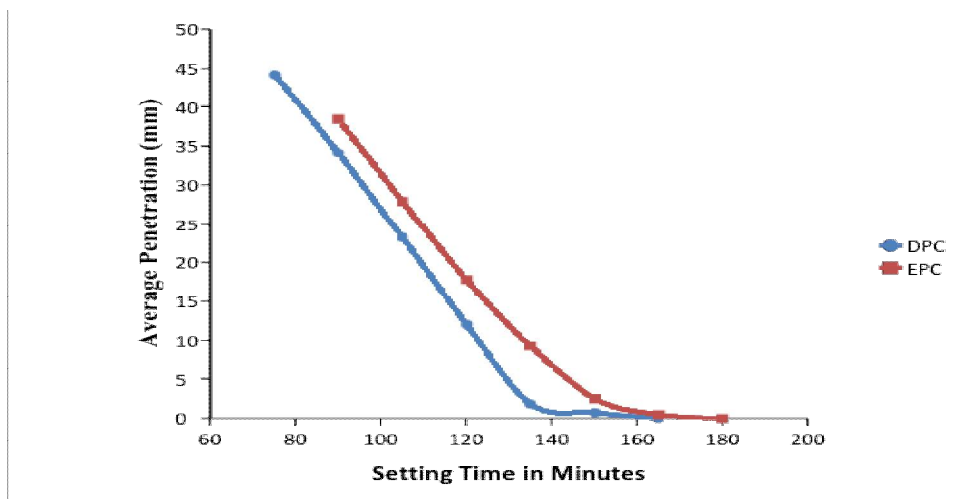


Fig. 3 Graph indicating the setting time of EPC and DC

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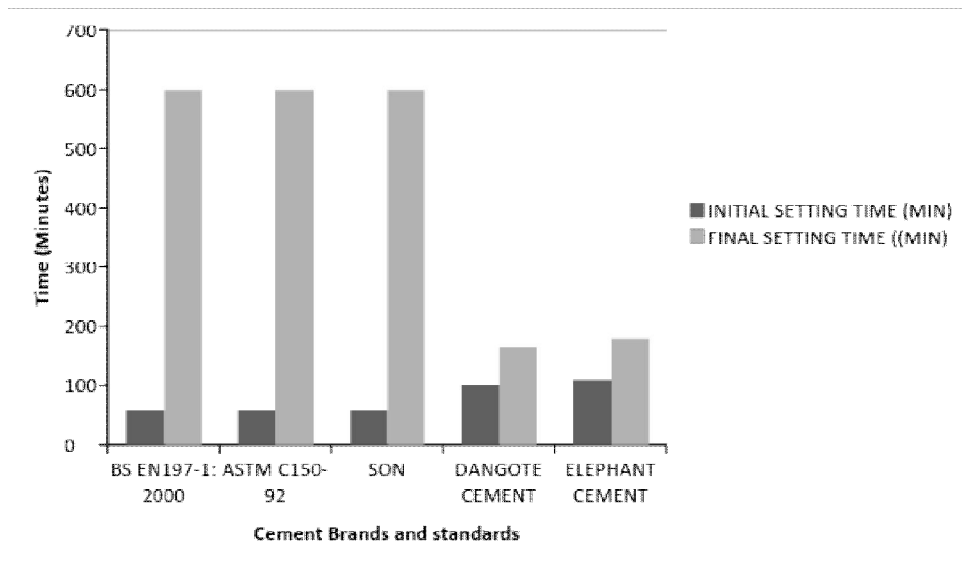


Fig. 4 Graph comparing the setting times of the two cement brands and international standard specifications

