American Journal of Construction and Building Materials
2024, Vol. 8, No. 2, pp. 35-51
https://doi.org/10.11648/j.ajcbm.20240802.12

Research Article

Cause of Construction Materials Wastages on Construction Project a Case of Mettu Town

Gamachu Wakoya Fufa*, Kebede Chaka Fite, Geremu Assefa Tucho, Temesgen Daba Wakuma

Department of Construction Technology and Management, College of Engineering and Technology, Mattu University, Mettu, Ethiopia

Abstract

The rapid development of the construction industry has caused in the construction materials wastage that negatively affect the environment, budget and humanity. The aim of this study is to assess the cause of construction materials wastages on public construction project a case of Mettu town. The target population was selected randomly consultant and contractors of public construction project in Mettu town. The questionnaires were distributed to the respondents' a categories of questionnaires according to five groups on the cause of construction materials wastage of construction project. The main technique of data analysis was descriptive statistics comprising of percentage, mean value and relative importance index. The result of data analysis are shows on the tables and figures of the data collection. Kruskal-Wallis test and Mann-Whitney U-Test were used to test the hypotheses. The first three highest contributors to cause of construction material waste are found Group 3 operation, Group 1 design and documentation, and Group 5 site supervision in terms of groups with average relative importance index of 0.697, 0.686 and 0.680 respectively. The three rank cause of key construction materials, which are wasted on construction sites are Tile, Block (HCB), concrete, the relative importance index value are 0.683, 0.680, and 0.678 are wasted respectively. The statistical difference in the perceptions of the various group's contractor and consultant concerning the most cause of wastage construction material produced during construction project. To evaluate the difference across five groups of cause of construction materials wastage on the contractor and consultant was tested using kruskal-wallis test. The test is significant difference of contractor, consultant and average (Aysmp sig. 0.000, 0.431, 0.812 are respectively. In the preference of cause of construction materials wastage for five groups of respondents are (Group 1=12, Group 2 = 19, Group 3 = 14, Group 4 = 13, and Group 5 = 5). The waste of construction materials is a common occurrence in Mettu town. Therefore, it is the obligation of all parties involved in the construction sector to minimize the construction materials waste. This study suggested that in order to achieve efficient waste reduction in the construction business, contractors and consultants need to receive the necessary training and motivation. The study's conclusions may have applications in waste management, construction technology, and control for environmentally friendly public construction projects.

Keywords

Construction Project, Consultant, Contractor, Material Wastage

*Corresponding author: wakoyagamachu@gmail.com (Gamachu Wakoya Fufa)

Received: 2 May 2024; **Accepted:** 15 June 2024; **Published:** 26 September 2024

1. Introduction

1.1. Background

The construction industry is the backbone of every nation, as it is one of the forces driving the socio-economic growth and development of nations of the world [1]. Construction material is one of the major cost components in any construction project. Depending on the types of project cost of materials 50% to 70% of the total construction cost [2-4]. Construction waste is becoming a serious environmental problem in many large cities in the world [1, 5-9].

Construction materials waste by the proportion of total wastes generated by countries shows that in the USA, it is 20-29%; 27% in Canada; 20% in Japan; 50% in Brazil; and 32% in England [3, 10]. With these statistics, the construction sector is adjudged to be among the largest contributor to waste. In Nigeria, the situation is no different. It was reported that for every 100 houses built, the materials waste would be enough to build another 10 houses [11]. Resource management is one of the biggest challenges in the performance of the Ethiopian construction sector. Most sectors consume material resources more than the amount originally calculated. If the material waste is not properly handled and managed on the project site, this will lead to financial crises, and eventually negatively impact the community and the environment [3].

According to [1], any material apart from earth material which needs to be transported elsewhere to the construction sites or used within the construction site itself for the purpose of land filling, incineration, recycling, reusing, or composting rather than the intended specific purpose of the project due to material change excess non-use, or noncompliance with the specifications or being a by-product of the construction process is regarded as construction waste [7, 12]. Five major sources of building material wastes are concrete, reinforcement, formwork, brick and block, and tiles [13].

The construction sector produces huge waste leading to environmental contamination and CO2 emissions [1, 10]. Inappropriate material management causes waste and results in environmental damage and financial loss during the various construction stages. For environmental protection and sustainable development, recycling of plastic is a feasible alternative to manage plastic waste [12]. In the last decades, the use of plastic waste in civil constructions has been studied extensively. In the most cases, plastic wastes have been used in concrete or mortars either as fine or coarse aggregate [14]. For instance, claimed that it is one of the major causes of building stakeholder's business failure in developing countries. The total cost overrun due to construction waste is 30% of the cost of materials. Depending on the material type, 8.5 to 16.6% of the materials was recorded as wastage [3]. Construction material wastage: most practitioners in the construction industry typically relate waste with any rubbish removed from a site and disposed of in landfills. Perhaps the main reason for this narrow view is the fact that such waste is relatively easy to see and measure [15].

Construction material waste arises from design, logistics, and physical construction processes. According to [13], design, operational procurement, and material handling attributes contribute to waste on construction site. These indicate that the reduction of waste should not be the sole responsibility of the construction company, as the client and designer can make environment friendly choices in the program of demands and designs. Subdivided sources of construction waste into six categories: design, procurement, material handling, operations, residuals and others [7, 16-18]. Construction waste results during the lifecycle of buildings; starting from design, going through construction, modifications and ending with demolition [15]. A number of studies concluded that the design phase is one of the primary causes of construction waste.

It also contributes additional cost to the overall construction because new purchases are usually made to replace wasted materials. Cost of rework and disposal also cause financial losses to the contractors [19]. Similarly, in Ethiopia construction materials wastage is becoming a serious problem, especially on public building construction projects and no attention was given to such problem. It is also a problem in Mettu Town in the same manner due to different reasons like poor workmanship, poor site management and so on.

The study mainly focused on the parameters like forms, causes and factors to the construction waste and measures to control construction waste effectively. Therefore, this study aimed to determine the current situation with regard to managing and minimizing construction materials waste in Mettu town and assess the effectiveness of the waste control measures to minimize construction materials waste in future construction projects.

1.2. Statement Problem

Waste management is an essential aspect of cost control in both production and construction industries. There are alarming reports of abandoned building projects especially in the developing nations probably because of inadequate waste management practices in construction sites [20]. Together with the advantages of urbanization, vast infrastructure, and rebuilding, construction projects have led to an alarming rise in the production of construction and demolition trash in recent years. If construction waste (CW) is not properly managed, environmental authorities is to reduce, as far as possible, the disposal of postconsumer glass in landfill and diversion to economically viable glass product streams [21]. it has a substantial detrimental impact on the environment, resulting in severe air pollution with higher levels of particulate matter and aerosols, due to a lack of disposal sites and commodities such as aggregates [22].

In Ethiopia, around the construction project site; there are many wasted of construction materials. This shows that construction materials wastage management has not received attention from researchers and project managers. However,

construction materials are costs are increasing from day to day in addition to this waste is becoming a serious problem since it is a high-cost component and effects on the environment, especially on public building construction projects no attention had given to such a subject [2].

