Construction Waste Minimisation & Management

Nilesh Jain[1], Avinash Shingan[2], Shantanu Paraspatki[3]
[1]Alumnus, Department of Civil Engineering, Sinhgad Institute of Technology & Science, India
[2]Assisatnt Professor, Department of Civil Engineering, Sinhgad Institute of Technology & Science, India
[3]Student, Department of Civil Engineering, Sinhgad Institute of Technology & Science, India

Abstract

The construction sector is a second largest industry in India after agriculture. It makes a substantial impact on the national economy and provides employment to a large number of people. This project consists of an investigation on the incidence of residential construction waste in Pune. Waste in the construction sector has been the subject of numerous research projects around the globe in recent years. There are different approaches adopted to reduce the amount of waste generated in the construction industry. The objective of present study is to identify waste generating processes, Classification of waste in a technical way and finding alternative techniques to be adopted for waste minimization. The main focus of the study is to design systematic approach to be adopted for waste quantification and minimization. The present study focuses on residential construction activities. The top three activities causing the major quantity of waste are identified. For this, we have adopted questionnaire technique and based on that the activities are ranked and causes are identified. Recommendations are given to the firm based on analysis to enhance the process and minimize the waste.

Keywords - *Construction Waste, Waste Management, Civil activities, Severity Index, Questionnaire.*

I. INTRODUCTION

Construction waste has proven to have an adverse effect on the budgetary condition of construction corporations and on the environment too. To weigh the present methods of waste diagnostic, questionnaires will transpire to recognize the most frequent categories that produce the construction waste on site affecting the final cost of the residential projects, the types of waste and their potential causes. The questionnaires will be sent to thirty construction companies. First, construction activities that produced the highest amount of waste would be chosen. Second, predominant causes and types of waste will be identified by the second questionnaire for top three activities. Third, implementation and recommendation will be chosen according to the previous study and it is given to the five construction companies out of thirty companies which will help them to minimize the waste in terms of cost, material and quality. Owners of Real-Estate, in the recent years, are facing severe complications. Over the past few years, they have consistently been in a situation that did not require an arduous quest for lower prices since they were relishing record closings and enthusiastic buyers. However, as the market plummeted and inventories rise, builders now find themselves in a situation that they have to reduce costs to have a place in this new competitive market. Through the comprehensive study from literature review and survey, a board range of aspects was diagnosed that affect the cost of project owing to a cohort of waste that takes place on the site. Following Fig. 1 shows the parameters that are put in place that might contribute to the generation of waste due to Monumental mismanagement.

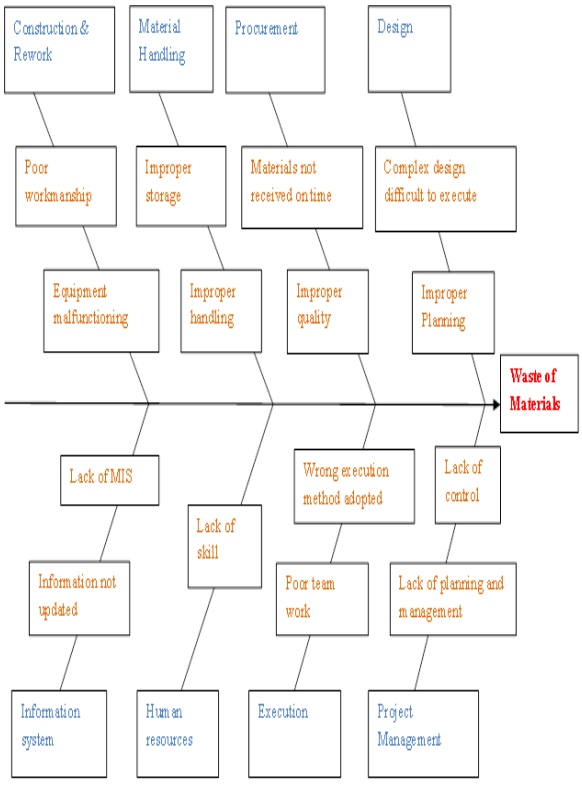


Fig. 1 Different Causes for waste of material found out from literature review and survey study

