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Necessity of Lean for Flyover Construction

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Abstract: **This paper deals with explaining the importance of application of lean management concepts for flyover construction. A detailed literature review was done to study the conventional practices and the influence of the lean approach in the construction industry. The study was based on primary data, which has been collected through a well designed questionnaire. A sample of 20 respondents was selected on covering different level of experience, profession, qualification and operational locations in the construction field. The questionnaire survey is performed based on causes of waste in flyover construction in the material storage and handling stage and in the procurement stage. The data collected was analyzed using sample t test. Various suggestions were made for minimizing waste in flyover construction based on literature study. Further study is proposed to be done to gain better insight about the adoption of Supply Chain Management in the Indian construction scenario.**

Keywords: flyover, causes of waste, suggestions for improvement.

I. INTRODUCTION

In India, construction industry is the second largest industry after agriculture. The work of many researchers has revealed that the industry's performance can be measured in terms of the following: completion on time, completion within budget and meeting construction codes. Under the increasingly competitive environment, it has become mandatory to improve the quality of work, increase work effectiveness, reduce wastes and costs and increase profit. There is an urgent need to improve the enterprises competitiveness, meet the client's requirement and increase the usage efficiency of resources. Many construction managers agree that the industry is susceptible to multiple wastes, overruns, delays, errors and inefficiency. Thus several project management approaches have emerged to improve construction performance such as lean construction, lean project management and value engineering.

Lean construction has been introduced as a new management approach to improve the productivity, eliminate waste and increase profit in the construction industry. Lean concept has been evolved from the production theory[3]. It accomplishes these objectives through the use of Supply Chain Management (SCM) and Just-In-Time (JIT) techniques as well as the open sharing of information between all the parties involved in the production process[2]. Some researchers believed that although lean concept was established for manufacturing industry, the similarities between the construction processes and manufacturing make lean production theory very applicable to construction.

II. PROBLEM STATEMENT

During the life cycle of the construction projects, most of the contractors are striving hard to reduce their losses and maximize their profits. But they still rely upon fundamental theories and traditional construction project management practices and tools which are already obsolete[1]. Most of them are unaware about new management methods and models that are emerging. In India, the implementation of lean in construction industry is a major task. Hence Indian Construction industry has to get familiarize in lean practices and adopt them into application.

At the flyover construction site obstacles to the current traffic can be observed. The obstacles like improper space management in the site leading to congestion in traffic. Many encroachments are seen in the site causing discomfort to the road users which are shown in the figure below. Due to insufficient budget, the completion of project may get delayed. Due to delay in construction, the issues observed in the site continues to prevail for long time. Hence proper management in scheduling and cost management helps in completion of project on time and within estimated budget. Hence lean concepts can be implemented on site for the management of work flows.

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Figure 1 : Encroachment in the Flyover Construction area

III. METHODOLOGY

In this methodology chapter, the objectives for the study, procedure followed for the identification of significant causes of waste generation in flyover construction are given. The basic lean principles are mentioned. The various stages in flyover construction and the waste generation in each of the stages were discussed. The data collection for analysis and the method of analysis of the collected data were explained. The formulation of questions for survey was given in the form of a table. The questionaire was prepared based on these questions. These questions were taken from the literature study[6].

A. Procedure Followed In The Study

The procedure followed in this study is as follows,

- The factors causing waste generation in each stage of flyover construction have been derived from literature study
- A questionnaire has been prepared with these factors
- Various construction professionals were asked to rate the questions on four point scale for the level of impact. The scale ratings are as follows

  0 - Not at all
  1 - Low
  2 - Average
  3 – High

- The collected data was analyzed using sample t test.
- One sample t test is used to test the statistical difference between a sample mean and a known or hypothesized value of the mean in the population
- Analyzing various causes of waste generation by keeping ‘waste generation is neutral’ as hypothetical value of the mean
- The significant causes of waste generation can be identified through the survey and from the result provided, suitable lean technique can be formulated to reduce the waste generation on site in the future study

B. Method of Calculation Used in the Study

The method adopted in the study for analyzing the waste generating factor is Sample t test. There are two types of sample test generally used for the study of a sample from a population. They are t – test and F – test. The Sample t Test is commonly used to test the following: Statistical difference between a sample mean and a known or hypothesized value of the mean in the population, Statistical difference between the sample mean and the sample midpoint of the test variable. The reasons for the adoption of this method in study are given below:

- Based on the literature study[6]
- When the number of respondents are less than 28 ($n<28$) the sample t test can be performed[13]
- F- test is generally used to check the goodness of fit and population variances but t – test helps in testing population mean
- In this study, ‘no waste generation’ is considered as neutral (mean) hypothesis. Hence causes of wastes in flyover construction by various factors are compared with the mean value (neutral)
- Data are normally distributed

