EVALUATION OF CAUSES OF CONSTRUCTION MATERIAL WASTE -- CASE OF RIVERS STATE, NIGERIA

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Abstract

This research paper evaluates the causes of construction waste generation on building sites in Rivers State, Nigeria. The methods employed to collect data include review of relevant literature and structured questionnaire. The statistical techniques used to analyse the data collected are Mean score method, ranking method and Man-Whitney U test. The results of analysis showed that the three most important factors contributing to construction material waste generation on building sites in Rivers State, Nigeria are "rework contrary to drawing and specification", "design changes and revision" and "waste from uneconomical shapes" respectively. It was also discovered that inappropriate equipment contributed least to waste generation on site and there is little "bottle neck" in obtaining work permit by contractors in Rivers State, Nigeria. The study revealed that all the 74 factors were considered important by the respondents. The study showed that there is no significant difference between the consultants and contractors perception about the factors affecting construction waste generation on building sites in Rivers State, Nigeria. This study therefore recommended that construction stakeholders should consider the studied factors at every level of the construction processes and in their waste management plan.

Key words: *Building Sites, Construction Waste, Evaluation, Factors, Nigeria.*

Introduction

Wastage on construction site has become a canker worm in Nigerian construction industry. This problem has negatively affected the performance of many projects in Nigeria. Obiegbu (2002) noted that wastage in construction firms has come to stay considering the fact that at least 5% is attained when preparing the estimate for a project which is usually not adequate. Wastage is seen in many ways as peculiarity of construction projects. This means that many construction works have wastage because it is an issue that cannot be divorced from construction work.

There have been different definitions of construction material waste by different authors. For the purpose of this study, building material wastage can be defined as the difference between the value of materials delivered and accepted on site and those properly used as specified and accurately measured in the work after deducting the cost saving of substituted materials transferred elsewhere in which unnecessary cost and time may be incurred by the material wastage (Shen and Tam, 2002). The causes of construction material waste can be measured and evaluated using a large number of construction phase related factors such as design and documentation, materials procurement and management, site management practices and site supervision including environmental conditions. The first set is related to designers and client's requirements; the people who consider the functional requirement of the building. The second set is related to construction team and contractors; people who consider the buildability and maintainability of the building. The third set is related to the site supervisors and the site operatives; people who are directly involved in the art of putting the raw materials together to form the building envelop.

Teo *et al.* (2009) observed that extra construction materials are usually purchased due to material wastage during construction. Previous studies from various countries have confirmed that waste represents relatively larger percentage

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of production. Tam et *al*. (2007) in a study in the United Kingdom reported an additional cost of 15% to construction project cost overruns as a result of material wastage. Bossink and Brouwers (1996) stated that material wastage accounts for between 20-30% project cost overruns. It is therefore glaring that the economic losses from construction material waste could pose a great threat to the economic growth of a nation. There is a growing consensus within the built environment in Nigeria that building materials account for over 50% of the total cost of a building project (Akinkurolere and Franklin, 2005).

It therefore follows that wastage of material will lead to increase in total cost of building project. This assertion is supported by Teo *et al*. (2009) who opined that building material wastage on construction sites contributes to cost overruns. This implies that in-depth review, identification of causative factors of waste, assessment of these factors and any improvement in material wastage management on construction sites will enhance the cost performance of projects in Nigeria.

This work had the following objectives. It studied the causes or factors affecting construction material waste generation on building sites in Rivers State, Nigeria and also assessed and analysed these factors statistically according to contractors' and consultants' perceptions. This is to establish the degree of severity or effects these researched factors have on construction sites waste generation in the study area and also proffer useful recommendations for contractors, consultants and other construction professionals in the study area.

Methodology

Data were collected using structured interviews and questionnaires which were designed to obtain in-depth factors affecting construction material waste generation on building sites in Rivers State, Nigeria. Various factors affecting construction material waste generation on building sites were identified from the available literature out of which a total of 74 were selected. A total of 160 questionnaires were purposively administered to key construction industry participants (consultants and contractors) in the ratio of 100 and 60 respectively. The questionnaire used for the study comprised of 49 and 84 for consultants and contractors respectively. The respondents were requested to rank these factors in order of importance. The rating values of 5, 4, 3, 2, and 1 were assigned to the options extremely important, very important, moderately important, slightly important and not important respectively in obtaining the respondents' perception on the factors affecting construction material waste generation on building sites in Rivers State, Nigeria. These factors were analysed based on the questionnaire.