There are a lot of wasted construction materials near the project site in Ethiopia. This demonstrates that project managers and academics have not given construction material waste management much thought. Since waste is a high-cost component and has negative environmental effects, it is becoming a severe issue as construction costs for building materials rise daily. This is especially true for initiatives to build public construction project where environmental concerns have not been adequately addressed. Construction project waste is becoming a severe issue in construction materials wastage on Mettu area. The primary factor driving this investigation is how much construction material is wasted at the Mettu area construction site. Then, this study determines the current situation with regard to cause of construction material in Ethiopia especially in Mettu town. Measure which key construction material is more wasted and issues involved in the generation of waste in the construction industry in Mettu town. Therefore, this study gives some importance for the improvement of the performance of contractors and consultant regarding the material wastage management as well as for the construction industry.

1.3. Objectives

1.3.1. General Objectives

The main objectives of this study is to assess the cause of construction materials wastages on public construction project a Mettu town.

1.3.2. Specific Objectives

1) To identify the cause of construction materials wastage on the public construction projects in Mettu Town.
2) To assess measures of minimizing construction material wastage on public construction project.

1.4. Study Hypothesis

They are two hypotheses were suggested for the study as follow:

H1; There is no significant statistical difference in the perceptions of the various groups contractor and consultant concerning the most cause of wastage construction material produced during construction project.

H2; There is no significant differences among the various groups of cause wastage construction materials concerning the most wasteful material produced during construction projects.

2. Methodology

2.1. Data Collection

This studies was used descriptive research method. They are used to follow different approaches of data collection namely: - the primary data collection was collected using a questionnaires, interviews, observation and document study (desk Study). The Secondary data collection; - Reference books, Journals, Documented thesis, and Internet.

2.2. Target Population and Sample Technique

A questionnaire survey was used to produce the perceptions of consultants and contractors, for a period of two years, about the cause and remedial action the generation of construction material wastes on construction project site in the Mettu town. Questionnaires were sent to randomly select consultants and contractors. The selection of consultants and construction contracting firms for this study was based on probability sampling, using the stratified random sampling technique. Data collected form those regulatory bodies was done through questionnaires whereas interview was used to collect data from concerned public bodies. The study was covered a population of Mettu town Construction Bureau, the Small and Micro Construction Enterprises in Mettu Town and Contractors (GC10-GC1 and BC10-BC1) and their consultants (supervisors), Municipality of Mettu Town that are employed in Mettu Town on public Construction project purposively and it was contact the project manager, office engineer, site engineer, and general Forman as well as the supervisors.

Table 1. *Target population of study.*

Name of organization	No of organization
General or/and Building contractor level (1-10)	40
Consultant	18
Total	58

3. Data Presentation and Analysis

The collected data were presented in tables and figures by the relative importance index and mean value was used to analyze and rank the data collected on cause of key construction material waste, sources and cause construction material wastage, measures to minimize construction materials wastage. Rating scale is one of the most common formats for questioning respondents on their views or opinions of an event or attribute. In this regard, participants was asked to indicate the importance or level of agreement of factors (research variables) by rating them on a five point scale; 1 – Strongly Disagree/ least Important, 2 – Disagree/ Of Little Importance, 3 – Neutral/ Neither Important, 4 – Agree/ Important and 5 – Strongly Agree/ Most Important.

$$Relative\ Importance\ Index = \frac{Wi*fxi}{A*N} \quad (1)$$

Where; - Wi = weight given to ith response; i = 1, 2, 3, 4, 5
fxi = Responses frequency
N = Total No of responses
A = Highest weight (5 in this case)
RII = Relative importance index, 0< RII<1 [5, 3, 13].

3.1. Validity

The degree to which a test measures what it claims to measure is known as validity. Validity is defined as the accuracy and usefulness of inferences drawn from study findings. Mann-Whitney U-Test was used to test for differences between two independent groups, where the overall Kruskal-Wallis test is significant. According to [1, 13] who states that if the overall K-W test is significant; Mann-Whitney tests should be conducted to compare the groups (to investigate which groups significantly differ). The decision rules for acceptance or rejection of the hypothesis are;

If P-value ≥0.05, then accept the hypothesis, and

P-value <0.05, then reject the hypothesis. These analyses were done using statistical package for social science (SPSS) Version 20.

3.2. Reliability

In order to test the internal consistency of the scale used in the questionnaires and thereby check the degree for measuring the same construct or each item's homogeneity, the reliability analysis is conducted. The reliable scale means that the individual items produce consistent results within the overall questionnaire. Several techniques can be used to test the reliability of the used scale. One of the most commonly preferred measures of scale reliability is Cronbach's alpha (α). This method estimates the reliability of a given set by using only a single test administration [5]. In this study, the reliability analysis was performed via the statistical package SPSS®. The standardized Cronbach's alpha can be calculated using Equation 2.

$$\alpha = \frac{N}{N-1} x \frac{\left(\sigma^2 x - \sum_{i=1}^{N} (\sigma^2 yi)\right)}{\sigma^2 x} \quad (2)$$

Where N is the number of items on the test, σ^2_x is the variance of the observed item scores, and σ^2_{yi} is the sum of all i item variances. Cronbach's alpha value ranges between 0 and 1. If it is closer to 1, it signifies high reliability of the used scale. The relationship between the Cronbach's alpha value and internal consistency is presented in Table 2 [5].

Table 1. *The relationship between the Cronbach's alpha value and internal consistency.*

Cronbach's alpha value (α)	Internal consistency
α ≥ 0.9	Excellent
0.9 > α≥0.8	Good
0.8>α≥0.7	Acceptable
0.7>α≥0.6	Questionable
0.6>α≥0.5	Poor
0.5>α	Unacceptable

In order to test the internal consistency reliability of the generated scale used in the questionnaire, Cronbach's alpha values were calculated. Cronbach's alpha values calculated for each group that cause of construction materials waste are presented in Table 3.

Table 2. *Cronbach's alpha value source in group of cause construction materials wastage.*

Group No	Major Cause	Number of question	Cronbach's alpha value
1	Design and documentation	12	0.70
2	Materials (procurement, onsite, handling, storage and transportation)	19	0.81
3	Operation	14	0.87
4	Site management and practices	13	0.81
5	Site supervisor	5	0.85

As show in table 3 the major cause of construction materials wastage of consistency used questionnaires are reliability of design and documentation, Materials (procurement, onsite, handling, storage and transportation), Operation, Site management and practices and Site supervisor of Cronbach's alpha value are 0.70, 0.81, 0.87, 0.81, and 0.85 respectively. Then a Cronbach's alpha value greater than 0.70 shows that the scale is consistent in explanatory studies, it can be con-

cluded that all reliability coefficients are acceptable (0.8>α>0.7).

Table 4. Cronbach's alpha value of key construction materials.

Major key construction materials	Number of questions	Cronbach's alpha value
Concrete	11	0.83
Steel reinforcement	11	0.85
Cement	11	0.82
Aggregate	11	0.79
Sand	11	0.91
Block	11	0.82
Tiles	11	0.84
Timber formwork	11	0.84

As table 4 shows key construction materials are more wasted in the reliability of concrete, steel reinforcement, cement, aggregate, sand, block, tiles and timber formwork of Cronbach's alpha value are 0.83, 0.85, 0.82, 0.79, 0.91, 0.82, 0.84, and 0.84 respectively. Thus a Cronbach's alpha value are greater than 0.70 shows that the scale is consistent in explanatory studies. Its summarize that some reliability coefficients of sand are excellent ($\alpha \geq 0.9$) concrete, steel reinforcement, cement, block, tiles and timber formwork are good ($0.9 > \alpha \geq 0.8$), aggregate are acceptable ($0.8 > \alpha > 0.7$). According to [1] reliability coefficient of 0.70 and above is good and acceptable. Supporting these views, state that Cronbach's alpha value of 0.80 or more is significant and reliable. Furthermore, opined that the alpha value is expected to be greater than 0.7, and that higher alpha value means greater reliability of data. Data for this study is therefore, reliable and consistence.