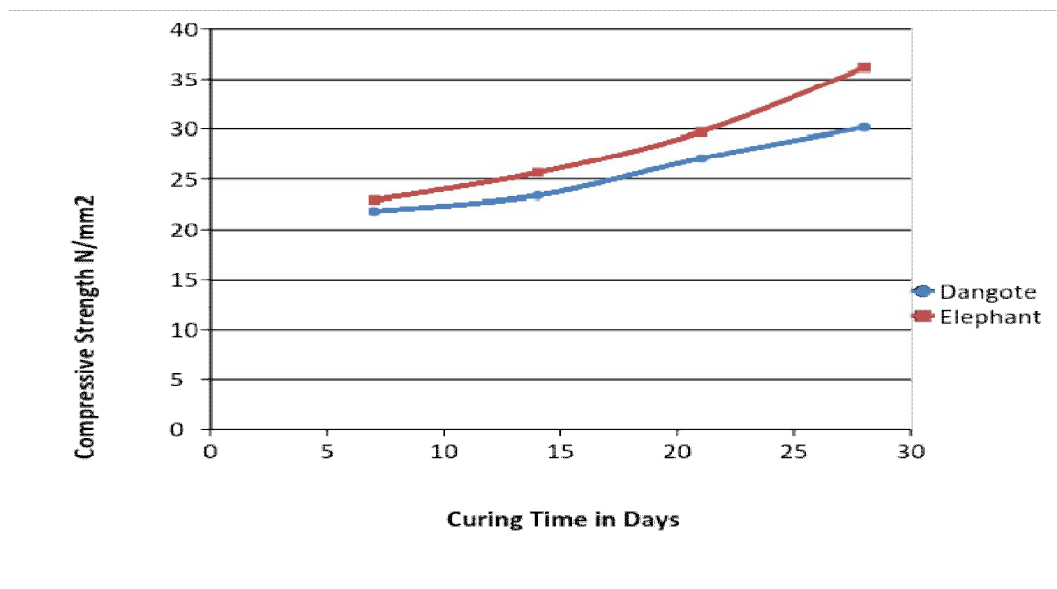


Fig. 5 Graph showing the rate of increase in compressive strength of the two cement brands after curing from 7-28 days period

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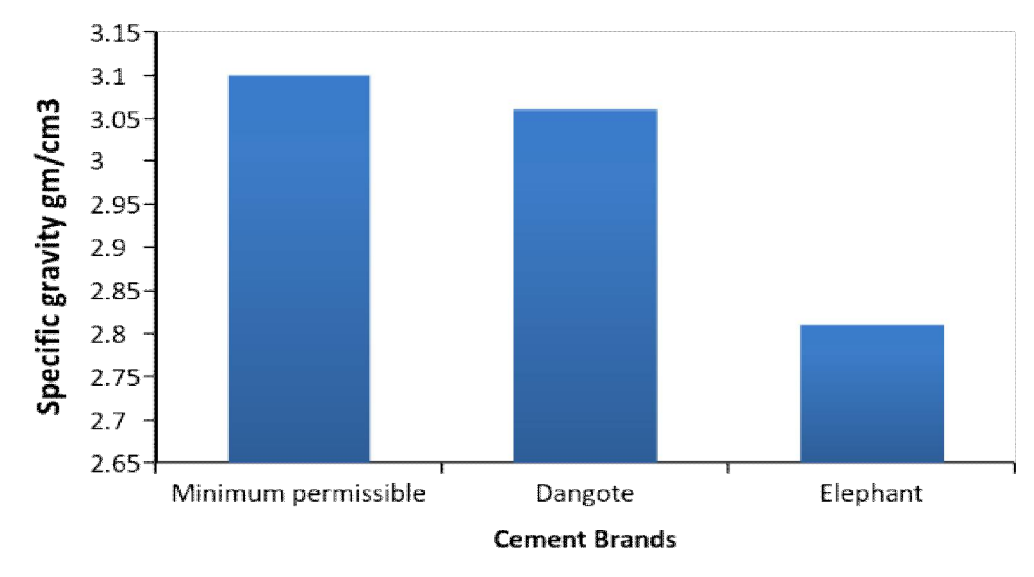


Fig. 6 Chart showing the comparison between the specific gravity of the two brands of cement