Data Analysis Techniques

The data analysis techniques used in this study include the Mean Score method, Ranking method and Mann-Whitney U Test. The Mean Score method was used to obtain the level of significance and importance of factors affecting material waste generation on building sites in Rivers State, Nigeria. The rating of the respondents was converted into actual scores. This can be illustrated mathematically as follows.

Rank sum (s) = $\sum_n W$ Equation 1

Mean Score (ms) = $\frac{\sum nW}{N}$ Equation 2

(Where S = Rank sum, Σ = summation, n = the highest attainable rating and W = corresponding weight of rank category, N = total number of respondents, m. s = Mean score).

The decision rule is that any factor whose mean falls between 0.5 – 1.49 is regarded as "not important", 1.5 – 2.49 is slightly important, 2.5 – 3.49 is moderately important, 3.5 – 4.49 is very important and 4.5 – 5.0 is regarded as extremely important.

Having established the perceptions of the consultants and contractors differently, there was also the need to further ascertain if consultants' perceptions were statistically different from the contractors' perception. This led to the use of Mann-Whitney Test. It is a non parametric test often used in place of t-test (Ho, 2006). In this test, decision to accept a null hypothesis is based on the Z value and the significance (2-tailed). If the significance level or the probability value (p)

is not less than or equal to 0.05, it implies there is no statistically significant difference in the result, thereby accepting the null hypothesis.

Results and Discussion

The result of analysis of consultant's perception of the selected factors affecting waste generation is presented in Table 1. It reveals the results of analysis of the consultants' perception. Table 1 shows that the consultants considered 53 factors out of 74 factors as being moderately important and 21 factors as very important. Table 1 also reveals that all the factors are important though their degree of importance varies. It is shown in Table 1 that the mean scores of the causative factors of waste generation on building sites in Rivers State ranges between 2.88 and 4.14. Rework contrary to drawings and specification has the highest mean score of 4.14 while inappropriate equipment has the least mean score of 2.88. This implies that the most important factor that causes waste generation on building sites in Rivers State according to consultant's perception is rework contrary to drawings and specification while inappropriate equipment is the least considered. This analysis further revealed the level of awareness and utilization of construction equipment by consultants in Rivers State.

Table 1 Consultants' Perception of Selected Waste Generation Factors in Rivers State

Factors	1	2	3	4	5	Sum	MS	Rank
Rework contrary to drawings and specifications		2	13	10	24	203	4.14	1
Design changes and revisions	1	5	10	13	20	193	3.94	2
Waste from uneconomical shapes		1	12	26	10	192	3.92	3
Severe weather conditions		6	10	18	15	189	3.86	4
Purchase of materials contrary to specification	4		16	13	16	184	3.76	5
Using untrained labours		9	8	20	12	182	3.71	6
Lack of on-site materials control		9	10	17	13	181	3.69	7
Use of incorrect material	1	6	12	18	12	181	3.69	7
Overproduction	3	6	9	18	13	179	3.65	9
Over ordering or under ordering	2	4	14	19	10	178	3.63	10
Substitution of a material by a more expensive one	2	9	8	16	14	178	3.63	10
Rework due to workers' mistakes	2	5	9	27	6	177	3.61	12
Poor workmanship		13	3	23	10	177	3.61	12
Errors in contract documents	2	6	15	13	13	176	3.59	14
Purchase of material contrary to specification		11	12	14	12	174	3.55	15
Inadequate supervision	2	8	15	9	15	174	3.55	15
Ambiguities, mistakes, and changes in specifications		7	22	7	13	173	3.53	17
Impossibility to order small quantities	2	8	11	18	10	173	3.53	17
Lack of information about types and sizes of materials on design documents	2	4	21	11	11	172	3.51	19
Choice of wrong construction method	2	7	15	14	11	172	3.51	19
Using excessive quantities of materials more than the required	2	11	10	13	13	171	3.49	21
Lack of skilled subcontractors	1	14	5	18	11	171	3.49	21
Selection of low quality product	4	5	12	20	8	170	3.47	23
Unnecessary material handling		9	18	14	8	168	3.43	24
Manufacturing defects		7	24	9	9	167	3.41	25
Theft and vandalism	2	2	25	14	6	167	3.41	25
Poor quality of materials	2	6	14	24	3	167	3.41	25
Damage to work done caused by subsequent trades	1	10	15	14	9	167	3.41	25
Lack of waste management plan		8	19	16	6	167	3.41	25
Lack of attention paid to dimensions of product	2	11	9	20	7	166	3.39	30
Ambiguities, mistakes, and inconsistencies in drawings		9	22	8	10	166	3.39	30

