



Assessment of quality of cement in Nigerian market and the controversy of building collapse

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Abstract The assessment of quality of some brand of cement in south east Nigeria and the controversy of building collapse was carried out with four brands of cement in four brands of cement in the market namely Ibeto cement, Danqote cement, Bua cement and Unicem cement. The following tests as specified by SON(NIS444-1:2003)compressive strength, setting time,soundness and chlorine content as test parameters to ensure quality control and quality assurance of cement in Nigeria were conducted. All the cement brands tested met the required standard set by SON. It was also discovered that the controversy linking cement quality to building collapse is misapplication of cement products. It was recommended that SON should upgrade the quality of cement sold in Nigeria to 32.5, 42.5 and 52.5as well as their quality and purpose should be clearly written on their packaged bags and public enlightenment on the different brands of cement and their uses amongst others.

Keywords Quality, Cement mixture, Cement concrete mix, building Collapse.

1. Introduction

Cement is a binder, a substance that sets and hardens and can bind other materials together. Cement can also be said to be a fine, soft, powdery-type substance. It is made from a mixture of elements that are found in natural materials such as limestone, clay, sand and/or shale. Four essential elements are needed to make cement. They are calcium, silicon, aluminum and iron; with calcium being the major ingredient which is obtained from limestone [1-2].

With all these qualities, cement is no doubt, a central factor in building construction. It serves as the major framework which all other materials cling to. Therefore, the quality of cement available contributes significantly to the type and quality of construction works undertaken in the construction industry. The construction products provide the necessary public infrastructure and private physical structures for many productive activities such as services, commerce, utilities and other industrial activities.

Recently, there were heated debates in the media over the quality of cement being sold in Nigeria market owing to the importance of cement in building and construction. These debates and campaign was undertaken by a coalition of civil society groups and professional bodies in the construction industry which launched a major campaign for what they called the standardization of cement production and its importation to Nigeria, on the grounds that government is turning a blind eye to the scourge of substandard cement in the country. This they attributed to one of the major causes of increasing and alarming rate of building collapse in Nigeria in recent times. In Anambra State for example this year 2014 alone there have been more than 15 buildings collapsed in the state.

The coalition urged the National Assembly to probe manufacturers and importers for compromising standards, enlisted the consumer protection council (CPC) to help with regulation, enforcing the National Building Code



and enlisting the Council Of Registered Engineers of Nigeria (COREN) and the Council Of Registered Builders of Nigeria (CORBON) in fighting sub-standard cement. The coalition of civic society groups also confronted the Cement Manufacturers Association of Nigeria (CMAN) for what it called poor standard of local and imported cement.

On the other hand CMAN deny the accusation leveled against them by the coalition, stating that they have all along complied with conventional practice in the cement industry. Dangote cement plc one of the leading cement manufacturers believe that some cement manufacturers and importers deal in substandard cement, but absolves itself from the practice. Meanwhile, the Standards Organization of Nigeria (SON) debunked the accusation leveled against it by the coalition of civil society groups, while affirming its stand not condoning infraction and those who contravene the law and go contrary to set standards in the Nigeria market [1].

Based on the foregoing it became necessary to study the quality analysis of cement available in Nigeria market to certain whether they conform to the standard and its role in the incessant building collapse in the country which has taken embarrassing dimension. To undertake this study with major cement brands available in Nigeria market.

1.1. Cement

Portland cement is by far the most common type of cement in general use around the world. This cement is made by heating limestone (calcium carbonate) with small quantities of other materials (such as clay) to 1450°C in a kiln, a process known as calcinations, whereby a molecule of carbon dioxide is liberated from the calcium carbonate to form calcium oxide, or quicklime, which is then blended with the other materials that have been included in the mix. The resulting hard substance, called clinker, is then ground with a small amount of gypsum into a powder to make 'Ordinary Portland Cement', the most commonly used type of cement (often referred to as OPC). Portland cement is a basic ingredient of concrete, mortar and most non-specialty grout. The most common use for Portland cement is in the production of concrete. Concrete is a composite material consisting of aggregate (gravel and sand), cement, and water. As a construction material, concrete can be cast in almost any shape desired, and once hardened, can become a structural (load bearing) element. Portland cement may be grey or whites [3].

Other classes of Portland cement as defined in EN197 includes:

- a) Portland cement: Compromising Portland cement and up to 5% minor additional constituents (gypsum)
- b) Portland-composite cement: - Portland cement and up to 35% of other single constituents.
- c) Blast furnace cement: Portland and high percentages of blast furnace slag up to 70% can serve as sulphate resistant cement.
- d) Pozzolanic cement: Portland cement and up to 55% of Pozzolanic constituents (volcanic ashes) popularly used in countries like Italy, Chile, Mexico, the Philippines where volcanic ashes are available.
- e) Composite cement: Composes Portland cement, blast furnace slag or fly ash and pozzolana [3-4].

