Identification of Factors Affecting Waste Generation in Construction Project and Waste Management by Six Sigma Principles

Pradeep Kshirsagar[1], Mr. S. V. Joshi[2]

[1]Student, Government College of Engineering, Karad
[2]Professor, Dept. of Civil Engineering, Government College of Engineering, Karad

---

Abstract - *In India, the construction industry is one of the largest industries after agriculture industry. It produces a large quantity of waste and consumes more resources. The main aim of the work is to identify the factors which are responsible for waste generation in construction industry. We have conducted questionnaire survey and by analysis of data collected from survey we got the some important factors. We need to concentrate on those factors to reduce waste generation. For waste Management in construction industry several methods such as DMAIC lean six sigma principle, 3R concept are used to control the waste generation and have cost efficient and environment friendly project.*

***Key Words*: DMAIC, Waste Management, cost efficient, Six Sigma, 3R etc**

1. INTRODUCTION

Construction waste has been considered as one of the burning issue in construction industry and due to construction waste cost of project is also increasing. So to reduce the cost of project we have minimize the generation of construction waste. In this work we are going to identify the factors which are responsible for construction waste generation and to reduce that by application of various advance methods.

1.1 .1 Objective

1) Identification of factors affecting waste generation and reasons for same through questionnaire survey.

2) Waste reduction through six-sigma application and model development for Construction waste reduction.

3) 3R application for further reducing the impact of waste materials on project and environment.

2. METHODOLOGY

The literature of research work carried out and identified the various factors affecting construction waste. Analysis the data collected from the different sites using RII method and also various methodologies adopted to reduce waste generation.

2.1 Data collection through questionnaire survey

The survey was distributed to different professionals with the titles of project manager, field engineer, and site supervisor etc. A questionnaire survey was designed to collect information to understand the factors affecting generation of construction waste on a construction site. Through research of survey development a survey of 26 factors was prepared and distributed among 48 construction professionals. The research process tried to explore the percentage of waste generated in the major construction activities like design, material handling, operation and procurement. These four major activities are divided into sub activities accordingly. A scale was prepared to determine the intensities of each sub activities.

2.2 Data Analysis

The feedback from the respondents had been analyzed using Microsoft Excel application. Based on the content of the questionnaires, the analysis was divided into two sections: demographic and relative importance index analysis. Relative index analysis was selected in this study to rank the criteria according to their relative importance. The following formula is used to determine the relative index

$RI = \sum W / (A \times N)$

Where w is the weighting as assigned by each respondent on a scale of one to five with one implying the least and five the highest. A is the highest weight and N is the total number of the sample.

Based on the ranking (R) of relative indices (RI), the weighted average for the two groups will be determined. According to Akadiri (2011), five important levels are transformed from RI values: high (H) ($0.8 \leq RI \leq 1$), high medium (H–M) ($0.6 \leq RI \leq 0.8$), medium (M) ($0.4 \leq RI \leq 0.6$), medium-low (M-L) ($0.2 \leq RI \leq 0.4$) and low (L) ($0 \leq RI \leq 0.2$).

Table- Output from questionnaire survey

Sr. No.	Category	Statement	Factors	Relative Index	Ranking by Category	Overall Rank
1	DESIGN, PLANNING	1.i	Lack of attention paid to dimensional coordination of product.	0.8292	3	7
2		1.ii	Changes made to design while construction is in progress.	0.8583	2	4
3		1.iii	Required quantity unclear due to improper planning.	0.7375	7	18
4		1.iv	Lack of attention paid to standard sizes available in the market.	0.7625	5	12
5		1.v	Designer's unfamiliarity with alternative products.	0.6917	10	25
6		1.vi	Complexity of detailing in drawing.	0.7042	9	23
7		1.vii	Lack of information in the drawing.	0.7667	4	11
8		1.viii	Error in contract document.	0.875	1	2
9		1.ix	Incomplete contract document at commencement of project.	0.7583	6	13
10		1.x	Selection of low quality product	0.7333	8	19
11	OPERATION	2.i	Error by trades person or labours.	0.7375	6	17
12		2.ii	Accidents due to negligence.	0.725	7	20
13		2.iii	Damage to work done caused by labours.	0.7125	8	21
14		2.iv	Use of incorrect material (those requiring replacement).	0.7458	5	16
15		2.v	Method adopted and sequence of construction.	0.7833	3	10
16		2.vi	Delaying in passing the information to the contractor on type of product to be used.	0.8	2	9
17		2.vii	Equipment manufacturing error.	0.7542	4	15
18		2.viii	Weather problem or atmospheric condition.	0.85	1	5
19	MATERIAL HANDLING	3.i	Damages during transportation.	0.8708	2	3
20		3.ii	Inappropriate storage leading to damage or deterioration.	0.8917	1	1
21		3.iii	Materials supply in loose form.	0.7583	4	14
22		3.iv	Unfriendly attitude of project team and labour.	0.8208	3	8
23		3.v	Theft.	0.7083	5	22
24	PROCRUMENT	4.i	Ordering errors (more or less).	0.8458	1	6
25		4.ii	Lack of possibility of order of small quantities.	0.6833	3	26
26		4.iii	Purchased product that do not comply with specification.	0.6958	2	24

