MINIMIZATION OF WASTAGE OF MATERIAL ON CONSTRUCTION SITES IN NIGERIA

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Abstract

This study, aimed at identifying factors responsible for material wastage on construction sites and finding possible ways of reducing or minimizing material wastage on sites. The research was restricted to residential, commercial and institutional building sites. It was conducted through the use of literature review of relevant and available text books and journals, discussion was held with site personnel and data collected from various sites were analyzed using suitable statistical techniques such as ranking method, simple percentages and chi-square.The research revealed that material wastage is not totally avoidable on site. Material wastage results from human error rather than being inherent in the process or methods. Sandcrete blocks are more prone to wastage due to their susceptibility to breakage during handling and transit as workers do not carefully stack blocks properly on site or sometimes stack them too high. Poor Supervision with the mean rank value of 0.8 was also ranked as high factor that causes material wastage on construction sites. Competent staff (supervisors) should be employed to supervise construction projects to enforce strict rules that will enhance minimization of material wastage.

KEYWORDS: Waste, Materials, Site Construction, Minimization

1.0 INTRODUCTION

Generally, it is recognized that not all the materials delivered to construction sites are used for the purpose for which they were ordered and builders frequently use more materials than they receive payment for, either that the materials are lost or used on the site in such a way that estimators cannot account for. Minimization of material wastage on construction site is a lesson which many construction industries are yet to learn. But with the rapidly rising cost of building materials those industries that have not learnt and adopted material control measures will soon close down (Akinkurolere and Franklin, 2005).

Materials constitute large portions of the total building project; this makes the control of these resources very imperative. Ibironke et. al (2013) identified that material wastage can be in many forms, from carelessness in handling a single block on site to even erecting building in a wrong place. This loss of precious resources is readily affected by all because, we believed that material wastage is a natural phenomenon and consequence of the building process, that is why allowance is made during the preparation of estimate of a propose contract to offset waste.

Depending on the site conditions, nature of work and condition of contracts, some factors are found to be responsible for the wastage of materials on site. These include lack of appreciation of material value, attitude of operatives towards waste, poor design, storage condition and site security. The overall effect these have on construction industries are of various magnitude ranging from competition during tendering (when tender is too high due to over estimation of allowance for waste), delay in execution of contract to accident on site. This cost as a result of waste will amount to staggering sum of money periodically, therefore, the construction industries can no longer afford to lose colossal amount of money and resources to wastage on building site in this present time of global and national economic recession when unnecessary should be completely discouraged due expensiveness of building materials

Material wastage on construction site is a problem which has over the years heightened the cost of building work. Many people have erroneously developed the attitude of accepting it as part of the building processes, without knowing that most of the factors causing the unnecessary loss of money due to materials wastage. This study is aimed at identifying material prone to wastefulness and identifying factors responsible for such

2.0 LITERATURE

The problem of material wastage on construction site dated back to the inception of building construction. It is difficult to establish a standard and acceptable method of arriving at a percentage waste for the individual building material.

Johnson (1981) asserted that sometimes, poor design contributes largely to material wastage due to dimension or specification inadequacies; he also observed that wastage could occur from shortage in materials delivered to site. Poor accounting procedures encouraged such practices to go on undetected, so that it becomes difficult to pin point the course of such losses, careless handling, poor workmanship and poor storage system all result in wastage.

Materials as resources employed by the construction industries undergo a number of processes before they are finally incorporated in the construction work. These processes bring about inadequacies of the materials such that at the end not all the materials procured and delivered to sites are used for the purpose for which they are ordered (Akinkurolere and Franklin, 2005).

The extent of material wastage varies between sites and it depends on some factors such as the attitude and skills of operatives and labourers, the efficiency of supervisors and foremen, managerial expertise of site or project manager. For instance, a firm that allows concrete for a housing contract to be mixed in front of each house of a propose estate will incur a greater proportion of material wastage than one which has controlled concrete mixing plant. The cumulative wastage in front of each of the building in the first case will be far more than that in a single mixing plant of the second case (Johnson 1981).

