

Characteristic Properties of Pervious Concrete Using Brands of Cement for Hydraulic Structure

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Publication Date: 2025/09/26

Abstract: The study investigated the characteristics of brands of cement to produced pervious concrete. A Convectional concrete was also produced to serve as control. The study involved the determination of compressive, flexural strength of concrete, permeability, void ratio content and pervious concrete density produced with 0.35 water cement ratio. The pervious concrete cubes with volume 150 x 150 x 150 mm³ and flexural specimen in a standard volume in mm³ were cured for three specific period of (7, 21, and 28days) using 1:4 mixed ratio. The brands of cement used were Dangote falcon 32.5, Dangote 3x grade 42.5, elephant Supaset 42.5 and elephant Lafarge 32.5 N/mm. The slump test carried out and shows that elephant supaset has the least slump values. Compressive strength was determined after 28days of curing and it was carefully observed with Dangote falcon had the highest strength of 16.99N/mm², Elephant supaset was second highest with 14.54 N/mm², Elephant Lafarge with 14.14N/mm² and Dangote 3x having 14.14N/mm². Elephant supaset (grade 42.5) had highest density with the value 2120.08 kg/m³, the water absorption showed that Dangote 3x (42.5) has affinity for water. It is concluded that elephant supaset is the most workable amongst the grades of concrete and Dangote 3x is the most suitable for plastering rather than casting of concrete. It can also be used as hydraulic structures to cheek floods.

Keywords: Pervious Concrete, Properties, Cement, Brands of Cement and Hydraulic Structure.

How to Cite: Adeyokunnu, A.T.; Ajisafe J.T. (2025) Characteristic Properties of Pervious Concrete Using Brands of Cement for Hydraulic Structure. *International Journal of Innovative Science and Research Technology*, 10(9), 1583-1588. <https://doi.org/10.38124/ijisrt/25sep024>

I. INTRODUCTION

Concrete has brittleness capacity and generally used for its properties in structural element in the construction sector. The propose of lightweight concrete has been the focus; and the study has been a challenges to the scientists and engineers. (Chandra *et al.*, 2011). Lightweight concrete constraint has impact on its density in which strength it is a major priority and not affecting the cost. Density of concrete can be lowered by adding another aggregates into the mix design. Ordinary concrete is produced by mixture of four components such as cement, sand, granite and water. A lightweight aggregates are commonly used in replacement of granite and sand. (Akinwumi, 2016).

Lightweight aggregates are prominent materials in concrete in which represent about 60-80% of total concrete constituent (Adesanya and Ejeh, 2014). The most effective properties of aggregate helps in concrete properties which works against environmental effects, static and dynamic loads on concrete by its own capacity. The workability, durability, strength, fire resistance and shrinkage are determined by the significant impact of composition, shape, characteristics, size of aggregate and source of aggregate.

Thus, the sources aggregate influence the properties of concrete produced thereof (Brook and Neville, 2012).

Pervious concrete has high porosity in formation, it minimizes runoff from a site and result to ground water. (Atoyebiet *al.*, 2018). Pervious concrete is formed with an aggregate, cementitious paste to bind the coarse aggregate particles and maintaining the voids against fast draining. It is important to the residential streets, parking lot, pedestrian walkways, and greenhouses (Sadiq and Atoyebi, 2015). The proper use of pervious is to provide storm-water management pollution control recognized by the United States environmental protection agency (Osuolaleet *al.*, 2019).

The pervious concrete has an advantage over normal cement concrete, it plays a vital role in the treatment of water for pollution removal, curbs and storm sewers, slide resistance in pavements, discharge to local aquifers (Mujeduet *al.*, 2014). Pervious concrete is a compound formed by coarse aggregate, Portland cement and water. The absence of fine aggregate makes it different from the convectional concrete, its aggregates are binded together with cement paste (Adesanya and Ejeh, 2014), which resulted into a concrete with highly interconnected voids which enhance

rapid percolation of water through it; in its function state. It voids ratio based on its uses is ranging from 15 to 40%. It has a less unit weight, high permeability and less compressive strength compared to conventional concrete (Akinwumi, 2016).