4. Result and Discussion

The data collected from the questionnaire survey were analyzed according to their ranking on RII facilitated by IBM SPSS and Microsoft of Excel package. The result presented using tables and descriptive breakdown of the questionnaires distributed and the response rate with the equivalent percentages. A total of 58 questionnaires were distributed to respondents as follows: among the 18 questionnaires distributed to the respondents of consultants, 12 questionaries' were returned and from the 40 questionnaires distributed to the respondents of contractors, 25 questionnaires were returned. A total of 37 questionnaires were received with a response rate of 63.7%% as follows: 12 (66.6%) from consultants and 25 (62.5%) from contractors as respondents as shown in Table 5. The selected factors are ranked and discussed on the basis of their respective group as follows:

Table 3. Rate of the response of the distributed questionnaire.

Target group	Distributed questionnaires	Returned questionnaire	Rate of response
Contractors	40	25	62.5%
Consultant	18	12	66.6%
Total	58	37	63.7%

Among the above 37 questionnaires successfully returned, from 25 respondent of contractor to response 2 (8%) of the respondents had 0-5 years of work experience, 16 (64%) of the respondents had 5-10 years of work experience, 4 (16%) of the participants had 11-15 years of experience, and 3 (12%) of the participants had 16-20 years of experience in the construction industry.

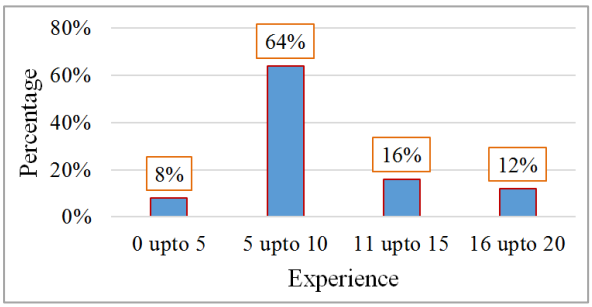


Figure 1. The graphical representation of contractors' response experience in the percentage.

Their positions were 4 (16%) of them was project manager, 3 (12%) of them were construction engineers, 11 (44%) of them were site engineers, 2 (8%) of them were foremen, 5 (20%) of them were office engineers. The respondents had also different positions in the construction company. Among the 12 questionnaires of consultant to response 3 (23.07%) of the respondents had 0-5 years of work experience, 6 (50%) of the respondents had 5-10 years of work experience, 1 (8.3%) of the participants had 11-15 years of experience, and 2 (16.6%) of the participants had 16-20 years of experience in the construction industry.

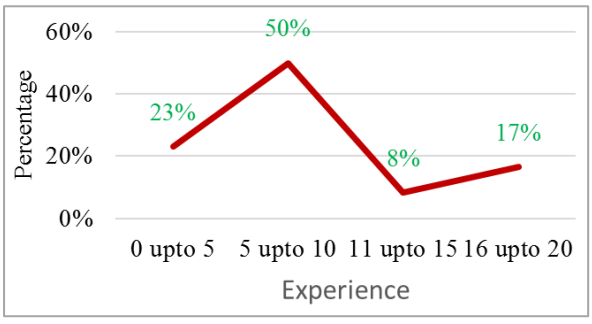


Figure 2. The graphical representation of consultant response experience by the percentage.

Therefore, the respondents of this study were experienced less than 20 years in the construction industry. Respondents were asked to score different factors of major issues which cause construction material wastage. The causes of construction materials wastage in construction projects were classified into five groups and key construction materials in the project, which are design and documentation, materials (procurement, onsite, handling, storage and transportation), operation (onsite, equipment), site management and practices, and site supervisor.

4.1. Cause of Construction Materials Wastage

4.1.1. Group 1 Design and Documentation

Respondents were asked to score factors considered to be causes of construction materials wastage arising from design and documentation. The evaluation of the various causes was based on their relative importance indexed. Comparison of the relative importance index of all the causes of material waste arising from design and documentation showed the differences between the responses of the contractors and the consultants. Responses of both groups of respondents were then shared together and presented in Table 6.

Table 4. *The design and documentation cause of wastage.*

Questions	Consultant		Contractor		Average	
Group 1. Design and documentation	**RII**	**RANK**	**RII**	**RANK**	**RII**	**RANK**
Design changes and revisions	0.617	5	0.736	9	0.676	6
Poor communication leading to mistakes and errors	0.550	8	0.776	4	0.663	8
Designer's inexperience in method and sequence of construction	0.550	8	0.736	9	0.643	11
Lack of attention paid to standard sizes available on the market	0.683	3	0.76	5	0.722	3
Poor/ wrong specifications	0.583	7	0.792	3	0.688	5
Lack of information in the drawings	0.550	8	0.76	5	0.655	9
Ambiguities, mistakes, and changes in specifications	0.700	2	0.76	5	0.730	2
Ambiguities, mistakes, and inconsistencies in drawings	0.550	8	0.752	8	0.651	10
Selecting the lowest bidder contractors and subcontractor	0.633	4	0.712	12	0.673	7
Rework that don't comply with drawings and specifications	0.550	8	0.736	9	0.643	11
Lack of knowledge about construction techniques during design activities	0.733	1	0.816	1	0.775	1
Selection of low quality products	0.617	5	0.8	2	0.708	4

Table 6 shows that relative importance index of all the 12 causes of design and documentation of construction materials wastage evaluated. The results table 6 show that the analysis average of different two parts which means contractor and consultants. They are ranked depending on the respondents by using the relative importance index analysis so, first rank are Lack of knowledge about construction techniques during design activities relative importance index are 0.775 was found to be very important technique to reduce construction materials wastages. Since this technique during the design and documentation phase helps to adjust the design to need for the techniques to follow the size of one thing match to design and with including the manufacturing. For example if the length of reinforcement are 12m, when used this reinforcement in the column structure, the designer should be consider the length of reinforcement and the construction techniques to follow for each activities. The design shows the use of a diameter of 20 reinforcement bar with length 4.4m but the length of one bar was 12 m and one (Beraga) of steel was used at two places the left 3.2m (26.7%) was wastage and there is wastage of reinforcement like these case [2]. Second rank to show in the above table 6 is ambiguities, mistakes, and changes in specifications have been ranked as the second major cause of construction materials wastage of relative importance index are (0.730), so due to lack knowledge employers on the activities there are different construction materials are wasted. According to the respondent the third rank are the Lack of attention paid to standard sizes available on the market (0.722) the size of construction materials are used asper as the detail drawing and specification can be paid, but if not they should be wasted in site due to the standard size. The fourth rank of RII value of Selection of low quality products have been ranked as the

(0.708), because contractors are profit makers and they want to minimize their expenses by using products with low quality and these products can be damaged before their application in the project. The fifth major cause of design and documentation are wrong specifications the RII value are (0.688). Specification is the coordination of different construction parties in the project. It is must be fulfil information about detail design, then to write clear specification about the project and readable for all employers. Unless they are wasted construction materials due to poor specification. They are seen five cause of construction materials wastage on the design and documentation. This support different research to agree on it [23, 24].

