# Statistical Analysis of Rice Husk Ash as a Construction Material in Building Production Process


**Abstract**

This study considers the statistical analysis of rice husk ash as a construction material in building production process. The quality of concrete mixture is of inevitable concern to all stakeholders in the construction industry in the zone when the climatic conditions of the zone are considered. The mix ratio is examined and all the prevailing construction/production practices are considered statistically. The statistical tools employed are descriptive, normality, process statistical summary and confidence estimation methods of statistics. The tools portrays the necessary information in the data to understand what the data information for further production process analysis.



**Keywords:** Concrete, Quality, Production, Process, Statistics, rice husk, ash




## 1. Introduction

Construction industry plays an active role in the fixed capital formation of any economy. It accounts for over sixty percent of the Gross Fixed Capital Formation of any nation, Ezeokonkwo, (2002). The construction industry thus is very strategic in its contribution to the gross domestic product of a country. From the foregoing, it has a very high capacity of generating growth and inducing multipliers effects on a nation's economy.

However, current events in construction industry in Nigeria are inducing negative effects within the industry. For instance the issue of collapse of buildings has been persistent in the country in recent times and the need to proffer solutions to avert future occurrences become obvious. Over the last ten years, the incidence of building collapse has become so alarming and worrisome and it does not show any sign of abating. Each collapse carries along with it tremendous effects that cannot be easily forgotten by any of its victim. These effects include loss of human lives, economic waste, loss of jobs, incomes, loss of trust, dignity and exasperation of crises among stakeholders and environmental disasters (Ede, 2010). It is believed that any pursuit in human life has its cost, but the cost being paid in South-Eastern Nigeria due to incessant incidents of building collapse cannot be comprehended and quantified.

Buildings are structures which provide shelter for man, his properties, and activities. As such, they must be properly planned, designed and constructed to obtain desired satisfaction from the environment. Major factors observed during building construction include; the functional performance requirements of durability, adequate stability to prevent structural failure, discomfort to the users, resistance to climatic conditions and use of good quality materials. The styles of building construction are constantly changing with the introduction of new materials and techniques of construction. Consequently, the work involved in the design and construction stages are largely those of selecting materials, component and structures that will meet the expected building standards and aesthetics on an economic basis Obiegbu, (2007).

A general survey shows that most of modern buildings in the south eastern Nigeria have concrete as their major component. It then becomes pertinent that the quality of concrete materials required for concrete used in the construction process must be of paramount importance. Many building failures are mostly linked to the use of substandard materials, poor workmanship and inefficient management in the production process. Experts have canvassed the assessment of quality of materials and the level of workmanship utilized in concrete production on project sites. According to Amana, (2010), there is also a need for an accurate assessment of quality, strength and variability of the materials used in forming the structural components.

He further observed that a good example of how quality, strength and variability play out in our environment is in the wide variability of the quality of concrete used in our construction sites.

Imaga, (1994) is of the opinion that enterprises in developing countries do not appear to pay sufficient attention to the areas of quality standards, definition and proper inspection of products produced in their organization. A critical look at this, now reminds us that the quality of a product is determined by the character it possesses. It then becomes imperative that the producers and professionals involved in the construction process must decide ahead of time what the characteristics of their product should possess and have them integrated into the design and specification of quality of concrete that should be employed in projects.

Quality therefore is defined as pre-determined standards (basis) sets to ensure a minimum level of requirement for achievable out-come. These predetermined standards are seen as an agreed reputable way of doing something. It is a published document that contains a technical specification or other precise criteria designed to be used consistently as a rule, guideline or definition.

Furthermore standards help to make life simpler and increase reliability and the effectiveness of many goods and services we use. Standards are created by bringing together the experience of all interested parties such as the producers, sellers, users and regulators of a particular material, product, process or service. Through these, the quality of any product now becomes achievable in the actual production process in construction sites. This study is therefore an effort to evaluate the quality control management of concrete works in building construction projects within the study area (Ezeokonkwo, 2015).

**The research method** used in this work is the application of Factorial design Analysis of Mathematical Models for Variables in the Zones. The method is used to study the relative influence of each of the factors on the slumps (workability) of concrete, density and compressive strength for each climatic season, quasi or mono factorial models were obtained. From the analysis, it is possible to make the following deductions on the influence of the different factors over the workability density and strength of concrete.