II. PROBLEM STATEMENT

For any organization, the profit is the paramount aspect that enables it to run efficiently and proliferate it's business deep into the market. Owing to this, many organizations seek for maximum profit. Wastages are one of the major factors in Construction sector that decrease the profit of the project than the baseline budgetary profit. These causes due to several reasons and thus it become important to control the wastages on site in order to meet the ultimate agenda of the project. The purpose of this study is to identify the most frequent waste categories affecting the final cost of residential projects in Pune and analyze the causes of its occurrences.

III. RESEARCH OBJECTIVES

Basically, this thesis will conduct an exploratory study on the implementation of methodologies for reducing the wastages after the proper scrutinization of a survey conducted for 30 residential projects through questionnaire followed by the experience of Project engineer and Project manager of respective projects. In this regards, in term of construction management, this dissertation is written for the objectives listed below:

1. To study the types of construction wastes.
2. Thorough data collection regarding construction waste minimization.
3. To study the most frequent waste categories affecting the final project cost.
4. To determine the possible causes of wastes.
5. Find solutions to be put into effect at residential construction sites to reduce waste productions.

IV. METHODOLOGY

In this study, questionnaires will be used as a tool for collecting data for quantitative analysis. The questionnaire is the most common method used to acquire the opinions of the respondents in a structured manner. Although designing a questionnaire appears to be relatively simple, it is a complex process. The questions must be formulated and selected carefully and the aim of the research must continuously be borne in mind. Due to the nature of the research, it is important to ensure respondents of confidentiality with which answer would be treated as it could drastically influence the accuracy of results. This aspect, therefore, enjoyed a high priority during the instruction phase.

A. Selection of Construction Firms

The companies were chosen from the survey of a location nearby Pune-Mumbai bypass. Two criteria were used to select companies for the study. First, only private companies were chosen. Second, only companies doing predominantly residential construction works were chosen. Firstly site engineers were contacted personally, giving them the whole idea and background of the project. Then questionnaires were mailed to them and received personally verifying the filled data. Personal interviews were taken later on for the extra information about waste generation and current practices of waste minimization. Personal interviews proved to be very knowledgeable giving a clear idea about quantification of waste.

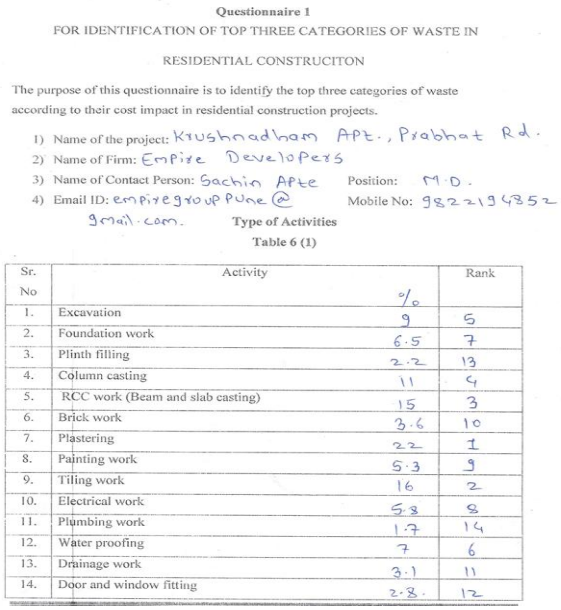
According to the Centre for Strategy Research (2006), the minimum sample size required to accurately estimating the reality in a questionnaire survey is 30 or more companies.