1.2. Qualities of cement in Nigeria marked as specified by SON

The issue of quality is associated with standard set by the British standard specification (BS12/197842.5R/N) as the acceptable quality which was adopted by Nigeria standard organization of Nigeria SON. The quality of cement produced in Nigeria as provided by the SON named NIS444-1:2003ICS 91.100.10.

Cement PART 1 – composition and conformity criteria for common cements. This stipulated two qualities of cement.

- a) CEMII/A-L 32.5NY this is used for light weight construction such as plastering walls, pavements, culverts, among other uses.
- b) CEMI42.5N:- This is used for erecting building structures, flyovers and other structures [1].

1.3. Quality of cement as a link to building collapse

Recently the coalition of civil society groups and professional bodies in the construction industry in Nigeria, made it open that cement is not cement and that 32.5 grades, commonly produced and used in the country is not the international standard for structure and could be responsible for most of the building collapse in the country. That it is now obvious that while 32.5 should only be used for pavements and culverts, 42.5 grade of cement is to be used for structures, columns and bridges and 52.5 grade of cement is best for multi storey buildings and for very tall multi-storey structures, bridges and dams.

The 32.5 grade of cement has been part of building in Nigeria for the last 54 years and are used widely throughout the world. The only problem with the product is the misapplication of the product and cutting corners by some scrupulous users. Also pointed out that the root cause of building collapse in the country is not cement but poor use of materials i.e. (their aggregates for concrete) especially 32.5 grade by contractors. He



stated further that after seminars and training to educate builders on how to use 32.5 grades in building, the unscrupulous ones among them still cut corners to cheat on quality [1].

The major determinate of cement quality as pointed out by Valteena [5] is limestone and the quality of clay used in right proportion and most importantly strict adherence to the 5% gypsum content as recommended by British standard specification for Portland cement. And owing to the high price of this raw materials which is imported into the country from Spain and Brazil. Manufacturers tend to compromise quality of gypsum in cement by reducing the content to as low as 3% to make more profit at the expense of unsuspecting consumers. This will quicken the drying time for block molders but good quality cement with required 5% gypsum will have a slow but standard setting period of about 27 days as gypsum is the hardener ingredient and responsible for the strength of cement. If gypsum content is reduced from 5% to 4%, 3% and 2.5% all you get is poor quality cement that will obviously lead to collapse building [5].

In the same vein said in an interview that if a building collapses, then the fault is in the formulation of the concrete. You have to consider the type of aggregates in your concrete. Are they of good quality? How much cement and water was used and under what conditions was it done?

Difference between the 32.5 grade and 42.5 grade of cement is that the 42.5 grade of cement is 30% stronger than the 32.5 grade [1].

1.4. Standardization of cement quality in Nigeria

There is the need for SON to standardize and regulate and ensure compliance with the cement standard in use in Nigeria. The coalition of civil society groups accused the CMAN of poor standard of local and important cement. But the CMAN deny the accusation leveled against them by the coalition, stating that they have all along complied with conventional practice in the cement industry. But Dangote Cement Plc one of the nation's leading cement manufacturers, however towed a somewhat different line because it believes through a statement from one of its managers Edwin that some cement manufacturers, and importers deal in substandard cement, it strongly disagrees that it is among such companies that it has maintained leading position in the market and complied with global best practices [1].

On the other hand SON responded that there is no substandard cement in Nigeria that it was a matter of application of cement in practice. And that it had been in contact with relevant stake holders to ensure compliance with standards.

However the write type of cement must be used for the right typing of construction. The advantage which the higher grade of cement has over the lower is that the higher (42.5) can perform most functions which the lower (32.5) can perform, but such is not obtainable when the reverse is the case. Therefore it is necessary that cement sold in Nigeria, their bags should be labeled its grade and the purpose they can be used boldly on their bags to safeguard the unsuspecting public [5].

1.5. Statement of the problem

There have been heated arguments about the quality of cement sold in the Nigerian market. This argument is spear headed by a coalition of civil society groups and concerned professionals in the construction industry. This concerned group is accusing the Cement Manufacturers' Association of Nigeria (CMAN) for manufacturing and importing sub-standard cement into the country and attributed this to one of the major causes of incessant building collapse being witnessed in the country today. The coalition group also accused the Standard Organization of Nigeria (SON) for turning a blind eye to this infraction by the CMAN. They also accused SON for not adopting the policy for global best practices in cement production by insisting that the minimum standard for cement marketed in Nigeria should be the 42.5 grade. Because of the foregoing it became necessary to look at the SON standard for cement used in Nigeria and its compliance with global best practices and to do a quality analysis of cement available in the Nigerian market and to check if they conform to the approved standard by SON. And to do this with cement brands available in Nigeria.