Difficulty in performance and professional work	3	10	7	23	6	166	3.39	30
Lack of coordination among crews		9	18	16	6	166	3.39	30
Incompetent consultants engineer	3	5	18	16	7	166	3.39	30
Over ordering or under ordering due to mistake in the estimated quantity	2	10	14	14	9	165	3.37	35
Unnecessary inventories on site	4	9	7	23	6	165	3.37	35
Interaction between various specialists	2	9	13	19	6	165	3.37	35
Effects of subsurface conditions	1	7	20	15	6	165	3.37	35
Waiting for design documents and drawings	2	10	14	15	8	164	3.35	39
Manufacturer's non-involvement		16	13	8	12	163	3.33	40
Breakdown of equipment		14	11	18	6	163	3.33	40
Incomplete contract documents at commencement of project	5	6	16	13	9	162	3.31	42
Poor capability of contractor's technical staff	2	8	20	11	8	162	3.31	42
Poor technology/malfunction of equipment		16	8	20	5	161	3.29	44
Poor site layout	6	6	13	16	8	161	3.29	44
Specifying materials and dimensions without considering waste		8	23	15	3	160	3.27	46
Lack of a quality management system	2	9	18	14	6	160	3.27	46
Lack of strategy to waste minimisation		10	22	11	6	160	3.27	46
Accidents due to negligence	2	16	6	18	7	159	3.24	49
Over-sized of building elements during execution	2	8	20	15	4	158	3.22	50
Double handling of materials	4	6	21	12	6	157	3.20	51
Government authority instruction/policy		17	8	21	3	157	3.20	51
Complexity of detailing in the drawings	2	10	15	21	1	156	3.18	53
Inadequate stacking and insufficient storage	4	11	19	6	9	152	3.10	54
Insufficient instructions about handling		12	24	10	3	151	3.08	55
Bad road condition	4	9	22	7	7	151	3.08	55
Site conditions significantly different from contract documents		11	27	7	4	151	3.08	55
Poor schedule of materials procurement	4	12	14	15	4	150	3.06	58
Damage of materials on site	4	12	16	11	6	150	3.06	58
Poor storage of materials	2	10	25	7	5	150	3.06	58
Restiveness	4	9	24	5	7	149	3.04	61
Slow response from the consultant engineer to contractor inquiries	2	13	21	7	6	149	3.04	61
Change orders		15	22	8	4	148	3.02	63
Supplier's non-involvement	2	16	17	8	6	147	3.00	64
Poor and wrong storage of materials	2	14	19	10	4	147	3.00	64
Inappropriate storage	2	9	29	5	4	147	3.00	64
Accident	6	10	18	9	6	146	2.98	67
Difficulties in obtaining work permits	1	19	15	9	5	145	2.96	68
Damage during transportation	4	11	20	12	2	144	2.94	69
Labour unrest	4	16	13	11	5	144	2.94	69
Wrong handling of materials	4	10	26	4	5	143	2.92	71
Contractor's non-involvement	4	16	14	11	4	142	2.90	72
Insufficient instructions about storage and stacking	2	11	29	4	3	142	2.90	72
Inappropriate equipment	4	13	20	9	3	141	2.88	74

N = 49

The contractors' perception was statistically analysed and the result is presented in Table 2. It shows that the contractors in Rivers State considered 14 factors out of the 74 factors to be very important while 60 factors were considered to be moderately important. Table 2 also shows

that all the 74 factors were considered important by contractors though their degree of importance or contribution to waste generation varies as revealed by the analysis. Table 2 shows that the mean scores of the factors contributing to waste generation on building sites in Rivers State, according to contractors, ranges between 2.90 and 4.13. Rework contrary to drawings and specification has the highest mean score of 4.13 while difficulties in obtaining work permits has the least mean score of 2.90. This implies that contractors in Rivers State considered rework contrary to drawings and specification as the most important factor contributing to waste generation on building sites while difficulties in obtaining work permit was considered as the least. This further revealed that there is little bottleneck in obtaining work permit by contractors in Rivers State, Nigeria.

