IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

REDUCTION OF CONSTRUCTION WASTAGES IN CONSTRUCTION SECTOR BY THE USAGE OF LEAN CONSTRUCTION TECHNIQUES

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ABSTRACT:

There are a lot of non-value adding activities or wastes in construction practices and many among those were left unnoticed or unattended. Previous studies have shown that there were significant amounts of values loss due to construction process flow wastes and tremendous productivity improvements can be achieved by simply targeting at reducing or eliminating those wastes and/ or improve the process flow.

This thesis was conducted on the basis to study the waste concepts and the level of "leanness" in local construction practices based on philosophies and principles drawn by Lean Construction.

The Indian construction industry is characterized by major challenges like low productivity, lack of skilled labour, time and cost overruns etc. These are associated with considerable waste present in the construction sites. While a few large construction companies have started to look into waste reduction and process improvement issues through concepts like lean construction, most organizations are yet to address this issue. As a prerequisite to implementing lean principles, in which a major focus is on elimination of waste, it is important to understand and quantify the amount of waste actually present in Indian construction sites. Waste includes both the incidence of material losses as well as the execution of unnecessary work by labour and equipment's that generates additional costs but do not add value to the product.

Based on the literature review it was identified that human resource issues contribute significantly to the waste in Indian construction sites. From questionnaire survey it was also found that project management and design and documentation issues play an important role in causing waste in construction sites. The average percentage time spent by labour and equipment in non-value adding activities was found to be 46% and 54% respectively. The total cost of waste calculated as percentage of project cost varied from 5.37% to 13.56%. The deviation cost of quality in advanced economies has been found to be at least 14% of project cost. The industry experts estimate that in India it should be higher. Hence it was concluded that considerable amount of waste is present in Indian construction sites (at least 15 to 25%) and there is a large scope to improve the project performance by implementing lean construction principles.

In conclusion, the outcomes of the research suggested that there still have rooms for construction process improvements with the application of lean construction and proper waste concepts instilled to all level of construction personnel and processes.

I. INTRODUCTION

BACKGROUND

Construction is the second largest economic activity after agriculture in India, and it makes significant contribution to the national economy. Construction exercise being labour ferocious has generated employment for around 33 million people in the country. There are predominantly three partitions in the construction industry like real estate, which includes domestic and corporate construction; infrastructure, which includes roadways, railroads, power etc. and industrial that consists of oil and gas refineries, channels, cloths etc.

Indian construction industry beheld a hefty-scale whump in the erstwhile two decades till the economic juncture in 2008.Most construction companies are forced to slow down some of their ongoing projects because of the economic meltdown. One of the major challenges facing this sector is the lack of skilled and quality human resources and the limited ability of capital equipment suppliers to meet the demand. As a result, most projects ends up in time and cost overruns. Skillful project management and innovative solutions are necessary to prevent these tailbacks. A total of $50 billion is estimated to be spent on construction every year in India.

After LPG reforms which are introduced in 1996 developed construction industry, the Real estate sector and Construction industry has become one of the leading industry in India that also plays a fundamental role in the economy of the country. According to an article in MV (Maier Vidor no), it is the 3rd largest contributor to economic growth. In addition, the construction industry employs more than 45 million people and has a majority of cheap workers.

Also, it has been anticipated that the construction assiduity in India will be the 3rd largest in the global market by 2025. It was presumed by government that the construction assiduity in value terms will anticipated to record a CAGR of15.7 to reach $738.5 bn by 2022 and the Real Estate sector to reach a request size of US$ 1 trillion by 2030 from US$ 120 billion in 2017. Despite this humongous growth and amount to spend, the industry has a lack of management and lack of the effective delivery of a certain project. According to Medows D (2011), Procedures in the construction sector are more wasteful than procedures in other industries. Besides, a study discovered that there is 12% waste in process of manufacturing while 57% waste in process time for construction of a project. Also, in the Indian construction sector, the lack of proficient labourers and well-grounded workmanship occasionally questions the quality of work.

- Harshil et. al. (2021)

To prevent the issues in management, waste in the process and increase the effective Lean technique was introduced in Japan for the manufacturing in the automotive industry to eliminate it. Accordingly, Toyota grew to be the world's leading automotive industry by espousing seven principles of reducing waste. Due to those benefits, the Lean fashion now can be applied in the construction sector as well. Therefore, efforts to increase the effectiveness of the construction industry or build industry Lean technique has been applied all over the globe to ameliorate the waste and designed to make projects sustainable, achieving sustainability of in building projects delivery is plausible by using technology and making the project leaner.

