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Implementation of Lean Construction And Its Problems On Construction Projects In India

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Abstract

The construction projects are festered with delays and cost over-runs in India. The basic wastages that create delays and cost overruns have occurred in time, men, money, material, and machines. These wastages can be reduced by applying better construction management practices like lean construction in the projects. The lean construction principles can be introduced into the projects by applying the tools like Last Planner System, The 5s process, First, run studies, Increased visualization and Value Stream Mapping, etc., The implementation of these tools is a difficult task in the construction sector which refuses to shed the conventional practices. The need to study the exact problems in the implementation of lean tools is essential to improve the efficiency of implementation. The application feasibility of the Lean Project Delivery System (LPDS), which is nothing but applying lean principles in all stages of construction, is yet to be studied in the Indian context. This project is aimed to study the implementation process of lean construction and its associated problems using a quantitative study. A questionnaire was prepared for collecting data from the lean practitioners all over the country. The collected data were analyzed statistically and the variables were ranked by the Analytic Hierarchy Process. The obtained results from this quantitative study revealed the prominent problems in the implementation of lean which are lack of top management support, lack of collaboration from all the stakeholders in the project, and reluctance to follow the new strategy. Regarding the application feasibility of LPDS, it is found out to be low in the Indian construction context which is in the primitive stage of lean construction evolution

Keywords: *Lean construction, Implementation problems, LPDS feasibility*

I. INTRODUCTION

The construction sector in India contributes around 11% of the nation's GDP (Ramaswamy et al 2009). But this economically important construction sector is deeply stuck in problems like delays, cost over-runs, poor planning strengths, diverse cultures, ill-trained labor, dependence on low technology processes and hierarchical management issues, etc. Better construction management practices like lean construction are the need of the hour to control these problems. Lean thinking is a philosophy based on the concepts of lean production. Lean principles date back at least as far as the early1900's when Henry Ford introduced the principle of the assembly line that revolutionized car production. In the early 1950s, lean production management principles were developed by Toyota led by engineer Ohno. The term "lean" was invented by the research team working on the International Motor Vehicle Programme at Massachusetts Institute of Technology to reflect both the waste reduction nature of the Toyota production system and to contrast it with craft and mass forms of production. Koskela (1992) proposed first to use the lean production principles in the construction context with his seminal technical-report. The author formulated the transformation-flow-value generation model of production, known as the TFV theory of production, which led to the modern lean construction foundations. The author also insisted on the need to review construction production as a combination of conversion and flow processes to remove waste, when traditional thinking of construction was only focusing on conversion activities and ignoring flow and value considerations. Lean construction practices have developed quite well over the last few decades and have lived up to their potential in many different countries, bringing in continuous improvement, inclusive culture, and improved levels of certainty in project delivery. Many lean tools have been developed over the years, such as the Last Planner System, work sampling, value stream mapping, and so on. The benefits such

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as completed within the stipulated time and cost with appropriate quality and safety have been attained in the last two decades by applying these lean construction tools in the projects. The problem-ridden Indian construction sector embraced lean construction for its proven benefits. But the implementations of these lean tools are difficult in this sector. The exact reasons for these implementation hindrances are needed to be studied. Lean Project Delivery System (LPDS) is the mechanism in which lean principles are applied in all phases of the construction project. Being in the primitive stage of the lean journey the application feasibility of the LPDS in India is needed to be studied because the LPDS application would be the ultimate development in the course of the lean journey. The objectives of this paper are to find the issues in the implementation of lean tools and to study the feasibility of the application of LPDS in Indian construction projects. The scope of this paper is restricted to the data collected from the construction professionals based in India.

