Analysis of Wastes in Construction Industry with Lean Thinking

S. S. Patil[1], A. K. Gupta[2], D. B. Desai[3]
1. Asst. Professor, Dr. J. J. Magdum College of Engineering, Jaysingpur-416101
2. Vice Principal Dr. J. J. Magdum College of Engineering, Jaysingpur-416101
3. Head of Department Dr. J. J. Magdum College of Engineering, Jaysingpur-416101

Abstract

Construction industry had the features like uniqueness, temporary multiorganisation and regular intervention of authorities which will affect the flow process of a project. This paper depicts various techniques that we can use to avoid these problems and under process smoothly and efficiently. This paper also emphasizes on the study of implication of wastage control of a construction project. This paper delivers a much broader concept to the waste in which each wastes were put under various classification and their elimination/ mitigation can be dealt with in the belonging class. In general, in waste paradigm sees that all those activities that produce cost, direct or indirect, but do not add value or progress to the product can be called waste. Waste is measured in terms of costs, including opportunity costs. Other types of waste are related to the efficiency of the processes, equipment or personnel and are more difficult to measure because the optimal efficiency is not always known. Next will give a clear picture about the classification of construction waste in which a much broader classification will be given to reduce/ mitigate it. Construction wastes are classified based on the ratio of prevention investment cost over the cost of waste & source of occurrence. This paper will be very useful to identify the waste and how the waste can be reduced/ mitigated.

1. Introduction

Industry researchers and practitioners have acknowledged that there are many non- value adding activities during the design and construction process and majority of those wasteful activities consuming time and effort without adding value for the client. Since the beginning of a construction project, Construction Managers have to deal with many factors that may negatively affect the construction process, producing different types of waste**.** Waste includes both the incidence of material losses and the execution of unnecessary work that generates additional costs but does not add value to the product**.** Moreover, some researchers, stated that waste in construction and manufacturing include delay times, quality costs, lack of safety, rework, unnecessary transportation trips, long distances, improper choice of management, methods or equipment and poor constructability.

Waste in the construction industry has been the subject of several research projects around the world in recent years. However, most of the studies tend to focus on the waste of materials, which is only one of the resources involved in the construction process. This seems to be related to the fact that most studies are based on the conversion model, in which material losses are considered to be synonymous of waste. Many people in the industry have considered waste are directly associated with the debris removed from the site and disposed of in landfills and they suggested that the main reason for this relatively narrow view of waste is perhaps the fact that it is relatively easy to see and measure. The main focus for those conventional material waste studies in construction were seen to be restricted to physical waste or material waste in construction and/ or the specific impacts due to the physical waste itself. In new production philosophy, "waste" has been given a broader concept and definition as compared to its usual narrow meaning.

According to the new production philosophy, waste should be understood as any inefficiency that results in the use of equipment, materials, labour, or capital in larger quantities than those considered as necessary in the production of a building. Waste

includes both the incidence of material losses and the execution of unnecessary work, which generates additional costs but do not add value to the product. In search for the waste, loss of value and non-value-adding activities in current construction practices, researchers have managed to present a few evidences from various partial studies done by other researchers around the world apart from the material waste from conversion activities. Although in research paper entitled "*TheApplication of the New Production Philosophy to Construction*" it has been stated that there has never been any systematic attempt to observe all wastes in a construction process but nevertheless, partial studies can be used from various countries to indicate the order of magnitude of non-value-adding activities in construction. Basically, In Koskela's research paper, he has been looking for the evidences of waste and value loss due to quality of works, material

2. Problem Statement:

It is presumably that construction industries in India are facing the same generic problems/ wastes on construction activities which were also faced by their counterparts regardless those in developed countries or developing countries. However, the main problem in India (might be the same for most of other countries) is the lack of clear indicators on quantitative parameters to assess the extent of those problems/ wastes to have been impacted on the overall performance and productivity of local construction industries. To date, there have not been many well documented quantitative studies and records on to process-related problems/ wastes which arisen on construction site in India. As a result of that, the introduction of the concepts and framework of new lean construction ideology are seen as an opportunity to address the existing problems in local construction industry and utilizing concepts and framework of new lean construction ideology can then go further to formulate the extent of impacts of those problems/ wastes on a more structured and quantitative basis.