**Comment [M1]:** I didn't find any compressive strength data in this paper.

**Formatted:** Font color: Red

## 2. Computer Analysis of the Experimental Results from the Two Zones

**Table 1: Values of Results from Hot Humid Zone (Awka)**

| Level of factors and test | $X_1$ = C Cement kg/m$^3$ | $X_2$= w water content kg/m$^3$ | $X_3$ = Fa fine Rice Husk kg/m$^3$ | $X_4$ = Ca coarse Aggregate kg/m$^0$ | Slump Swet (mm) |
|---|---|---|---|---|---|
| **Xnar Highest level** | 300 | 7 | 690 | 1380 | |

| | | | | | |
|---|---|---|---|---|---|
| **(+)** | 207 | 5 | 414 | 953 | |
| **Xim Lowest level (-)** | 254 | 6 | 552 | 1167 | |
| **Xer Central Level (0) average** | 46 | 1 | 138 | 213 | |
| **Interval of Change Δ** | | | | | |
| **Test No** | $X_1$ | $X_2$ | $X_3$ | $X_4$ | $Y_1$ |
| **1** | 207 | 5 | 414 | 953 | 88 |
| **2** | 207 | 7 | 690 | 953 | 109 |
| **3** | 207 | 5 | 690 | 953 | 160 |
| **4** | 207 | 5 | 690 | 953 | 156 |
| **5** | 300 | 7 | 414 | 953 | 65 |
| **6** | 300 | 5 | 690 | 1380 | 81 |
| **7** | 207 | 7 | 690 | 1380 | 99 |
| **8** | 207 | 7 | 690 | 1380 | 50 |
| **9** | 207 | 6 | 552 | 1167 | 67 |
| **10** | 300 | 7 | 552 | 1167 | 62 |
| **11** | 254 | 5 | 552 | 1167 | 82 |
| **12** | 254 | 7 | 552 | 1167 | 93 |
| **13** | 254 | 6 | 414 | 953 | 166 |
| **14** | 300 | 5 | 690 | 953 | 157 |
| **15** | 207 | 7 | 414 | 1380 | 110 |
| **16** | 254 | 6 | 552 | 1167 | 179 |
| **17** | 207 | 5 | 414 | 953 | 105 |
| **18** | 207 | 5 | 690 | 953 | 101 |
| **19** | 254 | 7 | 552 | 1167 | 95 |
| **20** | 254 | 5 | 552 | 1167 | 90 |
| **21** | 254 | 7 | 690 | 953 | 89 |

| | | | | | |
|---|---|---|---|---|---|
| **22** | 254 | 6 | 414 | 1167 | 102 |
| **23** | 254 | 6 | 552 | 1380 | 105 |
| **24** | 254 | 6 | 552 | 953 | 195 |
| **25** | 254 | 6 | 552 | 1167 | 165 |

**Source: Researcher's Field Work, 2018**

After experimentally generating data on Tables 1, the data was subjected to electronic manipulation with Statistical Packages for Social Science (SPSS) software and the following results with appropriates tables were obtained.