Raining is a nature which people in the world have experienced with unbearable consequence resulted from increased rainfall and reduced permeability in urban regions. An environmental problem can be solved with different approach around the region. Therefore, to overcome these difficulties; production of pervious concrete is considered the best management practice because of its capability to reduce excessive storm-water runoff (Adewoleet *al.*, 2014). At present, no attention is paid on production of pervious concrete using different coarse aggregates, this calls for concerted effort to investigate properties of pervious concrete using different coarse aggregates.

II. MATERIALS AND METHODS

➤ Materials

The constituents used were granite and brands of cement: such as Dangote falcon 32.5, Elephant Lafarge 32.5, Elephant Superset 42.5 and Dangote 3 42.5. The granite was obtained from quarry sites at Ona Ara Local Government Area, Ibadan, Oyo state. Fine aggregate and water was obtained locally in Ibadan land. The concrete mix ratio used was 1:4. The volume of the cube produced was measured in 150mm x 150mm x 150mm and were tested for compressive strength, density of concrete and the 150 x 150 x 450 mm³ of Flexural Specimens were tested in accordance with BS 1881: part 116:1970 and BS 1881: part 117:1983.

➤ Moisture Content

This test on granite was done by oven dry method, the containers were cleaned, and weighed before filling of sample. Samples of granite were placed inside the containers and the weight before oven dry was recorded. The container with the sample was placed in the oven for 24 hours at a temperature of 105°C to 110°C and after cooling the samples were weighed and recorded.

$$\text{Water Content (\%)} = \frac{(W_2 - W_3)}{W_3 - W_1} \times 100$$

W_1 = Weight of container (g)

W_2 = Weight of container and wet granite (g)

W_3 = Weight of container and dry granite (g)

➤ Slump Test

A cone height of 300mm was used in carrying the slump test. A smooth horizontal surface was prepared on which the cone with smaller opening at the top was placed. The concrete was poured in three layers inside the cone; each layer was tamped 25 times with a rod 16-mm diameter standard tamping steel. The top surface was strike off by using tamping rod in a sideways movement until it a flat surface is achieved. The cone was lifted immediately filling and the height

different of the slump from the center of the slumped concrete was measured and recorded.

➤ Compacting Factor Test

Compacting apparatus plays a vital role in carrying out a compacting factor test. The upper hopper was filled with concrete and then released for the next bottom hopper to be filled, the bottom hopper was released so that the concrete would drop to the lower hopper. The lower hopper was released after been filled for the concrete to fill the cylinder; excess concrete was cut off by two floats slide, across the top of the mould. The net weight is then known and the volume of the cylinder was determined.

Compacting factor was measured by ratio of the weight of partially compacted concrete to the weight of the fully compacted concrete.

$$C.F = \frac{\text{weight of partially compacted concrete}}{\text{weight of fully compacted concrete}}$$

➤ Density Test

Pervious concrete specimens were taken out from storage for density test after 28days of curing, according to ASTM C 642. The moisture present on the surface of the cured concrete was dried and turned to Saturated Surface Dry (SSD) condition. The weight of samples in air (C) at SSD was measured and recorded. The specimens were placed in the oven at a temperature of 100 to 110°C for 24 hours. The specimen was measured after oven dry, weight of samples in air (A). The specimens were inside bucket placed under water, weight under water (D) was obtained. Temperature of water at test day (T) was also recorded and water density (p) was calculated for that temperature. In conclusion the density of concrete was determined:

$$\text{Dry Density (Bulk Density)}, g_1 = \frac{Ap}{(C - D)}$$

Where:

A = Mass of oven-dried sample in air (g)

C = Mass of saturated surface-dry sample in air (g)

D = Mass of sample in water after immersion (g)

P = Density of water (kg/m³)

➤ Compressive Strength Test

The sample of pervious concrete was set for compressive strength test at required duration in accordance to ASTM C 39. The diameters of the cylinders and cross-sectional areas were determined in accordance to ASTM C 39. A load was exerted on the sample at a required loading by the universal testing machine. The cylinder was placed within the bearing blocks, the centroid axis of the specimens were aligned properly and compression was applied. The compressive strength of the specimen was derived by the ratio

of maximum load acquired during compression test to the cross-sectional area of the specimen.