NEED FOR THE STUDY

Major infrastructure development programs undertaken over the past two decades have provided the construction industry with the opportunity to undertake a number of mega projects. On its way to development, the industry is facing problems like time and cost increase, low productivity, low security, worst working conditions, poor quality etc. These are associated with significant waste at construction sites. Although some large construction companies have begun to look at process improvement issues through concepts such as waste reduction and lean construction, most companies have not yet solved the problem. Implementing lean principles that focus primarily on waste disposal is essential, as it is important to understand and quantify the actual amount of waste present at Indian construction sites. In general, project managers define the term "waste" as physical construction waste rather than the actual concept of waste. Waste involves both material loss and the execution of unnecessary work, which produces additional cost but does not add value to the product (Koskela 1992). This includes categories such as waiting time, unnecessary shipping, non-value added processing, extra inventory, and rework. However, project managers did not clearly identify such waste. Therefore, it is very important to have a good understanding of the concept of waste and to identify important waste variables and their causes. A proper methodology should be developed to calculate the different categories of waste in terms of cost. Therefore a new philosophy called Project Lean Construction seeks to identify, classify and calculate waste based on the principles of philosophy.

OBJECTIVES AND SCOPE

The objectives of the study are:

1. Identify important waste variables and related waste causes.

2. Determining the amount of different types of waste at construction sites.

3. Proposing ways to reduce them based on lean construction principles.

II LITERATURE REVIEW

CONCEPT OF WASTE IN CONSTRUCTION

In the new production philosophy, "waste" is given a broader concept and definition than its general narrow meaning. According to the new production philosophy, waste must be understood as any inefficiency caused by the use of equipment, materials, labor or capital required in the production of a building. Waste has both material loss and unnecessary work performance, which creates additional costs but does not add value to the product (Cosella 1992). Therefore, waste should be defined as any loss that arises directly or indirectly from cost-generating activities but adds no value to the product from a consumer perspective. Again, any improvement effort should focus on identifying waste in the manufacturing process, analyzing the causes of waste and working to reduce or eliminate these factors.

In this lean production paradigm, the concept of waste is directly associated with the use of resources that do not add value to the final product. This is very much different from the conventional conversion view of production processes where no significant attempts were made to separate the activities into value adding or non-value adding activities. The conventional view sees all activities combined as a whole and therefore waste is being monitored and evaluated as a whole conglomerated additional cost to the production and mainly it only captured costs for the material wastes. The new production philosophy intend to look into and detail out the dimension of waste by identifying non-value adding activities and introduce new measures to wastes such as additional costs or opportunity costs especially due to time waste and value loss which very much invisible in conversion model.

WASTE CLASSIFICATION

Alarcon (1994) Construction and construction waste include waste time, quality cost, lack of safety, rework, gratuitous transportation, long distance, indecorous choice of operation, styles or outfit and poor productivity. Huh.

Formoso (1999) observed that there's an respectable position of waste that can only be reduced by a significant change in the position of technological development. Based on the waste-to-avoid investment ratio, they classify waste into two general groups:

1. Indigestible waste (or natural waste), the investment required for its reduction exceeds the produced economy. The percentage of unavoidable waste in each process depends on the company and the specific site, as it relates to the level of technological development.

2. Preventable waste, in which the cost of waste is much higher than the cost of preventing it.

Shingo (1981) proposed the following waste classification, under which Toyota classifies waste according to its nature based on Ohno's structure of the production system.

1) Waste from over production, 2) Waste from waiting period, 3) Waste from transport, 4) Waste from system, 5) Waste from stock, 6) Waste from operation, 7) Waste from errors. . .

Formoso (1999) proposed a major classification of waste based on an analysis of some construction sites in Brazil as shown below.

1. Overproduction: Related to the production of quantities greater or less than required. This can be a waste of materials, working hours or equipment consumption. It usually produces a list of products that are incomplete or even their total loss in terms of perishable materials. An example of such waste is the high production of mortar, which is not used in a timely manner.

2. Alternative: monetary waste by replacing a material with an expensive material (with unnecessarily better performance); Performing routine tasks by a highly qualified employee; Or using the most sophisticated equipment to fit a more flexible tool.