B. Design of Questionaries

At this phase, two questionnaires will be designed to collect data. The questions will be created based on the concepts acquired on the literature review. They will be also designed in such a way that companies did not have to spend much time to answer

1) Questionary 1:

The first questionnaire will be designed to identify and rank the most frequent waste categories (such as excavation, foundation, brickwork, plastering, tiling and so on) present in the job site affecting the final cost of the residential projects. General activities on construction sites were mentioned and site engineers will be asked to rank them according to their capability of waste generation and also their effect on final cost by their past database by comparing the baseline cost to construction with the actual cost of construction and mentioning the percentage increase in case. Following are the few sample reports taken by the Engineers shown in Fig. 2. & Fig. 3



Questionnaire 1

FOR IDENTIFICATION OF TOP THREE CATEGORIES OF WASTE IN

RESIDENTIAL CONSTRUCITON

The purpose of this questionnaire is to identify the top three categories of waste according to their cost impact in residential construction projects.

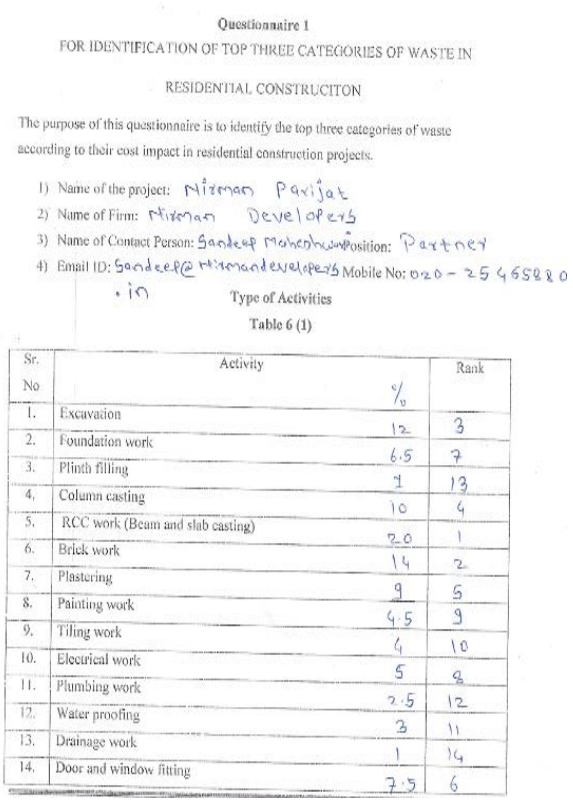
1) Name of the project: Krushnadham Apt., Prabhat Rd.
2) Name of Firm: Empire Developers
3) Name of Contact Person: Sachin Apte Position: M.D.
4) Email ID: empiregroup Pune @ gmail.com. Mobile No: 9822194852

Type of Activities

Table 6 (1)

Sr. No	Activity	%	Rank
1.	Excavation	9	5
2.	Foundation work	6.5	7
3.	Plinth filling	2.2	13
4.	Column casting	11	4
5.	RCC work (Beam and slab casting)	15	3
6.	Brick work	3.6	10
7.	Plastering	22	1
8.	Painting work	5.3	9
9.	Tiling work	16	2
10.	Electrical work	5.8	8
11.	Plumbing work	1.7	14
12.	Water proofing	7	6
13.	Drainage work	3.1	11
14.	Door and window fitting	2.8	12

Fig. 2 Survey 1 for Questionnaire 1



Questionnaire 1

FOR IDENTIFICATION OF TOP THREE CATEGORIES OF WASTE IN

RESIDENTIAL CONSTRUCTION

The purpose of this questionnaire is to identify the top three categories of waste according to their cost impact in residential construction projects.