II. LITERATURE REVIEW

Howell (1999) explained the history of lean production principles and how these principles are incorporated into construction projects as lean construction. Essential features of lean construction include a clear set of objectives for the delivery process, aimed at maximizing performance for the customer at the project level, concurrent design of product and process, and the application of production control throughout the life of the product from design to delivery. **Koskela et al. (2002)** gave explained information about various production theories including the Transformation Flow Value (TFV) theory which leads to the lean construction principle. How conventional practices failed and how the construction can be revived using lean principles were argued in this literature. The authors provided information regarding the Lean Project Delivery System (LPDS) which incorporates lean in every step of construction namely design, supply, and assembly. **Abdelhamid et al. (2005)** briefed about the basics of lean construction and its overall merits. The various tools of lean construction viz. Last Planner System, The 5s process, First run studies, Increased visualization and Value Stream Mapping, etc., are explained. **Alarcon et al. (2013)** studied the basic differences between Lean project delivery and traditional project delivery system in the domains of Operating system, Commercial terms, Allocation of risks and responsibilities, and Awarding contract. The important findings in this literature are new contracts should be developed for lean projects, mutual risk-sharing should be enabled and contracts should be awarded based on lean expertise. **Sarhan et al. (2013)** concluded that the barriers viz. Lack of adequate awareness and understanding, Lack of top management commitment, and Culture and human attitudinal issues are crucial in the implementation of lean in the UK. **Raghavan et al. (2014)** applied lean construction techniques in 9 construction sites in India and found out that the inhibiting factors were seen to be a lack of well-established planning and control systems, poor inclusive culture, or strengthen existing systems coming in the way of formal Lean implementation. **Chesworth (2015)** concluded with the following misconceptions in lean implementation Standardisation is essential for success – because certain things and changes should be done in a site-specific manner, corporate agenda drove the implementation, and Success without a strategic direction. **Vaidyanathan et al. (2016)** employed a lean construction technique in a building in Chennai and showed that the Last Planner System (LPS) is employed in civil works reduced slab cycle time by 50%. The authors suggested using an escrow agent to prevent the cash flow problems experienced by the contractors and concluded that without some fundamental process changes in design and finance management, attempts to bring lean construction processes to the Indian scenario has a risk of failure of adoption.

III. METHODOLOGY

A questionnaire was prepared with a sufficient review of the literature to find out the factors and problems involved in the implementation. The questions and factors mentioned in it were based on the kinds of literature and interaction with industry experts. The questionnaire consisted of 3 parts namely A, B & C. Part – A gave the demographic details of the respondents. Part – B consisted of questions regarding the implementation aspects of lean construction in India. Finally Part – C consisted of questions about introducing a lean project delivery system and its feasibility in implementation in India. The variables in the questionnaire were rated using a 5-point Likert Scale with 1 as Unimportant, 2 as Less important, 3 as Moderate, 4 as Important, and 5 as Most important. A purposive sampling technique was used for finding the potential respondents whose data would be more relevant for the study. The clientele details of the local lean consultant were utilized to find out the respondents. The created questionnaire was hosted as a web survey using Google Forms and sent to the potential respondents. The hard copies of the questionnaire were used for collecting data in person.

53 respondents had taken the questionnaire survey. The collected data were statistically analyzed with help of software like SPSS and Microsoft Excel. The Relative Importance Index (RII) was calculated first using the frequency distribution analysis in SPSS. In the calculation of the RII, the formula below was used.

$$RII = \frac{\Sigma W}{A * N}$$

where, W - weightings are given to each statement by the respondents usually ranges from 1 to 5, A - Highest weighting response integer, and N - total number of respondents. The RII served as the basis for giving the weights in the Analytic Hierarchy Process (AHP). Then the AHP weights were calculated in MS Excel and were used to rank the various factors in the collected data.

In the AHP method the variables were subjected to pairwise comparisons i.e., comparing each variable in pairs to judge which variable was preferred. For pairwise comparison, Saaty's scale of 1-9 was used. The weightings given in Saaty's scale for pairwise comparisons were constructed in the form of a matrix (a_{ij}) as shown in Table 1. Every planning method was compared in pairs with other planning methods. From this matrix, AHP weights can be calculated in different methods. The normalized matrix method was used in this project to find out the AHP weights for all variables.

