ASSESSMENT OF CEMENT QUALITY AND ITS LINK TO BUILDING COLLAPSE IN LAFARGE CEMENT COMPANY, ASHAKA

[1]A.U. SHELLENG [2]M. MIJINYAWA, AND [3]M.I BAMMAMI

[1]Deparment of Mathematics, Faculty of Sciences, Gombe State University, Gombe
[2]Deparment of Mathematics, Faculty of Sciences, Gombe State University, Gombe
[3]Department of Water and Environmental Resources Engineering, A.B.U Zaria
Corresponding Author: umssie@gmail.com

ABSTRACT

The sequential increase in building collapse in Nigeria has made it necessary to study the quality of cement that are available commercially in Nigeria. The assessment of some quality parameters of Lafarge Cement Company, Ashaka, Gombe state Nigeria was carried out in this research using a secondary data for 7 years (2009 to 2015). To ascertain whether the quality of cement produced by Ashaka cement company conform to the Nigerian Industrial Standard (NIS), the following tests as specified by Standard Organization of Nigeria, SON (NIS444-1:2003) compressive strength, setting time, and soundness are considered as test parameters to ensure the quality of the cement. R package was used to construct the control charts for the study variables. Process Capability Analysis was also carried out to know whether the process was capable of producing conforming products that meets SON's specification. It was discovered that Ashaka cement production was under statistical control and all the parameters tested met the required standard set by SON. It was also discovered that the controversy linking Ashaka cement quality to building collapse is misapplication of the cement product. It was recommended that SON should upgrade the quality of cement sold in Nigeria to 32.5, 42.5 and 52.5 brands and their quality and purpose should be clearly written on their packaged bags.

Keywords: Cement, Building Collapse, Control Charts, Process Capability, SON

INTRODUCTION

A company or Industry is usually established by corporate owners or Individuals with the ultimate aim of maximizing profit and also to produce product of conformed quality that could satisfy the consumer. However, the prospect of any such industry depends largely on the decision-making policy of the management of such industry. Customers have always demanded quality in any purchased product or service and there has always been a minimum standard. Consequently, it has become imperative for manufacturers to meet at least the standard set prior to production process. The main concern is how to reduce the hurdles of those variations since they are inevitable and inherent in nature and cannot be entirely eradicated but only abate the condition to improve standard of goods and services. Cement is a hydraulic binder, i.e. a finely ground inorganic material which when mixed with water forms a paste which sets and hardens by means of hydration reactions and other processes which after hardening, retain its strength and stability even underwater (Peter, 2003).

Hydraulic hardening of CEM cement is primarily due to the hydration of calcium silicates but other chemical compounds may also take part in the hardening process, e.g aluminates. The sum of the proportions of reactive calcium oxide (CaO) and reactive silicon dioxide (SiO2) in CEM cement shall be at least 50% by mass. Recently, there were intense arguments on the quality of cement produced by Nigerian cement industries, based on the foregoing it has become necessary to study the quality of cement available in Nigeria market to check whether they conform to the standard and assess its role in the incidences of building collapse. This controversy has the tendency of affecting the Nigerian economy. The recurring incidence of building collapse, results in the loss lives and destruction of properties worth billions of Naira. Many studies have been carried out and various workshops organized by various bodies and government agencies in order to look into causes of building collapse in Nigeria. Quality control was known to be a useful technique to achieve, sustain and improve the quality of cement production in Nigeria (Anyanwu, 2013).

Quality Control is an indispensable area in applied statistics which is concern with controlling the quality level of raw materials component parts and finished products. Consequently, many researchers have worked on this area in the past years. Isaac M. (2013) carried out a research to determine whether the cement produced by Dangote cement plc, Gboko, Benue state is in conformity with the set standard by NIS, but the parameters used were Lime Saturation Factor, Alumina ratio and Silica ratio. X bar and R chart techniques were used to ascertain if the data collected were within the specification limits and concluded that the process was under control. Ezeokonkwo and Anyanechi (2015) conducted a research on the assessment of quality of some brand of cement in south east Nigeria with four brands of cement namely Ibeto cement, Dangote cement, Bua cement and Unicem cement. Primary data was used to test the quality of the cements from which conclusions were reached that all the four brands produces conforming products and building collapse is as a result of misapplication of the cement.