4.1.2. Group 2 Materials

Comparison of the relative importance index of all the nineteen factors evaluated as possible causes of construction material waste arising from materials (procurement, onsite, handling, storage and transportation) showed differences between the responses of the contractor and consultant. relative importance index score of each causes of materials which attributes of construction materials wastage are presented in table 7 and The top 5 cause construction materials waste generation are ranked as per as to their cause of construction materials as purchased materials that don't comply with specification, damage materials on site, over ordering or under ordering due to mistake in quantity surveys, poorly schedule to procurement the materials, inadequate stacking and insufficient storage on site had the five relative importance index of ranked are 0.771, 0.760, 0.721, 0.713 and 0.697 respectively.

Table 5. *The relative importance index cause of materials analysis.*

	Consultant		Contractor		Average	
Group 2 Materials (procurement, onsite, handling, storage and transportation)	**RII**	**RANK**	**RII**	**RANK**	**RII**	**RANK**
Poorly schedule to procurement the materials	0.650	4	0.776	1	0.713	4
Purchased materials that don't comply with specification	0.767	2	0.776	1	0.771	1
Over ordering or under ordering due to mistake in quantity surveys	0.667	3	0.776	1	0.721	3
Conversion waste from cutting uneconomical shapes	0.583	11	0.76	4	0.672	9
Damage materials on site	0.783	1	0.736	11	0.760	2
Overproduction/Production of a quantity greater than required or earlier than necessary	0.550	17	0.736	11	0.643	18
Poor quality of materials	0.600	9	0.744	8	0.672	8
Lack of onsite materials control	0.567	16	0.76	4	0.663	11
Poor storage of materials	0.617	7	0.704	18	0.660	12
Using excessive quantities of materials more than the required	0.583	11	0.736	11	0.660	14
Wrong handling of materials	0.550	17	0.744	8	0.647	16
Unnecessary material handling	0.600	9	0.72	16	0.660	13
Insufficient instructions about handling	0.583	11	0.704	18	0.644	17
Wrong storage of materials	0.583	11	0.736	11	0.660	14
Inadequate stacking and insufficient storage on site	0.650	4	0.744	8	0.697	5
Insufficient instructions about storage and stacking	0.650	4	0.712	17	0.681	7
Inappropriate storage leading to damage or deterioration	0.617	7	0.752	7	0.684	6
Damage during transportation	0.517	19	0.736	11	0.626	19
Lack storage of materials near of construction site	0.583	11	0.76	4	0.672	9

The first major cause of materials are purchased materials that don't comply with specification the relative importance index are 0.771. Most of contractors when purchased construction materials for the project can’t consider the specifi-

cation because, contractors are consider only his own interest within/out specification. Therefore if the contractor are consider the specification it has reduce profit and reduce the wastage of construction materials. The consultants are approve the materials depending on the specification to write, unless if consultant are can't approve the purchased materials the contractor can't use for the construction purpose [23, 3]. The second major cause of materials are damage materials on site the relative importance index are 0.760. Due to different issues there are damaged different construction materials on site. In this case low quality of materials are damaged on the site when handling, transporting, storing and etc. to minimize the wastage on the site to improve the quality of construction materials, It's the responsibility of all parties. During the standard size of materials as per as the design of the project was prepared [5, 23]. The third major cause of construction materials wastage on the terms materials are over ordering or under ordering due to mistake in quantity surveys the relative importance index are 0.721. Due lack knowledge the employers are ordering the materials below or above on the quantity survey estimated. This is also wastage are happen in the project. As much as possible any construction parties are participate professional employers or cost engineer are estimate and read the quantity survey to solve this problem. The fourth major cause of construction materials wastage are poorly schedule to procurement the materials the relative importance index are 0.713. during the procurement process the contractor was plan the ordering of materials before the project was started, some construction materials are expired if the not schedule according the activities to need the materials. The fifth major cause of materials waste are inadequate stacking and insufficient storage on site the relative importance index are 0.697. Especially in Ethiopia there are different lack of storage, stocking and not keep properly with construction materials on the site. In this study to advise such like company are not keep properly the construction on the site. Depending on the construction materials to stoke from the site. Thus due to insufficient store and stacking of construction materials there are poor management system, time period, during transportation and etc. are happen in the construction site, as much as possible they was improve those thing to minimize the wastage of construction materials in terms of inadequate stacking and store different authors are agreed on it [13].

4.1.3. Group 3 Operation

The respondents were asked to rank the causes of construction materials wastage arising from operational activities on construction sites. Comparison of the relative importance index of all the causes of material waste arising from operational activities showed no significant differences between the responses of the contractors and the consultants. The Relative Importance Index each of the sub-factors of the onsite group, which causes of construction material waste is presented in table 8.

Table 6. *The relative importance index value of operation analysis.*

	Consultant		Contractor		Average	
Group 3 Operation	**RII**	**RANK**	**RII**	**RANK**	**RII**	**RANK**
Rework due to workers' mistakes	0.683	6	0.704	5	0.694	5
Damage to work done caused by subsequent trades	0.733	2	0.704	5	0.719	2
Use of incorrect material, thus requiring replacement	0.633	9	0.672	11	0.653	11
Poor workmanship	0.550	13	0.768	1	0.659	10
Lack of workers or tradesmen or subcontractors" skill	0.667	7	0.728	2	0.697	4
Choice of wrong construction method	0.650	8	0.704	5	0.677	8
Accidents due to negligence	0.733	2	0.688	8	0.711	3
Shortage of manpower (skilled, semiskilled, unskilled labor)	0.583	12	0.72	3	0.652	12
Using untrained labors	0.617	10	0.712	4	0.664	9
Lack of coordination among crews	0.550	13	0.688	8	0.619	14
Problems between the contractor and his subcontractors	0.733	2	0.64	14	0.687	7
Equipment frequently breakdown	0.600	11	0.672	11	0.636	13
Poor technology of equipment	0.717	5	0.664	13	0.690	6
Shortage of tools and equipments required	0.767	1	0.68	10	0.723	1

The first major cause of construction materials wastage on the operation factors are shortage of tools and equipments required the relative importance index are 0.723. Some contractors are used tools and equipment by modification. Example the loader are to use as transporting if there is not dump truck not available in the site, but loader buckets are $3m^3$ at once then at least 5 times are finish one dump truck. When hauling materials they are wasted in the store and when transporting also some materials are wasted. And also the same to that concrete are transporting from mixing plant to placing of activities by loader if not available to the site mobile truck. The mixing of concrete are used by hand mix and mechanical mix, thus mechanical mixer are reduced different construction materials wastage. The second major cause of construction materials wastage on the operation are damage to work done caused by subsequent trades the relative importance index are 0.719. Resulting from inadequate supervision, lack of responsibility, poor planning, materials or works already fixed and unprotected may be damaged by others often unavoidably if trades perform their activities out of sequence. The third major cause of construction materials wastage are accidents due to negligence with a relative importance index value of 0.711. During the execution of the work some employers are carelessness person in behavior. Workers mistake may result from different issues such as lack of knowledge and negligence of workers. The fourth major cause of operations wasted are lack of workers or tradesmen or subcontractors" skill with a relative importance index value of 0.697. Many subcontractors are does not control the waste materials, because doesn't purchased materials. Due to sign the agreement with the contractor only implementation of the work. So if the project manager and site engineer are strictly control the site area they should be minimize the wasted construction materials [23]. The fifth major cause of construction materials wasted in terms of operation are rework due to workers mistakes with a relative importance index value of 0.694. There are some mistake has happen during the execution of the work in terms of design error, alignment, lack knowledge, and etc.

