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Rice husk ash as an indigenous construction material in building process, a statistical evaluation

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Abstract

The research described the rice husk ash as an indigenous construction material used in building production process of the concrete design mix. The production process is analyzed statistically. The quality of concrete mixture is of inevitable concern to all stakeholders in the construction industry and on building production process in the zone when the climatic conditions of the zone are considered. The mix design ratio is investigated and all the prevailing construction/production practices are considered statistically to portray the experimental results in the system. The statistical tools applied in this research for clarity of the results are descriptive, normality, missing value analysis, process statistical summary and confidence estimation methods of statistics. The experimental matrix was designed using three level four factors. Twenty five (25) experimental runs was conducted the M-Estimator was used to obtain the missing value analysis, the estimate of the output parameter at each selected factor levels. The results show that all the factors selected are fit for the experimental analysis. The factors in M-estimators show that the response (Slump) can be as low as 68.8924mm and as high as 145.5352mm. In descriptive statistic, the mean for the parameters: cement, water, fine husk, coarse aggregate and slump are 242.56 kg/m3, 6.00 kg/m3, 568.56 kg/m3, 111544 kg/m3 and 110.84mm respectively. The tools portray the necessary information in the data to understand what the data information for further experimental process analysis.

Keywords: Concrete; Estimators; Experimental Process; Statistics; Descriptive; Construction industry and climatic conditions

1. Introduction

Construction industry plays an effective role in the fixed capital formation of any economy. It accounts for over 60% of the Gross Fixed Capital Formation of any nation [1]. The construction industry thus is very tactical 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, present 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 [2]. 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 [3].

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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 [4].

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 [5].

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 Aman, (2010), there is also a need for an accurate assessment of quality, strength and variability of the materials used in forming the structural components [6].

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 view that enterprises in developing countries do not appear to pay enough attention to the areas of eminence standards and appropriate inspection of products formed in their organization [7]. A vital look now reminds 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 [7].

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 or guideline [8].

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 [9].

This research work was performed to express the experimental process analysis of the concrete mix with fine rice husk, to create a design for the process mix of the product system and to establish a standard for the design and production of concrete mix using fine rice husk.

1.1. Significance Statement

This study discovered the slump concrete mix density in addition to the strength can be beneficial to construction industries. This study will help the researchers to uncover the critical mixture areas of concrete mix compositions that many researchers were not able to explore. Thus a new theory on concrete compositions mix with fine rice husk to achieve a superior concrete mix as well as concrete strength in the material composition was achieved.

2. Material and methods

The experiment is conducted in the hot humid zone at Awka, Anambra state, Nigeria. The experiment involves the input parameters of cement, water, fine rice husk and coarse aggregate and the output parameters called the slump. The twenty five (25) experimental runs were conducted with three levels, four factors techniques. The experiments were conducted within three months from second of September, 2018 to 5th of December, 2018.

The research method used in this work is the application of Factorial design Analysis of mathematical models for variables in the zones. The statistical tools used are SPSS version 21 and Minitab version 17.0. The software expressed the experimental analysis and the statistical analysis in the experimental design. 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 plus strength of concrete.

3. Results

3.1. Computer Analysis of the Experimental Results from the Two Zones

Table 1 Result Values 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	
Xim Lowest level (-)	207	5	414	953	
Xer Central Level (0) average	254	6	552	1167	
δInterval of Change Δ	46	1	138	213	
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/m^3)	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/m^3)	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/m^3)	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
Coarse aggregate (kg/m^3)	N	25		0	0	.	.
	Range	427.00					
	Minimum	953.00					
	Maximum	1380.00					
	Sum	27886.00					
	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

Slump (mm)	N	25		0	0	.	.
	Range	145.00					
	Minimum	50.00					
	Maximum	195.00					
	Sum	2771.00					
	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 explained the descriptive statistical analysis that was used to portray information in the data. It study the data statistically, reveals and details the information in the data. It also stress the data mean, median, sum, range, variance standard deviations, confidence level, residual errors in the data along with the standard error in the data.

