An assessment of some physical properties of different brands of cement in Nigeria

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Abstract. The durability of infrastructures has become a significant issue staring the face of professionals in the building industry as most recently constructed structures are deficient in this regard. This study was carried out to assess the physical properties of five different brands of Portland cement commonly used in Nigeria. The specific surface method was adopted in obtaining the fineness, and the specific gravity bottle was used to determine the specific gravity of the different cement brands. The result shows that sample A had the highest fineness value of 360 m\textsuperscript{2}/kg and the only sample that met the ASTM standard value of 280 m\textsuperscript{2}/kg. This implies that Sample A has a greater surface area for hydration which should lead to faster development of early strength and a higher rate of heat evolution. Sample E had the least fineness value of 168 m\textsuperscript{2}/kg. This means that Sample E has the least surface area for hydration and should be slow in early strength gain. Sample B had the highest specific gravity value of 3.266 and the highest value of bulk density of 1462.085 kg/m\textsuperscript{3}. The implication is that Sample B has more moisture because it has the highest specific gravity value. The quantity of sample B that will be required in the concrete making will be less relative to other samples as it had the highest bulk density.

1. Introduction
Most developed nations rely on the construction industry as a significant contributor to the growth of their economies. In developing societies, the construction industry provides many job opportunities for the formal and informal sectors [1]. Any negative impact in the sector has severe consequences on the economy. One common phenomenon bedevilling the attainment of sustainable development goals in Nigeria is the issue of building collapse [2]. Nigeria has continued to experience structural failure despite the measures that have been put in place to curb this incidence [3]. Several factors have been attributed to being causative factors of these incidences. Among others, poor quality of building materials has been highlighted as playing a leading role in the collapse of buildings [4]. Some cement brands available in the open market do not meet the standard requirement, possibly due to negligence on the part of the manufacturers [5]. It is, therefore, necessary, that materials used for construction purposes are tested to ensure they meet the minimum standard requirement. Most infrastructures like bridges, offices and residential apartments in Nigeria are made of concrete because it is widely available and relatively economical construction material. Concrete is a mixture of coarse and fine aggregates held together by a binder. The most commonly used binder is the ordinary Portland cement. The main qualities of cement used for civil construction are strength and a rate of setting suitable to the demands of the work [6]. Both chemical and physical tests are carried out to assess cement quality. Some of the physical tests generally performed to determine the acceptability of cement include fineness test, consistency test, setting time test, soundness test, strength test, the heat of hydration test, and specific gravity test. This study is,
therefore, geared towards investigating some of these parameters in the different brands of cement available in the Nigerian market. It will determine the granular size/particle size distribution, specific gravity and bulk density of the various cement brands in Nigeria.

2. Methodology
This work involved the determination of the fineness, specific gravity and bulk density of five brands of cement in Nigeria. A preliminary survey on the different types of cement available in Nigeria was carried out to determine their relative availability. The sample points include states within the Niger Delta region in Nigeria. These samples were labelled A-E, as shown in table 1 to make an unbiased study on their properties and variation.

Table 1. List of cement brands and their corresponding labels

| Sample | Brand of cement               | Classification          |
|--------|------------------------------|-------------------------|
| A      | Dangote 3x (R) cement        | CEM II A-L 42.5 R       |
| B      | Bua cement                   | CEM II A-L 42.5 N       |
| C      | Dangote 3x (N) cement        | CEM II A-L 42.5 N       |
| D      | Unicem limestone cement      | CEM II B-L 32.5 R       |
| E      | Elephant superset cement     | CEM II A-L 42.5 N       |

Fineness
The specific surface method was used to determine the particle sizes. This method involves using a cello-tape whose length and width was first weighted to get the weight of tape only after which it was placed on a clean flat slab. The cement sample was poured over the full length, and a form was used to spread the sample across the range of the tape until every part of the sticky side of the cello-tape was covered, then it was picked up and shook to get rid of the excess cement. This was then weighed and recorded. The specific surface was then calculated by dividing the area of the tape by the weight of the cement.

Specific gravity
The specific gravity of cement was determined using the Specific Gravity bottle according to IS: 2720-Part-3. The specific gravity was calculated using the formula:

\[
sg = \frac{(w2 - w1)}{[(w4 - w1) - (w3 - w1)]} \times \rho l
\]

Where,
W1 = weight of empty flask
W2 = weight of flask + cement
W3 = weight of flask + cement + kerosene
W4 = weight of flask + kerosene
\(\rho l\) = density of kerosene (0.924g/cm³)

Bulk density
The bulk density was determined using a container of known definite volume which was measured using a Vernier calliper and calculated using the formula for the volume of a cylinder. The cement was poured into the cylindrical container in three layers. It was tapped after each layer to remove air voids. A knife-edge was used to level the surface. This was to ensure that the volume of the cement equals the internal volume of the cylinder. This was then weighed and recorded. This process was repeated for all the samples.
3. Results and Discussion
From the fineness test results, as shown in figure 1, it is observed that sample A had the highest fineness value of 360m²/kg, which implies a greater surface area for hydration leading to faster development of strength and a higher rate of heat evolution. Other samples had values below 280m²/kg as specified by ASTM.

![Figure 1 fineness values for the different brand samples](image)

Figure 2 shows the specific gravity values for the various brands' samples. Sample B had the highest specific gravity value of 3.266, implying more moisture in the sample. This has a direct effect on the workability and bonding strength of the cement as the actual water/cement ratio will be altered.

![Figure 2 specific gravity values for the different brands' samples.](image)

Figure 3 shows that sample B had the highest bulk density value. The implication is that during mixing, a lesser volume of sample B will be required in making concrete.
4. Conclusion

From the results obtained, the following conclusion can be drawn.

1. Sample A has a greater surface area for hydration which should lead to faster development of early strength and a higher rate of heat evolution.

2. Sample E has the least surface area for hydration and should be slow in early strength gain.

3. Other samples except sample A did not meet the recommended minimum specific surface area value of 280m²/kg as specified by ASTM.

4. Sample B has the highest specific gravity value of 3.266, which implies more moisture in the sample.

5. Sample B has the highest value of bulk density, which implies a reduction in sample B quantity to other samples during the concrete mix.

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