4.1.4. Group 4 Site Management and Practices

The top five of site management and practice of construction materials wastage of relative importance index value are listed below Poor management and distribution of labours, materials and equipments, Poor provision of information to project participants, Ineffective planning and scheduling of the project by the contractor, Lack of team work, Poor coordination and communication between parties involved in the project are 0.783, 0.718, 0.709, 0.685, 0.668 and respectively. The relative importance index each of the sub-factors of the site management and practices which causes of construction material waste is presented in table 9.

Table 7. *The relative importance index of site management and practices.*

	Consultant		Contractor		Average	
Group 4. Site management and practices	**RII**	**RANK**	**RII**	**RANK**	**RII**	**RANK**
Lack of proper waste management plan and control	0.600	5	0.696	11	0.648	6
Poor project management	0.583	7	0.712	7	0.648	7
Lack of a quality management system aimed at waste minimization	0.517	11	0.744	4	0.630	10
Lack of strategy to waste minimization	0.533	10	0.704	8	0.619	11
Lack of team work	0.667	3	0.704	8	0.685	4
Poor site layout	0.600	5	0.688	12	0.644	8
Poor qualification of the contractors technical staff assigned to the project	0.567	9	0.704	8	0.635	9
Poor provision of information to project participants	0.717	2	0.72	6	0.718	2
Ineffective control of the project progress by the contractor	0.417	13	0.608	13	0.512	13
Shortage of technical professionals in the contractor "organization	0.500	12	0.728	5	0.614	12
Ineffective planning and scheduling of the project by the contractor	0.667	3	0.752	2	0.709	3
Poor coordination and communication between parties involved in the project	0.583	7	0.752	2	0.668	5
Poor management and distribution of labours, materials and equipments	0.750	1	0.816	1	0.783	1

The first major cause are wasted in terms of site management and practice are poor management and distribution of

labours, materials and equipment with a relative importance index value of 0.783. In different construction it can be happen such like case because of poor project manager leader. Its responsibility of project manager, if different site available in the one project it should equal share resource for all crews depending the progress of activities. Unless there are wasted some construction materials on the site due to lack leadership. The second rank of relative importance index value of poor provision of information to project participants are 0.718. The delivery of construction materials are necessary for the construction project. One employer are consider setting time concrete to delivery from mixing plant to placing area, environmental condition are collect information you need for your site before starting the project. The transportation materials to inform for the employers of the company, if you have information the delivery of materials you are prepare yourself for the next activities. The third major cause are ineffective planning and scheduling of the project by the contractor the relative importance index value of 0.709. The progress of activities of the project should be control by the planning and scheduling. The activities of project has plan within cost estimation, so the contractor are guide his schedule as per as the progress. If poor schedule the wastage of construction materials was happen on the project. The fourth major cause of materials are lack of team work with a relative importance index value of 0.685. In the construction industry team work is very crucial for success of the project. In the one crew there are different stakeholders or professional employers was participated to do activities of the project. Each and every employers it was handle his own responsibility and if necessary to support each other. If improve the team work in the project as much as possible to minimize the wastage of construction materials. The fifth major cause of construction materials are poor coordination and communication between parties involved in the project with a relative importance index value of 0.668. Construction parties are should be take his own responsibility and to communicate to each other. The relationship of those parties are disagreement was happen during the execution of the project some construction materials are wasted. According to [24] this is because the less the participants coordinate; the more misunderstanding has among the participants. This may result in performing irrelevant activities in the project and that's why it became the major cause of materials wastage in building construction.

4.1.5. Group 5 Site Supervisor

Top three of cause construction materials are wasted due to the site supervisor with a relative importance index value are listed below table 10 poor coordination and communication between the consultant engineer, contactor and client, change orders by owner, slow response from the consultant engineer to contractor inquiries are 0.7263, 0.726, and 0.680 and respectively are presented in the table 10.

Table 8. *The relative importance index analysis of site supervisor cause of wastage.*

	Consultant		Contractor		Average	
Group 5. Site supervisor	**RII**	**RANK**	**RII**	**RANK**	**RII**	**RANK**
Lack of supervision and delay of Inspections	0.583	3	0.736	4	0.659	4
Slow response from the consultant engineer to contractor inquiries	0.583	3	0.784	1	0.680	3
Poor qualification of consultant engineer's staff assigned to the project	0.450	5	0.760	2	0.605	5
Change orders by owner	0.700	2	0.752	3	0.726	2
Poor coordination and communication between the consultant engineer, contactor and client	0.717	1	0.736	4	0.7263	1

The first rank of site supervisor are poor coordination and communication between the consultant engineers, contactor and client the relative importance index value are 0.726. For each project it need supervisor in the side of contractor, consultant and client. But due to this respondents there are lack of coordination and communication of construction parties in the different project. During these case construction materials are wasted around the site because the supervisor are not guide and control the materials quality, design, progress of project and etc. The result suggests that contractors are of the opinion that with improvement on quality of supervision on site, and capable supervisors, the volume of material waste may be reduced. On the other hand, the consultants' perceptions seem to indicate that their roles and the qualities of their representatives on site are more significant to reduce material waste [25]. The second rank of construction material are wasted by change orders by owner with a relative importance index

value is 0.726. The owner was changed the work order due to lack of construction materials without the scheduling of contractor. So the materials are wasted, the contractors are to planning and scheduling the construction techniques and follow up the progress of activities of construction project. Slow response from the consultant engineer to contractor inquiries with a relative importance index value of 0.680 held the third position in cause construction material wastes. During the site supervision consultants are does not give response for the contractors, thus the wastage was happened in the project due the poor role of consultants.

4.2. Summary Causes of Construction Materials Waste on Construction Project

The questionnaire of this study considered 63 source of cause construction material are wasted in construction project and those are distributed into five groups as mentioned before, namely, Design and documentation, Materials (procurement, onsite, handling, storage and transportation), Operation, Site management and practices and Site supervision. In this table 11 gives the result of a collected data in the second section of the questionnaire, namely, causes of construction materials waste and shows the relative importance index value and ranking of each group.