**Table 2: Descriptive Statistics Analysis**

| | | Statistic | Std. Error | Bootstrap | | | |
|---|---|---|---|---|---|---|---|
| | | | | Bias | Std. Error | BCa 98% Confidence Interval | |
| | | | | | | Lower | Upper |
| Cement (kg/m3) | N | 25 | | 0 | 0 | . | . |
| | Range | 93.00 | | | | | |
| | Minimum | 207.00 | | | | | |
| | Maximum | 300.00 | | | | | |
| | Sum | 6064.00 | | | | | |
| | Mean | 242.5600 | 6.74316 | -.0956 | 6.7534 | 229.4800 | 255.6527 |
| | Std. Deviation | 33.71582 | | -.86767 | 3.35725 | 26.62624 | 38.66859 |
| | Variance | 1136.757 | | -46.496 | 217.272 | 707.324 | 1495.260 |
| Water Content (kg/m3) | N | 25 | | 0 | 0 | . | . |
| | Range | 2.00 | | | | | |
| | Minimum | 5.00 | | | | | |
| | Maximum | 7.00 | | | | | |
| | Sum | 150.00 | | | | | |
| | Mean | 6.0000 | .17321 | .0069 | .1755 | 5.6187 | 6.4213 |
| | Std. Deviation | .86603 | | -.02117 | .05960 | .75719 | .92736 |
| | Variance | .750 | | -.033 | .098 | .573 | .860 |
| Fine Rice Husk (kg/m3) | N | 25 | | 0 | 0 | . | . |
| | Range | 276.00 | | | | | |
| | Minimum | 414.00 | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Maximum | 690.00 | | | | | |
| | Sum | 14214.00 | | | | | |
| | Mean | 568.5600 | 21.55629 | .6624 | 20.3936 | 524.4000 | 612.7200 |
| | Std. Deviation | 107.78145 | | -2.60083 | 9.73109 | 85.47813 | 121.61760 |
| | Variance | 11616.840 | | -459.278 | 2026.610 | 7109.760 | 15044.760 |
| | N | 25 | | 0 | 0 | . | . |
| | Range | 427.00 | | | | | |
| | Minimum | 953.00 | | | | | |
| | Maximum | 1380.00 | | | | | |
| | Sum | 27886.00 | | | | | |
| Coarse aggregate (kg/m3) | Mean | 1115.4400 | 33.27011 | 1.9812 | 33.3459 | 1047.0400 | 1192.3457 |
| | Std. Deviation | 166.35055 | | -3.62956 | 15.74731 | 136.29115 | 188.17191 |
| | Variance | 27672.507 | | -946.655 | 5066.358 | 17966.090 | 35408.667 |
| | N | 25 | | 0 | 0 | . | . |
| | Range | 145.00 | | | | | |
| | Minimum | 50.00 | | | | | |
| | Maximum | 195.00 | | | | | |
| | Sum | 2771.00 | | | | | |
| Slump (mm) | Mean | 110.8400 | 8.01180 | -.2532 | 7.6574 | 94.0974 | 129.6330 |
| | Std. Deviation | 40.05900 | | -.98032 | 4.73820 | 28.62442 | 47.60430 |
| | Variance | 1604.723 | | -55.152 | 360.532 | 799.994 | 2281.044 |
| Valid N (listwise) | N | 25 | | 0 | 0 | . | . |

**Table 2 shows t**he descriptive statistical analysis which was used to portray information in the data. It analysis the data statistically, reveals and details the information in the data. It also emphasis the data mean, median, sum, range, variance standard deviations, confidence level, residual errors in the data and the standard error in the data.

**Coarse aggregate (kg/m3)**

**Table 3: Case Processing Summary**

| | Coarse aggregate (kg/m3) | Cases | | | | | |
|---|---|---|---|---|---|---|---|
| | | Valid | | Missing | | Total | |
| | | N | Percent | N | Percent | N | Percent |
| Slump (mm) | 953.00 | 11 | 100.0% | 0 | 0.0% | 11 | 100.0% |
| | 1167.00 | 9 | 100.0% | 0 | 0.0% | 9 | 100.0% |
| | 1380.00 | 5 | 100.0% | 0 | 0.0% | 5 | 100.0% |

**Table 4: Coarse aggregate M-Estimators**

Formatted Table

| | Coarse aggregate (kg/m3) | Statistic | Bootstrap |
|---|---|---|---|

| | | | | Bias | Std. Error | BCa 98% Confidence Interval | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower | Upper |
| Slump (mm) | 953.00 | Huber's M-Estimator | 125.6317 | -.3535[i] | 19.0402[i] | 89.7525[i] | 160.2611[i] |
| | | Tukey's Biweight | 125.8833 | -1.5816[i] | 22.1158[i] | 88.4845[i] | 162.9755[i] |
| | | Hampel's M-Estimator | 126.4545 | -.7262[i] | 19.6975[i] | 88.8551[i] | 162.6822[i] |
| | | Andrews' Wave | 125.8787 | -1.6135[i] | 22.1574[i] | 88.4890[i] | 162.9655[i] |
| | 1167.00 | Huber's M-Estimator | 92.4295 | 2.4849[j] | 14.4906[j] | 67.4795[j] | 162.6503[j] |
| | | Tukey's Biweight | 86.0199 | 6.2427[j] | 16.8065[j] | .[j] | .[j] |
| | | Hampel's M-Estimator | 86.0148 | 7.9399[j] | 15.8676[j] | .[j] | .[j] |
| | | Andrews' Wave | 86.0156 | 6.2076[j] | 16.8339[j] | .[j] | .[j] |
| | 1380.00 | Huber's M-Estimator | 95.0578 | -.9595[k] | 10.1189[k] | 65.6282[k] | 107.5000[k] |
| | | Tukey's Biweight | 99.4180 | -3.5515[k] | 10.9710[k] | 68.4169[k] | 108.4724[k] |
| | | Hampel's M-Estimator | 94.6979 | -.1041[k] | 10.6841[k] | 65.5000[k] | 108.7500[k] |
| | | Andrews' Wave | 99.6441 | -3.7565[k] | 10.9742[k] | 68.4245[k] | 108.4839[k] |