$$\text{Compressive strength (N/mm}^2\text{)} = \frac{\text{failure load (N)}}{\text{gross area of cube (mm}^2\text{)}}$$

➤ Flexural Strength Test on Pervious Concrete

For pervious concrete, this test was used to evaluate the strength of concrete in a slab and to test the ability of mass concrete slab to withstand failure in bending, (Raheem, 2012). The specimens were prepared by filling the mould with pervious concrete and were tamped with 35 blows in three layers. The specimen mould 150 x 150 x 450 mm. it will be demoulded after 24 hours and tested at 21, 28 and 56 curing age respectively. Continuous load was applied on specimen without stoppage till it gets to a point of failure. The flexural strength of pervious concrete was determined using equation.

$$F_r = \frac{PL}{bd^2}$$

Where:

b = Width of the specimen (mm)

d = Failure point, height of the specimen (mm)

L = Length of the Specimen (mm)

P = Maximum force applied (N)

➤ Water Absorption and Abrasion Test

Water absorption test was carried out on cubic specimens with a side of 150 mm, completely immersed and

cured for 28 days. The mass of each specimen were recorded after completely saturated and then samples were placed in a dryer with hot air circulation Pol-Eko SLW 400, at 105°C±5°C. In the dryer, the samples were dried to constant weight and the result was recorded again. Daily weight measurement of the samples was observed, with an accuracy of 1.0 g which shows the full cycle of testing the absorption of water by concrete. After this stage, determination of the water absorption levels in all materials was started. Calculations of water absorption were carried out according to the provisions of standard, i.e. EN 13369 [134] i.e. the standard relating to concrete precast elements.

Thus, the water absorption of concrete specimens was calculated according to Eq.

$$W_a = \frac{M_1 - M_0}{M_0} \times 100\%$$

Where: W_a = Water absorption

M_0 = Mass of the sample saturated with water

M_1 = Mass of the dried sample

III. RESULT AND DISCUSSIONS

➤ Workability of Pervious Concrete

The results of the slump test carried out is shown in fig 1 which indicates that the slump value of Dangote falcon (Grade 32.5) is higher than that of Elephant Lafarge (Grade 32.5), while Dangote 3X (grade 42.5) is higher than the slump value of Elephant superset (grade 42.5).