3. Waiting time is related to the lack of synchronization and material flow position and idle time due to work speed by dissimilar groups or bias. An illustration is idle time due to lack of accoutrements or workspace available to the gang.

WASTE IDENTIFICATION

One aspect that challenges Lean Manufacturing Lawyers is the systematic identification and calculation of waste, the development of lean operations and improved certification. Although it is very important to identify the waste to implement the lean, no large-scale research has been done in this area so far. Alvie et al. (2002a) Investigated waste incidents focusing on non-residential building and infrastructure projects among Indonesian contractor companies. Data were collected through a questionnaire. Research has shown that six factors such as work completion, material waiting, schedule delays, slow traders and on-site raw material waste and lack of supervision have been identified as major variables of waste. Changes in design, slow decision making, lack of skilled staff, improper construction practices, poor coordination among project participants, delay in material delivery to the site and poor planning and scheduling have been identified as critical variables.

A similar study was done by Alvie et al. (2002b) Also in the Australian construction industry. To minimize the negative impact of waste, the paper recommends that contractors keep a detailed record of all on-site incidents related to waste.

WASTE MEASUREMENT

Michael and Russell (January 2005) Architectural engineering is an important component of determining the amount of waste in an operation in a number of performance improvement programs in the construction industry. Contemporary management practices focus on reducing waste to reduce operating costs and increase operational accountability and flexibility. In construction, there are studies that document the level of time wasted on construction activities over the past 30 years as part of efforts to improve productivity. This paper relies on a meta-analysis method to provide a synthesis of the results of all these studies. Analysis shows that an average of 49.6% is allocated to passive activity during construction, although this amount varies widely. Among other things, these results demonstrate great potential for infrastructure improvement through programs that reduce waste activity levels.

Love & Lee (2000) Although it has been widely recognized that additional costs due to rework can adversely affect project performance, there is limited empirical research examining the factors that affect it. The purpose of the research presented in this paper is to determine the impact of different project types and procurement methods on reconstruction costs in construction projects. Using a questionnaire survey, resale costs were obtained from 161 Australian construction projects. The direct and indirect consequences of resale are analyzed and discussed. Contrary to expectations, it has been shown that resale costs do not vary with project type or collection method. In addition, resale contributed 52% to the cost increase of the project and it was found that there was a 26% variation in cost increase due to changes due to direct resale. In order to reduce resale costs and improve project performance, construction companies are expected to begin to gain an understanding of their size, identify the root causes, and begin to consider and measure effective prevention strategies.

In Bernard (2005) New Product Philosophy, "waste" is given a broader concept and definition than its general narrow meaning. According to the new production philosophy, waste should be understood as any inefficiency caused by the use of equipment, materials, labor or capital required in the production of a building. It involves both waste loss and unnecessary work performance, which creates additional cost but does not add value to the product. Therefore, waste should be defined as any loss that arises directly or indirectly from activities that create cost but does not add any value to the product from the consumer point of view. Again, any improvement effort should focus on identifying waste in the manufacturing process, analyzing the causes of waste and working to reduce or eliminate these factors.

III METHODOLOGY

Significant Waste Variables and Waste causing Variables can be identified by conducting a questionnaire survey. Respondents include project managers, construction managers, planning managers, planning engineers and site engineers. Survey has conducted as to know that the frequency of waste generation, the level of impact of waste categories on construction, and the importance of variables attributed to waste be rated on a scale of 1 to 5 on a five-point scale. Data collected and analyzed using the Concept relative importance index. Based on the literature review and questionnaire survey, construction waste is classified as Material Scrap Waste, Additional Inventory, Rework, Labor, and Equipment Inefficiency. Labor and equipment failures are classified as value-added activities such as waiting, idleness, transportation, over-processing and over-movement.

LEAN CONSTRUCTION REVIEW

There have been numerous reviews on lean construction principles, lean construction equipment and technologies, concept of waste in construction, waste identification and classification, waste classification, waste measurement, waste reduction, implementation of lean construction, process improvement, etc.

The following goals:

1. Identify and classify significant wastes and variables that cause waste.

2. Develop a framework for calculating waste types in terms of cost.

3. Suggest improvement measures to reduce waste at construction sites.

WASTE IDENTIFICATION

The literature review identified 56 variables related to waste activity. The variables are then divided into waste variables and waste cause variables. Waste variables can be defined as variables and waste cause variables that contribute to the reduction in the value of structural productivity.