Comment [M2]: What does the superscript i,j and k mean

**Table 5: Tests of Normality**

| | Coarse aggregate (kg/m3) | Kolmogorov-Smirnov | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|---|
| | | Statistic | df | Sig. | Statistic | df | Sig. |
| Slump (mm) | 953.00 | .216 | 11 | .160 | .924 | 11 | .351 |
| | 1167.00 | .296 | 9 | .022 | .826 | 9 | .041 |
| | 1380.00 | .259 | 5 | .200* | .876 | 5 | .290 |

**Fine Rice Husk (kg/m3)**

**Table 6: Fine M-Estimators**

| | Fine (kg/m3) | | Statistic | Bootstrap | | | |
|---|---|---|---|---|---|---|---|
| | | | | Bias | Std. Error | BCa 98% Confidence Interval | |
| | | | | | | Lower | Upper |
| Slump (mm) | 414.00 | Huber's M-Estimator | 101.3111 | 1.4796[i] | 10.8098[i] | 77.7682[i] | 135.5000[i] |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Tukey's Biweight | 98.4511 | 3.1955[i] | 11.4013[i] | .[i] | .[i] |
| | Hampel's M-Estimator | 98.8138 | 3.7421[i] | 10.9845[i] | .[i] | .[i] |
| | Andrews' Wave | 98.4261 | 3.1892[i] | 11.4333[i] | .[i] | .[i] |
| 552.00 | Huber's M-Estimator | 98.0502 | 5.0902[j] | 19.8758[j] | 69.5201[j] | 174.0098[j] |
| | Tukey's Biweight | 86.0940 | 13.3154[j] | 23.0046[j] | .[j] | .[j] |
| | Hampel's M-Estimator | 96.8503 | 5.8041[j] | 21.1481[j] | 66.8653[j] | 175.2135[j] |
| | Andrews' Wave | 85.7565 | 13.5551[j] | 23.0681[j] | .[j] | .[j] |
| 690.00 | Huber's M-Estimator | 106.3838 | 4.4396[k] | 19.3970[k] | 81.0441[k] | 156.4626[k] |
| | Tukey's Biweight | 107.4876 | 2.2151[k] | 21.0520[k] | 84.2190[k] | 157.9911[k] |
| | Hampel's M-Estimator | 109.2851 | 1.6786[k] | 20.2975[k] | 85.0286[k] | 158.0000[k] |
| | Andrews' Wave | 107.5429 | 2.1427[k] | 21.0657[k] | 84.1899[k] | 157.9906[k] |

**Table 7: Tests of Normality**

| | Fine (kg/m3) | Kolmogorov-Smirnov | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|---|
| | | Statistic | df | Sig. | Statistic | df | Sig. |
| Slump (mm) | 414.00 | .286 | 6 | .137 | .904 | 6 | .396 |
| | 552.00 | .269 | 10 | .039 | .850 | 10 | .057 |
| | 690.00 | .210 | 9 | .200* | .903 | 9 | .269 |

**Water Content (kg/m3)**

**Table 8: Case Processing Summary**

| | Water Content (kg/m3) | Cases | | | | | |
|---|---|---|---|---|---|---|---|
| | | Valid | | Missing | | Total | |
| | | N | Percent | N | Percent | N | Percent |
| Slump (mm) | 5.00 | 9 | 100.0% | 0 | 0.0% | 9 | 100.0% |
| | 6.00 | 7 | 100.0% | 0 | 0.0% | 7 | 100.0% |
| | 7.00 | 9 | 100.0% | 0 | 0.0% | 9 | 100.0% |

**Comment [M3]:** In this Table, there is no data changing, this table doesn't need, table 3 and table 11 are same as table 8.