Prior to assess the severity of the process-related problems/ wastes which existed in the construction processes for the local construction industries, the differentiation of traditional and new production/ construction concepts will have to be drawn prior to further investigation and evaluation on any project performances. New measurement parameters such as waste, value, cycle time or variability that was not covered under traditional concepts are to be introduced into this study; the local construction personnel will be subsequently examined with those new parameters to review the level of understanding and practicability in local construction industry compare to the requirements and the concepts set forth by lean construction philosophy

3. Objective

To identify wastes and non-value added activities by preparing questionnaire and taking the feedback from various companies and to analyze major cause and source of waste

4. Methodology

The research is conducted through structured questionnaires where those questionnaires were sent to the particular "qualified" respondents. The respondents were approached through their companies and firms, which registered in the ISO. A pilot survey was conducted during October year 2011 where 21 sets of questionnaires were sent out to a random group of pilot respondents in postal mail (with returned envelop and stamp attached) around Maharashtra for a period of 1 month but the respond rate to the questionnaires were are low with only 2 sets of surveys were returned during the trial period.

Due to the circumstances of low respond rate in the pilot survey, a new approach of distributing the questionnaires has been taken. The targeted research locations have been focus more into other region of Maharashtra where direct contacts with the potential qualified respondents were more easily accessible. Besides 21 new sets of questionnaires were posted out together with 21 sets post out through e-mail throughout Maharashtra, there were also 30 sets of questionnaires were hand-delivered (mainly in northern Maharashtra) to the respondents from December 2011 until February 2012. Until the due date, 21 of questionnaires were returned (including 2 from pilot survey) which represented an average response rate of 40%. Approximately..

This research was postulated around determining the general perceptions and actions of the construction personnel against wastes in construction and the concept of nonproductive time or wasted time as suggested by **Serpell et al. (1995)** were then

integrated into the research process as the key element of lean construction philosophy regarding flow concept. In this case, Waste in construction process is classified into three main categories, which are direct conversion waste, non-contributory time waste and contributory time waste. 19 waste elements are outlined consists of 9 direct conversion wastes, 7 non-contributory time wastes and 3 contributory time wastes as shown in **Table 1**

Table 1- Waste in construction process

#	Direct conversion waste	Non-contributory waste	Contributory waste
1	Over-allocation/ unnecessary equipment on site	Waiting for others to complete their works before the proceeding works can be carried out	Time in supervising and inspecting the Construction works.
2	Over-allocation/ unnecessary materials on site	Waiting for equipment to be delivered on site	Time for instructions and communication among different tiers and trades of workers
3	Over-allocation/ unnecessary workers on site	Waiting for materials to be delivered on site	Time for transporting workers, equipment and materials
4	Unnecessary procedures and working protocols	Waiting for the skilled workers to be on site	------
5	Material loss/ stolen from site during construction periods	Waiting for the clarification and confirmation by cilent and consultant	------
6	Material deterioration/ damaged during construction periods	Time for rework/ repair works/ defective works	------
7	Mishandling or error in construction applications/Installation	Time for workers' resting during construction	------
8	Materials for rework/ repair works/ defective works	------	------
9	Accidents on site	------	------

5. Ranking on frequencies of occurrences for wastes exist in construction processes

The purpose of this analysis is to determine the frequency of occurrences of construction wastes as experienced by the respondents, the frequencies of occurrences for construction wastes are analysed by using one-way *t*-test to determine the mean values, standard of deviation and standard error mean and the mean of scores were listed in descending order as shown in **Table2**

From the mean ranking results, it shows that time wastes categories regardless of contributory time or non-contributory time wastes occurred at the top of the list compared to direct conversion wastes. Therefore, it is recommended that for construction processes improvements, it is eventually those contributory and noncontributory times waste variables that have to be given more attentions and in real fact, most of them are related to process flows and sequences and this can lead to lean construction's tools and methods which are developed mostly to tackle those wastes resulted from process flow inefficiencies.

