

Reduction of Wastage of Construction Materials for Project Performance Improvement

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Abstract: The construction field plays a remarkable role in the expansion of the country. Construction wastage can be described as unwanted substances generated during construction activities. In the speedy development of this industry, the growing amount of waste generation is slightly unnoticed. This study is concentrated on the reorganization of sources of material wastage, percentage of material wastage and current scenario of material waste management. The top root causes of material wastage on construction sites were retrieved from previous literature. The questionnaire survey method is adopted to collect the primary data. The materials wood, sand tiles, mortar from plaster and bricks have their major input in wastage. The overall material percent waste ranges from 5% to 11%. The top five materials contributing to the excess cost due to wastage are cement, reinforced bar, sand, coarse aggregate and bricks. The results show that 60% organization waste minimization strategies can be improved for effective cost management. Based on the questionnaire survey and its results, few recommendations are given to reduce the amount of material waste in the construction industry.

Index Terms - Wastage of Construction material, Causes of wastage, Waste reduction, Construction management, Project performance improvement

I. INTRODUCTION

The construction field plays a remarkable role in the expansion of the country. In addition to the infrastructure the construction industry contributes the economy of the country. GDP from Construction firm in India increased to 3175.14 INR Billion in the initial period of 2021[15]. In the speedy development of the industry, the growing amount of waste generation is slightly unnoticed. According to the Building Material Promotion Council (BMPTC), India generates an estimated 150 million tons of construction and demolition (C&D) waste every year [15], but the official recycling capacity is a meager 6,500 tons per day (TPD), just about 1 percent [12].

The term 'wastage' was defined by Ghanim A. Bekr (2014) as any losses produced by activities that generate direct or indirect costs but do not add any value to the product from the point of view of the client. Construction wastage can be described as unwanted substances generated during construction activities. The waste can be generated during the construction work phase, renovation work or demolition process. Most of the materials produced are non-renewable. The generated waste from construction activities are heterogeneous in nature, hence it is very difficult to reuse [6].

Although the actual waste is generated on-site during construction activities, it depends on several preliminary factors contributing to its occurrence.



Fig.1 Phases in material management

The cost is the major parameter that decides the success or failure of any project. The construction industry consumes 40% of the world's raw materials [6]. Lack of effective planning generally puts the burden on resources. Depending upon the structures, the Materials consume almost up to 65% of the overall budget of the project. The efficient use of resources will directly lead to profit by saving material costs. Appropriate planning and construction management reduce the wastage of construction materials substantially. This in turn improves the performance and economy of the organization. To keep the project's cost within the feasibility limit and to curtail losses caused by erroneous usage of materials. It is essential to set up guidelines to ensure planning to be effective.

The current study is concentrated on the reorganization of sources of material wastage and percentage of material wastage. This present work aims to analyze & reduce the wastage of construction materials for the enhancement of project performance. The aligned objectives of the work are -

1. To find out the reasons for Wastage of Materials from literature review.
2. To collect data to find out the Percentage of Wastage of Materials on Construction site with questionnaire Survey.
3. To Suggest recommendations for Reduction of Wastage of Construction Materials

Classification of construction waste-

The construction wastage produced in various situations due to different uses. It can be grouped in different forms such as Waste according to the type of resource consumed (Physical or Financial), Waste according to its control (Avoidable or unavoidable) and Waste according to its nature (Direct or Indirect) [8].

II. REVIEW OF LITERATURE

B.Sasidharani, R. Jayanthi(2015) investigates the wastage level, causes and prevention methods for construction sites. The questionnaire survey technique was used for the collection of data regarding contribution of waste minimization and measures to waste reduction. The data analysis was performed in SPSS and the T-test statistical technique of comparing means was used. Detailed classification of construction waste was discussed. For percentage material wastage, three case studies from Chennai was analyzed.

Chakkrit Luangcharoenrat et al., (2019) aims to identify factors generating material wastage in Thailand's construction industry. Overall 28 factors for waste production were recognized and classify into four categories i.e. design and documentation, material and procurement, construction method and planning, and human resources. The required data was gathered from contractors, architects, and construction managers in Thailand in form of structured questionnaire survey. Relative Importance Index method and SPSS software were used for data examination.

Ghanim A. Bekr (2014) researches the root causes for the wastage of construction materials in Jordan. A questionnaire survey approach was used to gather the necessary data of causes and Percent of material wastage. Frequency Index, Severity Index and Important Index were used to rank the materials. The conclusion drawn was material percentage wastage ranges from 15 to 21.