Table 9. *The ranking over all causes of materials waste within group analysis.*

Group No	Major Cause	RII	Rank
1	Design and documentation	0.686	2
2	Materials (procurement, onsite, handling, storage and transportation)	0.679	4
3	Operation	0.697	1
4	Site management and practices	0.655	5
5	Site supervisor	0.680	3

Due to the average weight of relative importance index value of 0.697 are highly wasted construction materials in the cause of operation. The first rank of the major cause of construction materials wasted operations from the table 11. The variables in this group are directly the activities of the contractor's personnel which if managed very well may reduce waste and vice versa. The second rank of construction materials are wasted in terms of the cause design and documentation group is ranked in the above table 11. The relative importance index value are 0.686. According to these case there are different mistakes was happened in the construction industry. As much as possible all parties to take his own responsibility to minimize the wastage. If the design and document of the project is not fulfil information about the project, it need modification by the employers. So construction parties are prepare redesign and documentation for reconstruct, it need another materials and some construction materials are wasted due before working is changed. The common phenomenon to government projects where there is prevalence of project scope changes, poor document control and lack of effective project management, especially with respect to cost and project duration, may contribute to the level of material waste generated by this variable group [25]. The average weight of relative importance index value of 0.680 are third rank of construction materials are wasted on the cause of site supervisor. Any construction parties are prepare as site supervisor for each project. This professional employers are to guide and control progress of project, how to handle the construction materials and equipment, construction method and techniques to follow up, the construction constraints (quality, time and cost), design and etc. it's the responsibility of site supervisor. When supervisor are too saw during the execution of project every stakeholders are control their activities. If site supervisor are daily control the project site they are reduce the wastage of construction materials. Due to the response of this study there lack of site supervisor in the different project. Therefore to develop the skill and give guidance for site supervisor to enhance the problem. The average weight with a relative importance index value of 0.679 are fourth rank of construction materials are wasted due to the cause of materials (procurement, onsite, handling, storage and transportation). Material management are coordinates planning, assessing the requirement, sourcing, purchasing, transporting, storing and controlling of materials, minimizing the wastage and optimizing the profitability by reducing cost of material. It is concerned with planning, organizing and controlling the flow of materials from their initial purchase through internal operations to the service point through distribution. Materials represent a major expense in construction, so minimizing procurement costs improves opportunities for reducing the overall project costs. Poor materials management can result in increased costs during construction and also wastage are happen in the project. The average weight of relative importance index value are 0.655 are fifth rank of construction materials are wasted in the cause of site management and practices. There are lack site management to control materials handle, manpower and equipment. It suggests that site management and practices need improvement in the Mettu town construction project to reduce the volume of material waste generation. Generally it implies that some groups may contribute more construction material are wasted than others, advising that participants in the construction project should be

focus on the more important group without avoiding the others.

4.3. Key Cause of Construction Materials Are Wasted in Construction Project

The respondents were asked which material is highly wasted on the different project site. When the responses were the professionals (project manager, consultant, Construction engineer, site engineer, office engineer, general Forman, and supervisors). The results showing that the key materials, which are wasted on construction sites are Tile, Block (HCB), concrete, cement, Timber formwork, sand, reinforcement steel, and Course Aggregate. Thus, the respondents agree that the relative importance index value are 0.683, 0.680, 0.678, 0.669, 0.666, 0.663, 0.649, and 0.628 are wasted respectively as shown in table 12 below:

Table 10. *The relative importance index value of key construction materials wastage.*

Key materials	RII	Rank
Concrete	0.680	2
Steel reinforcement	0.649	7
Cement	0.669	4
Aggregate	0.628	8
Sand	0.663	6
Block (HCB)	0.678	3
Tiles	0.683	1
Timber formwork	0.666	5

As a result analysis of this table 12 shows that the tile are first ranking value of relative importance index value are 0.683 was highly wasted construction material. Some tiles are produced in the site and precast. When tiles produced in the site the contractors are not consider the quality of materials, delivery from production to the site, the skilled of employers, and handle of tile, due to this case different wastage was happen in the project. Tiles are highly wasted from the construction materials in a Mettu town. Therefore any construction parties was handle his own responsibility on the each activities as much as possible to minimize the wastage of tile. According to results of table 12 are shows that concrete are the second ranking value of the relative importance index value are 0.680. Concrete are crucial materials for construction industry, when produce cast in site its highly wasted construction materials. In different construction company concrete are more wasted, so to minimize the construction materials wastage are by using precast concrete and in terms of cast in site to manage properly the procedure and construction method on the site work during the casting of concrete.

4.4. Test of Hypothesis

In order to evaluate the differences across five group of construction materials wastage level, dependent on the respondents' position (contractor and consultant), were statistically significant, the Kruskal-Wallis test was conducted. There is no significant statistical difference in the perceptions of the various groups contractor and consultant concerning the most cause of wastage construction material produced during construction project (H1), was tested with the use of Kruskal-Wallis test at $p \geq 0.05$. The test reveals that there is no significant variation in the contributions of the identified cause of construction materials wastage according to consultants and the contractor's response as follow result are presented in table below.

Table 11. *The table shows analysis of Kruskal-Wallis test of contractor and consultant.*

Ranks						
	Grouping	**N**	**Mean Rank**	**Chi-Square**	**df**	**Asymp.sig.**
Contractor Ranking	Group1	12	45.79	25.640	4	0.000
	Group 2	19	37.45			
	Group 3	14	13.79			
	Group 4	13	26.54			
	Group 5	5	43.40			
	Total	63				
Consultant ranking	Group1	12	28.63	3.947	4	0.413
	Group 2	19	29.58			
	Group 3	14	40.46			
	Group 4	13	30.50			

Ranks

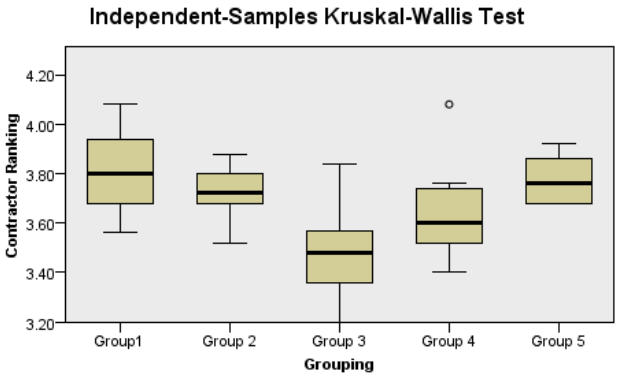
	Grouping	N	Mean Rank	Chi-Square	df	Asymp.sig.
Average	Group 5	5	29.50	1.584	4	0.812
	Total	63				
	Group1	12	35.54			
	Group 2	19	31.45			
	Group 3	14	33.04			
	Group 4	13	27.15			
	Group 5	5	35.30			
	Total	63				

Table 12. *The summary hypothesis tests of Kruskal-Wallis test of contractor, consultant and average.*

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Contractor Ranking is the same across categories of Grouping.	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.
2	The distribution of Consultant ranking is the same across categories of Grouping.	Independent-Samples Kruskal-Wallis Test	.413	Retain the null hypothesis.
3	The distribution of Average is the same across categories of Grouping.	Independent-Samples Kruskal-Wallis Test	.812	Retain the null hypothesis.

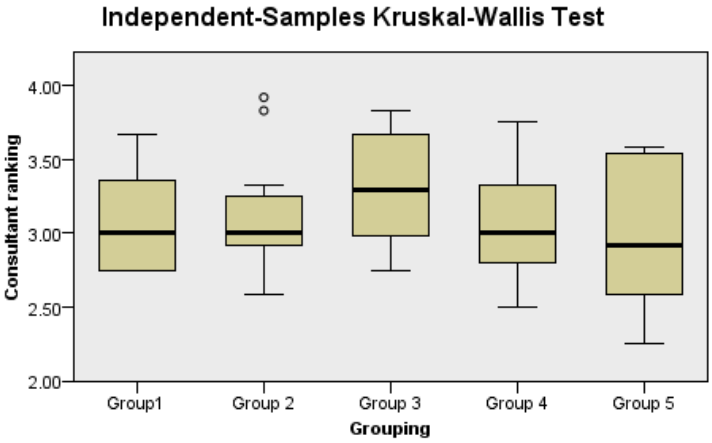
Asymptotic significances are displayed. The significance level is.05.