MATERIALS AND METHODS

Data Collection

Secondary data for 7 years (2009 to 2015) obtained from the quality assurance Department of Lafarge cement PLC, Ashaka Gombe was used for the purpose of this research work. These data were originally collected from the analysis conducted on samples of cement produced daily in the company. Control charts (X-bar and R-charts) and Process capability Analysis were used for the Analysis.

Statistical Process Control

Statistical process control is a systematic method for analyzing processed data (quality characteristics) in which we monitor and study the process variation. The goal is to stabilize the process and reduce the amount of process variation. The ultimate goal is to have a continuous process improvement.

Control Chart

A control chart is a simple chart characterized by three horizontal lines:

central line to indicate the desired standard or level of process, an upper and lower control limits. By plotting the data obtained from samples taken periodically at regular intervals. It is possible to check by the means of such chart whether the variation between samples may be attributed to chance or whether problems have entered the production process. The upper and lower control limits are utilized as decision criteria. When the sample data falls beyond them, one look for source of assignable variation, otherwise the process is allowed to continue. Control chart produces a convenient way of continually testing hypothesis relative to quality of manufactured products to decide whether the desired standard is met or not. The hypothesis being tested is that the process "is in control". If the hypothesis is accepted, then the process is allowed to continue without modification. If the hypothesis is rejected, that is, the process "is out of control" a search to discover the source of assignable non-random variation is to be conducted (Fragman, 2002).

X-bar and R Control Charts

X-bar and R charts are used to monitor the mean and variation of a process based on samples taken from the process at given times (hours, shifts, days, weeks, months, etc.). The measurements of the samples at a given time constitute a subgroup. Typically, an initial series of subgroups is used to estimate the mean and standard deviation of a process. The mean and standard deviation are then used to produce control limits for the mean and range of each subgroup. The lower and upper control limits for X-bar chart are calculated using the formulas:

$$LCL = \bar{\bar{x}} - m\left(\frac{\hat{\sigma}}{\sqrt{n}}\right) \quad (1)$$

$$LCL = \bar{\bar{x}} + m\left(\frac{\hat{\sigma}}{\sqrt{n}}\right) \quad (2)$$

The low and upper control limits for the range chart are calculated using the formula:

$$LCL = \bar{R} - md_3\hat{\sigma} \quad (3)$$

$$LCL = \bar{R} + md_3\hat{\sigma} \quad (4)$$

Process Capability

Process capability is the inherent reproducibility of a process's output. It measures how well the process is currently behaving with respect to the output specifications. It refers to the uniformity of the process. Capability is often thought of in terms of the proportion of output that will be within product specification tolerances. Process capability studies can indicate the consistency of the process output. It indicates the degree to which the output meets specifications and be used for comparison with another process or competitor. Process capability studies provide a baseline for us to understand how the process is operating relative to the specifications.

Process Capability Indices

Process capability index is a numerical summary that compares the behavior of a product or process characteristics to specifications. These measures are also often called capability or performance indices. It is defined as the ratio of the distance from the process center to the nearest specification limit divided by a measure of process variability.

$$\text{Process capability} = \min\left(\frac{USL-\mu}{3\sigma}, \frac{\mu-LS}{3\sigma}\right) \quad (5)$$

Where USL and LSL are the upper and lower specification limits respectively, μ and σ are process mean and standard deviation respectively for individual measurements of the characteristic of interest. Calculating the process capability requires knowledge of the process mean and standard deviation, μ and σ. These values are usually estimated from data collected from the process.

Data Analysis

Data collected on mechanical (i.e. early and standard strength) and physical (i.e. initial setting time and soundness) outcome for cement of CEM II A-L and 32.5 N is for a period of 7yrs. The basic parameters are compressive strength (early strength and standard strength), initial setting time and expansion or soundness (Chiemela, 2014).

RESULTS

Results (for 7th Day Strength)

Data collected on mechanical (i.e. early and standard strength) and physical (i.e. initial setting time and soundness) outcome for cement of CEM II A-L and 32.5 N is for a period of 7yrs. The basic parameters are compressive strength (early strength and standard strength), initial setting time and expansion or soundness. The following are the results from the analysis of the data:

Interpretation: From the results of 7th Day strength in fig.1 (X-chart) and fig.2 (R-chart) all the points are within the control limits. Also, from fig.3 the chart above shows that the process was under control since the capability index, $C_P > 1.00$.