Table 2-Construction waste variables ranking

#	Construction Waste Variables	N	Mean	Std. Dev.	Std. Error	Waste Categories
P3	Time in supervising and inspecting the Construction works.	21	4.1429	0.91	0.2	Contributory Time
Q3	Time for instructions and communication among different tiers and trades of workers	21	3.762	0.831	18	Contributory Time
E3	Waiting for the clarification and confirmation by cilent and consultant	21	3.714	0.902	0.2	Non-Contributory Time
A3	Waiting for others to complete their works before the proceeding works can be carried out	21	3.619	0.74	0.16	Non-Contributory Time
M3	Time for rework/ repair works/ defective works	21	3.476	0.68	0.15	Non-Contri.Time
N3	Materials for rework/ repair works/ defective works	21	3.381	0.804	0.18	Direct Conversion
C3	Waiting for materials to be delivered on site	21	3.333	0.966	0.21	Non-Contri.Time
B3	Waiting for equipment to be delivered on site	21	3.238	0.889	0.19	Non-Contri.Time
R3	Time for transporting workers, equipment and materials	21	3.238	0.995	0.22	Contributory Time
K3	Material deterioration/ damaged during construction periods	21	3.143	0.853	0.19	Direct Conversion
I3	Unnecessary procedures and working protocols	21	3.048	0.973	0.21	Direct Conversion
J3	Material loss/ stolen from site during construction periods	21	3	0.837	0.18	Direct Conversion
G3	Over-allocation/ unnecessary materials on site	21	2.952	0.865	0.19	Direct Conversion
O3	Time for workers' resting during construction	21	2.952	0.865	0.19	Non-Contri.Time
L3	Mishandling or error in construction applications/Installation	21	2.905	0.944	0.2	Direct Conversion
D3	Waiting for the skilled workers to be on site	21	2.857	0.964	0.21	Non-Contri.Time
F3	Over-allocation/ unnecessary equipment on site	21	2.55	0.926	0.2	Direct Conversion
S3	Accidents on site	21	2.524	0.75	0.14	Direct Conversion
H3	Over-allocation/ unnecessary workers on site	21	2.476	0.873	0.19	Direct Conversion

6. Ranking on likeliness for sources/ causes for the construction wastes

Table 3-Sources/ causes of construction waste ranking

#	Mean	Std. Dev	NO	Sources/ Causes for Construction Wastes	Sources/ Causes Factors
E2	3.7	0.458	21	Late information and decision making	Information &communication factor
A1	3.35	0.726	21	Poor coordination among project participants	management &Administration Factors
D2	3.35	0.653	21	Poorly scheduled delivery of material to site	Material Factors
E3	3.25	0.698	21	Unclear information	Information & communication factor
D3	3.25	0.622	21	Poor quality of material	Material Factors
A2	3.25	0.698	21	Poor planning and scheduling	management &Administration Factors
A3	3.2	0.509	21	Lack of control	management & Administration Factors
D1	3.2	0.812	21	Delay of material delivery	Material Factors
E1	3.15	0.653	21	Defective or Wrong information	Information & communication factor
D4	3.1	0.768	21	Poor equipment choice or ineffective equipment	Material Factors
B2	3.1	0.768	21	Inexperience inspectors	People Factors
D6	3.05	0.739	21	Poor site documentation	Material Factors
B3	3	0.447	21	Too few supervisors/ foreman	People Factors
C5	2.95	0.739	21	Poor site layout and setting out	Execution Factors
C6	2.95	0.668	21	Poor site documentation	Execution Factors
B5	2.95	0.739	21	Supervision too late	People Factors
B4	2.9	0.538	21	Uncontrolled sub-contracting practices	People Factors
C4	2.85	0.653	21	Poor equipment choice	Execution Factors
A4	2.8	0.748	21	Bureaucracy	management & Administration Factors
B1	2.8	0.678	21	Lack of trades skills	People Factors
C3	2.7	0.556	21	Equipment shortage	Execution Factors
D5	2.7	0.458	21	Poor storage of material	Material Factors
B6	2.65	0.572	21	Poor labour distribution	People Factors
C1	2.55	0.589	21	Inappropriate construction methods	Execution Factors
C2	2.5	0.5	21	Outdated equipment	Execution Factors