The pairwise comparison matrix was normalized by dividing all the elements of the matrix with the sum of corresponding column elements (Table 2). The sum of the row elements in the normalized matrix is the AHP weights of the planning methods. Each row denotes a planning method and its sum represents their AHP weight.

The important feature of AHP is that it has the facility to check the consistency of evaluation of decision-makers. The consistency ratio (CR) is the parameter used to find out whether the decision is consistent or not. The consistency ratio is expressed as

$$CR = \frac{CI}{RI}$$

where CI is the consistency index and RI is the average random consistency index developed by Saaty (1987).

The consistency index (CI) is given by

$$CI = \frac{(\lambda_{max} - n)}{(n-1)}$$

where λ_{max} is the largest eigenvalue of the matrixa_{ij}, n is the no. of variables (no. of planning methods in this case). The average random consistency index (RI) is the following set of numbers derived from a sample size of 500, of a randomly generated reciprocal matrix using the scale 1/9, 1/8, ..., 1, ..., 8, 9. The values of RI for small problems (n≤10) are shown in Table 3.

The consistency ratio CR should not be less than 0.10, if it is less than 0.10, study the problem again and revise the judgments of evaluation.

IV. RESULTS AND DISCUSSIONS

A. Demographic details of the respondents

In the survey construction managers (47%) constitute most of the samples followed by engineers (42%), project managers (7%), and Lean consultants (4%). Among them 30% of the respondents have experience of 5 – 10 years, 27% of respondents have 3 – 5 years of experience and 28% of respondents have less than 3 years of experience in the construction industry.

B. Choice of planning methods

The choice of planning method for a construction project is important because it governs the efficiency of implementation. Critical Path Method (CPM) (0.353), Work Breakdown Structure (WBS) (0.240) are the top methods used for planning purposes in various organizations followed by Daily progress reports (0.145) (Table 4). Usage of CPM and WBS shows the reluctance of professionals to shed old practices and follow the latest methods.

C. Causes of waste in construction projects

The opinion of respondents on the amount of waste existing in construction projects is that 42% of professionals responded that the Indian construction projects have 20-40% wastes in it and 40% of professionals responded that Indian construction projects have 40 – 60% wastes. It is evident from these results that the construction projects are needed to be improved on waste reduction area. The top 3 causes for the wastages (Figure 1) in construction projects according to the respondents are Lack of skills in laborers (0.804), Waiting for resources (0.751), and Poor site management (0.747). AHP weights usually don't hold good for variables more than 10, so RII is used as the ranking tool here. Most of these causes of wastes could be rectified by implementing lean construction tools in the projects.

D. The popularity of lean in India

The experience of respondents in lean construction projects is that 87% of the respondents worked in less than 3 lean projects and there are no respondents who worked on more than 10 lean projects. This shows the low popularity of lean construction in India.

E. Benefits of lean construction

The most significant benefits of lean construction according to the respondents are reduction in cycle time (0.333), reduction in waste, defects, and rework (0.233) and creation of culture among the employees (0.139) (Table 5). The benefits like an increased focus on customer requirements and identification of early problems are attributed to the collaborative planning characteristic in lean tools like the Last Planner System (LPS). The respondents don't think the benefit of an increase in profits as popular as others, because of the need for the initial investment to implement lean construction tools that would prevent the higher returns despite increasing productivity and efficiency.

