RESEARCH PAPER | Engineering | Volume : 4 | Issue : 6 | June 2014 | ISSN - 2249-555X

Waste Minimisation in Construction Industry

KEYWORDS: Construction waste, Construction Waste Management, Construction waste reduction, Sources Of Material Waste, Barriers To Implement Waste Management

Prof.B.Prakash Rao
Professor,Department of Civil Engineering, Manipal Institute of Technology, Manipal- 576104

Shivakumar B
Student, Department of Civil Engineering, Manipal Institute of Technology, Manipal Institute of Technology, Manipal- 576104

H S Suresh
Deputy General Manager, Prestige Estates Projects Ltd, White Meadows, White Field Main road, Whitefield, Bangalore- 560063

ABSTRACT *Material waste is considered one of the major problem in construction industry. Material waste causes negative impact on economy of the country and environment. This research work is based on material waste management in building construction through the dissertation work, attempt is made to identify general causes of material waste, barriers to implementation of waste management and what are the waste minimization measures practiced in construction industry by conducting questionnaire survey.*

I. INTRODUCTION

Material, Manpower Money and Machine play crucial role in construction projects and building materials account for 60 to 70% of the project cost [2]. Hence even one percent of material wastage will have huge negative impact on cost of construction and economy of the country. However construction industry in India generates about 10-12 million tons of waste annually [1].

Identifying sources of material waste not only have financial and environmental benefits but also shows the areas which need improvisation and also helps to finish the project on time showing how we can avoid rework. Hence effort can be made to reduce the overall cost of project by waste minimization or maximum utilization of resources.

II. RESEARCH OBJECTIVES

- Identifying General Causes of Material waste in construction.
- Identifying causes of waste for client supplied materials.
- Identifying importance of waste recognition, barriers to implement waste management and existing waste reduction techniques/strategies followed in construction industry.

III. METHODOLOGY

- Identifying causes of waste which contributes for generation of those construction waste by literature survey and site visits.
- Formulating questionnaires and validating, data collection by questionnaire survey.
- Analysing data.
- Discussion and interpretation of result.
- Conclusion and recommendation.

IV. QUESTIONNAIRE FORMAT

Based on literature survey and observation made on site the questionnaire is formed.

The questionnaire is divided into 4 parts:

Part 1: Personal information
Part 2: General causes of material waste
Part 3: Causes of waste for client supplied material
Part 4: Attitudes and perceptions toward construction waste management

V.QUESTIONNAIRE DISTRIBUTION AND RESPONSE

Totally 35 numbers of questionnaire were distributed to employees of 5 different construction companies in Bangalore. 31 out of 35 Reponses were collected (response rate is 88.6%).

VI.Analysis and results

A. Reliability Of Instrument

The reliability of a measuring instrument is a major criterion for assessing its quality and adequacy. An instrument can be said to be reliable if its measures accurately reflect the "true" measure of the attribute under investigation. The value of the reliability coefficient theoretically can range between -1.00 and +1.00. For most purposes, reliability coefficients above 0.70 are considered satisfactory.

In this case for 136 variables Cronbach's Alpha value was found out to be 0.984 for 31 respondents.

B. Mean And Ranking

For each causes mean was calculated and they are ranked descending order based on mean value with respect to their group. This was done to identify causes which contributes most to material waste in that group.

Part I: General Causes of Material waste:
TABLE I Ranking Of General Causes Of Material Waste

Symbol	Effects degree	
1	Very low influence	
2	Low influence	
3	Moderate influence	
4	High influence	
5	Very high influence	
Rank	Group I: Design and Documentation	Mean
1	Selecting the lowest bidder subcontractor without knowing their skills of handling material	3.871
2	Selection of low quality products which causes more rework	3.6774
3	Incomplete contract documents at commencement of project	3.4839
4	Lack of information in Good For Construction drawings	3.4194

Volume : 4 | Issue : 6 | June 2014 | ISSN - 2249-555X

5	Last minute client requirement (resulting in rework)	3.4194
6	Errors in contract documents	3.3871
7	Complexity of detailing in the Good For Construction drawings	3.3871
8	Lack of knowledge about construction techniques during design activities	3.3548
9	Rework that don't comply with drawings and specifications	3.3226
10	Design changes and revisions	3.2581
11	Determination of types and dimensions of material without considering waste	3.2581
12	Lack of information about types and sizes of materials on design documentation	3.2258
13	Waiting for design documents and drawings	3.1613
14	Lack of attention paid to dimensions of products available in market	3.1613
15	Ambiguities, mistakes, and changes in specifications	3.0968