1) Name of the project: Mitmari Parijat
2) Name of Firm: Mitmari Developers
3) Name of Contact Person: Sandeep Mahendrawa Position: Partner
4) Email ID: Sandeep@mitmandevelopers.in Mobile No: 020 - 25465880

Type of Activities

Table 6 (1)

Sr. No	Activity	%	Rank
1.	Excavation	12	3
2.	Foundation work	6.5	7
3.	Plinth filling	1	13
4.	Column casting	10	4
5.	RCC work (Beam and slab casting)	20	1
6.	Brick work	14	2
7.	Plastering	9	5
8.	Painting work	4.5	9
9.	Tiling work	4	10
10.	Electrical work	5	8
11.	Plumbing work	2.5	12
12.	Water proofing	3	11
13.	Drainage work	1	14
14.	Door and window fitting	7.5	6

Fig. 3 Survey 2 for Questionnaire 1

*2) **Questionary 2***

The objective of the second questionnaire is to identify the type of waste generated and their probable causes in top three activities identified in the first questionnaire. For performing this task the second questionnaire was filled by thirty Firms which were chosen for the first questionnaire as shown in the Fig. 4. & Fig. 5

The second step includes the analysis of the data collected from the second questionnaire. Severity index (SI) is a computation that is used to rank the types of waste for each category according to their degree of influence in affecting final project cost. In order to evaluate the degree of influence of each type of waste a three-point scale was used as follows:

- 1 = (highly significant)
- 2 = (moderately significant)
- 3 = (not significant)

Severity Index is illustrated by the following equation:

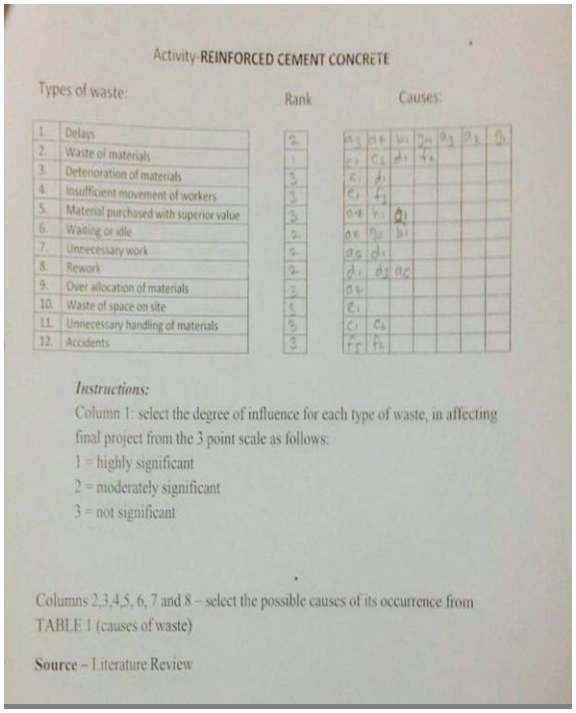
$$SI = (\Sigma 3i=1\ wi \times fi) \times 1/n$$

Where (i) represents the ratings 1–3, (fi) the frequency of responses, (n) the total number of responses and (wi) the weight for each rating. The types of waste with higher SI have more influence in affecting final residential construction project. The third and last step of the data analysis is to determine the possible causes of the Occurrence of the types of waste for the top three waste categories. The weighting factors are given as per the degree of influence of the type of waste on cost.

Phases considered during execution are design, procurement, material handling, construction and rework, project management, execution, human resources and information systems which includes subcategories listed under them the reason which contribute to the waste after comprehensive study as shown in Table 1 As per the review of construction Firms, the predominant 12 categories of waste were identified and their probable causes of their occurrence during various phases of execution were listed below:

Table 1: List of Causes for Waste Generation

A		**Design**
	1	Lack of knowledge in availability of alternate materials
	2	Insufficient drawing details
	3	Complex design difficult to execute
	4	Ambiguity in specifications
	5	Improper co-ordination
	6	Rework due to change in design
	7	Improper planning
B		**Procurement**
	1	Materials not received on time
	2	Improper quality of material
C		**Material handling**
	1	Improper storage
	2	Improper handling (on site or off site)
D		**Construction and rework**
	1	Poor workmanship
	2	Lack of site waste management plan
	3	Equipment malfunctioning causing rework
E		**Project Management**
	1	Lack of project planning and management techniques
	2	Lack of control techniques
F		**Execution**
	1	Poor teamwork
	2	Execution methods adopted
	3	Poor Arrangement of the working place
	4	Lack of personal equipment
	5	Lack of safety management plan
G		**Human Resources**
	1	Lack of skill
	2	Inadequate training facilities
	3	Improper utilization of human resources
	4	Excess work allocation
H		**Information Systems**
	1	Lack of information
	2	Information not updated
	3	Lack of MIS