Table 1 Criteria comparison matrix of planning methods

Planning methods	WBS	CPM	Look–ahead plans	Weekly plans	Daily progress reports	Productivity measurements	Constraint analysis
WBS	1	1/2	4	5	2	3	6
CPM	2	1	5	6	3	4	7
Look – ahead plans	1/4	1/5	1	3	1/2	1/2	2
Weekly plans	1/5	1/6	1/3	1	1/3	1/3	2
Daily progress reports	1/2	1/3	2	3	1	2	5
Productivity measurements	1/3	1/4	2	3	1/2	1	4
Constraint analysis	1/6	1/7	1/2	1/2	1/5	1/4	1

Table 2 Normalized criteria comparison matrix of planning methods

Planning methods	WBS	CPM	Look–ahead plans	Weekly plans	Daily progress reports	Productivity measurements	Constraint analysis	AHP weights
WBS	0.225	0.193	0.270	0.233	0.265	0.271	0.222	0.240
CPM	0.449	0.386	0.337	0.279	0.398	0.361	0.259	0.353
Look – ahead plans	0.056	0.077	0.067	0.140	0.066	0.045	0.074	0.075
Weekly plans	0.045	0.064	0.022	0.047	0.044	0.030	0.074	0.047
Daily progress reports	0.112	0.129	0.135	0.140	0.133	0.180	0.185	0.145
Productivity measurements	0.075	0.096	0.135	0.140	0.066	0.090	0.148	0.107
Constraint analysis	0.037	0.055	0.034	0.023	0.027	0.023	0.037	0.034

Table 3 Average Random consistency indices (RI)

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Table 4 Normalized criteria comparison matrix of planning methods

Planning methods	WBS	CPM	Look–ahead plans	Weekly plans	Daily progress reports	Productivity measurements	Constraint analysis	AHP weights
WBS	0.225	0.193	0.270	0.233	0.265	0.271	0.222	0.240
CPM	0.449	0.386	0.337	0.279	0.398	0.361	0.259	0.353
Look – ahead plans	0.056	0.077	0.067	0.140	0.066	0.045	0.074	0.075
Weekly plans	0.045	0.064	0.022	0.047	0.044	0.030	0.074	0.047
Daily progress reports	0.112	0.129	0.135	0.140	0.133	0.180	0.185	0.145
Productivity measurements	0.075	0.096	0.135	0.140	0.066	0.090	0.148	0.107
Constraint analysis	0.037	0.055	0.034	0.023	0.027	0.023	0.037	0.034
Consistency Ratio (CR)								0.028

Table 5 Normalized criteria comparison matrix of lean benefits

Lean construction benefits	Decreases cycle time	Creates a culture among the employees	Higher profits	Reduction in waste, defects, and rework	Increased focus on customer requirements	Identification of early problems	Helps manage conflicts	**AHP weights**
Decreases cycle time	0.366	0.391	0.227	0.438	0.361	0.316	0.233	**0.333**
Creates a culture among the employees	0.122	0.130	0.136	0.109	0.180	0.158	0.140	**0.139**
Higher profits	0.073	0.043	0.045	0.044	0.030	0.026	0.023	**0.041**
Reduction in waste, defects and rework	0.183	0.261	0.227	0.219	0.271	0.237	0.233	**0.233**
Increased focus on customer requirements	0.091	0.065	0.136	0.073	0.090	0.158	0.186	**0.114**
Identification of early problems	0.091	0.065	0.136	0.073	0.045	0.079	0.140	**0.090**
Helps manage conflicts	0.073	0.043	0.091	0.044	0.023	0.026	0.047	**0.050**
							Consistency Ratio (CR)	**0.042**

Table 6 Normalized criteria comparison matrix of lean tools

Lean Tools	Last Planner System	The 5s process	Increased visualization	Daily huddle meetings	Value stream mapping	Root cause analysis	**AHP weights**
Last Planner System	0.382	0.320	0.333	0.387	0.333	0.387	**0.357**
The 5s process	0.096	0.080	0.133	0.065	0.056	0.065	**0.082**
Increased visualization	0.076	0.040	0.067	0.065	0.056	0.065	**0.061**
Daily huddle meetings	0.127	0.160	0.133	0.194	0.222	0.194	**0.172**
Value stream mapping	0.127	0.160	0.133	0.097	0.111	0.097	**0.121**
Root cause analysis	0.191	0.240	0.200	0.194	0.222	0.194	**0.207**
						Consistency Ratio (CR)	**0.047**