Odeh (1992) construction processes are complex, difficult to plan and control because, they are affected by numerous uncertainties. Construction companies benefit more by minimizing waste generation in a number of ways: reducing transportation cost, land fill deposition cost and the purchasing cost of virgin materials. Waste production at a construction site may results from lack of attention being paid to the size of the product used, lack of interest of contractor and lack of knowledge about construction during activities. About 1 – 10% by weight of the purchased construction materials depending on the type of materials that leaves the site as waste. Generally, 50 – 80% of the construction waste is reusable or recyclable (Bossink and Brouwers, 1996).

In terms of sustainability, the topic of management and minimization of construction waste can be considered an issue that focuses on the danger of depletion of material used in the construction industry, such as timber, sand and gravel. It equally deals with the danger of environment contamination because it is still a common practice to transport construction wastage to landfills.

3.0 MATERIALS AND METHODS

In the process of carrying out this research work, primary and secondary data were both sourced and they formed the basis for data analysis. Structured questionnaires were used to find out the critical variables relating to the objectives of the research. The questionnaire comprises basically of questions related to the subject nature of enquiry. Also the following hypotheses were made for the validation of this research.

1. Ho: Material wastage totally avoidable on site?
   Ha: Material wastage is not totally avoidable on site.

2. Ho: Material wastage result from human error rather than being inherent in the process or method

   Ha: Material wastage does not result from human error rather than being inherent in the process or method.

The data collected were presented and analyzed using suitable statistical techniques. These are ranking method, simple percentage and chi-square. The result have been presented graphically using bar chart in Fig.1 and Fig.2

DATA PRESENTATION AND ANALYSIS

Information gathered from interviews conducted and questionnaires administered to respondents were converted to data expressed in percentages as presented in Table-1. The data were tabulated according to the response of the question answered with the use of yes or no options as required by variables.

Table 1: Questionnaires Administered according to categories of respondents.

Members of Building team	Questionnaires served	Questionnaire received	Percentage received
Builder	8	6	20.00
Quantity Surveyor	5	4	13.33
Architect	6	5	16.67
Site Supervisors	5	5	16.67
Foremen	6	4	13.33
Store keeper	5	6	20.00
Total	**35**	**30**	**100**

Source: field survey 2017

Table 1 above, comprises the respondents' backgrounds in the Questionnaires Administered according to categories of their professions. The respondents' backgrounds represent 20% Builders, 13%Quantity Surveyors, 17% Architects, 17%Site Supervisors, 13% Foremen and 20% Store keeper.

Similarly, Table 2 below shows that 12 respondents were of the view that sandcrete blocks have the highest level of wastage; ceiling boards with 6 respondents is next to it, while 2, 4, and 3 respondents were for tiles, timber and cement respectively.

Table 2: Wastage levels of materials

Options	Response	Percentage %
Timber	3	10.00
Reinforcement bar	2	6.67
Ceiling boards	6	20.00
Tiles	4	13.33
Cement	3	10.00
Sandcrete block	12	40.00
Total	**30**	**100**

Source: Field Survey 2017

Table 3 shows that 9 respondents were of the view that material wastage increasingly occur during loading and unloading, while 18 respondents were of the view that material wastage occur during placement. The remaining 3 respondents were of the view that material wastage increasingly occur after the completion of the construction work but before handing over.

Table 3: Material wastage level at various stages of construction on site.

Options	Response	Percentage
During loading and unloading	9	30
During placement	18	60
After erection but before handing over	3	10
Total	**30**	**100**

Source: field survey 2017

4.2 DATA ANALYSIS USING RANKING METHOD

This method was used to show factors that have the highest contribution to material wastage on site.

The following formula were used to achieve the percentage ranking of the factors

$$S = n \times W$$

Where S = the rank sum, n = the number of respondent (Samples) in the rank category.