Table 2 Contractors' Perception of Selected Waste Generation Factors in Rivers State

Factors	1	2	3	4	5	Sum	MS	Rank
Rework contrary to drawings and specifications			26	21	37	347	4.13	1
Design changes and revisions	2	11	13	32	26	321	3.82	2
Waste from uneconomical shapes	1	4	25	34	20	320	3.81	3
Lack of on-site materials control		8	22	32	22	320	3.81	3
Purchase of materials contrary to specification	6	5	20	28	25	313	3.73	5
Rework due to workers' mistakes	3	7	13	48	13	313	3.73	5
Poor workmanship	6	9	19	22	28	309	3.68	7
Impossibility to order small quantities	5	11	19	28	21	301	3.58	8
Using untrained labours	4	11	21	28	20	301	3.58	8
Severe weather conditions	1	10	27	33	13	299	3.56	10
Errors in contract documents	3	10	29	24	18	296	3.52	11
Overproduction	4	18	14	26	22	296	3.52	11
Inadequate supervision	4	13	28	14	25	295	3.51	13
Unnecessary inventories on site	4	16	14	34	16	294	3.50	14
Waiting for design documents and drawings	2	11	30	26	15	293	3.49	15
Use of incorrect material	5	13	18	32	16	293	3.49	15
Substitution of a material by a more expensive one	3	16	21	26	18	292	3.48	17
Over ordering or under ordering	4	10	26	31	13	291	3.46	18
Lack of waste management plan	2	14	28	23	17	291	3.46	18
Ambiguities, mistakes, and changes in specifications	1	16	32	14	21	290	3.45	20
Theft and vandalism	3	8	33	28	12	290	3.45	20
Poor quality of materials	3	12	19	44	6	290	3.45	20
Incomplete contract documents at commencement of project	4	13	28	20	19	289	3.44	23
Selection of low quality product	4	8	30	32	10	288	3.43	24
Manufacturing defects	1	15	34	15	19	288	3.43	24
Unnecessary material handling	3	13	27	27	14	288	3.43	24
Manufacturer's non-involvement	1	17	33	12	21	287	3.42	27
Lack of coordination among crews	2	13	29	28	12	287	3.42	27
Lack of attention paid to dimensions of product	2	21	15	33	13	286	3.40	29
Effects of subsurface conditions	5	9	28	31	11	286	3.40	29
Poor site layout	8	12	21	24	19	286	3.40	29
Incompetent contractor's technical staff	2	14	33	18	17	286	3.40	29
Specifying materials and dimensions without considering waste		10	36	35	3	283	3.37	33
Over ordering or under ordering due to incorrect estimate	4	15	27	22	16	283	3.37	33
Double handling of materials	4	12	31	23	14	283	3.37	33

Lack of skilled subcontractors	6	19	13	30	16	283	3.37	33
Lack of a quality management system	3	16	29	20	16	282	3.36	37
Lack of strategy to waste minimisation	2	12	37	20	13	282	3.36	37
Incompetent consultant engineer's staff	7	9	25	33	10	282	3.36	37
Purchase of material contrary to specification	3	19	23	24	15	281	3.35	40
Breakdown of equipment	3	22	20	21	18	281	3.35	40
Ambiguities, mistakes, and inconsistencies in drawings	1	13	38	21	11	280	3.33	42
Choice of wrong construction method	4	15	30	19	16	280	3.33	42
Inadequate stacking and insufficient storage on site	4	13	36	15	16	278	3.31	44
Using excessive quantities of materials more than the required	3	24	20	19	18	277	3.30	45
Interaction between various specialists	2	16	32	23	11	277	3.30	45
Lack of information about types and sizes of materials on design documents	4	10	40	18	12	276	3.29	47
Bad road condition	3	13	37	19	12	276	3.29	47
Accidents due to negligence	2	22	24	22	14	276	3.29	47
Poor technology/malfunction of equipment	3	24	17	28	12	274	3.26	50
Difficulty in performance and professional work	4	20	21	29	10	273	3.25	51
Government authority	1	27	14	36	6	271	3.23	52
Supplier's non-involvement	2	19	35	16	12	269	3.20	53
Complexity of detailing in the drawings	3	15	33	29	4	268	3.19	54
Accident	5	17	34	16	12	265	3.15	55
Damage to work done caused by subsequent trades	4	24	21	26	9	264	3.14	56
Slow response from the consultant engineer to contractor inquiries	3	17	40	13	11	264	3.14	56
Damage during transportation	3	14	42	19	6	263	3.13	58
Damage of materials on site	4	25	23	21	11	262	3.12	59
Poor storage of materials	3	16	43	12	10	262	3.12	59
Over-sized of building elements during execution	2	17	40	19	6	262	3.12	59
Poor and wrong storage of materials	2	23	32	19	8	260	3.10	62
Site conditions significantly different from contract documents	3	24	31	15	11	259	3.08	63
Poor schedule of materials procurement	5	18	34	21	6	257	3.06	64
Wrong handling of materials	5	20	36	13	10	255	3.04	65
Inappropriate storage	4	13	52	7	8	254	3.02	66
Inappropriate equipment	3	22	37	14	8	254	3.02	66
Insufficient instructions about handling	3	24	32	19	6	253	3.01	68
Change orders	2	21	43	10	8	253	3.01	68
Contractor's non-involvement	3	25	33	15	8	252	3.00	70
Labour unrest	8	25	20	22	9	251	2.99	71
Insufficient instructions about storage and stacking	3	16	52	7	6	249	2.96	72
Restiveness	9	14	44	9	8	245	2.92	73
Difficulties in obtaining work permits	5	32	23	14	10	244	2.90	74