Table 7 Normalized criteria comparison matrix of implementation issues

Lean tools implementation issues	Lack of collaboration from all the stakeholders	Lack of top management support	Indifference among the laborers regarding lean	Lack of knowledge about lean principles/tools	Reluctant tendency to follow the new strategy	Lack of training for employees	The complexity of the tool	**AHP weights**
Lack of collaboration from all the stakeholders	0.209	0.180	0.234	0.214	0.255	0.242	0.217	**0.222**
Lack of top management support	0.418	0.359	0.312	0.321	0.383	0.303	0.261	**0.337**
Indifference among the labours regarding lean	0.070	0.090	0.078	0.054	0.064	0.121	0.130	**0.087**
Lack of knowledge about lean principles/tools	0.105	0.120	0.156	0.107	0.064	0.121	0.130	**0.115**
Reluctant tendency to follow the new strategy	0.105	0.120	0.156	0.214	0.128	0.121	0.130	**0.139**
Lack of training to employees	0.052	0.072	0.039	0.054	0.064	0.061	0.087	**0.061**
Complexity of the tool	0.042	0.060	0.026	0.036	0.043	0.030	0.043	**0.040**
							Consistency Ratio (CR)	**0.021**

Table 8Normalized criteria comparison matrix of selection criteria for LPDS

Selection criteria for LPDS	Capital investment	Amount of increase in productivity	Amount of money saved	The complexity of the tool	**AHP weights**
Capital investment	0.100	0.087	0.120	0.077	**0.096**
Amount of increase in productivity	0.300	0.261	0.240	0.308	**0.277**
Amount of money saved	0.400	0.522	0.480	0.462	**0.466**
Complexity of the tool	0.200	0.130	0.160	0.154	**0.161**
				Consistency Ratio (CR)	**0.012**

F. Popular lean tools

The most popular lean tools in construction projects are the Last Planner System (0.357), root cause analysis (0.207), and Daily huddle meetings (0.172) in the opinion of the respondents (Table 6). The tool 5s process is never heard by 11% of respondents and the increased visualizations tool is never heard by 13% of the respondents. The other tools are at least heard by the respondents, though it's not used as much as the LPS, Daily huddle meetings, and the Root cause analysis. From this it pretty evident that LPS is extensively used rather than other tools in construction projects. For starters like India in Lean construction effective and rigorous implementation of lean is sufficient (Koskela 2002).

G. Implementation issues of lean construction

Only by knowing the basic implementation problems, we can improve the efficiency and effectiveness of lean implementation in future projects. The top 3 lean implementation problems are Lack of top management support (0.337), Lack of collaboration from all the stakeholders in the project (0.222), and Reluctance to follow the new strategy (0.139) (Table 7). The lack of top management support seems to be crucial in lean construction implementation because the top management is the one, which wants to implement lean in the first place. But most of the top management in the organizations are not giving the proper time and resources to the site executives for effective lean implementation and also they expect benefits instantly. Lack of collaboration among the stakeholders in the next crucial thing in implementation because construction projects usually involve many players viz clients, general contractors, subcontractors, suppliers, etc. Even if a single player disagrees with lean implementation, the entire lean implementation might affect because of its collaborative functioning. Reluctance to follow the new strategy is the next crucial problem. The basic mindset of an Indian construction professional is to have reluctance in shedding old practices as we have seen in the choice of planning methods also. Lack of knowledge about lean principles and tools is a problem but not as much as crucial those top 3 problems because awareness and knowledge about lean can be improved. Indifference among the laborers regarding lean is an inevitable problem because the lean training process usually never reaches the bottom end of the management hierarchy of the organizations.

The respondents show a keen interest in implementing lean tools again in their projects (97%) despite these implementation problems. This proves the lean is having positive effects on the projects amidst these issues.