Gihan L.Garas et al. (2001) studied material wastage in the Egyptian Construction Industry. Data were collected from a sample size of 35 contractors in the industry. The achieved response rate was 85%. Major causes of waste generation were examined and compared with international data.

Husnain Arshad et al.,(2017) studied the various types of building for their material wastages and their causes. Some Practical recommendations to reduce wastage were given based on experts opinions. This attempt of correlation of waste with building types offers a new perspective on sustainable construction. The descriptive and comparative analysis was performed in MS excel and for reliability and normality, SPSS software was used.

J. O. Ameh & E. D. Itodo(2013) analyzed the most wasteful materials with various subcontracting options. The components contributing to material wastage were also investigated. Data collected from 56 respondents with a response rate of 70%. Examination was performed by descriptive and inferential statistics methods. Because of the wastage of materials, the average budget expands by 21-30%.

K.T. Odusami et al.(2012) Used a questionnaire survey approach was utilized for data gathering and an accidental sampling method was used for Nigeria. Mean Items Score (MIS) and ranks were used for deciding the importance level of data. The difference between Site Managers and Estimators on waste allowance were analyzed. Top factors contributing to material wastage were ranked. Several strategies for waste minimization were studied and recommendations were given.

L. Muhwezi et al. (2012) analyzes the factor responsible for material wastage using structured questionnaire mode. T-test was performed using SPSS software.5 points Likert scale was utilized in a questionnaire which had a response rate of 86%. Various factors were analyzed under the attributes like design, management, procurement, material handling, storage and transportation, Environment and operational.

Mahesh D. Meghani et al. (2011) examine the five case studies from Gujrat, India. The main sources of wastage were collected from discussion with the experts. Effect of wastage on project cost was analysed for cement, sand, bricks, reinforcement and Coarse Aggregate. Results indicate that proper supervision and control can avoid wastage of material.

Muhammad Fikri Hasmori (2020) studies waste management practices in Malaysia. From the previous literature, 54 measures for reduction of waste were found out and divided into five groups i.e. are Human Resources, Material and equipment, Construction method, Administrative and Regulation. The mapping method was utilized to calculate frequency. Five significant management practices were found out for construction waste reduction.

Nann Lwin Phu1, Aye Mya Cho (2014) studied three brackets i.e. effective material management, components that promotes waste and problems associated to material management. The quantitative survey method was used for data collection. The Relative Importance Index was used for analysis while the Kruskal Wallis test was examined the degree of agreement amongst respondents. Conclusion drawn was current practices in Myanmar construction projects need more organized and functional control.

Saheed O. Ajayi et al., (2017) explores the waste mitigation measures at material procurement and logistics. The measure taken by the supplier was also explored. The methodology used was focus group exploration with professionals and then a questionnaire survey. Various waste management strategies were discussed as secondary data. SPSS was used for the analysis of data. Four features characterized waste efficient logistic and procurement process was suggested.

Siti Hafizan Hassan et al. (2012) studied the material wastage sources and barriers in waste management. A questionnaire survey was performed to gather the data which had got 42 responses. Likert 1-5 scale used for ranking in the questionnaire mode. The top-ranked issue was a lack of knowledge of construction waste management.

Hamed Taherdoost (2016) studied the various methods used for the detection of accuracy and consistency of questionnaire survey method. The various subtypes of validities were explored in detail. The concept of reliability was reviewed.

III. RESEARCH METHODOLOGY

This analysis required primary data of the percentage of material wastage which was collected using questionnaire survey mode. The causes of materials were retrieved from the secondary data using the literature review. The methodology adopted for this research work is presented below-