3.2. Coarse aggregate (kg/m^3)

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

	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]

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

3.3. 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	1.4796i	10.8098i	77.7682i	135.5000i
		Tukey's Biweight	98.4511	3.1955i	11.4013i	.i	.i
		Hampel's M-Estimator	98.8138	3.7421i	10.9845i	.i	.i
		Andrews' Wave	98.4261	3.1892i	11.4333i	.i	.i
	552.00	Huber's M-Estimator	98.0502	5.0902j	19.8758j	69.5201j	174.0098j
		Tukey's Biweight	86.0940	13.3154j	23.0046j	.j	.j
		Hampel's M-Estimator	96.8503	5.8041j	21.1481j	66.8653j	175.2135j
		Andrews' Wave	85.7565	13.5551j	23.0681j	.j	.j
	690.00	Huber's M-Estimator	106.3838	4.4396k	19.3970k	81.0441k	156.4626k
		Tukey's Biweight	107.4876	2.2151k	21.0520k	84.2190k	157.9911k
		Hampel's M-Estimator	109.2851	1.6786k	20.2975k	85.0286k	158.0000k
		Andrews' Wave	107.5429	2.1427k	21.0657k	84.1899k	157.9906k

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

3.4. 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%

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

3.5. Cement Quantity (kg/m^3)

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]
		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

	Cement (kg/m^3)	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.

3.6. 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.

Figure 1 Statistical Analysis of the Model Summary

Figure one shows the statistical analysis of the result summary. It shows the information criterion of the akaike and the information criterion of the Bayesian. The information criterion of the akaike and the information criterion of the Bayesian show that there is less error on the statistical analysis in the system

4. Discussion

The discussion of results is based on the graphs, tables and figures generated in the cause of this research. However, 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 shows the descriptive statistical analysis which was used to portray information in the data. It expressed the variables mean for cement, water, coarse aggregate, fine rice husk and slump as242.56 kg/m3, 6.00 kg/m3, 111544 kg/m3, 568.56kg/m3 and 110.84mm respectively. It expressed the variables standard deviation for cement, water, coarse aggregate, fine rice husk and slump as 33.72 kg/m3, 0.866 kg/m3, 166.35 kg/m3, 107.78kg/m3 and 40.06mm respectively. It also expressed the variance of the parameters for cement, water, coarse aggregate, fine rice husk and slump as 1136.76 kg/m3, 0.750 kg/m3, 27672.51 kg/m3, 11616.84kg/m3 and 1604.72mm respectively. 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. 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. 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. Tables 4, 6, 9 and 12 show the analysis of different types of M- Estimators in the parameters. It reveals that the factors in M-estimators express that the response (Slump) can be as low as 68.8924mm and as high as 145.5352mm no matter the type of M-estimators adopted in the system. The statistical tools express the estimate of the response in the variables using different estimators. However, there is always a need to apply some other statistical and optimization tools, to validate the results of this research. The research work is also recommended for further studies in other geopolitical areas, so as to understand the optimal solutions of the slump and its statistical implications in the related studies.

5. Conclusion

On the basis of the analysis, the mathematical analysis for the slumps (workability) concrete in a hot humid zone as functions of quantity of cement, water-cement ratio, fine rice husk and quantity of aggregates, it is possible to evaluate the composition of the concrete mix by varying the independent factors (variables) for various seasons. Twenty five (25) experimental runs were conducted and different M-Estimators were used to obtain the missing value analysis and the estimate of the output parameter at each selected factor levels. The results show that all the factors selected are fit for the experimental analysis. The factors in M-estimators show that the response (Slump) can be as low as 68.8924mm and as high as 145.5352mm. The statistical results developed will help to understand the data and what the data portrays.

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest in this research.

References

[1] Ezeokonkwo JU. Quality Control in Construction, Project. Effective Building Procurement and Delivery in Nigerian Construction Industry. Rex Charles and Patrick Ltd. Nimo Anambra State. 2002; 85-101.

[2] Edeh et. Al. Analysis of Environmental Risk factors affecting Rice farming in Ebonyi State, South Eastern Nigeria. 2011.

[3] Heiseman. Concrete Characteristics. Sweet Haven publishers. 2007.

[4] Dhir RK,Green JW. Protection of Concrete Processing. Paper presented at International Conference held at the University of Dundes Scotland, UK on 11-13 September, 1990.

[5] Obiegbu ME. The Professional Builder. Magazine Published by Nigerian Institute of Building. 2007.

[6] Aman A. Assessment of the Quality Strength and Variability of the Consturtion Materials. Nigerian Institute of Structural Engineers Conference. 2010; 10-12.

[7] Imaga. Theory and Practice of Production Management. Afritrade International Limited Publishers. 8/10 Broad Street 10th Floor Western House. 1994.

[8] US Research Department of Transportation, Federal Highway Administration. Concrete Mixture Optimization Using Statistical Methods. FHWA-RD-03-060. 2012.

[9] Ezeokonkwo JU. Assessment of Quality Control of Concrete Production Works in Nigeria, Publisher: LAP LAMBERT Academic Publishing, Deutschland, Germany. 2015; ISBN: 9783659389306.