Activity- REINFORCED CEMENT CONCRETE

Types of waste:

Rank

Causes:

1. Delays
2. Waste of materials
3. Deterioration of materials
4. Insufficient movement of workers
5. Material purchased with superior value
6. Waiting or idle
7. Unnecessary work
8. Rework
9. Over allocation of materials
10. Waste of space on site
11. Unnecessary handling of materials
12. Accidents

Instructions:

Column 1: select the degree of influence for each type of waste, in affecting final project from the 3 point scale as follows:

1 = highly significant

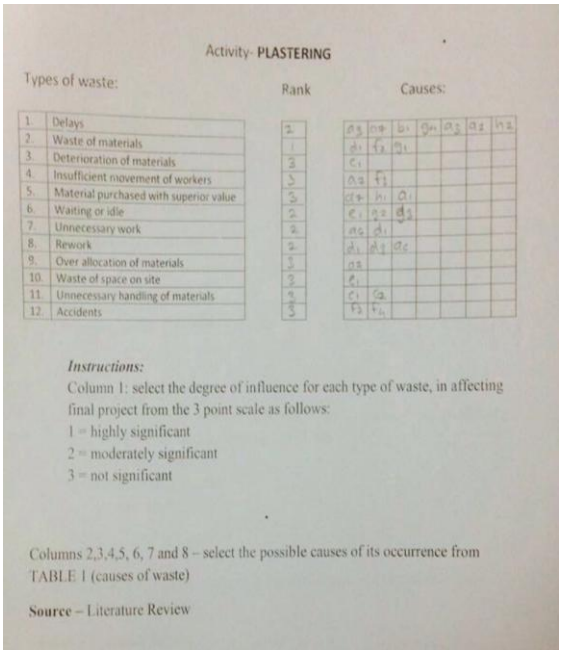
2 = moderately significant

3 = not significant

Columns 2,3,4,5, 6, 7 and 8 – select the possible causes of its occurrence from TABLE 1 (causes of waste)

Source – Literature Review

Fig. 4 Survey 3 Questionary 2



Activity- PLASTERING

Types of waste:

Rank

Causes:

1. Delays
2. Waste of materials
3. Deterioration of materials
4. Insufficient movement of workers
5. Material purchased with superior value
6. Waiting or idle
7. Unnecessary work
8. Rework
9. Over allocation of materials
10. Waste of space on site
11. Unnecessary handling of materials
12. Accidents

Instructions:

Column 1: select the degree of influence for each type of waste, in affecting final project from the 3 point scale as follows:

1 = highly significant

2 = moderately significant

3 = not significant

Columns 2,3,4,5, 6, 7 and 8 – select the possible causes of its occurrence from TABLE 1 (causes of waste)

Source – Literature Review

Fig. 5 Survey 4 Questionary 2

V. DATA ANALYSIS

A. *Result from Questionnaire 1*

Data obtained from the first questionnaire was analyzed to identify top three activities causing the major quantity of construction waste. The approach adopted for identification of waste was based on frequency analysis. Frequency analysis normally made through the analysis of an arrangement of data that displays the number of times or frequency of occurrence of different values of a data set. It is used to show frequency of each variable or item outlined in the questionnaire form. The surveyors ranked the waste categories from 1 to 14, with 1 being the most frequent category present in the job site affecting the final cost of the project and 14 the least one. Moreover, the responses were given by the respective sites, who ascertains the activities as most one that creates more wastage were added and represented in the graphical form of questionnaire 1 as shown in the Fig. 6 Top three activities found out from the survey were:

1. Reinforced Cement Concrete,
2. Plastering
3. Brickwork

A further focus of the project was kept only on these top three activities and causes related to these activities were found out.