Total N	63
Test Statistic	25.640
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	.000

1. The test statistic is adjusted for ties.

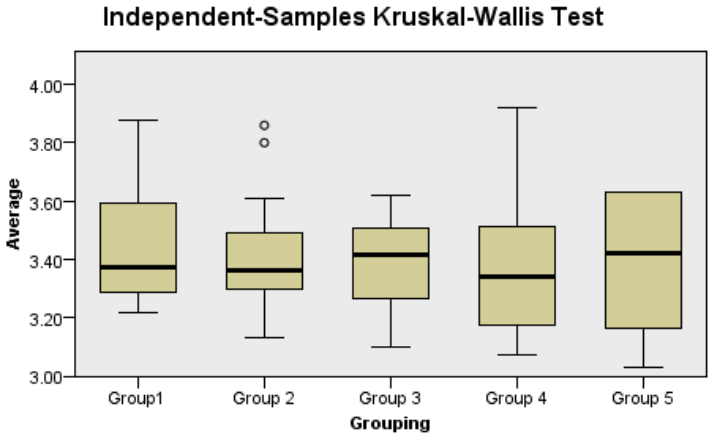
Figure 3. *The independent sample test of contractor ranking of kruskal-wallis test.*



Total N	63
Test Statistic	3.947
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	.413

1. The test statistic is adjusted for ties.
2. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Figure 4. *The independent sample of consultant ranking of kruskal-wallis test.*



Total N	63
Test Statistic	1.584
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	.812

1. The test statistic is adjusted for ties.
2. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Figure 5. *The independent sample of average ranking of kruskal-wallis test.*

4.5. Mann-Whitney U Test of Grouping the Cause of Construction Materials Wastage

To evaluate the difference across five groups of contractors and consultants of response for preference of cause construction materials wastage was tested using Mann-Whitney test. Since the overall Kruskal-Wallis test is significant at p value is greater than 0.05 for all combined groups of respondents; a series of Mann-Whitney U tests was conducted to compare perceptions between pairs of the groups. Mann-Whitney U test was performed at $p \geq 0.05$ (95% level of significance) and in all it was observed that in every pairs of the groups, the P-value are greater than 0.05 and these led to the acceptance of the hypothesis. Hence, it is concluded that there is no significant differences among the various groups of cause wastage construction materials concerning the most wasteful material produced during construction projects (H2).

Table 13. The comparisons groups of contractor and consultant in the Mann-Whiteny test.

Target group	Contractor				Consultant			Average		
	N	M-W	P	Dec	M-W	P	Dec	M-W	P	Dec
Group 1&2	31	75.5	.113	Ac	109	.838	Ac	98	.515	Ac
Group 1&3	26	10.5	.000	Re	52.5	.102	Ac	78	.757	Ac
Group 1&4	25	29.5	0.01	Re	75.5	.891	Ac	57	.253	Ac
Group 1&5	17	25	.591	Ac	28.5	.873	Ac	29.5	.958	Ac
Group 2&3	33	29	.000	Re	87	.092	Ac	126	.798	Ac
Group 2&4	32	74	.056	Ac	118	.832	Ac	105	.477	Ac
Group 2&5	24	36	.406	Ac	47	.971	Ac	41.5	.668	Ac
Group 3&4	27	44.5	.023	Re	61.5	.151	Ac	73	.382	Ac
Group 3&5	19	4	.004	Re	23.5	.285	Ac	30.5	.677	Ac
Group 4&5	18	13	.053	Ac	30.5	.843	Ac	27	.587	Ac

Hint; - N= No of questionnaires', M-W = Mann-Whintey, P; - p-value, Dec= decision and Ac = Accept, Re= reject

4.6. Measures of Minimizing Construction Material Wastage on Public Construction Project

The minimization of construction materials wastage are the duties of all parties. The degree of parties are different according to the organizations. Contractor are with appropriate control and managing of wastage of construction materials, contractor can be saved from the expending unnecessary extra investment. Contractor by handling and communicate the project any technical staff and to control the project. So contractor more responsible to reduce the wastage of construction materials because, using materials in modern construction methods that means use technical manpower, skilled person, use machinery and works with his the equipment properly and use materials properly on store and stoking at the time. The consultants are also reduce waste of construction materials, when supervising and committed his duties of the project according to the specification. The clients are also support by supervising and controlling the site handling the project and also release the budget according to the contractor requesting the payment of the project.

The impact of wastage of construction materials are the economic loss for the country, quality of construction project that means if the contractor side use the waste materials rework they have some effect on the quality of the project, polluted environment by discharging the chemicals (examples wastage of cement), loss of benefit for the contractor, cost overrun, cause of disease (cause of injury to workers), inefficiency of construction works, delaying of project and etc. Any construction projects are highly impacts on the tradition construction methods (example use concrete by hand mix and stock of materials are not keep properly).

The future outline for minimizing materials wastage on construction site are use appropriate design, use organized specification and detail drawing during construction progress, good communication between all parties, follow appropriate work order, use skilled manpower, reduce construction mistakes during the implementing the work, set correct standard and size of construction materials, change working methodology and update any new technology (like machinery and equipment). There are several frameworks and strategies that

can be implemented to minimize material wastage such as waste management plan, lean construction, BIM, training etc.

5. Conclusion

The aim of this study was to determine construction material wastage are reduced in the construction projects in Mettu town. In this study, it was found that using material waste management in the construction project to handle waste issues could considerably reduce the group of construction material wastes. Some cause of materials are waste can be contributed in Mettu town, those causes are design and documentation, Materials (procurement, onsite, handling, storage and transportation), Operation, site management and practices and site supervision. The major cause of construction materials wastage are operation, design and documentation and etc. operation of construction project are different mistakes during the execution, construction method are not fulfil information about the project, lack equipment and tools, it is not usual to assign professionals at every construction sites particularly to treat the waste issues. It is essential to put a specific person to handle the cause construction material wastage. So during the implementing the activities any employers should be attention the handling, storing, producing, preplanning of the work in the construction project, as much as possible to minimize the wastage of construction materials.

The mechanisms of minimizing wastage of construction material are given awareness for staff members about wastage management, suitable storage and stocking of materials, appropriate site supervision and management techniques, use technology, professional employed to carry out construction site, delivery of construction materials, to arrange the operation of work, to prepare good plan for the execution of the activities, Appropriate procurement managing, prefabrication of construction materials (off-site), mechanical handling of materials and etc.

Generally, the most essential benefits of construction material wastage are minimization because, they are saving total project cost without additional cost of removal and transport, to reduce the environmental protection, control the quality of project, increased profits of contractor, complete within duration of project, and cleaner and safe construction site conditions.

