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

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Short Research Article

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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

The construction sector plays an active role in the formation of fixed assets in any economy. It represents more than sixty percent of the fixed capital formation of any nation, [1]. The construction industry, therefore, is very strategic in its contribution to a country's gross domestic

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product. From the above, it has a very high capacity to generate growth and induce multiplier effects in the economy of a nation.

However, current developments in the construction industry in Nigeria are inducing negative effects within the industry. For example, the problem of the collapse of buildings has been persistent in the country in recent times and the need to offer solutions to avoid future events becomes evident. In the last ten years, the incidence of the collapse of buildings has become so alarming and worrisome that it shows no signs of diminishing. Each collapse has tremendous effects that none of its victims can easily forget. These effects include the loss of human lives, economic waste, loss of jobs, income, loss of confidence, dignity and the exasperation of crisis among stakeholders and environmental disasters [2]. It is believed that any search in human life has its cost, but the cost paid in the southeast of Nigeria due to incessant incidents of collapse of buildings cannot be understood or quantified.

Buildings are structures that provide shelter for man, his properties and activities. As such, they must be planned, designed and constructed properly to obtain the desired environmental satisfaction. The main factors observed during the construction of the building include; the functional performance requirements of durability, adequate stability to avoid structural failures, discomfort for users, resistance to weather conditions and use of good quality materials. Building styles of buildings are constantly changing with the introduction of new materials and construction techniques. Consequently, the work involved in the design and construction stages are, to a large extent, those of selection of materials, components and structures that will comply with the standards and aesthetics of construction expected on an economic basis [3].

A general survey shows that most modern buildings in southeastern Nigeria have concrete as their main component. Then, it becomes pertinent that the quality of the concrete materials required for the concrete used in the construction process must be of the utmost importance. Many building failures are mainly related to the use of substandard materials, poor workmanship and inefficient management in the production process. Experts have examined the evaluation of the quality of the materials and the level of labor used in the production of concrete at the project sites. According to Amana, [4] it is also necessary to make an accurate assessment of the quality, strength and variability of the materials used to form the structural components [5].

Furthermore, he noted that a good example of how quality, resistance and variability play in our environment is the great variability in the quality of the concrete used on our construction sites.

Imaga, [6] believes that companies in developing countries do not pay sufficient attention to the areas of quality standards, the definition and adequate inspection of the 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 has. It therefore becomes imperative that producers and professionals involved in the construction process have to decide in advance what the characteristics of their product should be and integrate them into the project and into the concrete quality specifications that should be used in the projects.

Therefore, quality is defined as a set of predetermined (basic) standards to ensure a minimum level of requirements for a obtainable result. These predetermined standards are seen as an agreed and reliable way to do 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 [7].

In addition, standards help simplify your life and increase the reliability and effectiveness of many of the products and services we use. Standards are created by bringing together the experience of all stakeholders, such as manufacturers, sellers, users and regulators of a particular material, product, process or service. Through these, the quality of any product can now be achieved in the actual production process at 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 [8].

2. THE RESEARCH METHODS

The research method used in this research is the use of Factorial design psychoanalysis of numerical model for Variables in the areas of this study. The technique applied is used to learn the effects of each of the parameters on the slumps (workability) of concrete, density and compressive strength for each climatic season conditions, quasi or mono factorial models were obtained. From the analysis, it is possible to make the subsequent deductions on the control of the dissimilar factors over the workability density and strength of concrete.

3. ANALYSIS OF THE EXPERIMENTAL RESULTS FROM THE TWO ZONES

After experimentally generating data on Table 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 shows the 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.

Table 1. Variables of results from hot moist zones (Awka) [9]

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	
δ Interval 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

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
Coarse aggregate (kg/m3)	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	.	.

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

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[l]	19.0402[l]	89.7525[l]	160.2611[l]
		Tukey's Biweight	125.8833	-1.5816[l]	22.1158[l]	88.4845[l]	162.9755[l]
		Hampel's M-Estimator	126.4545	-.7262[l]	19.6975[l]	88.8551[l]	162.6822[l]
		Andrews' Wave	125.8787	-1.6135[l]	22.1574[l]	88.4890[l]	162.9655[l]
	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

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%

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.

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. The superscript of I, j k and h express the concrete mix component variations using different selected estimators.

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]

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.

Table 13. 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.

4. 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 rice ash husk used will improve and strengthen the concrete mixture of the component although it can decompose within a long period of time. The statistical results developed will help to understand the data and what the data portrays.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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