1.6. Aim and Objectives

The Aim of this study is to analyze the quality of cement brands available in the Nigeria market. In this regard, the specific objectives of the study include:

- To know whether the quality of cement sold in the Nigeria market conform to SON standards.
- To X-ray whether the SON specifications & standard on cement sold in Nigeria conform to global best practices.
- To identify whether there is any linkage between quality of cement and building collapse.

2. Materials and Methods



Qualities of cement was determined

2.1. Cement used

Four brands of cement were chosen on the bases of popularity of use and availability. They are (a) Dangote Cement (b) Ibeto Cement (c) Bua Cement (d) Unicem Cement.

2.2. Objective of the tests

The objective of this test was to ascertain their quality as compared against the SON (NIS444-1:2003) requirement.

2.3. Tests conducted

The SON (NIS444-1:2003) specified the following test parameters

- a) Compressive strength
- b) Setting time
- c) Soundness
- d) Chlorine Content

2.4. Compressive strength test

The compressive strength test determines the strength or pressure the cement cube is able to withstand. It is calibrated in Nmm^2 . The test is subject to the 7th day and the 28th day respectively after setting. The minimum compressive strength required by the (NIS444-1:2003) for the cement cube to resist breakage is set at 16N/mm^2 and 32.5N/mm^2 for 7 and 28th days respectively for 32.5 RN grade.

The result as found on the tested samples are thus in increasing order of strength at stipulated days. The procedure for testing for the compressive strength was as follows:

Step 1: 125g of clean and approved water was measured.

450g of cement sample.

Measure out $1350\text{g} \pm 2$ of approved sand.

Step 2: Using an auto mixer; pour the measured water into the auto mixer. The specified quantity of cement was added and mixed. Stop and add the specified quantity of sand and mix for 30seconds. Stop and check for mix consistency. Mix again for 90 seconds.

Step 3: Pour out the mixture into a mortar prism mold. Place on the jolting table and vibrate for 60seconds. Stop and add sufficient mixture to fill mold appropriately. Vibrate for 60 seconds.

Step 4: Remove mold from the jolting table and label for 7 and 28 days. De mold after 1 day and place mortar prism in the curing tank for 7 and 28 days as specified.

Step 5: Place the prism on the support in compressive machine set to flexural mode. Load the prism until breakage. Record reading.

Step 6: Calculate compressive strength.

$$\text{Compressive strength} = \text{Load} \div \text{Area (N/mm}^2\text{)}$$

2.5. Setting Time Test

The setting time as specified by the (NIS444-1:2003) for (CEMII/A-L 32.5N) is the initial setting time, only. The limit is set at a minimum of 75minutes. The initial setting time determines the amount of time required for the cement (mortar or concrete) to set (harden). It is a function of the amount of heat generated when water is added to the cement (mortar or concrete).

The shorter the initial setting time the harder it's to shape the cement mortar or concrete mix when placing. The longer the initial setting time the easier it is to shape the cement mortar or concrete mix. It is controlled by the calcium chloride content in the cement. The more the calcium chloride content, the longer the initial setting time, and vice versa.

The procedure for testing for the initial setting time was as follows:

Step 1 Weigh 125g of water into an auto mixer bowl.

Weigh 500g of cement sample and carefully add to the water. Note, the time of addition shall be within 5 to 10 seconds.

Start the mixer immediately, running at low speed for 90 seconds.

Stop the mixer for 15 seconds and using a suitable scraper remove any paste adhering to the sides of the bowl and return to the mix

Restart the mixer and run at low speed for a further 90seconds.

Repeat the procedure such that total running time accumulates to 3minutes.



- Step 2** Transfer paste immediately to mold which has previously been placed on a lightly greased plane of glass.
Fill mold to excess and gently remove without undue compaction vibration.
Smoothen exposed surface of paste and place on the vacant apparatus.
- Step 3** Raise plunger to the standby position and adjust mold to sit directly at the center of the plunger and release.
Repeat procedure every 4minutes and record values given by the scale which indicates the depth the plunger penetrates at given time intervals.

2.6. Soundness Test

The soundness expansion length as specified by the (NIS444-1:2003) is set at a maximum of 10mm per meter. Soundness for Portland cement refers to the ability of the cement (mortar or concrete) to retain its volume after setting without the delayed destructive expansion. This destructive expansion is caused by excessive amount of free lime (Cao) or magnesia (Mgo) within the mix. Curing is a process where concrete or mortar is hydrated (kept moist with water) to increase strength and become durable. This happens from 5th to the 7th day after placement.

The procedure for testing for the soundness was as follows:

- Step 1** Collect a sample of freshly mixed paste (cement and water), and place in a Le Chatelier apparatus.
- Step 2** Set the humidity level and leave for 24hours.
- Step 3** Remove sample and measure the length. Place sample in a water bath and boil for 3hours. Remove and measure length of expansively.
Expansively (mm) = Length after boiling – Length when cool.