W = the corresponding weight or scores of the rank category

The relative index (RI) is a ranking index that reduces scores attracted to the importance of items in an opinion survey to a common base. It is calculated as

$$RI = \frac{S}{X(n)}$$

Where X = number of ranks. The RI ranges from 0 to 1. The item with the highest RI is ranked first and the next to it follows. The percentage ranking is given by RI x 100

3.4.2 SIMPLE PERCENTAGE

The simple percentage was used to compare the level of achievement of the objective in the types of material prone to waste on construction sites. This is calculated using the formula

$$\frac{X}{N} \times 100$$

Where X = number of observation in each question

N = number of observation in all question

Table 4: Factors contributing to material wastage on construction sites.

Factors	**Respondents**			**Rank sum (S)**	**Relative index (RI)**	**Ranking order**	**% of ranking**
	1	**2**	**3**				
Poor supervision	4	10	16	72	0.80	1st	80
Vandalism	14	6	10	56	0.62	6th	62
Attitude of workers	6	13	11	65	0.72	2nd	72
Theft	13	10	7	54	0.60	7th	60
Inefficient designer	12	8	10	58	0.64	4th	64
Poor workmanship	12	8	10	58	0.64	4th	64
Inexperience workers	8	10	12	64	0.71	3rd	71

Source: field survey 2017

The study showed that *Poor Supervision* was ranked the highest factor causing construction waste as it has a Mean Rank Value of 0.8 representing 80%. This corroborates with similar study by Harris et al (2001); they suggested that some methods to be applied in material minimization includes employment of reliable store keepers that possessed clerical experience and well trained stores controls. Also, Jayawardane (1998) found that considerable amount of construction waste is mostly due to improper management and poor supervision on sites.

Attitude of worker with a mean ranking score of 0.72 representing 72% was ranked second. It is a significant contributor to waste generation as workers sometimes show nonchalant attitude characterised by misuse of material when there is improper supervision.

Inexperience with a mean value of 0.71 representing 71% is ranked third. Lack of experience will cause construction waste. Incompetence at the design stage can result to mistakes or change order which implies waste of material. Inexperienced foremen contribute to defective works or poor workmanship. Wan et. al, (2009) agrees with the same submission.

The study further shows that some of the installed facilities made on construction sites can be vandalised when there is inefficiency in the security measure provided and Inefficient work or poor workmanship hence both factors are coincidentally ranked fourth as they have mean rank score of 0.64 representing 64% simultaneously.

Vandalism with a mean value of 0.62 representing 62% was ranked sixth while theft during construction with the Mean Rank of 0.6 representing 60% is placed as the seventh factor causing construction waste.

Table 5 shows ranking of levels of waste of various materials.It indicates that the RII for sandcrete block was 0.82, representing 82 percent which implies "very high" The analysis shows that sandcrete blocks are more prone to wastage due to their susceptibility to breakage during handling on construction sites. Ceiling boards (with RII equal to 0.72) fall within the "high" level of relevance range, indicates that Ceiling boards are prone to wastage which may be due to lack of proper handling by inexperience workers. Cement with a mean value of 0.71 representing 71% is ranked third as cement is liable to form lumps due to presetting action. Of these Ranking of levels of waste of various materials, tiles with (RII = 0.63) ranked fourth. It is followed by timber with a mean value of 0.61 representing 61% was ranked fifth while reinforcement bars with the Mean Rank of 0.6 representing 60% is placed sixth and are prone to waste due to cutting waste.

Table 5: Ranking of levels of waste of various materials

Options	**Respondents**			**Rank sum (S)**	**Relative index (RI)**	**Ranking order**	**% of ranking**
	1	**2**	**3**				
Timber	14	7	9	55	0.61	5th	61
Reinforcement bars	15	6	9	54	0.60	6th	60
Ceiling board	8	9	13	65	0.72	2nd	72
Tiles	13	7	10	57	0.63	4th	63
Cements	6	14	10	64	0.71	3rd	71
Sancrete block	3	10	17	74	0.82	1st	82