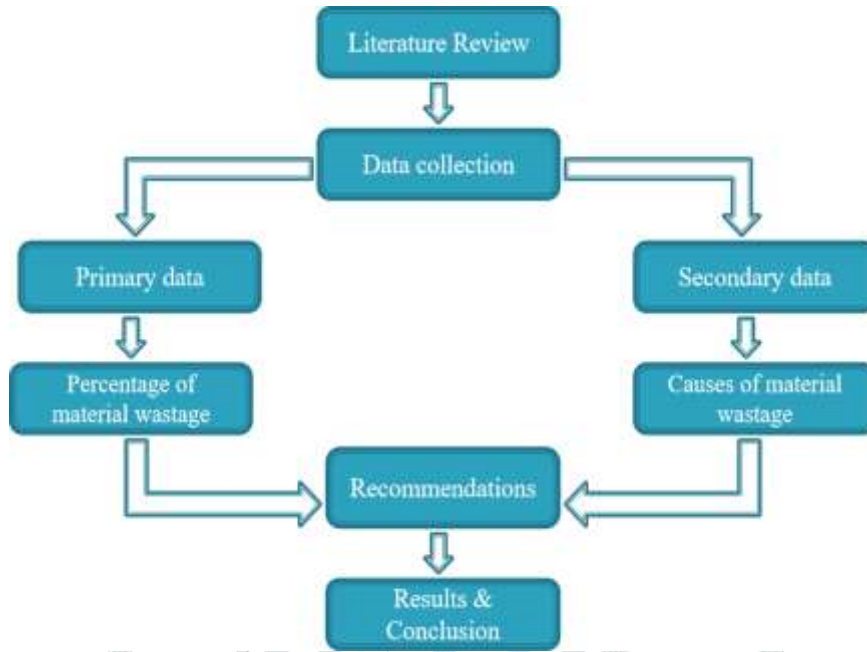


Fig.2 Methodology for research work

3.1 Top causes of material wastage-

The root causes analysis helps to concentrate on shortcomings and give opportunity of their improvements. Top root causes of material wastage on construction site were retrieved from ten literature papers-

Table1. Causes of material wastage

Sr. No	Reasons of Material Wastage	[1]	[2]	[3]	[4]	[6]	[8]	[9]	[10]	[12]	[14]
1	Deficient supervision	✓	✓	✓	✓	✓	✓	✓	✓	✓	
2	Rework		✓	✓		✓		✓		✓	
3	Inferior management	✓	✓			✓	✓		✓		
4	Unfavorable weather conditions	✓		✓		✓		✓		✓	
5	Lack of waste reduction planning			✓		✓		✓			✓
6	Substandard skilled manpower			✓	✓	✓		✓	✓		✓
7	Equipment malfunction	✓				✓					
8	Changes in design	✓	✓		✓	✓		✓	✓	✓	✓
9	Improper packaging			✓		✓					
10	Error in contract documents	✓	✓	✓		✓		✓			
11	Ineffective cutting					✓				✓	
12	Inadequate Storage	✓	✓	✓		✓	✓	✓	✓	✓	✓
Sr. No	Reasons of Material Wastage	[1]	[2]	[3]	[4]	[6]	[8]	[9]	[10]	[12]	[14]
13	Negligent transportation	✓		✓	✓	✓		✓	✓	✓	
14	Ordering error	✓	✓	✓		✓		✓			
15	Poor Quality control	✓				✓		✓	✓	✓	
16	Supply error	✓				✓					
17	Theft/vandalism	✓		✓		✓	✓		✓		
18	Changes in specification	✓		✓			✓		✓		
19	Complexity of project details	✓						✓			

20	Lack of information in drawing	✓			✓		✓				
21	Slowness in Decision making	✓			✓						
22	Mistakes in Quantity survey	✓		✓							
23	Delay in material delivery	✓								✓	
24	Material supply in loose form	✓		✓							
25	Use of incorrect material	✓									
26	Overestimating the quantity required						✓			✓	
27	Poor Planning		✓				✓	✓		✓	
28	Negligence						✓		✓		
29	Improper material handling		✓	✓			✓				✓

3.2 Questionnaire survey-

For the collection of secondary data, a questionnaire survey was performed. The Questionnaire created in online mode using Google forms. The questionnaire was divided into two sections-

1. General Information
2. Percentage of material wastage

The first section collects the information Organization type, Job profile, experience in the construction field, size of the project. The second section collects information about the percentage of material wastage, major materials causing cost overrun, the current status of the waste management in the organizations and recommendations.

Total 50 Questionnaires were circulated between the different firms of construction industry. 40 complete valid responses were received with the response rate of 80%.

