Comparative Analysis Of Portland Cements In Nigeria

Ige, Olubisi Adekunle
Civil Engineering Department, Osun State Polytechnic, Iree, Nigeria.

Abstract

Portland cement remains the most common type generally in use throughout the world as a basic ingredient of concrete. Five brands of Portland cement commonly available in Nigeria were investigated through series of tests conducted to determine their strength characteristics, setting time, soundness, workability and fineness among others and examined if they meet the minimum standard as stipulated by the British Standard Institute. Five brands of cement considered were Dangote, Elephant, Burham, Diamond and Purechem. The results show that all the brands examined meet the British Standard requirements on all the tests subjected to. Burham cement was fastest with initial setting time of 100 minutes ahead of other, while Dangote cement was the least with initial setting time of 180 minutes. The strengths characteristics of the five brands are similar with slight difference recorded. Dangote cement had the highest strength at 28th day curing period of 474 KN as the crushing load while the least strength was of Purechem at 370.6 KN as the crushing load.

Key words: Portland cement, compressive strength, concrete, Ordinary, Brands.

1. Introduction

Portland cement is a substance which binds together the particles of aggregates (usually sand and gravel) to form a mass of high compressive strength concrete. It is a combination of limestone or chalk with clay mixed in a proportion depending on the type of cement desired. Portland cement is the most common type of cement generally used around the world because it is a basic ingredient of concrete, mortar and stucco. It is a fine powder produced by grinding Portland cement clinker more than 90%, and a limited amount of calcium sulphate which

controls the set time. Portland cement clinker is a hydraulic material which consist at least two-thirds by mass of calcium silicates ($3CaO.SiO_2$ and $2CaO.SiO_2$).

Portland cement can also be defined as cement that only hardens by reacting with water but also forms a water-resistant product produced by pulverizing clinker consisting one or more of the forms of calcium silicates, usually containing one or more of the calcium sulphate, the low cost and wide spread availability of the limestone, shale and other naturally occurring materials make Portland cement one of the lowest – cost materials widely used over the last century throughout the world, (Neville and Brooks, 1987).

2. Background of the Study

Portland cement was developed from natural cements made in Britain in the early part of the nineteenth century, and its name was derived from its similarity in colour and quality of the hardened form to Portland stone, a limestone that was quarried on the Isle of Portland in Dorset, England which describes a cement obtained by intimately mixing together calcareous and argillaceous, or other silica, alumina, and iron oxide- bearing materials, burning them at a clinkering temperature and grinding the result clinker, (Neville, 1995). The production of Portland cement however, originated from a British bricklayer from Leeds called Joseph Aspdin. It was one of his employees (Isaac Johnson) however, who developed the production technique, which resulted in more fast-hardening cement with a higher compressive strength in 1824. Isaac Johnson's cement was an artificial cement similar in properties to the materials known as "Roman Cement", (Gillberg, B, Johnson, A. and Tillman, A. M. 1999).

However, in Nigeria, there are various brands of Portland cement in market which are used in construction industries. There have been sentimental and unconfirmed analyses by various groups in the industry comparing between the available brands of cement on setting time, workability, fineness and compressive strength. It is then long overdue for a proper independent academic research to ascertain the properties of each of the brands of cement available. Apart from the extreme special cases in which specialized cements are required, there are other few cases where the construction personnel will be in doubt of which of the brands of cement available will perfectly meet the instant need like a little delay in setting time

or early setting time as the case may be. The result of this investigation will clear all these doubts.

3. Materials and experiments

The research was carried out in civil engineering laboratories of Osun State Polytechnic, Iree and Federal polytechnic Ede, Osun State, Nigeria. The five brands of Portland cement used for analysis were procured from main depot in Osogbo and Ibadan, Nigeria to enhance good and accurate results. The cement brands made available were (I) Elephant Portland cement, (ii) Dangote Portland cement, (iii) Burham Portland cement, (iv) Diamond Portland cement, and (v) Purechem Portland cement. The aggregates (coarse and fine) used were those specified in line with (BS 8110, 1985) as recommended, (Ige, 2008; Mccarter, 2010).