WASTE CATEGORISATION

The variables are divided into waste variables and waste cause variables. Waste variables are pitched variables and waste cause variables are portrayed as waste generating factors to reduce the value of structural productivity.

Waste variables are classified into five orders – Rework, Material, Human Resource, Waiting, and Operations. Waste cause variables are classified into six orders – People, Design and Documentation, Material Management, Project Management, Execution, and External.

QUESTIONNAIRE SURVEY AND DATA ANALYSIS

The questionnaire is given in the appendix and consists of three sections. Details of respondents, projects and company profiles are collected in the first section. The second section includes questions on waste frequency and waste impact / impact level on construction projects. Data analysis was performed based on data collected from the site.

IMPROVEMENT MEASURES

Possible measures of improvement based on questionnaires and sizing from literature and analysis. More interviews were conducted with construction industry experts to get their opinion on reform measures to reduce waste in construction areas.

IV RESULTS AND ANALYSIS

STRUCTURE OF QUESTIONNAIRE

The questionnaire is given in the appendix and consists of three sections. Details of respondents, projects and company profiles are collected in the first section. The second section includes questions on waste frequency and waste impact / impact level on construction projects. Respondents were asked to rate the frequency of generation of waste as (1) never; (2) rarely; (3) occasionally; (4) often; and (5) always. Also the impact / effect level of waste categories on the structure is rated from 1 (no significant effect) to 5 as (high detrimental effect) per waste variable. The causes of waste are discussed in the third section. Waste cause variable effect/impact level on the structure should be estimated from 1 (no significant effect) to 5 (most harmful effect).

The collected data were analyzed using the concept of Relative Importance Index (RII). Importance index for the frequency and effect of the variables is calculated using the following equation.

$$RII = \frac{(5M1 + 4M2 + 3M3 + 2M4 + 1M5)}{5(M1 + M2 + M3 + M4 + M5)}$$

where,

M1 = number of respondents who rated 5

M2 = number of respondents who rated 4

M3 = number of respondents who rated 3

M4 = number of respondents who rated 2

M5 = number of respondents who rated 1

Frequency index calculated for waste variables indicates the frequency at which waste occurs at construction sites. The calculated impact index for the waste variable indicates the effect of the waste variable on the construction performance. Similarly, the calculated impact index for a waste cause variable indicates the importance of the waste cause variable on waste generation at construction sites. Frequency index and impact index were calculated by equation. The frequency index and the impact index are calculated by the equation. The weighted index for each waste variable is calculated by multiplying the frequency index by the impact index. The waste variable is set up in a declining system of their weighted index evaluation to assess the situation. In the case of a waste cause variable, the rank is determined by arranging the variables in the order of decrease of the effect index calculated by the equation. Variable ranking is used to separate important variables.

Weighted Index for waste variable = (Frequency Index) x (Impact Index)

The critical waste and waste cause variables associated with the questionnaire survey specifically refer to the insights of respondents who see waste in the construction industry. It has been equally noted from literary reviews that there are in fact many studies to calculate all types of waste in construction. Adherence to Lean Construction in construction sites is effective if the level of waste in each category is known so that appropriate importance is given and progress can be made to minimize impact. Therefore, an attempt was made to calculate the associated significant waste categories based on literature review and questionnaire research. As the most important step for quantification purpose, waste in construction is classified as materials, quality, inefficient due to equipment and labour.

Material cost is more than 40% of the total construction cost and this is an important factor for the success of a construction project. Material waste includes scrap waste generated on sites and waste due to additional inventory placed in stores. Scrap waste on sites can be caused by a variety of factors, including poor performance, rework, and material loss. Scrap is expressed as a percentage of the amount of waste and generally theoretical or measured quantity compared to the amount of waste.

Excess movement can be defined as any unnecessary or inefficient movement made by workers or equipment during work. Poor working conditions, improper construction methods, etc. can cause this.

