

A Study on Lean Management System Indicators and its Impact to Waste Minimization

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Abstract— Waste within the industry has been the topic of many analysis comes round the world in recent years. The lean manufacturing is a popular means of continuous improvements that has reshaped manufacturing process, practices and principles globally. Originating from the construction industry, the approach has been used extensively in the manufacturing sectors. Lean producing focused round the philosophy of unceasingly up performances by consistently eliminating wastes. Lean construction considers construction wastes as potential wastes that hinder flow of values to the client and should be eliminated. The aim of the study is to advance knowledge in construction site waste minimization through the lean principles. The main objective of this study is to assess the impact of lean principles in construction using key performance indicators. KPI can be used to help a group to describe their ideas in a pictorial form which has been applied in many different areas; elimination of waste, shifts in organizational behavior, procurements, quality, and delivery as fast as possible, continuous improvements. The main tool for the collection of data is structured questionnaire. The target population for the data collection is projects managers, supervisors of the construction firms. SPSS will be employed to analyze the data obtained. After this step the KPI will be evaluated using those results from which, it will be concluded that, how the construction companies can apply in construction firm its continuous improvements.

Keywords— *Lean principles, Eliminating waste SPSS.*

I. INTRODUCTION

The core plan is to maximise client worth whereas minimizing waste. Simply, lean means that making additional worth for patrons with fewer resources. A lean organization understands client worth and focuses its key processes to incessantly increase it. The ultimate goal is to supply good worth to the client through an ideal worth creation method that has zero waste. To accomplish this, lean thinking changes the foremost target of management from optimizing separate technologies assets and vertical

departments to optimizing the flow of product and services through entire worth streams that flow horizontally across technologies assets and departments to customers. Eliminating waste on entire worth streams, rather than associate degree isolated points, creates processes that require less human effort, less space, less capital and less time to make products and services at abundant} less prices and with much fewer defects, compared with ancient business systems. Companies ar able to reply to ever-changing client needs with high selection, prime quality, low value and with in no time turnout times. Also data management becomes a lot of less complicated and additional correct. Construction projects usually involves multiple discrete organization workings all together on jam packed sites. They suffer from waste that's manifested in waiting time for crews, reworks, unneeded movements and handling of materials, unused inventories of workspaces and of materials, etc. achieving smooth work flow with minimal waste requires not only appropriate construction planning but also effective production management. A Lean operation produces simply what's required, once it's required with no extra labor, costs, inventory or time. Learn the abilities necessary to use Lean techniques to cut back waste and improve method potency. Gain a sensible understanding of Lean continuous improvement techniques and the way to use them to cut back errors, inventory and production time interval.

II. LITERATURE REVIEW

D.T. Matt et al. (2013) Implemented of Lean Production Principles over the last twenty years has had a notable impact on many manufacturing enterprises. After implementation in large enterprises belonging to the automotive sector the concept of lean thinking was introduced successfully in medium sized enterprises. Considering statistical data and analysis about the economic importance of small enterprises we can see, that they are numerous and create a notable part of the total value added in the non-financial business economy

Raid Al-Aomar (2012) Investigate the applying of lean construction practices within the industry and develop a sensible and applicable framework that includes Six letter rating into the simplest practices of lean construction. The objective is to assist the business scale back waste and value, increase effectiveness, and improve quality. Lean construction practices and 6 letter rating completely impact these vital aspects and infrequently lead to reducing waste and prices, up safety and saving energy resources in construction comes.

Rafael Sacks et al. (2010) Explained Lean construction and building information modeling BIM are quite different initiatives, but both are having profound impacts on the construction industry, if properly understood in theoretical terms, can be exploited to improve construction processes beyond the degree to which it might be improved by application of either of these independently, the matrix is not considered complete but rather a framework for analysis to explore the degree of validity of the interactions. Construction executives, managers, designers and developers of information technology systems for construction can also benefit from the frame work.

Chandan Deep Singh et al. (2013) Studied however the principles of 'flow' and 'pull' production suggesting a daily, demand-driven product flow is also enforced for the (semi-) method business by introducing cyclic schedules. Lean manufacturing and JIT play an importunate role in better functioning of SCM. Some of the lean producing principles are: JIT inventory principle, JIT production principle, JIT human resource principle, JIT quality principle, JIT provider relation principle, the current analysis involves role of lean manufacturing and JIT principles in SCM.

III. NEED FOR THE STUDY

The aim of the lean construction is to design, produce and deliver products/services, which exceed customers' expectations in terms of costs/quality/time/performance. The participants will be able to experiences how different management's concepts are integrated and can be applied to build a lean organization focused on customers value creations. Learn to discover and remove wastes in their organizations, own jobs, and simplify process. Cost reduction through process simplifications, inventory reduction and development of managers with acute awareness of creating customers value for top line growth. Lean construction is new way to manage construction. The objective, principles and techniques of lean construction taken together from the basis for new programmatic improvements efforts, lean construction provides the foundations for an operations based project delivery system.