All the experiments were carried out under normal temperature of 32^0C using concrete mix ratio 1:2:4 and clean water in line with (BS: 12 1996). Some of the properties of cement brands analyzed were in Compressive strength test, Slump test (workability), Fineness test, setting time test among others.

The compressive strength of various brand of cement were accomplished by batching of the concrete materials which was done by weight (Ige, 2008). The concrete materials, cement and aggregates were mixed by manual and the materials were mixed together thoroughly by shoveling to form a uniform mass. The cube moulds were cleaned with lubricant to prevent the development of bond between the mould and the concrete and permit easy removing. Each mould was then filled with prepared fresh concrete in three layers and each layer was compacted with tamping rod using twenty five (25) strokes uniformly distributed across the sections of the concrete in the mould. The top concrete was later smoothened by hand-trowel to level with the edge of the mould and then left in the open air for 24 hours. For each of the cement brand, three cubes of concrete were cast for a particular period and therefore, a total of 60 cubes were produced for testing. The concrete cubes were demoulded after 24 hours of the concrete setting under air. They were kept in curing tank measuring 2.0m x 2.0m filled with tap water only for periods of 7, 14, 21 and 28 days respectively.

The slump test, fineness test and setting time test were carried out as stipulated in BS 8110 (1985) and analyzed by (Shetty, 2001). The usual slump cone was used with three different volumes of water, 1000 ml, 1500 ml and 2000 ml to

compare the workability of the cement brands. Fineness test was accomplished using Sieve test with standard sieve No 15. The vicat mould, base – plate and timing clock were used to carry out setting time. The penetration-test was repeated at regular interval of 15 min when setting was beginning, the interval between tests was 5 minutes.

4. Results and discussion

4.1 Analysis of fineness test

The result of fineness of brands of cement is as shown in Table 1.

Table 1: Fineness Analysis of Brands of Cement.

S/N	CEMENT	WEIGHT OF CEMENT BEFORE SIEVING (g)	WEIGHT OF RESIDUE (g)	WEIGHT OF FINE CEMENT AFTER SIEVING (g)
A	Dangote	100	2.2	97.8
B	Elephant	100	5.5	94.5
C	Bur ham	100	3.0	97.0
D	Diamond	100	2.5	97.5
E	Purechem	100	3.5	96.5

It is shown from the Table 1 above that though, all results were in agreement with the stipulated standard, Dangote cement gives the best fineness result. The fineness of cement has an important bearing on the rate of hydration, and hence, on the rate of gaining of strength. Finer cement offers a greater surface area for hydration hence faster the development of strength, (Pomeroy, 1989).

Figure 1 shows a clearer picture of Elephant cement having the largest weight of residue of all the brands tested.