3. Construction Waste Management

Calculation of six sigma level

3.1 DMAIC Methodology

Steps to calculate current six sigma level:

Calculation of Defects per million opportunities

DPMO = (Number of defects)* 1000,000 /

((Number of Opportunities/Unit) x Number of Units)

No of defects -Wastage quantity

No of opportunities - Check against waste

No of units - Estimated quantity

DESCRIPTION	ESTIMATE	TRANSPORTATION DAMAGE	USED	ON SITE DAMAGE	DPMO	SIGMA LEVEL
Reading 1	900	19	871	29	46605263	3.41
Reading 2	4152	57	4076	76	72175439	3.74
Reading 3	1072	11	1051	21	96500000	3.75
Reading 4	450	8	446	4	56000000	3.76
Reading 5	750	8	740	10	93125000	3.78
Reading 6	600	7	592	8	85142857	3.77
Reading 7	380	4	376	4	94500000	3.81

Table- Calculation of sigma level for AAC block

DMAIC in the Six Sigma methodology is being used as the definitive for planning and application of the project and for improving the process. This methodology abide of five steps.

Define --> Measure --> Analyze --> Improve ->Control

- Define : The problem that needs to be advised is determined
- Measure: Measure the problem and process from which it was developed.
- Analyze : Analyzing the data and process to determine root causes of defects.
- Improve : Improve the process by analyze actions to decide, decline and Prevent forthcoming problems
- Control : Implement, control, and preserve the actions to improve the processes.

3.2 The 3R

Reduce: The main motive of "Reduce" is to bank resource and to reduce waste. In other terms, reducing refers to using the things with care to reduce the amount waste generated. In general reduction can be done in many ways like,

- Resource saving.
- Reduction of waste by controlling the factors generating it.
- Development of resource saving design.

Recycle: The word recycle mean to use all or a part of waste or used product/materials with the help of processing techniques. Recycling is the last step in the 3 R system after which the material or product is directly disposed. In recycling phase the materials are processed up to a extend so that they can be used again.

Reuse: Reusing includes the repeated use of items or parts of the products which still have the ability of being used. This can be done by proper management and segregation of waste by which each material can be categorized accordingly. The following can be used for reusing of materials/products,

- Easy separation of materials.
- Inspection techniques.
- Promoting reuse of materials.

4. CONCLUSIONS

1) From the study it can be concluded that following factors affect waste generation and following materials contribute towards waste:

Factors –

- Inappropriate storage leading to damage or deterioration.
- Error in contract document.
- Damages during transportation.
- Changes made to design while construction is in progress.
- Weather problem or atmospheric condition.

2) Six sigma tools were used to minimize the waste generation on site which resulted in increase of level from 3.41to 3.81.

3) By application of waste management model the waste can be sorted in proper manner and can be reused and recycled

5. REFERENCES

1. Hee Sung Cha, Jeehye Kim and Ju-Yeoun Han, (2009) "Identifying and Assessing Influence Factors on Improving Waste Management Performance for Building Construction Projects", Journal of Construction Engineering and management, volume 135.

2. Sunil V.Desale, Sharad V.Deodhar (2014)''Indentifiction and eliminating waste in construction by using lean and six sigma principles.'', International Journal of Innovative Research in Science, Engineering and Technolgy ,Volume 3.

3. T.Subramani, Shanu Khan (2018) "Lean Technology And Waste Minimization In Construction Industry Using SPSS.", International Journal of Emerging Trends & Technology in Computer Science (IJETTCS).

4. T.O. Adewuyi, I.A. Odesola, (2015) "Factors affecting material waste on construction sites in Nigeria", Journal of in Engineering and Technology. Vol. 6.

5. K. Agyekum, J.Ayarkwa, (2013) "Minimizing Materials Wastage in Construction- A Lean Construction Approach" Journal of Engineering and Applied Science.

6. AmithaP1,Dr.T.Shanmugapriya2 (2016) "IMPLEMENTATIONOFLEANSIXSIGMAIN CONSTRUCTION:AREVIEW", InternationalJournalofScience,Engineering andTechnologyResearch(IJSETR) Volume5.

7. Sukumar. S & Radhika. R (2017) "A Study of Implementing Lean Six Sigma in Construction Industry", Imperial journal of inter disciplinary Reasearch(IJIR)

8. Dharati Sote – Wankhade, Dinesh Bhonde(2014) "Optimizing energy through on-site reuse and recycle construction waste in residential project – A Case Study of Pune", 30th INTERNATIONAL PLEA CONFERENCE.

9. L. Y. Shen, Vivian W. Y. Tam, C. M. Tam and D. Drew, (2014) "Mapping Approach for Examining Waste Management on Construction Sites, Journal of Construction Engineering and Management, Volume 13.

10. Mansi Jain, (2012) "Economic Aspects of Construction Waste Materials in terms of cost savings – A case of Indian construction Industry", International Journal of Scientific and Research Publications, volume 2.

11. Kuo-Liang Lee, Yang Su (2013) "Applying Six Sigma to quality improvement in construction" ASCE, Journal of management in Engineering, Vol. 29