**Table 9: Water Content (kg/m3) M-Estimators**

| | Water Content (kg/m3) | | Statistic | Bootstrap | | | |
|---|---|---|---|---|---|---|---|
| | | | | Bias | Std. Error | BCa 98% Confidence Interval | |
| | | | | | | Lower | Upper |
| Slump (mm) | 5.00 | Huber's M-Estimator | 103.7866 | 4.2753[i] | 20.2857[i] | 82.5721[i] | 156.4945[i] |
| | | Tukey's Biweight | 102.2221 | 3.6057[i] | 22.6701[i] | 82.6736[i] | 158.3351[i] |
| | | Hampel's M-Estimator | 107.2360 | .8281[i] | 21.8922[i] | 83.6913[i] | 158.2500[i] |
| | | Andrews' Wave | 102.3307 | 3.4688[i] | 22.6921[i] | 82.6725[i] | 158.3075[i] |
| | 6.00 | Huber's M-Estimator | 143.9491 | .3490[j] | 23.7487[j] | 93.6233[j] | 183.1073[j] |
| | | Tukey's Biweight | 145.5352 | .9948[j] | 27.1169[j] | 88.8371[j] | 189.0046[j] |
| | | Hampel's M-Estimator | 143.5207 | 1.1220[j] | 24.1167[j] | 90.5028[j] | 185.8005[j] |
| | | Andrews' Wave | 145.4891 | 1.0361[j] | 27.1510[j] | 88.6338[j] | 189.0296[j] |
| | 7.00 | Huber's M-Estimator | 88.5363 | -.4308[k] | 9.4347[k] | 61.2381[k] | 108.8327[k] |
| | | Tukey's Biweight | 88.0530 | .8954[k] | 10.6101[k] | 54.0308[k] | 109.7560[k] |
| | | Hampel's M-Estimator | 86.8562 | 1.2952[k] | 9.6713[k] | 56.7241[k] | 109.7500[k] |
| | | Andrews' Wave | 88.0466 | .9086[k] | 10.6317[k] | 54.0397[k] | 109.7560[k] |

**Table 10: Tests of Normality**

| | Water Content (kg/m3) | Kolmogorov-Smirnov | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|---|
| | | Statistic | df | Sig. | Statistic | df | Sig. |
| Slump (mm) | 5.00 | .263 | 9 | .073 | .787 | 9 | .014 |
| | 6.00 | .271 | 7 | .129 | .901 | 7 | .338 |
| | 7.00 | .226 | 9 | .200* | .899 | 9 | .246 |

**Cement (kg/m3)**

**Table 11: Case Processing Summary**

| | Cement (kg/m3) | Cases |
|---|---|---|

| | | Valid | | Missing | | Total | |
|---|---|---|---|---|---|---|---|
| | | N | Percent | N | Percent | N | Percent |
| Slump (mm) | 207.00 | 10 | 100.0% | 0 | 0.0% | 10 | 100.0% |
| | 254.00 | 11 | 100.0% | 0 | 0.0% | 11 | 100.0% |
| | 300.00 | 4 | 100.0% | 0 | 0.0% | 4 | 100.0% |

Tables 3, 8 and 11 reveal the validity of a data and the missing values in the data using a method that is known as case processing summary. This method reveals the number of values in the lower boundary, mean boundary and upper boundary in the data system and the possibility of valid data in the boundaries. However, it also reveals the possible missing data in the lower boundary, mean boundary and upper boundary in the data system.

**Table 12: Cement (kg/m3) M-Estimators**

| | Cement (kg/m3) | | Statistic | Bootstrap | | | |
|---|---|---|---|---|---|---|---|
| | | | | Bias | Std. Error | BCa 98% Confidence Interval | |
| | | | | | | Lower | Upper |
| Slump (mm) | 207.00 | Huber's M-Estimator | 102.0348 | 1.1497[h] | 11.6041[h] | 71.4591[h] | 155.2357[h] |
| | | Tukey's Biweight | 100.1067 | 2.3994[h] | 12.2625[h] | 58.2672[h] | 159.1125[h] |
| | | Hampel's M-Estimator | 100.5684 | 2.3589[h] | 11.9952[h] | 70.2221[h] | 158.9132[h] |
| | | Andrews' Wave | 100.1103 | 2.4031[h] | 12.2662[h] | 58.1394[h] | 159.1173[h] |
| | 254.00 | Huber's M-Estimator | 104.2431 | 6.9247[i] | 19.7272[i] | 89.6182[i] | 169.8525[i] |
| | | Tukey's Biweight | 93.7213 | 12.3619[i] | 22.8537[i] | .[i] | .[i] |
| | | Hampel's M-Estimator | 100.4116 | 8.9054[i] | 21.0067[i] | 86.6663[i] | 173.9062[i] |
| | | Andrews' Wave | 93.7216 | 12.2897[i] | 22.8952[i] | .[i] | .[i] |
| | 300.00 | Huber's M-Estimator | 73.5722 | 6.1730[j] | 17.2994[j] | 63.5000[j,k] | 119.0000[j] |
| | | Tukey's Biweight | 68.8974 | 7.3918[j] | 17.9252[j] | 62.6465[j,k] | 119.0000[j] |