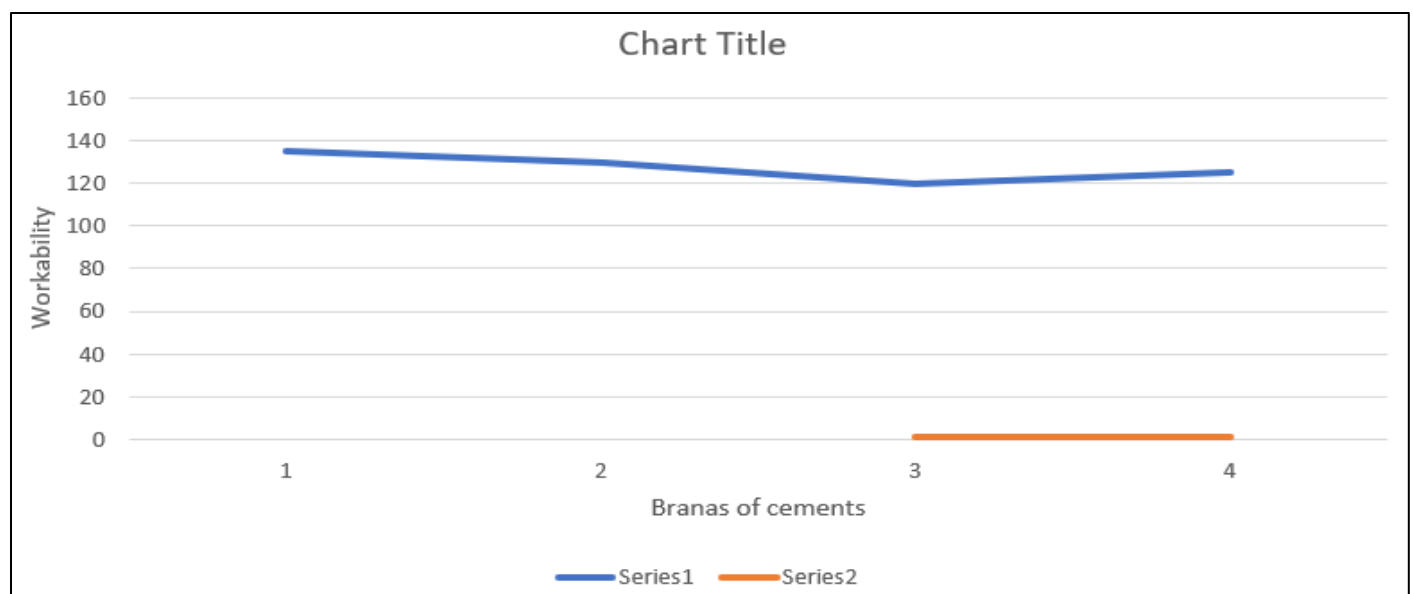


Fig 1 Plots of Workability against Brands of Cements

➤ Compressive Strength of Concrete

The compressive strength test was carried out on pervious concrete at 14, 21 and 28 days curing period. The result derived from the test is presented in figure 2. It was observed that Dangote Falcon (grade 32.5) leads the other

brands of cement at 14 days curing period with 12.0 N/mm² followed by Supaset (grade 42.5) to Elephant Lafarge (grade 32.5) Dangote 3X (grade 42.5) been the least of all At 21 days curing period, it was observed that Dangote falcon (grade 32.5) had the highest strength value 14.80 N/mm² followed by

Elephant supaset with 13.59 N/mm², Elephant Lafarge (grade 42.5) with 13.18 N/mm², and Dangote 3X (grade 42.5) with 12.94 N/mm².

Lafarge of 14.14N/mm² and Dangote 3X having 13.79 N/mm².

At 28 days of curing, the final strength test was carried out on the brands of cement with Dangote falcon (grade 32.5) having the highest compressive strength 16.99N/mm² followed by Elephant supaset of 14.54 N/mm² , Elephant

At this point, it was discovered that Dangote falcon (grade 32.5) produced the highest strength after 28 days curing period. Generally, strength increases as curing period increases.