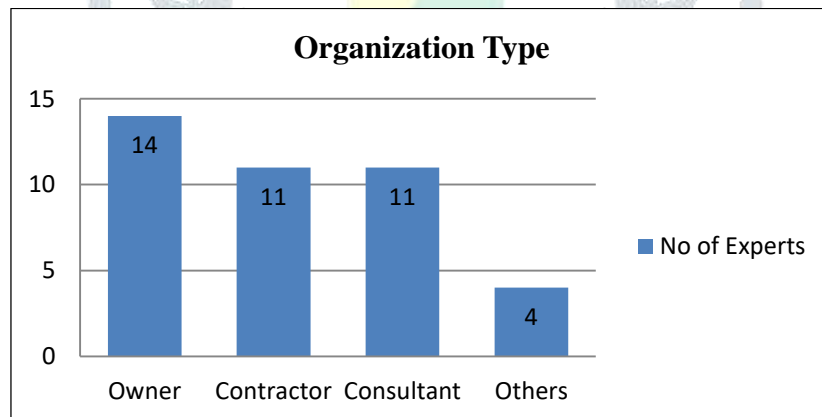
The questionnaire link-

https://docs.google.com/forms/d/e/1FAIpQLScX1ahzAA5URWT3P83YLK2oOmY89TCdnuY07ksg7DE6rKvqVw/viewform?usp=sf_link

IV. RESULTS AND DISCUSSION

Analysis of questionnaire part-I

Microsoft Excel and SPSS software was used for the analysis of data. The viewpoints of construction experts were collected from various types of organization firms such as owners, contractors, consultants and others. The respondents are working on various designations such as Project Manager, Senior Engineer, Estimator, etc. The analysis shows 35% are owners, 28% are contracting firms, 28% are consulting firms and 9% are from other organizations. Graph No. 1 shows the nature of the organization



Graph No.1 Details of organization types

On basis of the size of buildings, the projects were categorized into small, medium and large projects.

1. Small- Single multi storey building
2. Medium- Two multi storey buildings
3. Large- Multiple multi storey buildings

From the collected data, the major part i.e. 75% of the projects is large size projects. The responses collected from small and medium size organization are 12.5% each.

Table2. Size of project

Size of project	No of Experts	Percentage contribution
Small (Single multi storey building)	5	12.5
Medium (Two multi storey buildings)	5	12.5
Large (Multiple multi storey buildings)	30	75

The experiences of respondents were grouped into various groups at interval of 5 years. Table 3 represents the details about the experience of respondents-

Table3. Experience of respondents

Experience	No of Experts	Percentage contribution
0-5 years	13	32
5-10 years	10	25
11-15years	4	10
16-20 years	3	8
Over 20 Years	10	25

Analysis of questionnaire part-II

Percentage wastage of various materials-

Wood formwork is the highest percentage wastage i.e.10.53%. Sand and tiles were the second and third-ranked with the percentage of 8.55% and 8.5% respectively. Mortar from plaster is the fourth-ranked material having 8.08% wastage. This followed by the Bricks having 7.16 % of material wastage. The study reveals some materials having low wastage percentage such as Paints with 4.93% wastage, wires and cables with 4.95% wastage.

Table 4. Percentage wastage of various materials

Materials	Percentage of Waste	Rank
Cement	6.25	7
Bricks	7.16	5
Reinforced bars	6.00	8
Tiles	8.50	3
Wood (formwork)	10.53	1
Steel Formwork	5.10	10
mortar from plaster	8.08	4
Sand	8.55	2
Aggregates	6.93	6
Paints	4.93	12
Wires and cables	4.95	11
Metal pipes (Mild Steel /GI)	5.20	9

The 5 major materials that contributes to cost overrun (financial wastage)

The analysis shows that cement is the top-ranked material for contribution in cost overrun of project. Out of 40 respondents, 39 respondents voted cement as a contributing material for cost overrun. The reinforced bar is the second chosen material with a frequency of 32 respondents. 28 respondents graded Sand as the top third material contributing to cost overrun. Followed by Coarse aggregate by 21 and 19 respond respectively. Metal pipes and paints are the least cost contributing materials.

Table 5. Percentage wastage of various materials contributing to cost overrun

Material	Frequency	Rank
Cement	39	1
Reinforced bar	32	2
Sand	28	3
Coarse Aggregate	21	4
Bricks	19	5
Tiles	16	6
Wires and Cables	11	7
Steel formwork	10	8
Wood Formwork	9	9
Paint	7	10
Metal pipes	4	11

Organization waste minimization strategies

The data was collected to know the current status of waste management of organizations. 60% of respondents said that their organizational level waste minimization strategies can be improved for better results. 40% of respondents were satisfied with their organization waste minimization policies.



Fig.3 Organization waste minimization strategies

Organization of any training programme for waste minimization strategies

To increase the awareness of waste minimization, 19 organizations the additional knowledge or training sessions are organized. 13 organizations dose not conduct any special training and 8 respondents were not sure about it. The questionnaire tried to identify the effect of an individual’s attitude or behavior on waste generation. The results are in favor of agreement of the effect of behavior on waste generation.12 respondents were strongly agreed while 19 respondents voted for agreeing on response. 5 respondents had a neutral attitude. 4 respondents were strongly disagreed on the effect of an individual’s attitude on waste generation.