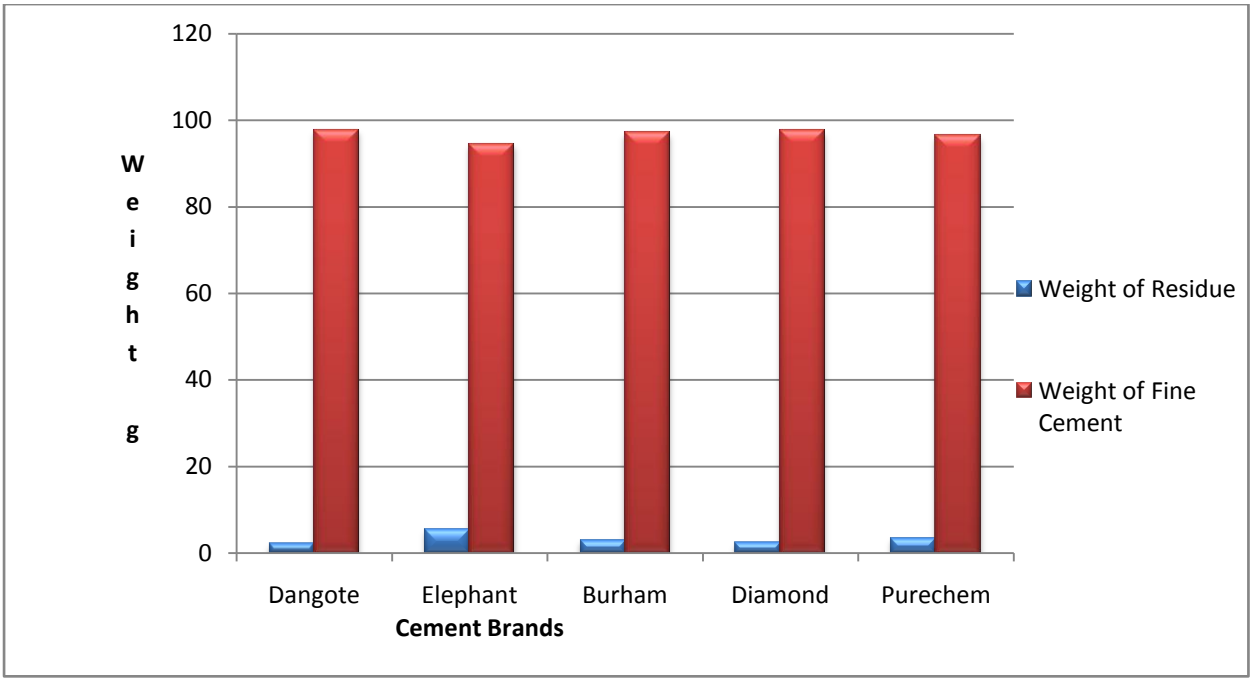

Fig. 1. Weight of residue and fine cement after sieving

4.2 Compressive strength characteristics.

From the experiment, the following was calculated and known;

1. Mass (kg) of each concrete cube, i.e. weight of the cube
2. Density (mass / volume) density = (M x 1000000) / 150m^3
3. Crushing strength (N/m^2) = $\frac{\text{Force (crushing load) x 1000}}{\text{Cross sectional area (150 x 150)}}$

Table 2: Results 7 days crushing load

Cement	Crushing Load 1 (kg)	Crushing Load 2 (kg)	Crushing Load 3 (kg)	Mean Crushing Load (1 + 2 + 3)/3 kg
Dangote	210	216	208	211.3
Elephant	200	206	202	202.6
Burcham	210	218	210	212.6
Diamond	208	200	206	204.0
Purechem	196	200	192	196.0

Table 3: Results of 14 days crushing load

Cement	Crushing Load 1 (kg)	Crushing Load 2 (kg)	Crushing Load 3 (kg)	Mean Crushing Load (1 + 2 + 3)/3 kg
Dangote	250	218	210	226.0
Elephant	216	220	220	218.0
Burcham	220	216	218	218.0
Diamond	214	214	210	212.6
Purechem	210	198	206	204.6

Table 4: Results of 21 days crushing load

Cement	Crushing Load 1 (kg)	Crushing Load 2 (kg)	Crushing Load 3 (kg)	Mean Crushing Load (1 + 2 + 3)/3 kg
Dangote	440	426	400	422.0
Elephant	338	324	340	334.0
Burcham	386	324	380	363.3
Diamond	360	316	372	349.3
Purechem	310	318	296	308.0

Table 5: Results of 28 days crushing load (mean)

Cement	Crushing Load 1 (kg)	Crushing Load 2 (kg)	Crushing Load 3 (kg)	Mean Crushing Load (1 + 2 + 3)/3 kg
Dangote	470	472	480	474.0
Elephant	390	396	394	393.3
Burcham	400	410	416	408.6
Diamond	400	406	410	405.3
Purechem	380	382	350	370.6

The plot of Crushing load against the curing age which is the result of the compressive strength is shown in figure 2 below. It shows that compressive strength increases as the days of curing increases.