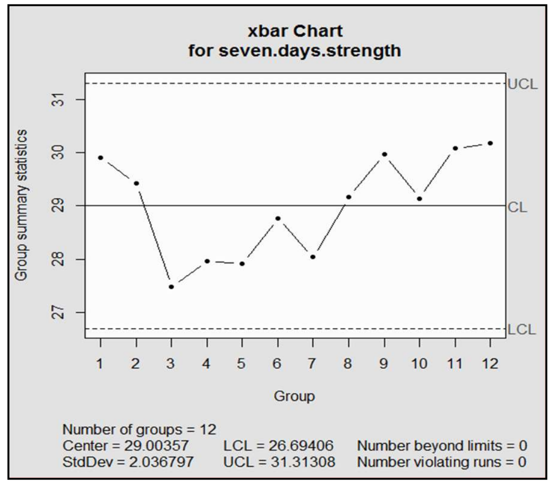

Figure 1: X Bar Chart for 7th Day Strength

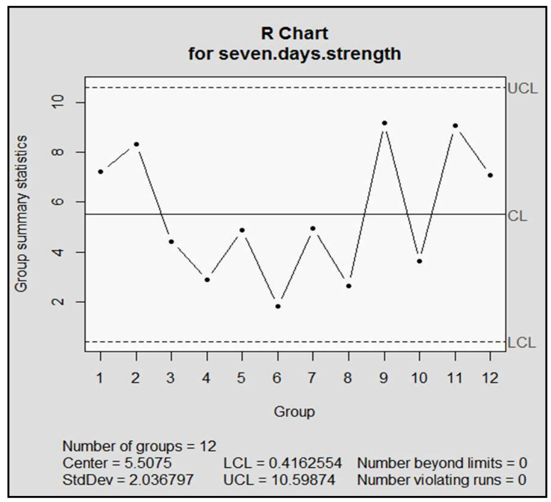

Figure 2: R Chart for 7th Day Strength

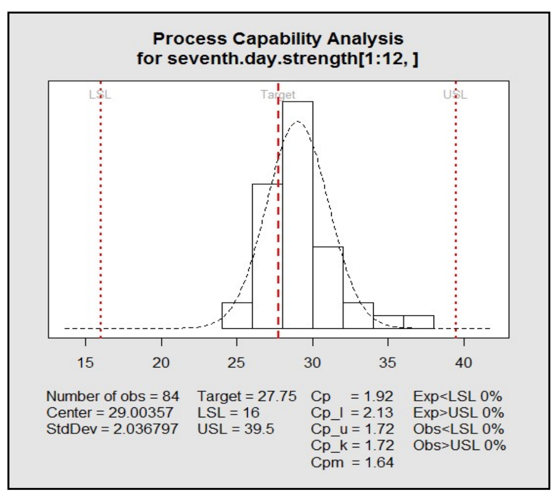

Figure 3: Process Capability Analysis for 7th Day Strength

Results (for 28th Day Strength)

Interpretation: From the results of 28th Day strength in fig.4 (X-chart) and fig.5 (R-chart) all the points are within the control limits. Also, from fig.6 the chart above shows that the process was under control since the capability index, $C_P > 1.00$.