As from the mean ranking result shows that Item E2: *(Late information and decision making)* is highly regarded as the main contributory sources or causes to theconstruction wastes with the highest mean value (3.7) and with a 0.35 from the secondrank item D2: *(Poorly scheduled delivery of material to site)* Among the clusters of cause factors observed from **Table3.**

There are 3 categories ofwaste sources/ causes factors are widely acknowledged as the key contributory factorsto construction wastes. Those categories included Information and CommunicationFactors, Management and Administration Factors and Material Factors as most of theCause factors captured under these 3 categories are rated with the mean value over 3.Overall, the likelihood of recognising the items above as the sources/ causes of wastesthat will impact on the productivity of the projects, are still reasonably high as most ofthe mean value for the items tested were clustering around the scale “3” valuerepresenting “likely as a sources/ causes

of wastes". However, there are also someexceptions such as Item C1: *(Inappropriate construction methods)* and Item C2: *(Outdated equipment)* both recorded a slightly low mean values of 2.55 and 2.50respectively..

7. Conclusion

Degree of problems arisen of the wastes identified Based on the ranking of the event occurrences frequencies for waste events existed in construction processes shows that the most frequent waste events occurred in construction activities are actually flow related with both contributory time wastes and non-contributory time wastes were at the top of the ranking list. On the other hand, many direct conversion wastes are recorded rather low scores mostly in the range of "Seldom" and "Very Rare" occurrence events. Eventually by breaking down the waste categories, it is made clear that the flow time wastes are the prominent events that occurred in construction processes. Therefore, based on that information, better performance improvement strategies can be arranged to target at those flow related wastes events, as those events are usually invisible or ignored by conventional construction management. The construction processes can be further streamlined by reducing or eliminating those flow waste elements by implementing the lean construction principles and practices such as employee involvements, kanzan, JIT concepts etc at all level of construction processes.

In this research, major sources of wastes are also been identified directly related to the respective construction wastes from the wastes causes and effects matrix. From the aggregated results shows that management and administrative factors are recognised as the dominant sources of wastes for most of the cases while material factors and people factors are more dominant for a few wastes types. If compared to the ranking of the likelihood for waste factors to impact the construction productivity in general, information and communications factors which are hardly seen as a dominant factor of any construction wastes types at the top of the ranking list follow tightly by management and administrative factors. On the low side, the executive factors and people factors scored relatively low in the ranking.

This is a very good exercise to point out the causes and effects relationship between the sources of waste and waste itself for processes control, reengineering or redesign by targeting directly at the respective sources of wastes for processes improvement. In most leaner construction organization, they usually practice this exercise in a survey called waste identification survey (WIS) through work sampling practices in order to monitor and improve their flow performance from time to time during their construction activities..

8. References

1. Abdulah, F. (2003), "Lean manufacturing tools and techniques in the process industry with focus on steel", University of pitsburgh, school of engineering, U.S.A
2. Alarcone, L.F. (1997), "Tools for the identification and reduction of wastes in construction projects", lean construction, A.A.Balkrma, pp. 365-377.
3. Ballard G. & Howell G (1997a)", Implementing lean construction stabilizing: work flow", Lean construction, A.A.Balkerma. pp. 105
4. Ballard G. & Howell G (1997b), "Towards construction JIT", Lean construction, A.A. Balkerma. pp. 297
5. James P. Womack, Daniel T. Jones " Lean Thinking: Banish Waste and Create Wealth in Your Corporation", Simon Schuster Publishers, 2003.
6. Wincel, J. (2004). Lean supply chain management: a handbook for strategic procurement. Vol. 15. New York: Productivity Press.
7. Womack, James P and Daniel T. Jones (2003) lean thinking, pp. 352