CHALLENGES IN IMPLEMENTING LEAN CONSTRUCTION

Because of the spread concepts and principles of Lean Manufacturing, it will be more difficult to implement in existing processes, especially as this implementation will have to face psychological and cultural changes. Therefore, it is illustrated with some major challenges that need to be seriously considered in order to successfully adopt and implement the new philosophy of lean manufacturing in traditional methods.

i. Management Commitment

Leadership is needed to grasp the fundamental change of philosophy with the goal of improving every activity in the organization. Without active initiative from management, change will cease at all natural limits. Management needs to understand and internalize the new philosophy. Change can only be felt by the people; As in the case of investing in new technology it is not entrusted to staff professionals. The management should create an environment conducive to change.

ii. Focus On Measurable And Actionable Improvement

The focus should be on actionable and measurable development rather than capacity building. In fact, defining different flow processes and focusing on their limitations to accelerate and smooth the flow of material and information is just that. Short-term successes strengthen the motivation for further improvement.

In fact in JIT, reducing or deleting a list is a broader goal. However, the reduction in inventory revealed other issues that needed to be addressed in response to the compulsion. Bicycle time, location and variation are also used as drivers because they are fraught with inherent problems. Bicycle timing in particular provides an excellent, easy-to-understand driver that is constantly being improved.

iii. Involvement

Employee involvement naturally occurs when organizational hierarchies break down and new organizations are formed with self-directed teams responsible for controlling and improving their process. However if the hierarchy is intact, participation through problem-solving teams can be encouraged. Therefore employee involvement is required, but not sufficient, to realize the full potential of continuous improvement.

iv.. Learning

Implementation requires a significant level of learning. First, the learning process should focus on the principles, tools, and techniques of improvement. In the next step, the vision becomes empirical.

V CONCLUSIONS

CONCLUSIONS

Construction methods include many worthless ancillary activities or waste and many of them go unnoticed or undetected. The above studies have shown that significant amounts of value are lost due to construction process runoff waste and that tremendous productivity improvement can be achieved by specifically targeting those wastes to eliminate or destroy and / or improve course flows.

This thesis is based on the concepts and principles described by Lean Construction to study the level of "leanness" in waste concepts and local construction methods. Quantitative audit was conducted through a structured questionnaire on a selected group of administrative staff without a target engaged in construction activities.

Lack of skilled manpower, poor planning and scheduling, design changes, inaccurate construction methods and ambiguous specifications were added as the first five important waste cause variables. Workers resting during the construction, wasting raw materials on site, idle workers, waiting for materials and traveling empty - handed are the top five hypercritical waste variables.

QUANTIFICATION OF WASTE

The following conclusions were made after calculating the waste based on data collected from six construction projects:

1. Cement waste as scrap waste, the percentage of total cement in the studied projects ranges from 2.3% to 4.6%.

2. Total 20mm waste in the form of scrap waste changed from 2.7% to 4.1% of the total 20mm in the studied projects.

3. Percentage of total waste of 10 mm in the form of scrap waste, the percentage of total volume of 10 mm ranges from 1.2% to 5.4% of the studied projects.

4. Waste of river sand as scrap waste The percentage of river sand in the studied projects ranges from 3.4% to 4.7%.

5. Reinforcement waste in the form of scrap waste accounts for 1.5% to 2.1% of the total reinforcement amount in the studied projects.

6. The percentage of cement waste in inventory along with the total volume of cement in the studied projects ranges from 33% to 0.67%.

7. 20 mm of total waste was 1.7% to 4.7% as an additional inventory for the total 20mm size in the studied projects.

8. 10 mm total waste as an additional inventory to the total 10 mm total which varies from 2.8% to 5.1% between the studied projects.

9. River sand waste in the studied projects is 0.78% to 3.5% as a percentage of the total river sand amount in the form of additional inventory.

10. Waste amount of reinforcement varies from 1.4% to 2.1% of studied projects as a percentage of reinforcement and inventory

11. % of construction cost during data collection on studied projects Ô Rework cost ranges from 0.064% to 0.141%

In conclusion, research results indicate that there is still room for improvement in the manufacturing process, including lean manufacturing and implementation of appropriate waste concepts for construction personnel and processes at all levels.

SCOPE FOR FURTHER RESEARCH

More case studies should be developed with the help of construction companies to show the benefits of low construction implementation in the Indian construction industry.

Some lean construction tools like Last Planner System, Enhanced Visualization, Daily Huddle Meetings and First Run Studies need to be implemented on some sites and its potential benefits in the Indian construction industry need to be explored in detail.

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