Table 2: Frequency Table of Activities

Activities	Valid	Min frequency	Max frequency
Excavation	30	1	14
Foundation Work	30	2	14
Plinth Filling	30	1	14
Column casting	30	2	11
RCC work	30	1	9
Brickwork	30	1	10
Plastering	30	1	11
Painting Work	30	3	14
Tiling Work	30	2	11
Electrical Work	30	3	14
Plumbing Work	30	3	14
Water Proofing	30	5	14
Drainage Work	30	2	14
Doors & Window fitting	30	2	14

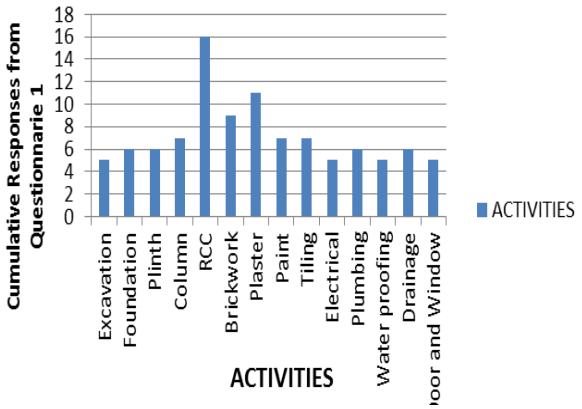


Fig. 6 Graphical Representation of Responses from First Questionnaire

B. *Result from Questionnaire 2*

During site visits to thirty selected Firms, the process of execution adopted by a construction Firm was studied. During the process of execution by observing the process map, the probable wastes generated due to the method of execution was identified. Further by studying the process in depth,

the perspective causes for the types of wastes identified were listed. This analysis ranked the types of waste, for each category identified on the first questionnaire, which were: delays, waste of materials, deterioration of materials, inefficient movement of workers, material purchased with superior value, work not done, waiting or idle, unnecessary work, rework, over allocation of materials, waste of space on site, unnecessary handling of materials, inefficient movement of workers, abnormal use of equipment, accidents and clarifications, according to their severity index (SI) and selected the top five. Moreover, the frequencies of activities that contribute the wastage were calculated from Questionnaire 1 for highest 3 activities viz. RCC, Brickwork, and Plastering as shown in Table 3, Table 4 & Tale 5 in order to satisfy the Severity Index.

Table 3 : Reinforced Cement Concrete Frequencies

Effectiveness rating given by the respective Sites	Frequency	Percent
1	16	53.33
2	3	10.00
3	3	10.00
4	2	6.67
5	3	10.00
6	1	3.33
8	1	3.33
9	1	3.33
Total	30	100.00

Table 4 : Brick Work Frequencies

Effectiveness rating given by the respective Sites	Frequency	Percent
1	6	20.00
2	3	10.00
3	9	30.00
4	3	10.00
5	3	10.00
6	3	10.00
7	2	6.67
10	1	3.33
Total	30	100.00

Table 5 : Plaster Work

Effectiveness rating given by the respective Sites	Frequency	Percent
1	2	6.67
2	11	36.67
3	4	13.33
4	5	16.67
5	3	10.00
7	2	6.67
8	1	3.33
9	1	3.33
11	1	3.33
Total	30	100.00

After the top 5 types of waste were identified for each category, the answers to the second questionnaire was analysed and identified their possible causes such as poor design and specifications, poor job site layout, unnecessary requirements, lack of control and so on, which were selected by the respondents from Questionnaire 2 and the significance of impact are represented in the graphical form as shown in the Fig.7