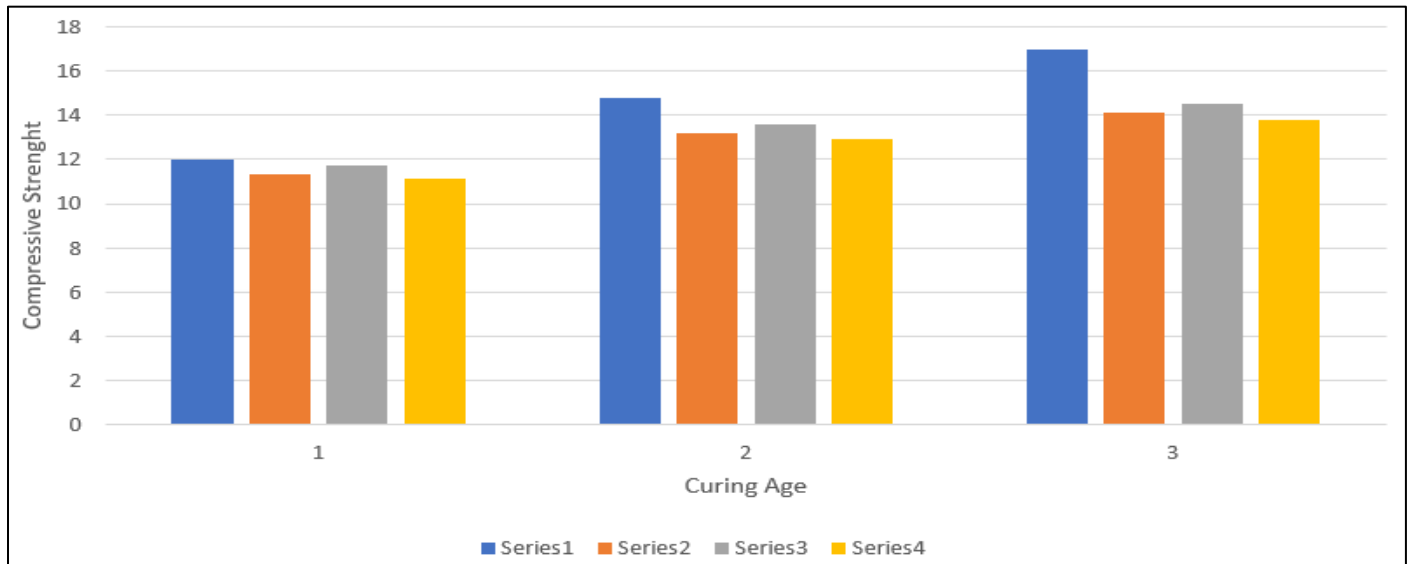


Fig 2 Illustration of Compressive Strength against Cement Brands

➤ Bulk Density of Previous Concrete

The result of bulk density for the brands concrete is produced in fig.3. The density for the Dangote falcon (grade 32.5) ranges from (176.21 - 2090.30), Elephant Classic (grade 32.5) ranges from (1763.14 - 2068.14), Elephant supaset (grade 42.5) ranges from (1787.00 - 2120.08), and Dangote 3X (grade 42.5) varied from (1760.19 - 2075.41) kg/m³. The density of the previous concrete increases as curing period is increases. Elephant supaset (grade 42.5) had highest density followed by Dangote falcon (grade 32.5) with value 1765.21 kg/m³, Elephant Lafarge (grade 32.5), and

Dangote 3X (grade 42.5) with value 1760.19 kg/m³ at 14 days curing period.

At 21days of curing period, Elephant supaset (grade 42.5) had highest while Elephant Lafarge (grade 32.5) had lowest density value. At 28days of curing period, Elephant supaset (grade 42.5) had highest density with the value 2120.08 kg/m³, followed by Dangote Falcon (grade 32.5) with 2090.30 kg/m³ and Elephant Lafarge (grade 42.5) with the density of 2068.14 kg/m³.

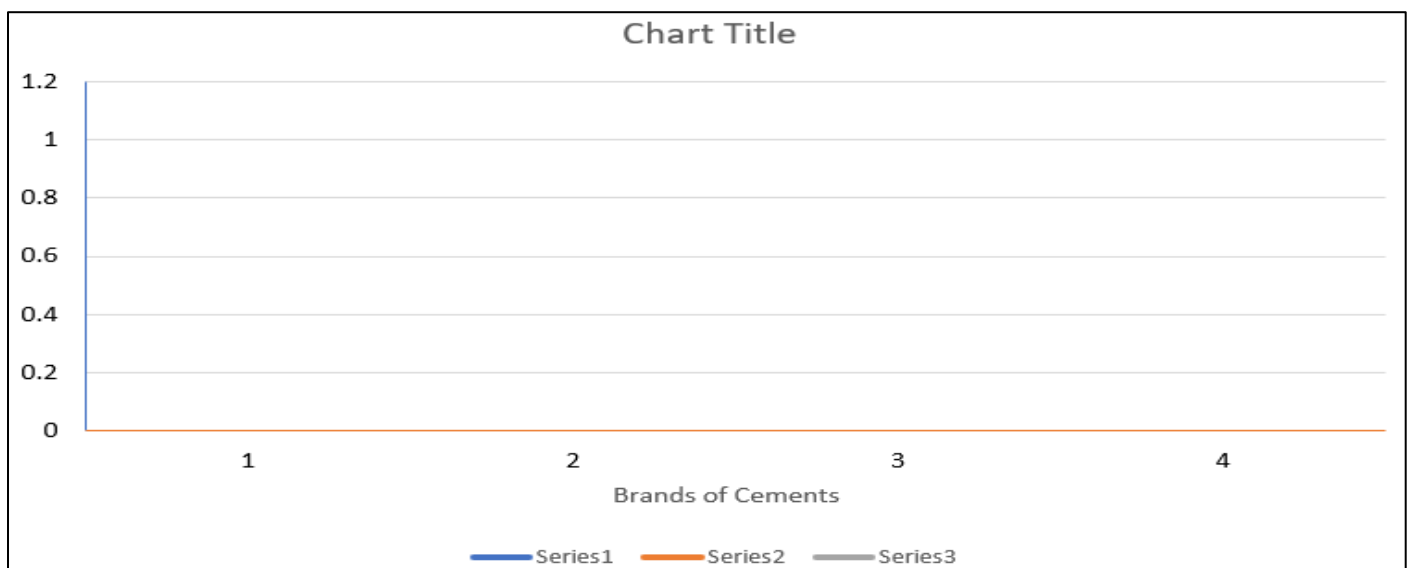


Fig 3 Illustration of Density against Brands of Cements

➤ Water Absorption of Pervious Concrete

The result obtained from the absorption test on concrete cubes are presented in fig.4. The result indicated that Dangote 3X (grade 42.5) had the highest water absorption with the value 3.43%, followed by Elephant Lafarge (grade 32.5) with