Source: field survey 2017

Table 6: Effectiveness of methods for minimization of material wastage on site

Options	Respondents			Rank sum (S)	Relative index (RI)	Ranking order	% of ranking
	1	2	3				
Tight security arrangement	12	7	11	59	0.66	3rd	66
Material schedule	13	7	10	57	0.63	5th	63
Proper storage facilities	6	12	12	66	0.72	2nd	73
Adequate supervision	3	12	15	72	0.80	1st	80
Effective store control	12	8	10	58	0.64	4th	64

Source: field survey 2017

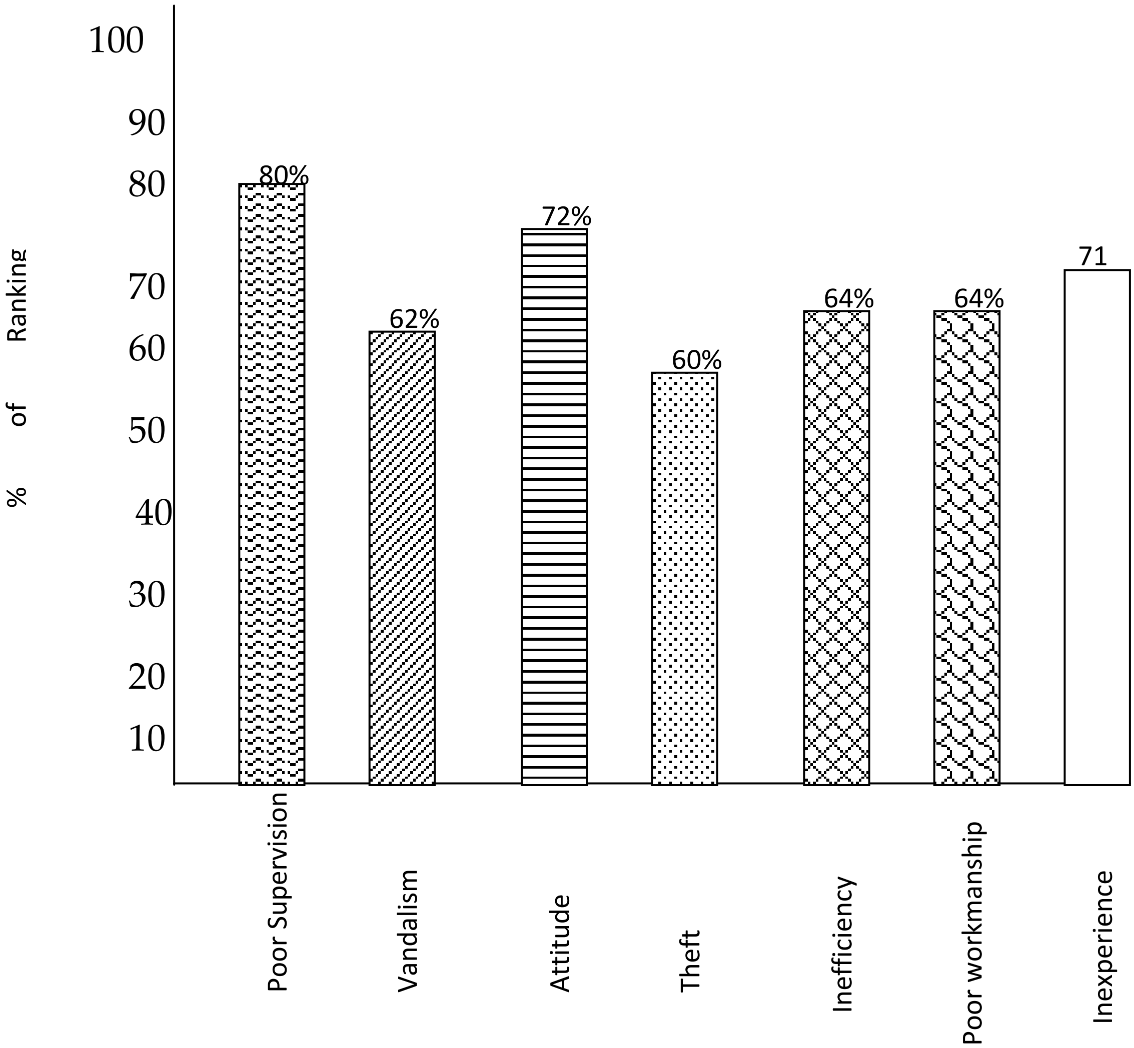

Figure 1: The factors contributing to material wastage on construction sites.