Abbreviations

BC	Building Contractor
BIM	Building Information Modeling
CO2	Carbon Dioxide
CW	Construction Waste
GC	General Contactor
H1	Hypothesis One
H2	Hypothesis Two
HCB	Hollow Concrete Block
RII	Relative importance Index
IBM SPSS	Statistical Package for Social Science
USA	United State of America

Acknowledgments

The authors are very grateful to all construction professionals from Mettu town and all buddy or staff members of construction technology and management department of Mettu University for their helpful collaboration in completing the questionnaire and acceptance to take part in the interviews. The authors also thank the editorial team and the anonymous reviewers for their helpful comments that greatly contributed to improving the final version of the paper.

Author Contributions

Gamachu Wakoya Fufa: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing – original draft

Kebede Chaka Fite: Writing – review & editing

Geremu Assefa Tucho: Software

Temesgen Daba Wakuma: Supervision

Conflicts of Interest

The authors declare no conflict of interests.

References

[1] E. E. C., S. R., E. O. P., and L. O. S, 'Assessment of materials waste in the construction industry: A view of Construction Operatives, Tradesmen and Artisans in Nigeria.', *Int. J. Eng. Sci.*, vol. 06, no. 04, pp. 32–47, Apr. 2017, https://doi.org/10.9790/1813-0604013247

[2] G. Wokjira Fayisa and S. Garoma Wayessa, 'Cause of Construction Material Wastage on Public Building Project in Western Oromia', *Am. J. Civ. Eng.*, vol. 9, no. 2, p. 55, 2021, https://doi.org/10.11648/j.ajce.20210902.14

[3] S. Tafesse, 'Material waste minimization techniques in building construction projects', *Ethiop. J. Sci. Technol.*, vol. 14, no. 1, pp. 1–19, Jan. 2021, https://doi.org/10.4314/ejst.v14i1.1

[4] I. Albert, W. Shakantu, and K. Ibrahim, 'IMPACT OF MATERIALS MANAGEMENT PRACTICES IN THE NIGERIAN BUILDING CONSTRUCTION INDUSTRY', Jun. 2018.

[5] G. Polat, A. Damci, H. Turkoglu, and A. P. Gurgun, 'Identification of Root Causes of Construction and Demolition (C&D) Waste: The Case of Turkey', *Procedia Eng.*, vol. 196, pp. 948–955, 2017, https://doi.org/10.1016/j.proeng.2017.08.035

[6] R. A. Begum, C. Siwar, J. J. Pereira, and A. H. Jaafar, 'A benefit–cost analysis on the economic feasibility of construction waste minimisation: The case of Malaysia', *Resour. Conserv. Recycl.*, vol. 48, no. 1, pp. 86–98, Jul. 2006, https://doi.org/10.1016/j.resconrec.2006.01.004

[7] S. Bavuno, C. Ahuma-Smith, G. O. Dokyi, and E. E. Ablordeppey, 'The Perspective of Tradesmen on Material Wastage in the Construction Industry', *Int. J. Eng. Res.*, vol. 9, no. 08, 2020.

[8] M. S. Bajjou and A. Chafi, 'Identifying and Managing Critical Waste Factors for Lean Construction Projects', *Eng. Manag. J.*, vol. 32, no. 1, pp. 2–13, Jan. 2020, https://doi.org/10.1080/10429247.2019.1656479

[9] S. S. Kolaventi, T. Tezeswi, and M. Siva Kumar, 'An assessment of construction waste management in India: A statistical approach', *Waste Manag. Res. J. Sustain. Circ. Econ.*, vol. 38, no. 4, pp. 444–459, Apr. 2020, https://doi.org/10.1177/0734242X19867754

[10] C. Luangcharoenrat, S. Intrachooto, V. Peansupap, and W. Sutthinarakorn, 'Factors Influencing Construction Waste Generation in Building Construction: Thailand's Perspective', *Sustainability*, vol. 11, no. 13, p. 3638, Jul. 2019, https://doi.org/10.3390/su11133638

[11] E. C. Eze, I. A. Awodele, and S. Ikechukwu, 'Labour–Specific Factors Influencing the Volume of Construction Waste Generation in The Construction Industry', 2021.

[12] D. Q. Zhang, S. K. Tan, and R. M. Gersberg, 'Municipal solid waste management in China: Status, problems and challenges', *J. Environ. Manage.*, vol. 91, no. 8, pp. 1623–1633, Aug. 2010, https://doi.org/10.1016/j.jenvman.2010.03.012

[13] F. C. Hung and N. S. Kamaludin, 'PROFESSIONALS' VIEWS ON MATERIAL WASTAGE LEVEL AND CAUSES OF CONSTRUCTION WASTE GENERATION IN MALAYSIA', vol. 21, Apr. 2017.

[14] N. H. Zulkernain, P. Gani, N. Chuck Chuan, and T. Uvarajan, 'Utilisation of plastic waste as aggregate in construction materials: A review', *Constr. Build. Material*, vol. 296, p. 123669, Aug. 2021, https://doi.org/10.1016/j.conbuildmat.2021.123669

[15] G. J. Sweis, A. Hiari, M. Thneibat, M. Hiyassat, W. S. Abu-Khader, and R. J. Sweis, 'Understanding the Causes of Material Wastage in the Construction Industry', *Jordan J. Civ. Eng.*, vol. 15, no. 2, 2021.

[16] O. Joseph, 'Causes and Minimization Techniques of Materials Waste in Nigerian Construction Process.' 2009.

[17] A. A. Salihu, S. Gambo, F. M. Oyeleke, and J. Usman, 'ASSESSING THE CAUSES OF MATERIAL WASTAGE AS IT AFFECTS VARIOUS BUILDING MATERIALS ON NIGERIAN CONSTRUCTION SITES', 2021.

[18] G. A. Bekr, 'Study of the Causes and Magnitude of Wastage of Materials on Construction Sites in Jordan', *J. Constr. Eng.*, vol. 2014, pp. 1–6, Oct. 2014, https://doi.org/10.1155/2014/283298

[19] G. M. Makebo, 'Assessing the Major Factors for Construction Material Wastage and their Remedial measures on Building Construction Projects in SNNPR, Wolaita Sodo Town', vol. 06, no. 10, 2019.

[20] J. C. Nwekete and E. I. Egba, 'Determining Extent of Structural Material Wastage in Building Construction Sites in Ebonyi State of Nigeria', 2020.

[21] A. Shayan and A. Xu, 'Value-added utilisation of waste glass in concrete', *Cem. Concr. Res.*, vol. 34, no. 1, pp. 81–89, Jan. 2004, https://doi.org/10.1016/S0008-8846(03)00251-5

[22] A. Nawaz, J. Chen, and X. Su, 'Factors in critical management practices for construction projects waste predictors to C&DW minimization and maximization', *J. King Saud Univ. - Sci.*, vol. 35, no. 2, p. 102512, Feb. 2023, https://doi.org/10.1016/j.jksus.2022.102512

[23] K. Agyekum, J. Ayarkwa, and T. Adjei-Kumi, 'MINIMIZING MATERIALS WASTAGE IN CONSTRUCTION- A LEAN CONSTRUCTION APPROACH', 2013.

[24] A. E. Yadeta and A. M. Eshetie, 'CAUSES OF MATERIALS WASTAGE IN BUILDING CONSTRUCTION PROJECTS', vol. 10, no. 10, 2019.

[25] T. O. Adewuyi and I. A. Odesola, 'FACTORS AFFECTING MATERIAL WASTE ON CONSTRUCTION SITES IN NIGERIA', *J. Eng. Technol.*, vol. 6, no. 1, 2015.