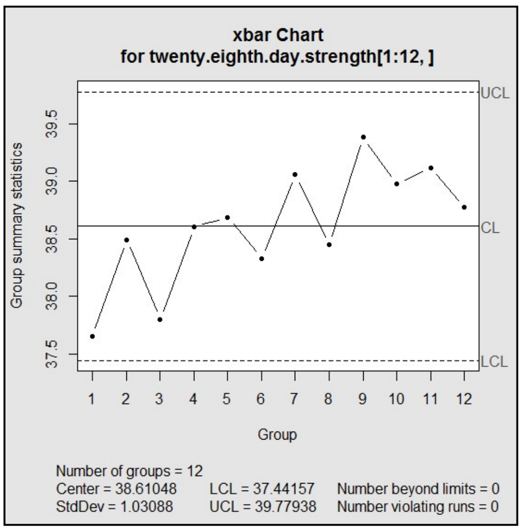

Figure 4: X Bar Chart for 28th Day Strength

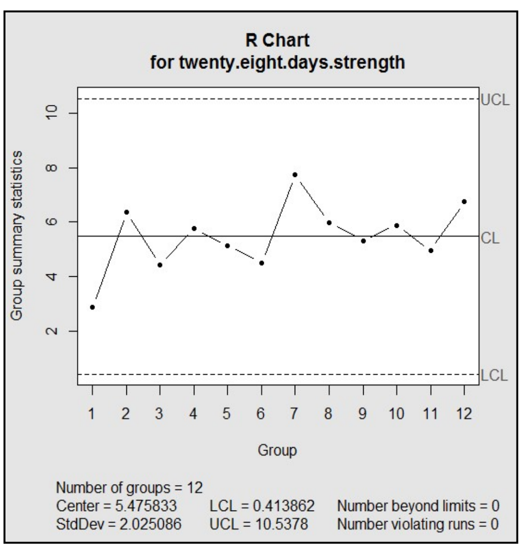

Figure 5: R Chart for 28th Day Strength

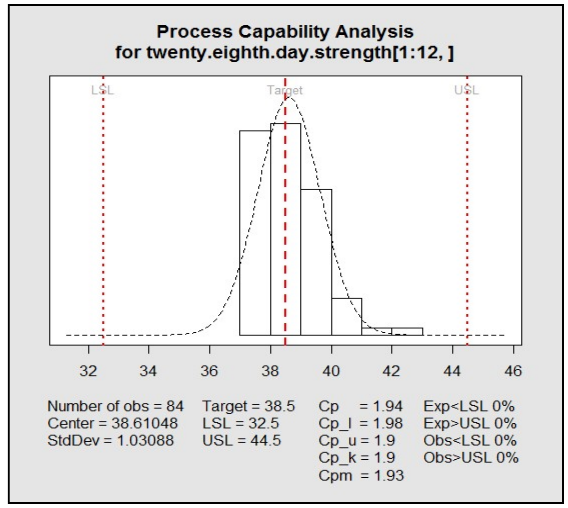

Figure 6: Process Capability Analysis for 28th Day Strength

Results (for Initial Setting Time)

Interpretation: From the results of Initial Setting Time in fig.7 (X-chart) and fig.8 (R-chart) all the points are within the control limits. Also, from fig.9 the chart above shows that the process was under control since the capability index, $C_P > 1.00$.

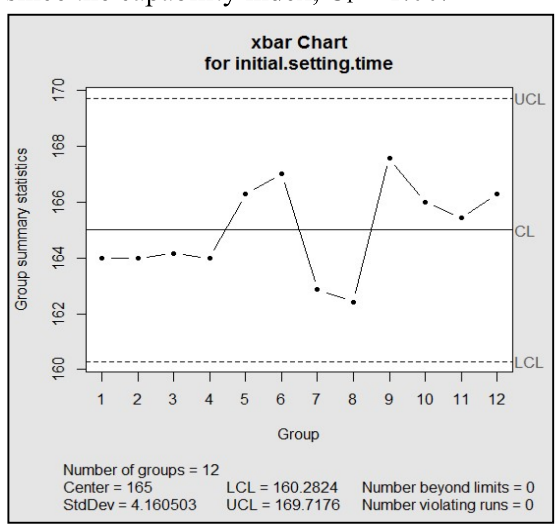

Figure 7: X Bar Chart for Initial Setting Time

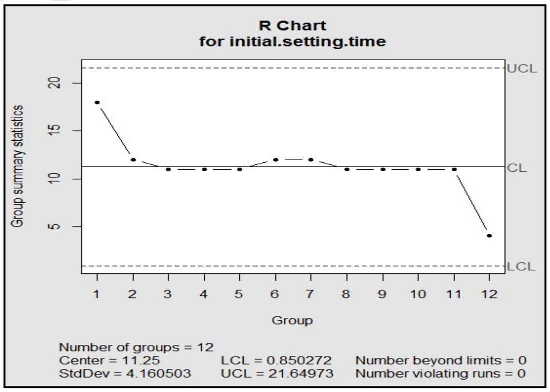

Figure 8: R chart for initial setting time

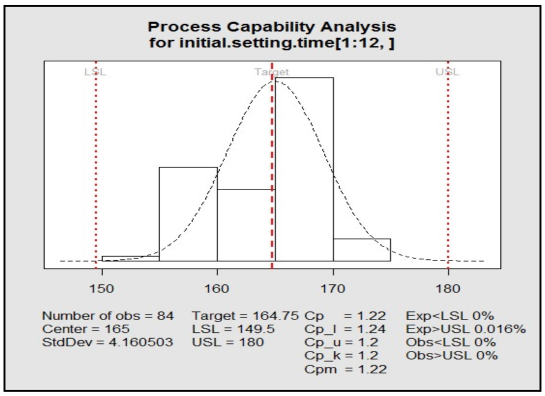

Figure 9: Process capability analysis for initial setting time

Results (Soundness)

Interpretation: From the results of Soundness in fig.10 (X-chart) and fig.11 (R-chart) all the points are within the control limits. Also, from fig.12 the chart above shows that the process was under control since the capability index, $C_P > 1.00$.