Rank	Group II: Material Based	Mean
1	Damage materials on site	3.6129
2	Using materials with manufacturing defects	3.5484
3	Damage due to Improper packing of materials	3.4839
4	Using excessive quantities of materials more than the required	3.4839
5	Inadequate stacking and insufficient storage in inventory	3.3548
6	Conversion waste from cutting uneconomical shapes	3.3226
7	wrong storage of materials while execution	3.2581
8	Unnecessary inventories in site which lead to waste	3.2581
9	Damage due to improper loading and unloading technique	3.2258
10	Wrong handling of materials on site	3.2258
11	Over-sized elements which are very difficult to handle	3.2258
12	Inappropriate storage leading to damage or deterioration	3.2258
13	Lack of onsite materials control	3.1613
14	Theft and vandalism	3.129
15	Wrong storage of materials at inventory	3
16	Unnecessary material handling	2.9677
17	Insufficient instructions about handling	2.9677
Rank	Group III: Execution based	Mean
1	Using untrained labors	3.7097
2	Rework due to workers mistakes/Poor workmanship	3.7097
3	Lack of workers skill	3.6129
4	Improper Interaction between engineers and workers	3.5806
5	Using wrong construction method	3.5161
6	Using wrong Equipment/Tool for execution	3.4839
7	Using damaged Equipment/Tools which leads to rework	3.4516
8	Use of incorrect material, thus requiring replacement	3.4194
8	Use of incorrect material, thus requiring replacement	3.4194
9	Carrying out work without using Equipment/Tool Due to shortage/Unavailability	3.3871
10	Unfriendly attitudes of labour	3.3871
11	Carrying out work without taking clearance from engineer	3.3871
12	Accidents due to negligence	3.3871
13	Damage to work done caused by subsequent trades	3.3226
14	Severe weather conditions	3.1935
15	Difficulties in obtaining work permits	3.129
16	Effects of political and social conditions	2.7742
Rank	Group IV : Site Management	Mean
1	Slow in making decisions	3.7097
2	Insufficient information provided to project participants	3.5806
3	Lack of supervision and delay of inspections	3.5161
4	Shortage of technical professionals	3.5161
5	Lack of a quality management system aimed at waste minimization	3.4194
6	Poor coordination and communication within the parties involved in the project	3.4194
7	Poor site layout which leads to unnecessary handling of materials	3.3871
8	Ineffective planning and scheduling of the project	3.3871
9	Poor qualification of the technical staff assigned to the project	3.3226
10	Improper material management	3.2903
11	Lack of waste management plan	3.2258
12	Lack of strategy to waste minimization	3.129

Part II: Causes of waste for client supplied materials:
This thesis work was carried out under one of the client company in Bangalore. Hence only these three materials which client was supplying to contractor were chosen specifically.

TABLE II RANKING OF CAUSES OF WASTE FOR CLIENT SUPPLIED MATERIAL

Symbol	Effects degree
1	Very low influence
2	Low influence
3	Moderate influence
4	High influence
5	Very high influence

Rank	Material I: Reinforcement steel	Mean
1	Mistakes in BBS	3.9677
2	Using longer bars than what are mentioned in BBS	3.5806
3	Unnecessary replacement of some bars by large diameter bars	3.5806

Volume : 4 | Issue : 6 | June 2014 | ISSN - 2249-555X

4	Unnecessary cutting of bars instead of using short pieces	3.5161
5	Short unusable pieces are produced when bars are cut	3.4516
6	Damage during storage and rusting	3.3871

Rank	Material II : Cement	Mean
1	unnecessary chipping of plaster due to lack of interaction between finishing , electrical, plumbing teams	3.8387
2	Poor performance causing rework	3.7097
3	Using excessive thickness of plaster	3.7097
4	Mixing of quantities greater than the required	3.6129
5	Using excessive quantities during mixing more than the required	3.5806
6	Wrong storage	3.4839
7	Damage the external plaster due to rainfall	3.3871
8	Not reusing fallen mortar	3.2903
9	Damage resulting from severe weather conditions	3.2903
10	Multiple handling of the same batch of mortar	3.2903
11	Damage the fall mortar during plastering	3.2903
12	Loading the cement manually in the mixer using inadequate equipment and tools	3.2581
13	Excessive consumption of mortar in joints	3.2258
14	Inappropriate way of transportation	3
15	Mixing in unsuitable places	2.9032

Rank	Material III : Granite/Marble/Tiles	Mean
1	Rework as a result of executive mistakes	3.6129
2	Deploying Unskilled workers	3.5806
3	negligent handling in site	3.5806
4	Damaging the tile during the necessary cutting process	3.5484
5	Cutting unnecessarily instead of using small pieces	3.5161
6	Improper packing while transportation	3.4516
7	Damage during transportation	3.4516
8	Damage caused after finishing work by subsequent works	3.3871
9	Damage due to improper storage	3.3548
10	Unable to use small piece	3.2903
11	Manufacturing defects	3.2903

Part III: Attitudes and perceptions toward construction waste management:

This part contains questions regarding importance of waste recognition, barriers to implement waste management and existing waste reduction techniques/strategies followed in construction industry.