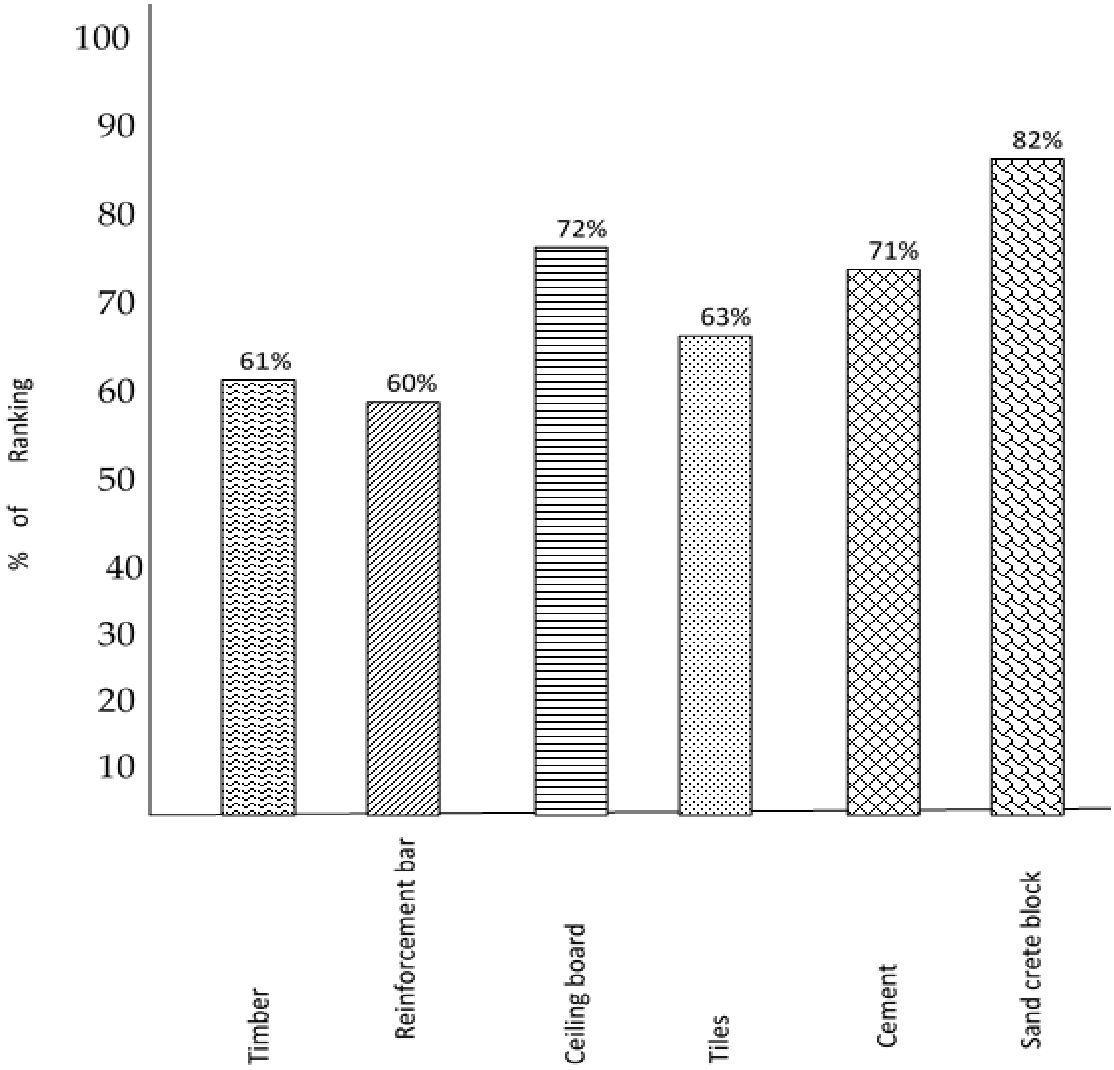

Figure 2: The Ranking of levels of wastage of various materials

4.3.1 TEST OF HYPOTHESIS

The two hypotheses stated were tested using Chi-square (X^2).

$$x^2 = \sum \frac{(F_o - F_E)^2}{F_E}$$

Where F_o = Observed frequency
F_E = Expected frequency
Determination of degree of freedom is found by formula
(R – 1) (K - 1)
Where R = Number of rows
K = Number of columns
The level of significance is denoted by α = 0.05

4.3.3 Hypothesis I

Table 7: Is materials wastage totally avoidable?

Opinion	Sites within Abuja	Sites within Idah	Total
Yes	8	3	11
No	6	13	19
Total	14	16	30

Source: field survey 2017

There are two rows, two columns therefore the degree of freedom is:

(R – 1) (K – 1)

(2 – 1) (2 – 1)

(1) (1) = 1

The level of significance if freedom is given by 3:841. Computation of Expected frequencies (FE)

For yes row

$\frac{11 \times 14}{30} = 5.1$

$\frac{11 \times 16}{30} = 5.9$

For No Row

$\frac{19 \times 14}{30} = 8.9$

$\frac{19 \times 16}{30} = 10.1$

Table 9: Contingency table

Opinion	Sites within Lokoja	Sites within Idah	Total
Yes	8 (5.1)	3 (5.9)	11
No	6 (8.9)	13 (10.1)	19
Total	**14**	**16**	**30**

F_O	F_E	$F_O - F_E$	$(F_O - F_E)^2$	$\frac{(F_O - F_E)^2}{F_E}$
8	5.1	2.9	8.41	1.6
3	5.9	- 2.9	8.41	1.4