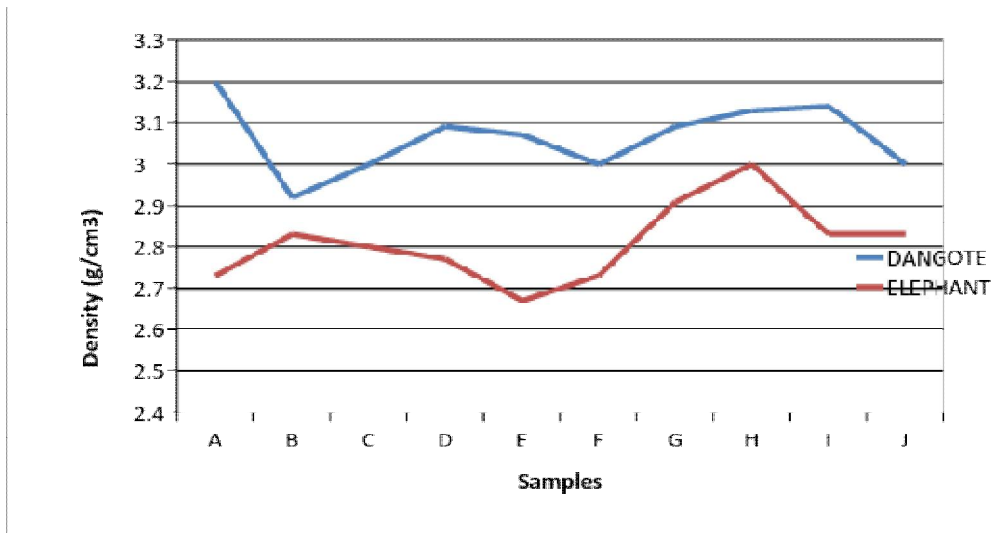


Fig. 7 Graph showing the bulk density of EPC and DC

Fig. 1 Shows EPC with a lower fineness value, this makes it prone to air setting than DC with the higher fineness value that will be less susceptible to air setting, the size of cement particle has an important effect on the rate at which it will hydrate when exposed to water. Fineness, the particle size of cement affects rate of hydration and strength gain, while fine cement is desired for rapid strength development, very fine cement is susceptible to air set and early deterioration [15]. Specifications require that percentage of cement retained on 75µm sieve (No.200) shall not exceed 22% and on

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150 μm sieve (No.100) not more than 10% and since 75 μm sieve was used to carry out the fineness test, both cement brands conform to standard. This study agrees with Nwankwojike et al [13], in their study, fineness for DC and EPC brands are 2% and 0.34% respectively with the use of 150 μm sieve (No.100). EPC was found to be finer than DC and they both conform to standard (not greater than 10%) as confirmed by this study.

On Consistency variation test, in fig. 2, there is a small variation in the consistency between EPC & DC samples tested. The average consistency between the two brands of Portland cements range from 27.4 (W/C Ratio %) for EPC and 25.6 (W/C Ratio %) for DC. This result is satisfactory and correlates with the findings of Anejo, et al [6]. Consistency of a cement paste measures its ability to flow expressed as percentage by weight of water content of the paste to dry cement [13]. Assessment of setting time and strength development rate of any particular cement demands the knowledge of its consistency. Cement paste of standard consistency has a specified resistance to penetration by a standard plunger. The water required for such a paste is determined by trial penetrations of pastes with different water contents. Content of water is expressed as percentage by mass of the cement. The consistency of 32.5N and 42.5N of Dangote cement are 28.8% and 37.4% respectively not correlating to the current findings.

The final setting times for EPC and DC are 180mins and 160mins respectively as found by this study (fig. 3). This finding does not agree with the findings of Anejo, et al [6] which states that the final setting time for EPC is 9hrs 33mins and DC is 8Hrs 22mins reason for this disparity can be researched further by other scholars. While most standards recommend a minimum initial setting time of 60mins to maximum setting time of 600mins (see fig. 4 above). Though, Yahaya [18] found that the physio-mechanical analysis shows considerable deviation from ASTM [3] and BSI [7] respectively.

The result of this study shows a disparity in the rate of increase in the compressive strengths of the two brands (fig. 5). This study finds that at the various curing periods of 7-28 days, the compressive strength of EPC ranges from 23.0 N/mm² – 37.0 N/mm² while DC ranges from 22.0 N/mm² – 30.0 N/mm² respectively. These results correlate with the minimum allowable standards for Portland cements. These results correlate with most similar research findings; [9], [13], [17], [18] and [14].

Figure 6, shows the comparison of the allowable standards on specific gravity and the results obtained by this study for EPC and DC Portland Cements respectively. DC has a SG close to the allowable minimum of 3.1 g/cm³ while EPC has a SG of 2.8 g/cm³ or there about.

According to Nwankwojike et al [13], the Bureau of Indian Standards (BIS) and European Standard EN 197-1, for Portland cement used for intensive load bearing superstructures is expected exhibit minimum of 3.1 g/cm³ which is met by DC but failed by EPC. Therefore, DC Conform to the standard but EPC does not.

Finally, this study establishes that the bulk density (BD) of both brands of Portland cements vary considerably (fig.7). This study establishes the average BD of EPC as 2.81 g/cm³ and DC, 3.06 g/cm³ respectively; meaning that DC has more pores in its make-up than, EPC.

IV. CONCLUSION

Based on this study investigations and results presented, the following conclusions can be reached:

1. The two brands of Portland cement investigated, conform with set standards in the terms of fineness while EPC is finer than DC which may result in rapid strength development;
2. Elephant and Dangote Cements both conform with the standards set by SON, ASTM and BS; in-terms of initial and final setting times for Portland cement, while the setting times for DC is lower than EPC;

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3. The compressive strength of DC (42.5), does not meet the British Standard's minimum strength allowable but conforms to the ASTM standards while EPC (32.5) conforms with both the ASTM, SON and British standards respectively and its slightly higher than the CS of DC (42.5);
4. EPC and DC brands of Portland cement do not meet the minimum standards set for SG but DC is closer to the minimum standards than EPC.

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