H. Selection criteria for LPDS

As far as the LPDS awareness is concerned 57% of respondents don't know about the existence of the Lean Project Delivery System (LPDS). Lack of awareness about LPDS will affect the feasibility of its implementation in Indian construction projects. The respondents precisely need some economic benefits (0.466) when they are going to implement the Lean Project Delivery System (Table 8). The increase in productivity (0.277) is the next primary motive for applying LPDS among the respondents. The complexity in the project delivery system is the next important criterion for the selection of LPDS. Since it involves the application of lean principles from the design stage itself the new tools' (in design phase) complexity will impact the selection process more. The capital investment won't be that much of a problem as far as it gives gains to the project and the organization.

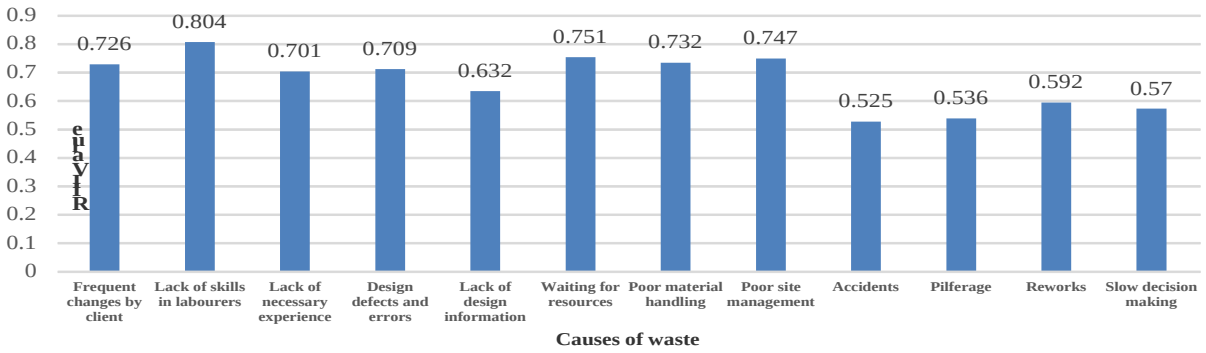

Figure 1 Causes of wastes

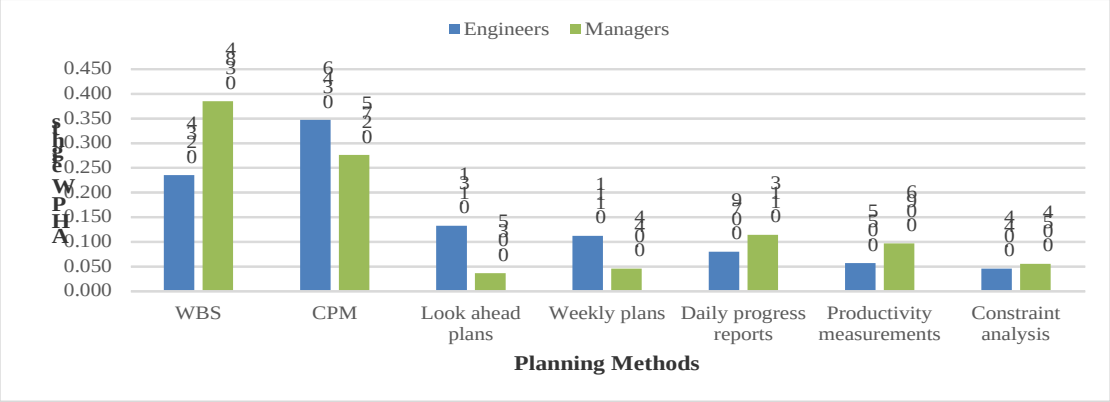

Figure 2 Attitude of Engineers and Managers in planning methods

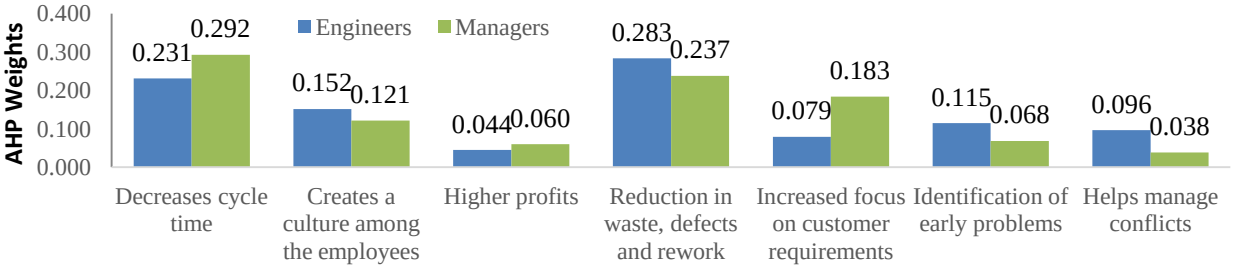

Figure 3 Attitudes of engineers and managers on Benefits of employing lean construction tools

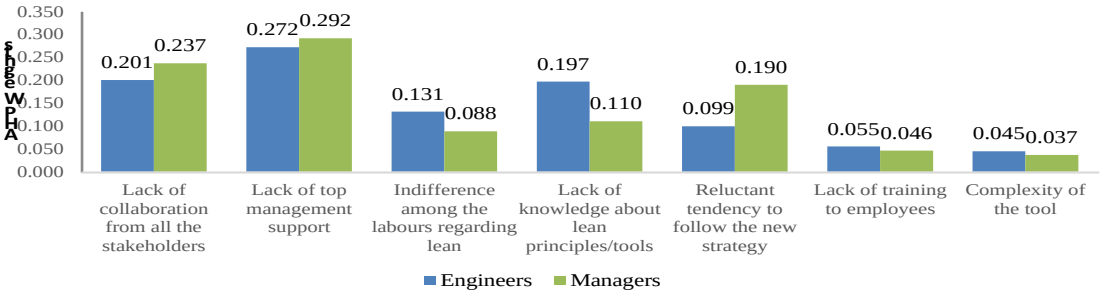

Figure 4 Attitudes of engineers and managers on implementation issues

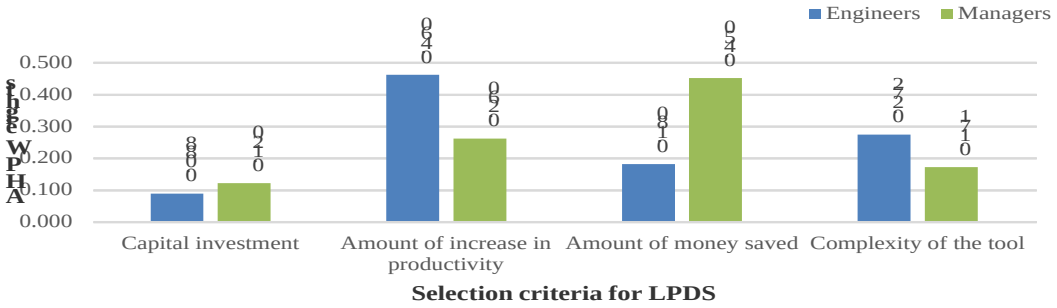

Figure 5 Attitudes of engineers and managers on Selection criteria for LPDS adoption

I. The difference in Attitude between Engineers and Managers

Among the respondents, construction managers and engineers constitute the major proportion. The differences in opinion among these two dominant groups are studied on important variables of this survey.