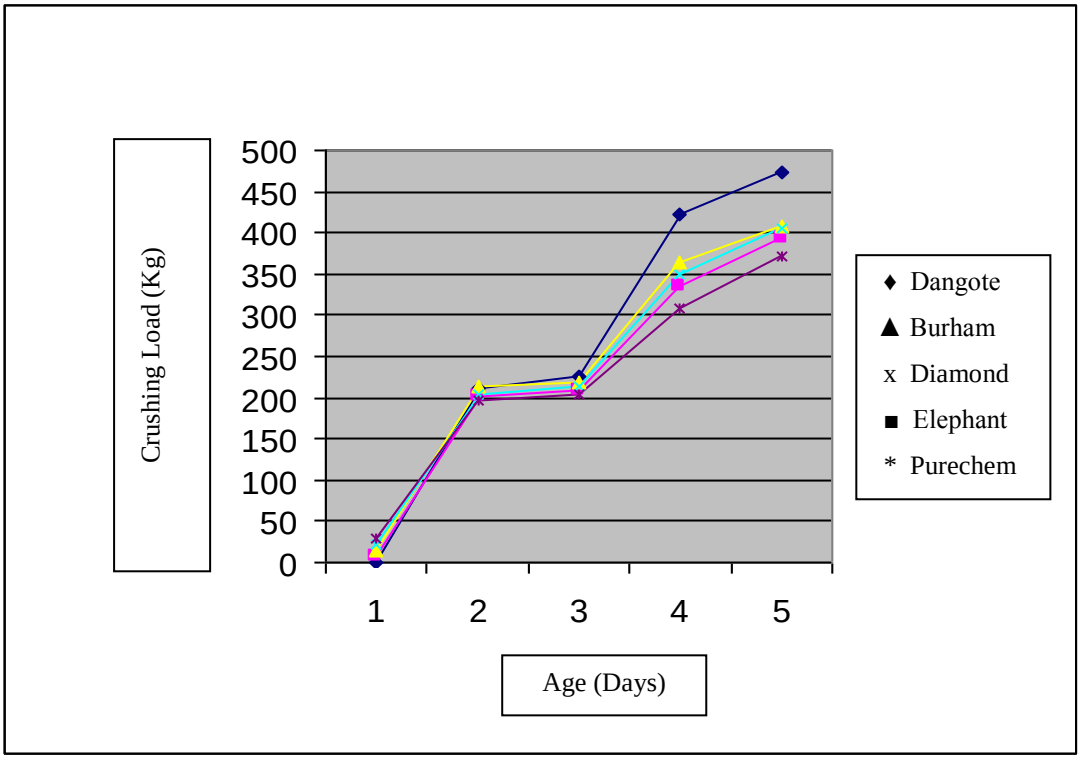

Fig 2: Crushing loads (kg) versus concrete age (days)

The result shows Diamond cement in early gain of strength ahead of other cements with the crushing load of 204 KN at 7th day cure while Dangote had the highest strength of crushing load of 474 KN at 28th day strength.