6	8.9	- 2.9	8.41	0.9
13	10.1	2.9	8.41	0.8
				4.7

Source: field survey 2017

Therefore,

$$x^2 = \sum \frac{(F_o - F_E)^2}{F_E}$$

Result

- Chi square value X^2 calculated = 4.7
- From Critica value from the table, X^2 tabulated at 1 degrees of freedom and a significance level α = 0.05 = 3.841
- **Decision**: Since Chi square value (X^2) calculated > Critical value X^2 tab, HO is rejected
- **This means that material wastage is not totally avoidable on site**

4.3.4 Hypothesis II

Table 9: Does material wastage result from human error rather than being inherent in the process or method?

Opinion	**Sites within Lokoja**	**Sites within Idah**	**Total**
Yes	5	4	9
No	9	12	21
Total	**14**	**16**	**30**

Source: field survey 2017

Computation of expected frequency (FE) for:

Yes Row

$$\frac{9 \times 14}{30} = 4.2$$

$$\frac{9 \times 16}{30} = 4.8$$

No Row

$$\frac{21 \times 14}{30} = 9.8$$

$$\frac{21 \times 16}{30} = 11.2$$

Table 10: Contingency table

Opinion	**Sites within Abuja**	**Sites within Idah**	**Total**
Yes	5 (4.2)	4 (4.8)	9
No	9 (9.8)	12 (11.2)	21
Total	**14**	**16**	**30**

F_O	F_E	$F_O - F_E$	$(F_O - F_E)^2$	$\frac{(F_O - F_E)^2}{F_E}$
5	4.2	0.8	0.64	0.15
4	4.8	- 0.8	0.64	0.13
9	9.8	- 0.8	0.64	0.07
12	11.2	0.8	0.64	0.06
				0.41