N = 84

Comparison between Consultants and Contractors Perception of Causative Factors of Waste Generation on Building Sites

The perceptions of consultants and contractors about the first three factors are the same, hence their level of importance. These are rework contrary to drawings and specifications, design changes and revisions and wastes from uneconomical shapes.

In order to establish further if there is significant difference in their overall perception, the hypothesis which states that there is no significant difference between the perception of consultants and contractors about the factors

contributing to waste generation on building sites in Rivers State was postulated. The hypothesis was tested using Mann –Whitney U test with $p \leq 0.05$ (5% significant level). The rule for the rejection of the hypothesis is that when the p-value is > 0.05, the test fails to reject the hypothesis but when the p-value is ≤ 0.05, the test rejects the hypothesis. The result of the test of hypothesis is presented in Table 3.

The result of the Mann Whitney U test presented in Table 3 shows that the p-value is 0.880. This value is greater than 0.05 significant level set for the test. This implies that there is no significant difference in the overall perception of consultants and contractors about the factors contributing to waste generation on building sites in Rivers State, Nigeria. The similarity in the perceptions of the consultants and contractors is a clear indication of their awareness and knowledge of the effects of construction waste on project performance. Therefore identifying the causative factors, evaluation of these factors and determining their level of importance and their contribution to waste generation on building sites will have the potential to enhance the construction projects performance with cost-saving benefits. This will reduce the problem of construction cost overrun in Nigeria.

Table 3 Mann-Whitney U test Result for Comparing Consultants' and Contractors' Perceptions

Rank group	N	Mean Rank	Sum of Ranks
Consultants	74	73.97	5473.50
Contractors	74	75.03	5552.50
Total	148		
Consultants'/Contractors' Perception			
Mann-Whitney U	58.500		
Wilcoxon W	124.500		
Z	–.152		
Asymp. Sig. (2-tailed)	.880		

This study considered the choice of consultants and contractors as key stakeholders in construction suitable enough to identify the problems of waste generation. The consultants are involved in the planning, control and management of cost from the preconstruction stage to the completion of the projects while the contractors are directly involved in on-site management of resources, wastes and the application of waste minimisation strategies/techniques. Additionally, the factors used for the study emanated from the direct input of these two groups in construction process. Hence, their agreement on the ratings of the listed factors shows the reliability of the results. The same phenomenon holds in this research and similar studies where rework contrary to specifications appears to be a crucial factor leading to material waste generation. For example, the factor was ranked among the first three in Al-Hajj and Hamani (2011), Muhwezi *et al*. (2012), Galvilan and Bernold (1994) and Ekanayake and Ofori (2000). The result of this research is of benefit to all players in construction in their cost, waste management and control techniques.

Conclusion and Recommendation

This research was aimed at evaluating the factors affecting construction material waste generation on building sites in Rivers State, Nigeria. From the results of analysis, it was concluded that the three most important factors contributing to construction material waste generation on building sites in Rivers State are "rework contrary to drawings and specification", "design changes and revisions" and "waste from uneconomical shapes" respectively. It was also concluded that all the factors in this study were considered important in waste generation on site

by consultants and contractors. The result shows that there is proper utilisation of construction equipment on building sites in Rivers State. It was further revealed that there is little bottleneck in obtaining work permit by contractors in Rivers State and the perception of the consultants and contractors about the causative factors of waste generation on building sites in Rivers State is not significantly different. For effective optimisation of building projects performance in Rivers State, this research work recommends that stakeholders in construction industry should consider all the studied factors at every level of their construction processes and waste management plans.

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