1) One Sample T Test: This procedure provides several reports for making inference about a population mean based on a single sample. These reports include confidence intervals of the mean or median, the t-test, the z-test, and non-parametric tests including the randomization test, the quantile (sign) test, and the Wilcoxon Signed-Rank test. The assumptions[8] of the one-sample t-test are:

- The data are continuous (not discrete)
- The data follow the normal probability distribution
- The sample is a simple random sample from its population. Each individual in the population has an equal probability of being selected in the sample

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The hypothesis used in the calculation of sample test are given below. To attain the above mentioned objectives, the following hypothesis are proposed to be tested. All hypothesis are stated as Null Hypothesis[6]. H01:The opinion of respondents on causes of waste in Material Storage and Handling phase is Neutral (no waste generation). H02: The opinion of respondents on causes of waste in Procurement phase is Neutral (no waste generation).

2) Lean Priciples: There are five fundamental principles for lean thinking, which have to be followed step by step to gain the maximum benefit of the lean success. Five key principles of the lean methodology as follows: Identify Customer value, Map the value stream, Make the product flow, Use pull logistic and Seek perfection in all operation.

C. General Causes and Remedy for Waste Generation in Flyover Construction

1) Pile Foundation for Flyover: Flyovers have been constructed with pier resting on a single pile or on two piles in developed countries. They help in reduction of usage of concrete which is described in the form of a figure below. However, in India, three or four piles per foundation is insisted upon which is not justified[18]. Socketing of piles into hard rock may be justified in specific cases and should not be universalized.

Figure 2 : Pile foundation for flyover

2) Piers of flyover: Ideally, circular piers of 1m to 2m diameter in high strength concrete should be adequate for up to six lanes of traffic[18]. The pier configuration can also be carefully chosen to eliminate pier caps. This reduces the construction time.

Figure 3 : Circular piers used in flyover construction

3) Superstructure of flyover: Most of the urban flyovers are built on heavily congested roads. Therefore in-situ work is reduced to the minimum. Beams, segments etc. are precast off-site, transported and erected during night. Precast pretensioned beams are extensively used for spans upto 45m. Indian flyovers use beams with conservative L/D ratio of 15-25 which will be expensive[18]. In USA, pretensioned beams of large spans to 45m are in vogue with slender L/D ratio of 25 to 35.[18]

4) Span range of the flyover: The span range directly results from the site conditions. The span length influences the selection of cross sections and also the erection method of 20 m beam are easily erected using a single 50 t crane[18]. The individual spans should be transformed into a full continuous system by using diaphragms and continuous deck slab at the supports. By eliminating bearings under each individual girder, the width and thickness of the pier can be substantially reduced.

5) Flyover beam cross section: Many different types of cross sections have been used for precast beams. As per IRC, precast T beams placed at 0.6m to 4m centres with in-situ concrete deck slab is common. In India, for a typical 30 m span, it was usual to provide four T beams for a 7.5 m carriageway[18]. This was subsequently reduced to three beams and also two beams by many designers in order to realize the minimum quantities of concrete and/or steel. This does not necessarily result in overall economy and ease of construction. 6) High strength concrete used in construction: High strength concrete up to 80 MPa is now permitted in IS 456 2000. A shallow section with a high strength concrete

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can be more cost effective than a deeper section with normal strength concrete.

7) Standardization of Precast materials: The Ministry of Road Transport and Highways (MORTH) has attempted to set up standard drawings for spans up to 40 m in reinforced and prestressed concrete. These are not been widely used as they are not economical. In the absence of standardization in India, chaotic conditions prevail[18]. No two designs, even by the same organization are identical. Formwork has to be manufactured for each flyover increasing the cost. The equipment in the precasting yard is not standardized, leading to duplication of work.

8) Project management in construction: Traditionally, the engineers appointed by owners have been managing the projects. Employment of independent project management consultants (PMC) based on expertise in flyovers facilitate fast track construction[18]. The PMC can assist the owners in soil investigation, preparation of tender documents, pre-qualifying the bidders, evaluation of tender documents.

9) Quality assurance in construction: Due to the speed of construction and pressure on supervisory personnel in fast track construction, unintended quality deficiencies may occur. The measures to minimize deficiencies in quality are given. Adoption of ISO: 9000 minimises quality deficiencies. The design and construction organizations should get ISO: 9000 certification or should atleast follow all the ISO: 9000 requirements in practice.

10) Reinforcement detailing: The detailing should use a minimum number of diameters of bars. It is always a good practice to standardize the diameter of the reinforcement to be used.

11) Mineral admixtures: IS 456:2000 permits blending of mineral admixtures- fly ash, GGBS etc – to produce blended cements or in the concrete batching plants. The minimum cement content specified in the codes is really meant to be "minimum cementitious materials content".