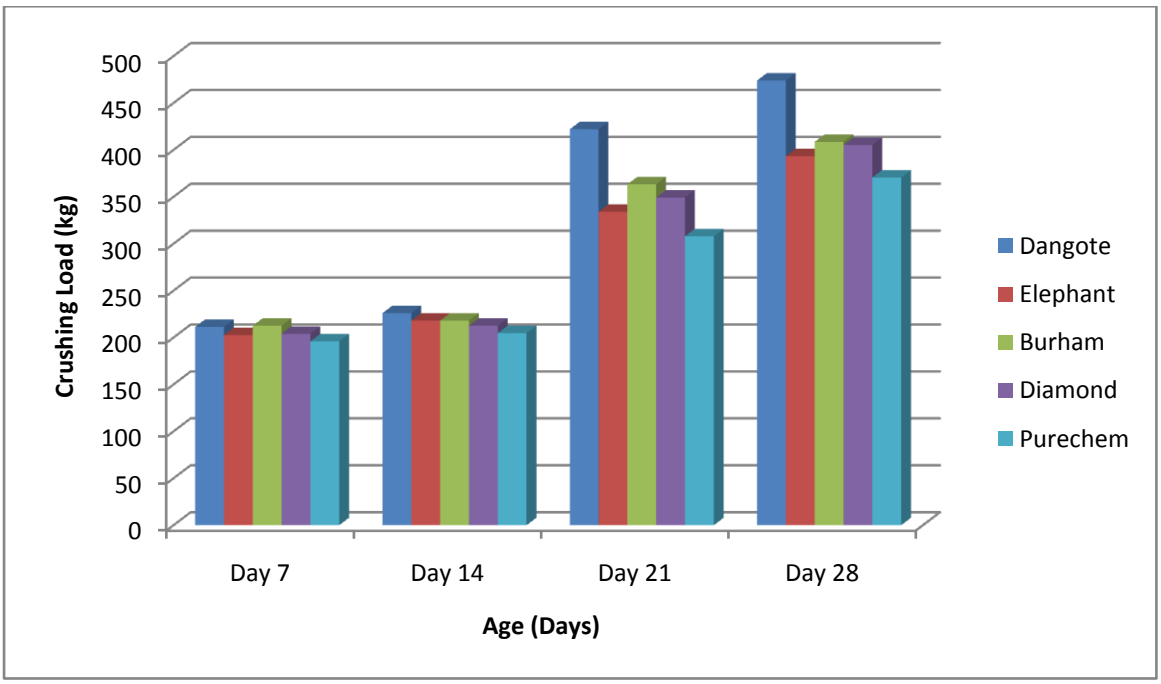

Fig 3: Strength analysis of brands of Portland cement.

4.3 Analysis of slump test

Table 6: Slump test analysis

S/NO	CEMENT	1ST RESULT AT 1000ML WATER CONTENT (MM)	2ND RESULT AT 1500ML WATER CONTENT(MM)	3RD RESULT AT 2000ML WATER CONTENT (MM)
A	Dangote	210 True	190 True	140 False
B	Elephant	250 True	230 True	130 False
C	Burham	218 True	200 True	135 False
D	Diamond	215 True	180 True	120 False
E	Purechem	221 True	205 True	142 False

The results indicate good workability of the resulting concrete produced from various brands of cement for 1000 and 1500 ml of water where true slump exists.

4.4 Soundness

The respective lime saturation factor (LSF) is as shown in table 3. Three of the cement brands had very low expansion, Dangote, Burham and Diamond brands indicating existence of low impurities. The chemical composition of these brands of cement would result in rapid hydration. (Chris, 2001)

All the cement brands meet the requirement of BS 12, (1996) section 12, which recommends an expansion of not more than 10 mm for Ordinary Portland Cement.

Table 7: Soundness characteristics of cement brands

	Expansion on making (mm) a	Expansion before boiling (mm) B	Cool expansion (mm) c	Expansion after boiling (mm) d	Expansion (b – d) (mm)
Dangote	3.5	3.5	0.0	3.5	0.0
Diamond	6.0	6.5	0.5	7.0	0.5
Elephant	1.0	1.0	0.5	2.0	1.0
Burham	2.0	2.0	0.0	2.0	0.0
Purechem	4.0	4.0	0.0	4.0	0.0

4.5 Setting time

The initial and final setting times of various brands of cement are shown in table 8 and figure 4. Setting time of any brand of cement depends on quantity of C_3S and C_3A, high percentages of which lead to more rapid setting, (Melita, 1986).

Table 8: Setting Time of Brands of Cement.

S/N	CEMENT	Initial Setting Time (Minutes)	Final Setting Time (Minutes)
A	Dangote	180	225
B	Elephant	160	245
C	Burham	100	205
D	Diamond	135	180
E	Purechem	120	150

From the above result, Burham cement sets faster than all others with initial setting time of 100 minutes while Purechem and Diamond cements taking the lead with final setting time of 150 and 180 minutes respectively ahead of Burham cement closely followed with 205 minutes. However, all results fall within the standard minimum stipulated by BSI.