**Comment [M4]:** Can you show the source of this Estimator, and also include others

| | | | | | | |
|---|---|---|---|---|---|---|
| | Hampel's M-Estimator | 69.3333 | 9.3889[j] | 17.9394[j] | 62.7500[j,k] | 119.0000[j] |
| | Andrews' Wave | 68.8924 | 7.3635[j] | 17.9294[j] | 62.6457[j,k] | 119.0000[j] |

Tables 4, 6, 9 and 12 shows that some M-Estimators cannot be computed in one or more split files because of the highly centralized distribution around the median. Some results could not be computed from jackknife samples or the estimators, so this confidence interval is computed by the percentile method rather than the BCa method. M-Estimators is a method used to determine the average estimated confidence level of the data using several estimation methods to achieve more effective results. The estimation methods developed their confidence methods around the lower value, mean value and the upper value of the used data. However, it will be noted that the estimated confidence level in this research is 98 percent (%), this is used because of the economic importance and its necessity to construction.

**Table 14: Tests of Normality[c]**

| | Cement (kg/m3) | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|---|
| | | Statistic | df | Sig. | Statistic | df | Sig. |
| Slump (mm) | 207.00 | .236 | 10 | .122 | .926 | 10 | .411 |
| | 254.00 | .306 | 11 | .005 | .804 | 11 | .011 |
| | 300.00 | .341 | 4 | . | .773 | 4 | .062 |

Tables 5, 7, 10 and 13 investigates and reveals tests of normality using Kolmogorov-Smirnov and Shapiro-Wilk which shows that statistically, the data is not normally distributed along the upper and lower boundaries of the data mean except at the mean. The cement data is significance along the mean of slump data but is not significance at the upper and lower boundary of the slump wet data. This is applicable in the two normality test methods applied.



**Generalized Linear Mixed Models**

**Model Summary**

Target: Slump (mm)

| | | |
|---|---|---|
| Target | | Slump (mm) |
| Probability Distribution | | Gamma |
| Link Function | | Log |
| Information Criterion | Akaike Corrected | 2,246.667 |
| | Bayesian | 2,235.293 |

Information criteria are based on the -2 log pseudo likelihoo (2,196.667) and are used to compare models. Models with smaller information criterion values fit better. When compar models using pseudo likelihood values, caution should be us because different data transformations may be used across tl models.

## Conclusion

On the basis of the statistical analysis, the derived mathematical model for the slumps (workability) and strength of concrete in a hot humid zone as functions of quantity of cement, water-cement ratio and quantity of aggregates, it is possible to evaluate the composition of the concrete mix by varying the independent factors (variables) for various seasons.

The statistical results developed will help to understand the data and what the data portrays.

## References


Aman, A. (2010): *Assessment of the Quality Strength and Variability of the Consturtion Materials.* Nigerian Institute of Structural Engineers Conference 2010. 10-12.

Dhir, R. K. and Green J.W. (1990): *Protection of Concrete Processing.* Paper presented at International Conference held at the University of Dundes Scotland, UK on 11-13 September, 1990.

Edeh, et.al, (2011): Analysis of Environmental Risk factors affecting Rice farming in Ebonyi State, South Eastern Nigeria.

Ezeokonkwo, J.U. (2002): Quality Control in Construction, Project. *Effective Building Procurement and Delivery in Nigerian Construction Industry.* Rex Charles and Patrick Ltd. Nimo Anambra State. 85-101.

Ezeokonkwo J.U. (2015). "*Assessment of Quality Control of Concrete Production Works in Nigeria*", Publisher: LAP LAMBERT Academic Publishing, Deutschland, Germany. ISBN: 9783659389306

Heiseman, (2007): *Concrete Characteristics*. Sweet Haven publishers.

Imaga, (1994):*Theory and Practice of Production Management.* Afritrade International Limited Publishers. 8/10 Broad Street 10th Floor Western House.

Obiegbu, M. E. (2007): The Professional Builder. Magazine Published by Nigerian Institute of Building.

US Research Department of Transportation, Federal Highway Administration (2012): *Concrete Mixture Optimization Using Statistical Methods.* FHWA-RD-03-060.