Source: field survey 2017

Therefore $x^2 = \sum \frac{(F_o - F_E)^2}{F_E}$ =0.41

Result

- Chi square(X2) calculated = 0.41
- From Chi square table, X2 tabulated at 1 degrees of freedom and a significance level $\alpha = 0.05$ = 3.841
- **Decision**: Since Chi square value (X^2) calculated 0.41 < Critical value X^2 tab, Ho is accepted
- ***This means that wastage results from human error rather than being inherent in the process or methods***

5.1 SUMMARY OF FINDINGS

In the course of this study, certain findings were made and necessary recommendations were also made as follows:

1. In hypothesis 1, based on the decision rule, the null hypothesis (Ho) was rejected and the alternative hypothesis (Ha) accepted. Thus, it was concluded that material wastage is not totally avoidable on construction site.

2. In hypothesis 2, the null hypothesis (Ho) was accepted and it was concluded that wastage results from human error rather than being inherent in process or methods.

3. After the analyses of the ranking of factors responsible for material wastage on construction site, the following factors were discovered to contribute to material wastage on construction site in the under listed order:

i. Poor Supervision = 80%
ii. Attitude of worker = 72%
iii. Inexperience = 71%
iv. Inefficiency = 64%
v. Vandalism = 62%
vi. Poor workmanship = 64%
vii. Theft = 60%

From the above ranking, it was established that the major cause of material wastage on construction sites is the attitude of workers to their various jobs. This arises from the facts that most workers do not appreciate the work they found themselves doing. It ultimately results in a nonchalant attitude to work and this affects the way they handle materials on construction sites.

Based on the observation made during the course of this study, the following can be attributed to the level of material wastage on construction sites. On most sites, there was poor supervision giving room to most workers to work as they please on site. Example; already mixed mortar was left without placing for more than two hours by workers who claimed that they went for break. Also, there was inadequate or lack of good storage facilities on some site. It was equally observed that there was lack of proper security arrangement, therefore cases of theft were reported which could have been perpetrated by site workers or other persons.

The following order was arrived at as the order in which materials investigated are prone to wastage on construction site:

- Sandcrete blocks = 82%
- Ceiling boards = 72%
- Cement = 71%
- Tiles = 63%
- Timber = 61%
- Reinforcement bar = 60%

The analysis shows that sandcrete blocks are more prone to wastage due to their susceptibility to breakage during handling and transit. Most workers do not carefully stack blocks properly on site or sometimes stack them too high. Ceiling boards are also prone to wastage due to lack of proper handling by inexperience workers, cement are liable to get in contact with wet surfaces and being wastage because of setting. Tiles when not carefully cut breaks easily while timbers are prone to defects such as warping, splitting, termite attack when not properly season, treated and well arranged. Whereas reinforcement bars are liable to cutting waste.

5.2 CONCLUSION

The study identified that material wastage is not totally avoidable on site. Material wastage results from human error rather than being inherent in the process or methods. Sandcrete blocks are more prone to wastage due to their susceptibility to breakage during handling and transit as workers do not carefully stack blocks properly on site or sometimes stack them too high. Poor Supervision was also ranked as high factor that causes material wastage on construction sites; it is therefore concluded that competent staff (Supervisors) should be employed to supervise construction projects to enforce strict rules that will enhance minimization of material wastage.

5.3 RECOMMENDATIONS

Based on the findings of this study, the following have been put forward as recommendations:

1. Monetary incentives should be introduced so that workers get motivated and thereby change their negative attitude to work.
2. There is need for workers to exercise more care when carrying out their work especially while working with breakable materials such as sandcrete blocks, tiles, ceiling boards etc.
3. Competent staff (Supervisors) should be employed and allocated to construction sites to enforce strict rules that will enhance minimization of material wastage.
4. Adequate security should be provided for construction materials on site.
5. There is need to ensure that materials delivered to sites are those specified and ordered for.
6. There should be awareness programmes for all construction companies on construction waste management. Formal education should be given to storekeepers and foremen on effective material handling system.
7. Finally, the use of computers for storing records on construction sites should be encouraged.

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