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.

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	.	.
Coarse aggregate (kg/m3)	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
	N	25		0	0	.	.
Slump (mm)	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 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.

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%

91

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

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	Kolmogorov-Smirnov	Shapiro-Wilk

	(kg/m3)	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]
	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.

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