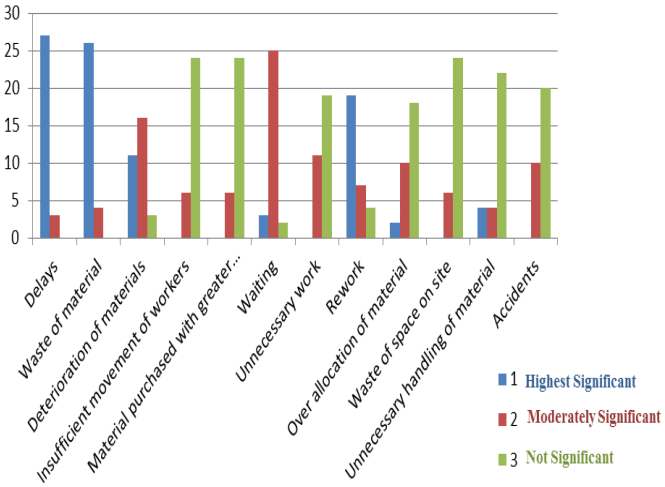


Fig. 7 Graphical Analysis of the Questionnaire 2

From the data obtained from questionnaire 1 and questionnaire 2 i.e. frequency and level of significance of activities on the generation of wastages as above, the Severity index is calculated in order to find the parameter that accrues the wastage in Construction activity as shown in Table 6.

Table 6: Severity Index

Severity Index for the Types of Waste on Reinforced Cement Concrete, Brickwork, and Plastering	
Delays	2.90
Waste of materials	2.87
Deterioration of materials	2.27
Insufficient movement of workers	1.20
Material purchased with superior value	1.20
Waiting or idle	2.03
Unnecessary work	1.37
Rework	2.50
Over-allocation of materials	1.47
Waste of space on site	1.20
Unnecessary handling of materials	1.40
Accidents	1.33

From the above data it has been found that following are major factors that lead to the creation of

the wastage on site and further increases the cost of the project substantially:

1. Delay
2. Waste of Material
3. Deterioration of materials
4. Rework
5. Waiting

Knowing the factors that contribute more for the wastage and thus increases the cost of the project were meticulously ramified into the micro study and identified the reason that leads above factor to become significant. Moreover, the mean for the causes of generation of waste as shown in Table 1 were calculated in order to know the impact of 5 above factors that contribute to wastage The survey was same carried out with 30 respective sites.

VI. RECOMMENDATION

A. *Recommendation to Reduce Material Waste*

- Use of prefabricated material and pre-cut components.
- Use of materials having fewer finishes. (Like natural wood ceilings)
- Proper ordering of materials-Just in time delivery.
- The creating market for recycling and reuse of materials.
- Avoiding rounding up of purchasing requirement.
- Not to over order the materials.
- Promoting use of environment improved and recycled content products.
- Specify exact requirement to the supplier.
- Carrying out study related to embodied energy of materials: study shows that few construction materials have reuse potential up to 35% and recycle potential up to 27%.

B. *To Reduce Waste in Planning & Designing Phase*

- Carrying out detail study of the site regarding slopes and other minutiae so that the structure will be resource proficient.
- The design of building pertaining to need and purpose that is going to serve and consequently deciding the size of the building.
- Design and plan a building for a greater lifetime and accordingly choose materials so that cost of repairs and maintenance in future will reduce.
- Practicing integrated planning approach involving architect, designer, builder and sub-contractors.
- Carrying out examination related to new planning and designing approach that will decrease waste in planning phases itself.
- The design of buildings in harmony with their surroundings i.e. Plans the building to reduce earthworks, driveway length, and paved surfaces.
- Consider piles or poles on sloping sites to avoid unnecessary excavations.
- Consider module sizes in the design i.e. standard sizes of flooring and roofing.
- Achieve service efficiency through design. E.g. Group the wet areas (kitchens, laundries, and bathrooms) close together; it will reduce pipework length and sharing of gully traps.
- Design for simplicity and user friendliness by avoiding complex shapes in design.
- Consult with the every person involving in the project and take the time to plan well. Have to brainstorm ideas that will reduce waste.
- Try to avoid or minimize design variations.
- In designing and planning phase, the focus should be on exclusion of waste rather than minimization.