Fig.4 Organization training

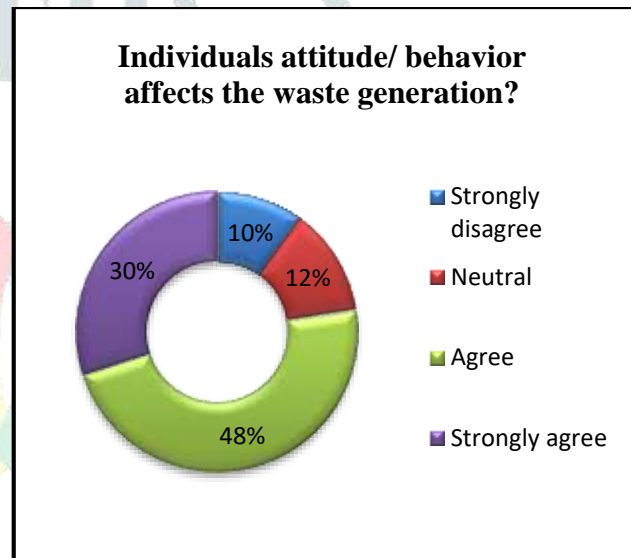


Fig.5 Effect of individuals behavior

Project stage wise contribution in waste generation

The generation of waste occurs at all stages of construction. For further analysis construction activities were divided into five project stages- Planning, Procurement, Logistic, Material Handling and Execution. For the analysis, 5 points Likert scale was used [1=Very low, 2=Low, 3=Moderate, 4=High, 5=Very high] Results indicated that the Contribution of the planning stage is 4(High). The contribution of procurement stage and material handling are 3 with moderate input. With the impact of 2 logistics has low input in waste generation. The Execution phase has a very high (5) contribution to the generation of waste.

Table 6. Project stage wise contribution in waste generation

Project stage wise contribution in waste generation	Responses for Rating				
	1	2	3	4	5
Planning	6	5	6	16	7
Procurement	10	8	13	2	7
Logistic	10	11	10	5	4
Material Handling	3	3	15	10	9
Execution	3	4	11	7	15

Reliability and Validity

For construct and face validation, the pilot test of the questionnaire was performed. The review of the questionnaire was taken from the three construction industry experts having more than fifteen years of experience. The required modifications were adopted and then the revised questionnaires were circulated for data collection. This process improves the quality of the questionnaire [5].The Cronbach’s alpha test was to measure the reliability of the data. With the alpha value of 0.86, the results are highly reliable [5].

IV. CONCLUSION

- This study concludes the major parameter contributing to material waste generation on construction sites are Deficient supervision, Rework, Inferior management, Unfavorable weather conditions, Substandard skilled manpower, Changes in design, Inadequate Storage, Negligent transportation, Ordering error, and Poor Quality control.
- The materials Wood, sand tiles, mortar from plaster and bricks are major have their major input in wastage. The overall material percentage Waste ranges from 5% -11%. Hence, through cost savings wastage reduction ultimately improves the project performance.
- The top five materials contributing to the cost excess due to wastage are cement, reinforced bar, sand, coarse aggregate and bricks.
- The 60% organization waste minimization strategies can be improved for effective cost management.
- Only 47% of organizations provide training which should be increased to raise awareness and reduce negligence towards material waste management.
- Individuals attitudes or behavior have an impact on the generation of wastage.

V. RECOMMENDATIONS

Based on the questionnaire survey and its results, few recommendations are given to reduce the amount of material waste in the construction industry.

1. Adequate planning with execution will efficiently lead to wastage cutting.
2. Regular Monitoring will update the current information as well as upcoming requirements
3. Execution of accurate handling methods and attentive handling of materials
4. Regular reconciliation of material improve control
5. Guidance from professionals to labours before execution of activities
6. Optimize Design, eliminate unnecessary over allowance
7. Application of Lean practices
8. Recycling waste will lead to waste minimization as well as cost savings
9. Availability of previous similar data will enhance estimation
10. People associated with the Construction Project must be well aware of the minimization of waste. And active involvement of each stakeholder is expected
11. Training sessions on waste minimization will improve its practice on site
12. The requirements of the Waste manager on site will detail monitor the material waste
13. A good market study of availability and cost of materials will improve stock management and cost-saving
14. Targets should be set for the reduction of wastage percentage

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