IV. FACTORS IDENTIFICATION

1. Elimination of Waste

Wastage pertains not only to waste of materials but also to precious time lost in waiting for decision, fronts, materials, resources, wasteful processes and practice, double handling of materials, using wrong equipment, as the right one was not available when required. Some of the other common wastages at construction sites which

gets eliminated by lean methods are: waiting for materials or resource or inputs, unnecessary transportation, using wrong methods, unnecessary inventory, buffering to provide for uncertainties, rework as a results of poor quality or misunderstanding of work content or methods, defects and reworking, inefficient team work/ communications. Interest during construction which is an expensive fall out of avoidable delays is another form of waste, which is mitigated by ensuring on time completion using lean principles.

2. Procurements

Procurement is that the method of finding, agreeing terms and deed merchandise, services or works from associate external supply, typically via a tendering or competitive bidding method. The process is employed to make sure the client receives merchandise, services or works at the most effective potential worth, once aspects like quality, quantity, time and placement area unit compared. Corporations and public bodies typically outline processes meant to push honest and open competition for his or her business whereas minimizing risk, like exposure to fraud and collusion. Almost all buying choices embody factors like delivery and handling, marginal profit, and worth fluctuations. Procurement typically involves creating shopping for choices below conditions of insufficiency. If smart information is accessible, it's smart apply to form use of economic analysis ways like analysis or cost-utility analysis.

3. Deliver as fast as possible

Solution owners like rapid delivery and who wouldn't? This may appear contradictory to the last construct to make a decision as late as attainable. But deciding as late as possible helps teams stay flexible and helps teams deliver fast. This is also a direct descendent of JIT (Just in Time) delivery used in manufacturing. With speed comes efficiency; once selections do ought to be created, the probability of delaying is diminished as a result of the speed of the project can force speedy selections once the decision must be made. This concept is typically achieved by breaking down the solution into smaller deliverables working on the sub projects as quickly as possible. Make a place, online or in a team room, where people can go to view the progress of projects. This should give team members a feel for what's been done, what needs to be done, and what is currently being worked on. When a bottleneck or problem arises that may slow down the delivery of a solution, Agile managers should be quick to build a bottleneck task force. The bottleneck task force's job is to break down the problems as quickly as possible to keep the project.

4. Quality

In producing, a live of excellence or a state of being free from defects, deficiencies and vital variations. It is led to by strict and consistent commitment to bound standards that succeed uniformity of a product so as to satisfy specific client or user needs. ISO 8402-1986 commonplace defines quality as "the totality of options and characteristics of a product or service that bears its ability to satisfy explicit or inexplicit desires." If an automobile company finds a defect in one among their cars and makes a

product recall, client responsibility and thus production can decrease as a result of trust being lost within the construction quality.

5. Continuous Improvements

The definition of method improvement looks axiomatic, however it's a lot of advanced in theory and difficult to observe than you would possibly notice. The term refers to the task of distinguishing opportunities for improvement, implementing changes, and, ideally, measure the impact of these changes. Without a structured, continuous approach to method improvement, it's troublesome to stay momentum moving. It's additionally way too simple for busy, overworked groups to become desensitized to method inefficiencies, and permit dangerous habits to fester and have an effect on the standard of their work and speed of their delivery. Continuous improvement (also known as Kaizen) may be a Lean method improvement methodology that has the disciplined approach groups got to keep improvement as their high priority.

6. Leadership and communications

Leadership communications consists of these messages from a frontrunner that area unit unmoving within the values and culture of a company and area unit of great importance to key stakeholders, e.g., employees, customers, strategic partners, shareholders and the media. Values, Messages reflect vision, mission, and culture.

7. Shift in organizational behavior

Organizational behavior (OB) is that the study of the approach individuals act inside teams. Normally this study is applied in an endeavor to make a lot of economical business organizations. The central plan of the study of structure behavior is that a scientific approach are often applied to the management of employees. Organizational behavior theories square measure used for human resource functions to maximise the output from individual cluster members.

V. RESEARCH METHODOLOGY

The methodology is framed according to the goal of the project. The factors that impact the selection of waste are identified through comprehensive review of literature.

From the factors identified, questionnaire is prepared. The questionnaire is to be distributed to construction project managers, contractor across the country through Google forms.