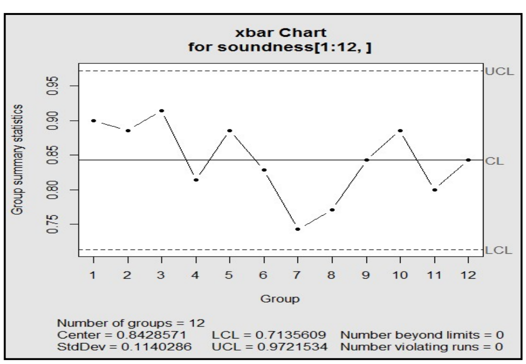

Figure 10: X bar chart for soundness

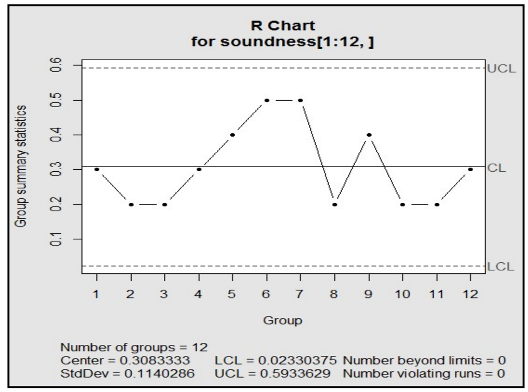

Figure 11: R chart for soundness

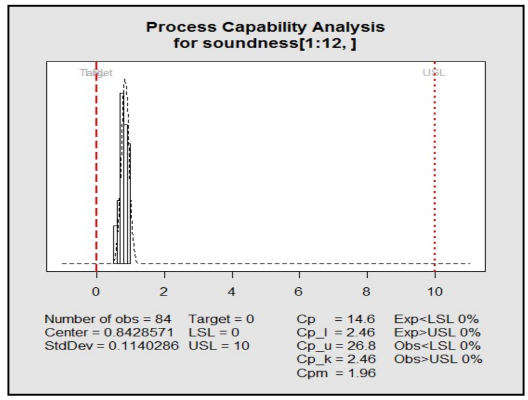

Figure 12: Process capability analysis for soundness.

DISCUSSION

Results from the analysis carried on the data collected for (mechanical and physical properties) of cement shown in fig.1 (X-chart), fig.2 (R-chart), fig.4 (X-chart), fig.5 (R-chart), fig.7 (X-chart), fig.8 (R-chart), fig.10 (X-chart) and fig.11 (R-chart) all have their points within the control limits, indicating that all the processes were under statistical control for the period under consideration. Also, from fig.3, fig.6, fig.9, and fig.12 the charts show that the process was under control since the capability index is greater than 1 ($C_P > 1.00$) in all the charts, which implies that the process capability is less than the tolerance. Hence, the situation is most desirable. $C_{PK}>1.00$, indicates that the process is producing products that conforms to specification. The analysis carried out on the four physical and mechanical requirements of cement was to ensure that quality control and quality assurance of the products are within the required standard. Looking at the results above, all the four physical and mechanical requirements of cement meet the standards, as stipulated by the standard Organization of Nigeria SON in accordance with NIS: 446:2003 and NIS: 447:2003 (for seventh day strength; $16\text{mpa} \leq X \leq 32.5\text{mpa}$, for twenty eighth day strength; $32.5mpa \leq Y \leq 52.5mpa$, for initial setting time; $75 \text{ min} \leq Z \leq 180 \text{ min}$, and for expansion; $0mm \leq W \leq 10mm$) (NIS, 2003).

CONCLUSION

Since all the physical and mechanical requirements tested meet the required standards, one can conclude that Ashaka Cement Company are producing conforming products that meets the NIS standard and that high level ignorance among Nigerian consumers of Ashaka cement coupled with the negligence and poor construction practices have largely contributed to the current controversy on cement quality and its link to building collapse.

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