TABLE III RANKING OF IMPORTAMCE OF WASTE REGGNITION FACTORS

Rank	Importance of Construction Waste Recognition	Mean
1	To know the real requirements of the project represented in materials, time and cost	3.9355
2	It participates in project success and achieving profits	3.8065
3	To know the exact required quantities for project execution	3.8065
4	It helps the contractor to prepare accurate schedules to procure materials	3.7419
5	It keeps environment out of pollution	3.6774
6	It participates in increasing the national income in construction industry	3.6452
7	It encourages companies and firms to decrease waste	3.6129
8	It helps contractors in pricing bids	3.5806
9	Achieving the project according to its definite budget	3.5484
10	It puts an end to contractors failure	3.5161
11	To get enough finance for a project	3.3871

TABLE IV RANKING OF BARRIERS TO IMPLEMENT WASTE MANAGEMENT

Rank	Barriers To Implementation of Waste Management	Mean
1	Lack of technical skills	3.9032
2	Inadequate pre-planning	3.7419
3	Less involvement of contractors and specialists in design process	3.6774
4	Poorly defined individual Responsibilities	3.6452
5	Unsuitable organizational structure	3.6129
6	Lack of training	3.5484
7	Lack of interest from clients	3.4839
8	Waste accepted as inevitable	3.3871
9	Long implementation period	3.3226
10	High dependency of design specifications on in-situ materials and components rather than standardized and industrialized prefabricated components	3.2903

TABLE V RANKING OF EXISTING WASTE REDUCTION TECHNIQUES/STRATEGIES FOLLOWED IN CONSTRUCTION INDUSTRY

1	2	3	4	5
Not practiced at all	Not practiced	Practiced	Frequently practiced	Most frequently practiced

Rank	Waste Minimization Measures	Mean
1	Training of construction personnel	3.6452
2	Changing attitude of workers towards the handling of materials by proper training	3.6452
3	Improving supervision	3.6129
4	Good coordination between store and construction personnel to avoid over-ordering	3.6129
5	Proper storage and handling of materials on site	3.4839
6	Good construction management practices	3.4839
7	Employment of skilled labour	3.4516
8	Minimizing design changes	3.4194
9	Use of more efficient construction equipment	3.3871
10	Adoption of proper material management techniques	3.3548
11	Reusing some of waste materials on site	3.2903
12	Minimizing waste at the source of origin only	3.1935
13	Issuing raw materials that are just sufficient to sub-contractor	3.129
14	Waste management officer or personnel employed to handle waste issues	3.0645
15	Giving incentives	2.9677
16	Recycling of some waste materials on site	2.9355
17	conducting waste audits	2.9032

Volume : 4 | Issue : 6 | June 2014 | ISSN - 2249-555X

C. One Way ANOVA

One way Analysis of Variance was done to compare means of all groups (dependent) against Experience of respondents (Independent).

Here are the hypothesis set for the analysis

H_o: There is no statically significant difference between means of all the variables.

H_a: There is statically significant variation in means of all variables

TABLE VI ONE WAY ANOVA

GROUP NAME	Sig.
Design and documentation	0.301
Material based	0.065
Execution	0.433
Site management and practices	0.122
Cement	0.182
Steel	0.197
Marble/tiles	0.051
Importance waste recognition	0.182
Barriers to implement waste management	0.094
Strategies/techniques	0.100

As we can see in table VI all the groups have significance level greater than 0.05. Hence test fail to reject null hypothesis. In words there is no statistically significant difference between means of these groups even though respondents experience different.

VII. conclusion

The generation of construction waste also contributes to the depletion of raw materials used in the construction industry hence leading to shortage of raw materials.This study is focused on material waste in construction projects, it also identified the major causes of waste in construction and presented a comprehensive analysis of these causes.

The top twenty factors causing material wastes are Selecting the lowest bidder subcontractor without knowing their skills of handling material, Using untrained labors, Rework due to workers mistakes/Poor workmanship, Slow in making decisions, Selection of low quality products which causes more rework, Damage materials on site, Lack of workers skill, Improper Interaction between engineers and workers, Insufficient information provided to project participants, Poorly scheduled materials procurement, Using materials with manufacturing defects, Purchased materials that don't comply with specification, Using wrong construction method, Shortage of technical professionals, Lack of supervision and delay of inspections, Incomplete contract documents at commencement of project, Using excessive quantities of materials more than the required, Damage due to Improper packing of materials.

Also causes of wastage for cement, reinforcement steel and marble/granite/tiles were identified and ranked to know which factors influences more.

Top five reasons for waste recognition are, to know the real requirements of the project represented in materials, time and cost, it participates in project success and achieving profits, to know the exact required quantities for project execution, it helps the contractor to prepare accurate schedules to procure materials, and it participates in increasing the national income in construction industry.

Top five barriers to implement waste management in construction industry are, Lack of technical skills, Inadequate pre-planning, less involvement of contractors and specialists in design process, poorly defined individual Responsibilities and Unsuitable organizational structure.

Top five strategy/techniques practiced in constructing industry currently are, Training of construction personnel, changing attitude of workers towards the handling of materials by proper training, Improving supervision, Good coordination between store and construction personnel to avoid over-ordering and proper storage and handling of materials on site.

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