C. *On Site Approach of Waste Reduction*

- Keep the site neat and clean.
- The site layout should be proper including an arrangement for storage, equipment etc.
- Reserving central area for carrying out cutting activities of metals so that cut pieces of metals will find at a single place so that they can be reused.
- Promoting reuse of temporary works for similar structures like scaffolding, formworks.
- Strict supervision and controlled use of materials.
- Intensifying security so as to reduce thefts.
- Effective implementation of the waste management plan.
- Improving storage facility.
- Improving transport systems.
- The organisation of containers or bins for collection of material wastage so that it will be segregated and easy to reuse or recycle.
- Plan for safe disposal of unavoidable waste.

D. *Management Techniques to Reduce Waste*

- Finding right people for execution of work that will understand the importance of waste reduction.
- Preparing documentation related to waste (quantity purchased and actual quantity used).
- Learning from the past experience by avoiding past errors.
- Increasing standardization of processes.
- Create awareness among clients and contractors by providing them knowledge related to economic benefits of waste minimization and management.
- Providing training and education to the unskilled employee.
- Establishing a good line of communication between top management and workers.
- An imposing condition in the contract regarding waste minimization so that it will be enforced by law also.

E. *Reuse of Waste Material*

- Blocks - To use as curbs to stop water runoff from garden areas.

- Tiles - To create pathways and walkways in landscape area.
- Concrete - To use as aggregate for concrete.
- Mortar - Collect mortar at the end of the day and pour water in it and reuse it by crushing and adding cement for lower grade work for next day.
- Soil - To manufacture mud blocks, clay blocks which can be used for fencing around trees and shrubs in landscaping.
- Bricks - Paving in the landscape, plinth filling, brick bat-coba for terrace and toilets.
- Water - Use gunny bags or cork bags while curing to reduce water use.
- Steel - Reuse of small cut pieces of bars in miscellaneous parts like lintels, special projections.

VII.CONCLUSIONS

Construction waste management is the aspect which is going to help the country to develop in a sustainable manner. Applying waste management theories will reduce issues related to the environment, social and also gives economic benefits for the firm.

It can be concluded from the study that systematic analysis of waste generation is helpful for identification of major causes of waste. Once it is identified, it can be avoided or minimized resulting in major financial benefits for the firm.

Thirty firms dealing in residential construction were selected for the study. It is observed from analysis of data that:

- Reinforced cement concrete
- Plastering
- Brickwork

are the major wastes causing activities Further analysis was done to identify types of waste and their causes based on this analysis recommendations were given to firms like Nirman Construction, Shree Construction, Kasat Kothadiya Associates

REFERENCES

[1] Abbasian Hosseini, A. Nikakhtar, K.Y. Wong, A. Zavichi "Implementing Lean Construction Theory To Construction Processes' Waste Management." (2011).(Pg no.- 414-421) ,ASCE Publications.

[2] B.A.G. Bossink And H.J.H. Brouwers "Construction Waste: Quantification And Source Evaluation" (March 1996) (Pg no.55-60), Journal Of Construction Engineering And Management.

[3] Carlos T. Formoso, Lucio Soibelman M.ASCE,Claudia De Cesare and Eduardo L.Issato studied "Material waste in building industry : Main causes and prevention"

[4] Cristiano R. Castelo Branco "An Effective Way to Reduce Residential Construction Waste" (2007),A Case Study In Texas, December(Pg no. 1-62)

[5] Daniela Dietz Viena, Carlos Torres Formoso and Bo Terje Kalsaas studied "Waste in construction : A systematic literature review of empirical studies"

[6] Ramaswamy,K.P., Satyanarayana N., Kalidindi "Incidence of Material Waste In Indian Building Industry" NICMAR-Journal Of Construction Management,Vol.XXVIII,No.4,October-December. (2013)

[7] Said Jalali studied "Quantification of construction waste amount"Author for Waste Tool Handbook.

[8] Sasitharan Nagapan, Ismail Abdul Rahman, Ade Asmi "Factors Contributing to Physical and Non-Physical Waste" (Pg no. 1-10) International Journal of Advances in Applied Sciences.