The significant difference in the attitudes of engineers and managers are seen in the following cases. The engineers prefer look-ahead plans more than the productivity measurements preferred by the managers in the choice of planning methods (Figure 2). The engineers opine that the reduction of wastes, defects and reworks their chief benefit of lean construction, while the construction managers choose a decrease in cycle time as their chief benefit of lean construction (Figure 3). In the implementation issues, the engineers give more importance to the lack of knowledge about the lean tools and concepts rather than the problem of reluctance to follow the new strategies and practices which is preferred by the managers (Figure 4). While the engineers see an increase in productivity as the prominent criteria for the selection of LPDS, the managers see the amount of money that could be saved because of LPDS implementation (Figure 5).

In all the above cases the attitude changes between engineers and managers are mostly because of the common aspect i.e., the engineers tend to think in a way that execution of the project is important than anything. On the contrary, the managers tend to think with a wider perspective of the project rather than focussing just on the proper execution of the project. The managers' concern about both the financial performance of the project and the execution performance of the project meanwhile engineers care about the execution performance of the project only. Their attitude differences will be of greater use when specific decisions are needed for effective implementation of lean in the projects. If money is the constraint we should go with the opinions of managers and if time is the constraint we should go with the opinions of engineers.

V. CONCLUSIONS

From the study, it is clear that the popularity of lean construction in India is very low since most of the respondents (87%) are having less than 3 project experience of lean construction implementation. As far as the usage of lean tools are concerned Last Planner System (0.357) is the most prominent tool used in the country followed by Root cause analysis (0.207), daily huddle meetings (0.172), and Value Stream Mapping (0.121). This is a good sign because the rigorous implementation of LPS is the primitive step for full-fledged lean construction implementation (Koskela 2002). The important benefits of lean construction as given by the respondents are reduction in cycle time (0.333), reduction in wastes, defects, and reworks (0.233), and creation of culture among the employees (0.139). The serious problems faced during the implementation of lean construction tools are lack of top management support (0.337), Lack of collaboration from all the stakeholders in the project (0.222), and Reluctance to follow the new strategy (0.139). From the interviews of respondents, some specific problems like LPS schedule mismatch with master schedule are noted duly. Despite these problems, the respondents (97%) are very optimistic about lean and very keen to implement lean tools for their future projects also.

Almost 60% of the respondents don't know the existence of such a project delivery system. The important selection criteria for LPDS adoption in India are the Amount of money that could be saved because of LPDS (0.466), the amount of increase in productivity (0.277) followed by the complexity of the tool (0.161), and capital investment (0.096). Since LPDS is very new to India expenses on pilot studies, initial investments in training would result in poorer returns during the initial phase of LPDS in India. The respondents having an eye on the financial benefits of LPDS as the important selection criteria this initial investment factor could prove costly for its feasibility of an application. Moreover, during the interviews, almost all of the respondents opined that the contractual difficulties will be the deciding factor for the feasibility of the application of LPDS. By considering all these results the feasibility of the application of LPDS is low in the Indian construction context which is in the primitive stage of lean construction evolution.

VI. RECOMMENDATIONS

- The construction fraternity should shed the reluctance to shed conventional methods and to follow new strategies and principles because unless risks are taken we will end up sticking with only conventional methods
- Modifications should be made in the lean tools so that it will be more compliant with our local construction system
- Proper time should be given to reap the full benefits of lean construction since it's a gradual development
- Training on improving the basic knowledge and principles behind the lean tools should be given to the employees
- Support from top management for lean implementation should be substantial and it should prod the site executives to follow lean tools in all circumstances

- Strategic decisions towards lean construction should be designed by all the organizations in the lean journey
- Proper awareness about LPDS is the need of the hour now
- More Pilot studies should be encouraged to get more pros and cons of LPDS in real-time application
- Unless proper contractual provisions are framed the application feasibility of LPDS is almost nil in Indian construction projects. Design-build contracts should be promoted more
- Without contractual obligations, the organizations should come forward to function in a collaborative manner
- More governing bodies like the Institute for Lean Construction Excellence (ILCE) should be developed in India for promoting the lean construction techniques

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