VI. ANALYSIS AND RESULTS

A. Demographic profile

TABE NO 1- DEMOGRAPHIC PROFILE

| Profile | categories | No. of response | percentage |
|---------------------------|-----------------|-----------------|------------|
| gender | Male | 155 | 74.2 |
| | female | | 25.8 |
| Age group | Below 25 yrs | 155 | 40.0 |
| | 26-35 yrs | | 33.5 |
| | 36-45yrs | | 21.3 |
| | Above45yrs | | 5.2 |
| Designation | Project manager | 155 | 40.6 |
| | Site engineer | | 49.7 |
| | others | | 9.7 |
| Educational qualification | Engineering | 155 | 74.2 |
| | Diploma | | 25.8 |
| Experience in the field | Below 2 yrs | 155 | 29.7 |
| | 2-6 yrs | | 38.1 |
| | 6-10 yrs | | 21.3 |
| | Above 10yrs | | 11.0 |

The statistical mean refers to the mean or average that is used to derive the central tendency of the data in question. The questionnaire was framed in 5 point scale. The mean value for all factors were computed. Based on the mean value the factors are categorized and ranked. The Questionnaire were designed with scale as 1 = Strongly agree; 2 = Agree; 3 = Neutral; 4 = Disagree; 5 = Strongly disagree. From the result analysis general factors have the mean close to 2 (Agree).

B. Reliability Analysis

Internal consistency reliability analysis is a parametric procedure used to evaluate the consistency of results across items within a single scale or subscale that is composed of multiple items.

TABLE NO 2 - RELIABILITY

Reliability Statistics

| Cronbach's Alpha | N of Items |
|------------------|------------|
| .831 | 40 |

Reliability coefficients can be interpreted as

- Very high reliability = .90 and above
- High reliability = .70 to < .90
- Moderate reliability = .50 to < .70
- Low reliability = .30 to < .50
- Little if any reliability < .30

C. Regression

TABLE NO 3- MODEL SUMMARY

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|-------|-------------------|----------|-------------------|----------------------------|
| 1 | .649 ^a | .421 | .397 | .43512 |

R is the correlation, its value is 0.999 and R square is degree of determination, its value is 0.999. The degree of determination shows the extent to which waste minimization.

TABLE NO 4 - ANOVAa

| Model | Sum of square | df | Mean square | F | Sig. |
|------------|---------------|-----|-------------|-------|-------------------|
| Regression | 20.338 | 6 | 3.390 | 3.390 | .000 ^b |
| Residual | 28.020 | 148 | .189 | .189 | |
| Total | 48.358 | 154 | | | |

ANOVA table shows that the significant value is less than 0.01, which means dependent variable that is waste is significantly predicted by independent variables namely elimination of waste Supply at 99 % of confidence level.

D. Chi square

Chi-square which is available in cross tab is used to test whether there is a significant association between two variables.

TABLE NO 5- CHI SQUARE TEST

| | Value | df | Asymp. Sig. (2-sided) |
|------------------------------|---------------------|----|-----------------------|
| Pearson Chi-Square | 48.390 ^a | 45 | .338 |
| Likelihood Ratio | 48.737 | 45 | .325 |
| Linear-by-Linear Association | .415 | 1 | .519 |
| N of Valid Cases | 155 | | |

GENDER

- The calculated value is 1.20 E2 which means 12.7 and it significant at this level of significance 0.000 at degrees of freedom 16.
 - In SPSS, if the significant value is less than 0.05 then reject null hypothesis and accept alternate hypothesis. In the above obtained result the significant value is less than 0.05 so, reject null hypothesis.
 - Hence there is significant association between total income and total saving.
- Calculated value (128.7) is greater than table value (39. 253) at degrees of freedom 16 in the 0.000 level of significance in the chi-square table. so we can reject the null hypothesis and accept the alternative hypothesis

AGE GROUP

TABLE NO 6- CHI SQUARE TEST

| | Value | df | Asymp. Sig. (2-sided) |
|------------------------------|---------------------|----|-----------------------|
| Pearson Chi-Square | 10.620 ^a | 15 | .779 |
| Likelihood Ratio | 12.419 | 15 | .647 |
| Linear-by-Linear Association | 4.611 | 1 | .032 |
| N of Valid Cases | 155 | | |

E. ANOVA

Analysis of variance (ANOVA) is used as a test of means for two or more populations. The null hypothesis, typically, is that all means are equal. Analysis of variance must have a dependent variable that is metric (measured using an interval or ratio scale). There must also be one or more independent variables that are all categorical (nonmetric). Categorical independent variables are also called factors.