D. Questionnaire Design

The questionnaire was collected from various construction professionals to analyze the causes of waste generation in flyover construction with accuracy. The survey can be done by two modes as direct survey and online survey.

The questionnaire includes: Details about respondents, 14 questions were related to waste generation due to improper material storage and material handling and 5 questions were about improper procurement. Table 1 shows the format of questionnaire which was conducted to gather information about the causes of waste generation in flyover projects.

Table 1 - Formulation of Questions

MATERIALS STORAGE AND HANDLING	
1	Does Overloading of transport equipment occur?
2	Does usage of wrong method of transport observed?
3	Poor method of storage on site
4	Poor handling of materials
5	Does use of whatever material close to working place take place?
6	Does fear of Theft occur?
7	Is there any possibility of damage to materials on site?
8	Do any waste results from cutting uneconomical
9	Is there any unnecessary inventories on site leading to waste?
10	Overproduction/ production of a quantity greater required or earlier than necessary?
11	Is there any possibility of manufacturing defects?
12	Do lack of onsite materials control observed?
13	Using excessive quantities of materials than required occur?
14	Insufficient instructions about handling?
PROCUREMENT	
1	Is there any errors during ordering (ordering significantly more or less)?
2	Does the Purchased products not comply with specification?
3	Is there any unsuitability of materials supplied to site?
4	Does substitution of a material by a more expensive one happen?
5	Does Changes in material prices cause waste?

IV. RESULT

A combined mean score of Material Storage and Handling and Procurement is calculated by computing variables and converting 14 statements of Material Storage and Handling into one variable and 5 statement of Procurement into one variable. Furthers tests are applied on the new variables.

One sample t-test is applied to check the causes of waste in Material Storage and Handling phase and to determine the significant cause. Null hypothesis was formulated. Table 2 and table 3 shows the One sample t test results for the analysis done to determine the waste generating factor in material storage and handling stage and in procurement stage respectively.

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Table 2 – One sample t test results for material storage and handling

Q.NO.	T	Df	S	$\bar{x}$	95% confidence interval	
					Lower	upper
1	-2.791	19	0.015	-0.684	-1.22	-0.15
2	-1.200	19	0.331	-0.211	-0.65	0.23
3	5.267	19	0.000	1.158	0.70	1.62
4	4.444	19	0.000	0.684	0.36	1.01
5	-0.181	19	0.858	-0.053	-0.66	0.56
6	-1.045	19	0.310	-0.263	-0.79	0.27
7	3.750	19	0.001	0.526	0.23	0.82
8	2.455	19	0.025	0.474	0.07	0.88
9	3.525	19	0.002	0.789	0.32	1.26
10	4.726	19	0.000	1.158	0.64	1.67
11	3.750	19	0.001	0.789	0.35	1.23
12	5.144	19	0.000	1.105	0.65	1.56
13	4.825	19	0.000	0.789	0.45	1.13
14	4.025	19	0.001	0.789	0.38	1.20

Table 3 – One sample test result for procurement

Q.NO.	T	Df	S	$\bar{x}$	95% confidence interval	
					Lower	Upper
1	2.342	19	0.030	0.316	-0.22	0.85
2	0.960	19	0.350	0.263	-0.33	0.84
3	2.382	19	0.035	0.474	0.04	0.91
4	-1.810	19	0.088	-0.444	-0.96	0.07
5	2.157	19	0.045	0.579	0.02	1.14

A. SIGNIFICANT CAUSES OF WASTE AS PER TEST RESULTS

1) For Material Storage and Handling: Overloading of transport equipment, Poor method of Storage on Site, Poor Handling, Damage to material on site, Waste resulting from cutting uneconomical shapes, Unnecessary inventory on site lead to waste, Overproduction, Manufacturing defects, Lack of onsite materials control, Using excessive quantities of material than required and Insufficient instructions about handling.

2) For Procurement: Ordering errors, Unsuitability of materials supplied to site and Change in material price.

B. SUGGESTIONS FOR WASTE REDUCTION

From the results obtained in the sample t test, suggestions are made for the reduction of waste generation in flyover construction. These suggestions have been taken from the literature study[6].To reduce waste in infrastructure project, management should thoroughly understand the cause of waste that occurs in Material storage, material handling phase and Procurement phase. Managers should look in to the matter of overproduction and using excessive quantities of material than required and unnecessary inventory by proper planning of activities. Purchase managers should be much more sensible while ordering materials to site as ordering errors lead to a huge stocking of materials on site which leads to waste. Keeping in view that material price might rise in near future; managers tend to buy a bulk of materials to avoid losses due to price rise. Bridges, flyovers etc design should be studied thoroughly before actually starting construction as once constructed with wrong design, structure can only be dismantled, hence leading to waste.Stores should be in such a way that it is not affected by the calamities like rain etc.

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