2.7. Chloride Content Test

The chloride content as specified by the (NIS444-1:2003) is set at $\leq 0.10\%$ of the composition volume of the cement. The chloride within the cement provides the heat that hydrates the compound in the presence of water. This is the process called curing. The hydration process increases the strength and durability of the concrete or mortar.

The procedure for testing for the chloride content was as follows:

- Step 1** Measure 5g of cement into a bowl and add 50ml of approved water. Stir until mix is consistent. Add 50ml of HNO₃ and continue stirring.
- Step 2** Heat mixture to boiling for 1minute. Add 5ml of AGNO₃ by pipette into the boiling mix. Boil for a maximum of 1 minute.
- Step 3** Filter the mixture using a fine sieve. Collect filtrate. Wash filtered residue with HNO₃ 1+100 into 500ml flask until volume reaches 200ml. Cool the filtrate below 25°C add 5ml of indicator.
- Step 4** Titrate solutions with HN₄SCN solution. Shake vigorously until solution produces a faint reddish brown coloration which no longer disappears on shaking. Record V₁.
Repeat same procedure on black sample and record V₂.

3. Results and Discussion:

The results of the analysis carried out on the six samples are shown in Table 1. The analysis carried out on the five brands of cement was to ensure that quality control and quality assurance of the products are within the required standard. The quality of a system or product is an acceptable standard of excellence that is distinct and can be depended upon. While quality assurance in this case is a planned system review, to measure and control the quality of the product as its being developed or checked if it continued to conform to the stipulated standard. Looking at results in table 1, all the five brands of cement meet the standards, as stipulated by the standard Organization of Nigeria SON. Since the product qualities were met and the product quality represents best possible standards.

The Dangote 42.5N grade of cement met the required specifications of SON. And it is pertinent to note that all the 32.5 grade of cement that met the stipulated standards and are appropriate for general use such as block molding, blockwork, plastering, pavements & culverts. While the 42.5 grade of Dangote cement is suitable for structure, columns and bridges.



Table 1: Result analysis of the tests for quality of cement [4]

S. No.	Tested Parameter		Test Result						NIS 44-1-2003 requirement (CEIY11/AL32.5N)	NIS 444-1-2003 Requirement (CEMI 42.5N)
			Dangote cement 32.5N	Dangote cement 42.5N	Ibeto cement 32.N	Bua cement 32.5N	Mina cement 32.5N	Unceam cement 32.5N		
1.	Compressive strength (Mortar prism (N/mm ²))	2 days	14.55	19.35	19.66	23.31	13.29	11.9	NA	≥10.00
		7days	20.4	27.13	31.04	30.41	22.85	18.18	16 minimum	NA
		28days	38.8	50.6	40.22	36.10	39.8	36.4	32.5minimum	≥42.50
2.	Setting Time (Minutes)	Initial	156	207	170	149	143	111	75 minimum	≥ 60
		Final	260	345	226	175	203	175	N/A	NA
3.	Consistence (%)		28.8	37.4	29.27	28	25.2	26	N/A	NA
4.	Soundness (mm)		0.24	0.31	0.25	0.02	0.09	0.08	10 maximum	10 maximum
5.	Loss on ignition (lo) (%)		6.8	4.72	1.50	4.20	4.25	2.75	NA	5.00 maximum
6.	Insoluble Residue (IR) (%)		1.5	1.45	2.79	4.50	5.2	1.15	NA	5.00 maximum
7.	Sulphate content (SO ₃) (%)		2.3	2.9	3.33	3.76	2.33	2.40	NA	3.50 maximum
8.	Chloride content (%)		0.051	0.054	0.062	0.046	0.051	0.041	≤ 0.10	≤ 0.10

4. Conclusion

Since all the six cement samples tested meet the required standards, one can conclude that high level ignorance among Nigerian consumers coupled with the negligence on the part of producers and poor construction practices have largely contributed to the current controversy on cement quality and its link to building collapse. To this end it well is appropriate for Nigeria to produce these three grades of cement, that is 32.5N, 42.5N, and 52.5N and its uses and grades clearly written on their cover bags.

5. Recommendation

Nigeria should upgrade to the production of the three brands of cement ie 32.5N, 42.5N and 52.5N and their uses clearly written on their bags. And SON should ensure this.

- Government and the stakeholders should mount public enlightenment campaign to educate Nigerians on the availability of the three brands cement in the market and their various uses.
- The level of skill, education and awareness in the construction sector must be improved to ensure good construction practices.
- The relevant stake holders in the construction industry should join hands with the SON to monitor the qualities of cement in the Nigerian market to ensure adherence to the stipulated standards by the manufacturers and importers of cement in the country.

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