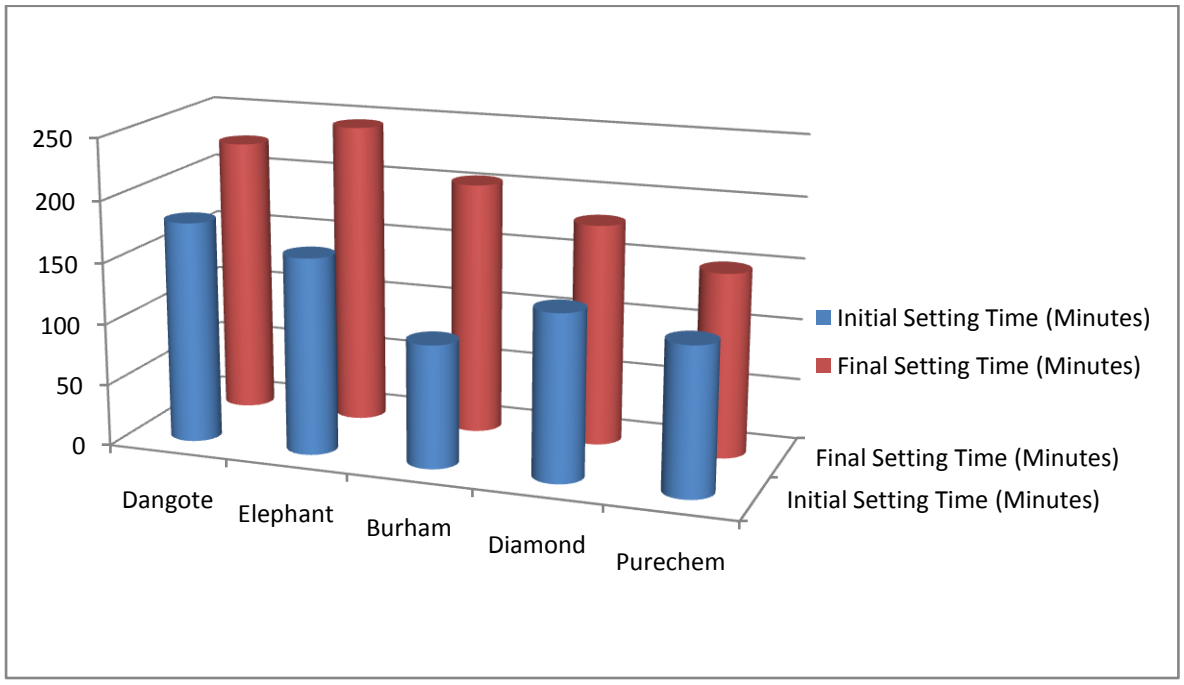

Fig. 4: Initial and final setting time of cement brands

5. CONCLUSION

The following conclusions can be drawn from the study and result of this project:

1. Generally, all the brands of cement meet the minimum standard stipulated by the British Standard Institution on Ordinary Portland Cement and any one of the brand available will optimally perform in construction industry.
2. Dangote Portland cement can be generally rated as the best among the selected Portland cements due to its strength, setting time, fineness and workability, followed by Elephant Portland cement Burham Portland cement, Diamond Portland cement and Purechem Portland cement.
3. The strength in the concrete increases with age for all the selected brands of Portland cement as it can be seen by the crushing loads.
4. All the cement brands can be recommended for large concrete pours with provision for expansion joint to prevent cracking.
5. The densities of concrete cubes do not vary much but dependent on the age of curing while the strength increases with the age of curing

6. REFERENCES

British Standards Institution, BS 12 (1996): Portland Cement (Ordinary and Rapid Hardening) BSI London.

British Standards Institution, BS 8110: Part 2[1985]: Structural Use of Concrete: Code of Practice for Design and Construction. BSI London.

Chris Boyd (2001): Recovery of Wastes in Cement Kilus. Retrieved March 30, 2011 from http://web.archive.org/web/20080624/html.

Gillberg, B, Johnson, A, Tillman, A. M. (1999). Concrete and Environment. Sweden: Stockholm, AB Svensk Byggtienst.

Ige, O.A. (2008). Science and Properties of Materials. Nigeria: Sandmarks Innovations, Ring road,Ibadan.

MCCarter W.J (2010): Admixture in Cement: A Study of Dosage Rates on Early Hydration. New Delhi: S Chand Co. Ltd.

Melita P.K (1986): Concrete Structure, Properties and Materials. Englewood Cliffs, N.J Prentice-Hall Inc.

Neville, A. M. (1995). Properties of Concrete, Fourth Edition. England: Longman Group Limited.

Neville, A. M. & Brooks, J. J. (1987). Concrete Technology. England: Longman Group Limited.

Pomeroy, D. (1989): Concrete Durability: from Basic Research to Practical Reality. ACI Special Publication, SP – 100: 111 – 31.

Shetty, M.S (2001): Concrete Technology Theory and Practice. New Delhi: S. Chand and Co. Ltd.