the value 3.26% the Dangote falcon (grade 32.5) with the value of 2.06% and Elephant supaset has the lowest water absorption. It shows that the pervious concrete becomes more workable as the water absorptivity value is lesser than 3% as recommended by British standard specification values.

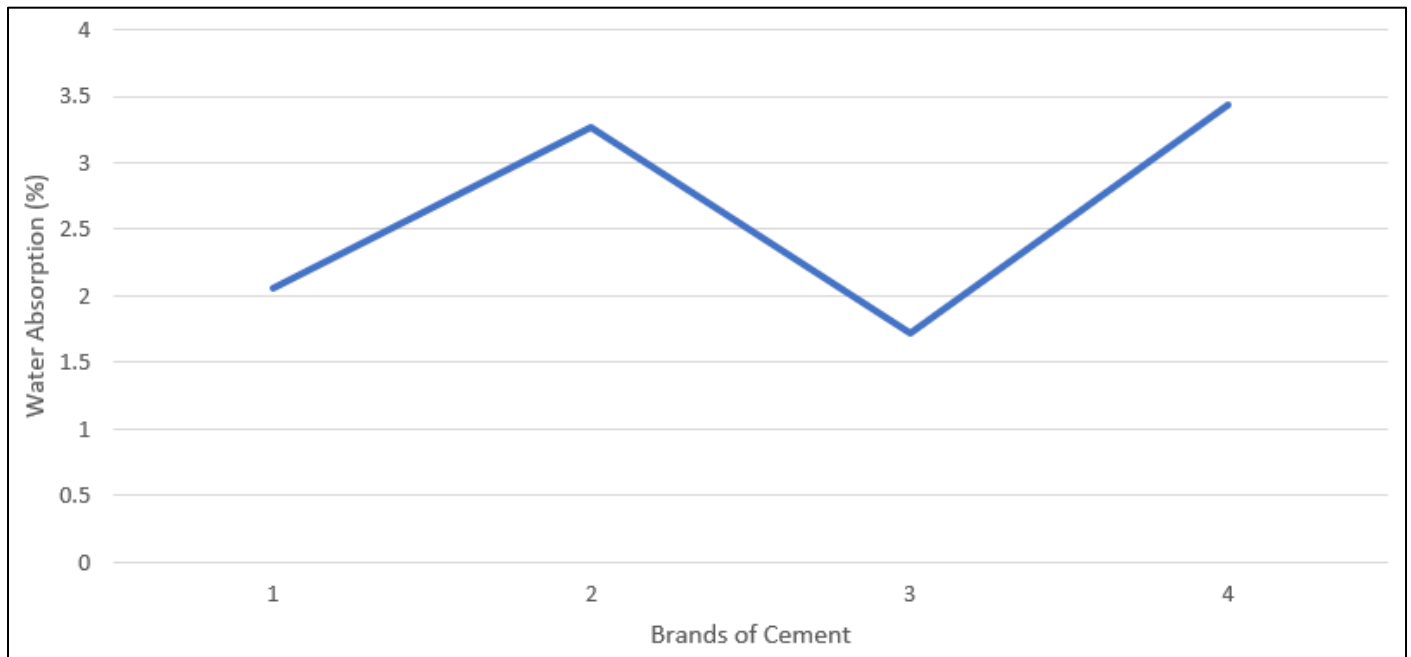


Fig 4 Plots of Water Absorption against Brands of Cements

It was observed that Dangote 3x has high affinity for water, there is recommended for usage of plastering and rendering rather than concrete casting.