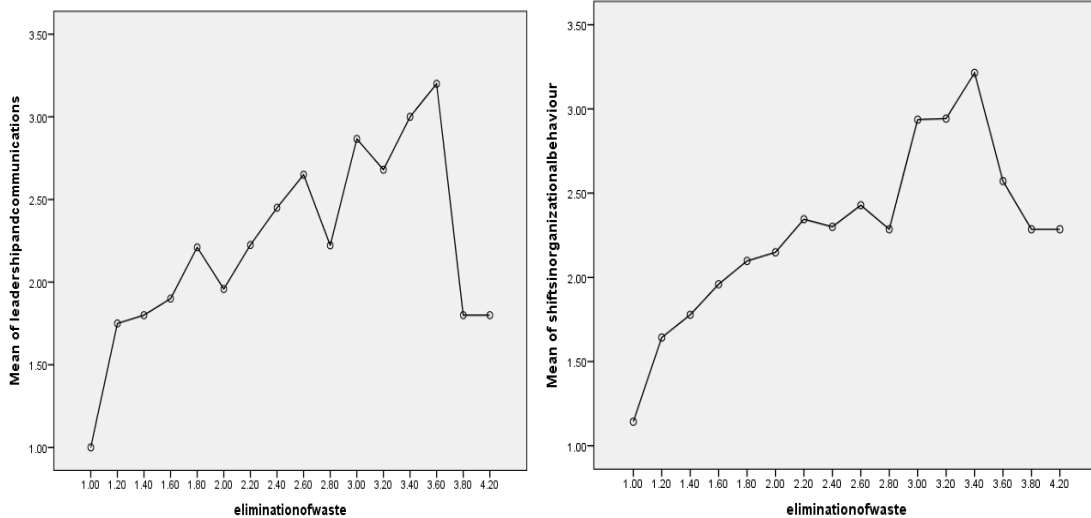


FIG NO 1- ANOVA

| | | Sum of Squares | df | Mean Square | F | Sig. |
|--|----------------|----------------|-----|-------------|-------|------|
| procurementsanddeliverasfastaspossible | Between Groups | 12.758 | 15 | .851 | 5.543 | .000 |
| | Within Groups | 21.329 | 139 | .153 | | |
| | Total | 34.087 | 154 | | | |
| qualityandcontinousimprovement | Between Groups | 13.424 | 15 | .895 | 3.932 | .000 |
| | Within Groups | 31.635 | 139 | .228 | | |
| | Total | 45.059 | 154 | | | |
| leadershipandcommunications | Between Groups | 17.644 | 15 | 1.176 | 4.614 | .000 |
| | Within Groups | 35.435 | 139 | .255 | | |
| | Total | 53.079 | 154 | | | |
| trainingandempowertheteam | Between Groups | 15.233 | 15 | 1.016 | 4.046 | .000 |
| | Within Groups | 34.887 | 139 | .251 | | |
| | Total | 50.119 | 154 | | | |
| shiftsinorganizationalbehaviour | Between Groups | 15.845 | 15 | 1.056 | 6.307 | .000 |
| | Within Groups | 23.280 | 139 | .167 | | |
| | Total | 39.124 | 154 | | | |
| employersperceptions | Between Groups | 11.026 | 15 | .735 | 3.292 | .000 |
| | Within Groups | 31.037 | 139 | .223 | | |
| | Total | 42.063 | 154 | | | |

TABLE NO 7- ANOVA

F. CORRELATION

Correlation is a statistical technique that can show whether and how strongly pairs of variables are related. The mean response of the factors are analyzed. From the responses it is seen that elimination of waste factors are highly correlated having correlation coefficients as 0.672. While Inventory waste factors and damage factors have less correlation with a coefficient of 0.015.

As a rule of thumb use the following guide for the absolute value of correlation (r):

- o .00-.19 “very weak”
- o .20-.39 “weak”
- o .40-.59 “moderate”
- o .60-.79 “strong”
- o .80-1.0 “very strong”

Which is based on the coefficient of determination (r^2). Which indicates the proportion of variance in each of two correlated variables which is shared by both. An index of the degree of lack of relationship is also available. It is the square root of the proportion of unexplained variance and is called the coefficient of alienation $(1-r^2)^{1/2}$. This in turn leads to an estimate of error reduction $1-(1-r^2)^{1/2}$.

VII. CONCLUSION

From the literature study, it was found that lean construction is a best tool for waste minimization, productivity improvements and maximizes values of the customers. A detailed structures questionnaire is prepared based on factors of lean construction such as elimination of waste, shifts in organizational behavior, procurements, deliver as fast as possible, quality, continuous improvements, leadership and communications, training and empowerments, employers perceptions and focus on complexity for successful implementation of lean in construction. The questionnaire has been framed and for the second phase, the questionnaire will get distributed to companies and through Google forms. The data collected from their responses will be analyzed by SPSS& SEM software. KPI will be developed using those results from which it will be concluded that how the construction

industries can apply lean in construction for its continuous improvements with minimization of wastes.

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