➤ Abrasion Resistant Test

The result of the abrasion resistance test of brands of cement is presented in figure 5. It shows that the pervious concrete produced with Dangote 3x (grade 42.5) has the

abrasion value 0.31 kg/m³, followed by Elephant Lafarge with the value of 0.25 kg/m³, the Elephant supaset with the abrasion value of 0.19 and Dangote falcon with the abrasion value of 0.12 kg/m³. These results suggest that the Dangote falcon (grade 32.5) has least resistance to abrasion, which is an indication of lowest shrinkage and cracking. This type of cement is best recommended for plastering and rendering.

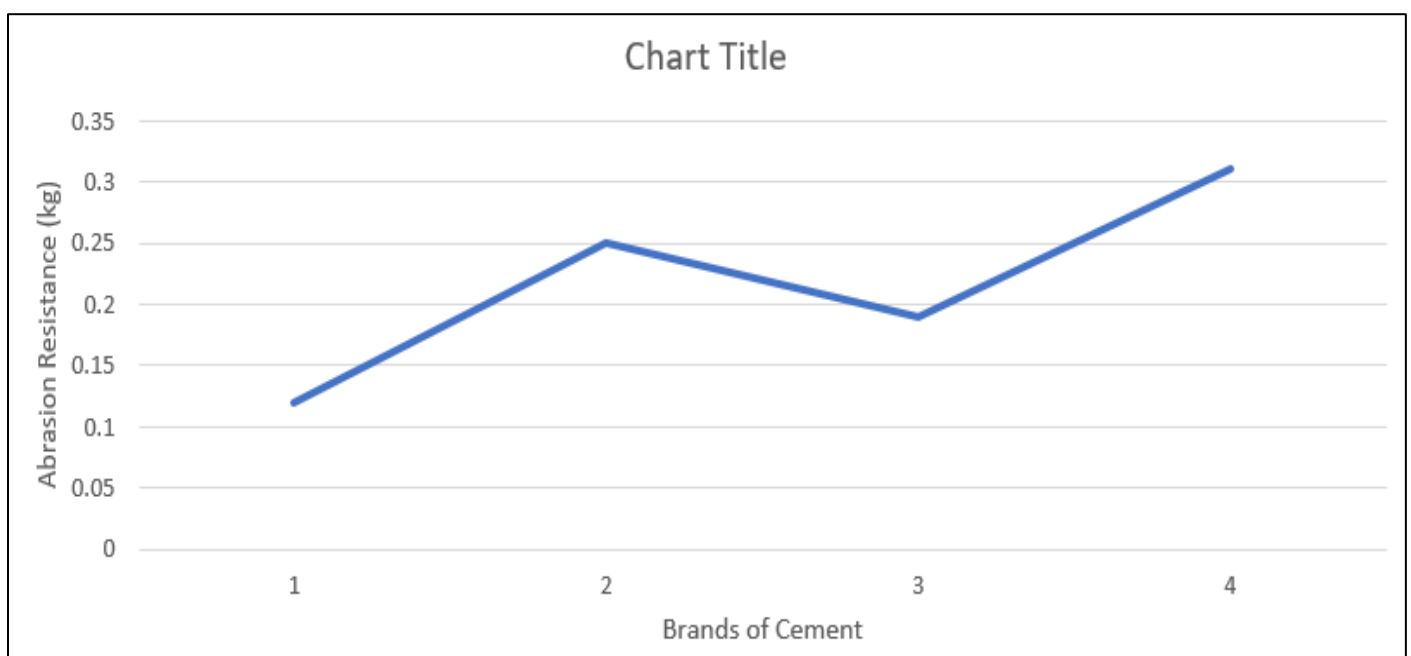


Fig 5 Abrasion Resistance of Concrete against Brands of Cement

IV. CONCLUSIONS

➤ *Based on the Results Obtained, the Following Points were Concluded:*

- Elephant supaset (grade 42.5) had the least slump value, which is most workable
- Dangote falcon (grade 32.5) had the highest compressive strength value at every designed curing period.
- The Elephant supaset (grade 42.5) cement had the highest bulk density
- The rate of water absorption for Dangote falcon (grade 32.5) and the Lafarge Elephant supaset (grade 42.5) cement does not exceed 3% recommended by British standard.
- The Dangote falcon (grade 32.5) cement had the least abrasion value, which made it more reliable

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