

# TEACHING AND TRAINING EFFORTS OF ACADEMIA AND INDUSTRY TOWARDS LEAN CONSTRUCTION IN INDIA

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## ABSTRACT

Lean construction is gaining traction in India. While there are a few companies which have become first movers and gained advantages of lean implementation in construction projects, there still are many companies which still need to adopt lean construction. At this juncture, the role of academia and industry is vital for accelerating lean implementation. However, the studies indicating lean teaching and training efforts are limited in the Indian context. Therefore, research is conducted to explore how Indian construction companies are adopting lean and how academia is contributing to lean construction, which is the aim of the study. Multiple research methods are used to obtain information on lean implementation. The results indicate that organisations have started lean implementation mainly for cost and time benefits, but there is a difference in training their employees and trade partners. Academia is teaching lean construction majorly as an elective than as a compulsory course. Further, measures to accelerate lean implementation in India are proposed. Overall, this paper presents the efforts of industry and academia towards lean implementation in India and is a source of information for construction companies in emerging and developing economies wishing to initiate the lean journey.

## KEYWORDS

Lean construction, collaboration, education, process, change.

## INTRODUCTION

One of the largest industries in the world on a global scale is construction. Around 7% of the world's working population is employed there. Every year, more than \$10 trillion is spent on construction products and services, which is equal to 13% of the GDP. According to Invest India (NIPFA (n.d)), an official Government of India database, India's construction industry is anticipated to contribute about 9% of the nation's GDP and employ 51 million people. By 2025, it is anticipated to reach USD 1.4 trillion as one of the major economic sectors in the world is constructed. The industry supports 7% of the world's working population and has an impact that extends far beyond its borders by creating the buildings where we live, work, generate our energy, produce our materials and goods, and travel. However, compared to other sectors, the construction industry's productivity has been appallingly low for decades (Ramaswamy & Kalidindi, 2009).

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Adopting Lean tools and principles can help the construction industry improve its operational efficiency, promote collaboration with business partners, and thus enhance its ability to deliver projects as per the commitments made to customers more consistently. Moreover, it would help the organisations improve their overall business performance. Similarly, introducing any new philosophy requires sufficient training efforts, either through in-house training or academic institutions (Moradi, Sormunen 2013, Raghavan et al., 2014, & Bayhan et al., 2019). However, the research in this direction is limited in the Indian context. Therefore, this research work aims to understand the current level of efforts in teaching and training in India. Further, the following research questions were focused upon: How typical or different is the lean implementation in Indian construction companies? and How are the companies and academia engaging in lean training and teaching?

This study summarises the journey of lean implementation in a few client, consultant and contractor firms in India and provides an overview of the current situation from the perspective of lean implementation engineers and academicians and is helpful for researchers and practitioners in developing countries.

## LITERATURE REVIEW

In order to understand the current status of lean implementation, the International Group for Lean Construction (IGLC) and Lean Construction Journal (LCJ) are the primary sources of literature. A keyword such as "India", "Lean construction", and "Lean implementation" were used to search for the literature in the IGLC conference papers. Various researchers across the globe have studied lean implementation.

Smith & Ngo, 2017 studied lean implementation by finishing contractors in the United States and observed that Last Planner System (LPS) was the most common tool used. The driving force for lean implementation is cutting costs and reducing schedules. Mossmon (2009) has mentioned that the need for lean education is one of the reasons for no more implementation in the UK. In the case of Brazil, Valente et al., 2020 have observed that in a case study company, various initiatives like participating in lean conferences, using LPS, encouraging continuing education, and lean training for partners as the main success factors for lean sustaining. Forbes et al., (2021) have presented case study examples of lean education initiatives by US-based Owners, Architect, Engineering, and Construction (OAEC) stakeholders based on semi-structured interviews.

In the Indian context towards lean implementation, Karanjawala & Baretto, 2018 have provided case studies of implementing lean at multiple project sites in India. Raghavan et al., (2014) have identified that in Indian construction, lean implementation is subject to factors like site and organisational culture, planning and engineering expertise, and site and top management support, based on the experience of working with a contractor and client firm in India, Kalyan et al., (2018) have proposed that lean tools at the site level, as a bottom-up approach and then that can be complemented with a top-down approach that builds awareness, empathy, and knowledge at the leadership level. Further, Anandh et al., (2018) have observed that lean implementation through academia could be much higher in India and have suggested measures to add Lean construction in India.

The above literature indicates that there are studies on lean implementation in various countries, including India. However, in the Indian context, the existing literature is reported primarily by the institute/organisation implementing lean as their experiences, which is a perspective from the top level. Further, studies indicating teaching and training efforts similar to Forbes et al., (2021) are unavailable, and there is a need to take a bottom-up approach of enquiring from the project level (Arbulu & Zabelle, 2006). Therefore, there is a need to understand the views of the people who are implementing lean at sites and also from the faculty who are teaching lean. Accordingly, the study aims to explore how Indian construction

companies are adopting lean and how academia is contributing to lean construction. Further, the objective is to identify potential commonalities and differences in lean education (training and teaching) and measures to accelerate lean implementation in India. The research necessitates using multiple research methods to achieve the study's aim and objectives.

## RESEARCH METHODOLOGY

Multiple research methods, such as desk research, survey form, and case studies, were used to achieve the purpose of the study, with qualitative case study methodology, as a combination of different data collection methods (Pinfield, 1986; Anderson, 1983). Using multiple methods has many advantages, such as increasing the creative potential of the research, and it also allows for covering more details and findings (Kathleen, 1989).

Purposive sampling was used to identify the respondents who are currently implementing lean. Purposive sampling is a non-random sampling technique which is helpful for the researcher in an exploratory study where the researcher finds out who can and will provide information through practice, knowledge, and experience (Etikan et al., 2016). One of the authors participated in Indian Lean Construction Conference (ILCC) held at Hyderabad, Telangana, India, during 15-17 December 2022 to identify the respondents from the companies and academic institutes participating in the conference and approached forty attendees for participating in the survey.

Fifteen participants have agreed to participate in the survey. However, instead of the interview, there was a need for more time as they were busy at the conference and agreed to share their inputs through the web-based survey form. Further, the company/institute where the participant's work is considered a case study example. The selected companies and academic institutions are known for their leadership in lean construction and are playing a pivotal role in the Indian Lean Construction Excellence (ILCE) community in India.

The research methodology involved a structured questionnaire survey (web-based) with open-ended questions for obtaining input from the respondents from the case study companies and educational institutions. Further, the company information is obtained through desk research. The desk research method is used for referring to ILCC conference proceedings, souvenirs, magazines covering lean construction aspects in India, being the members of ILCE, in order to be through with the lean journey of the case companies. Further, a qualitative content analysis was performed on the raw data provided by the respondents. The goal of qualitative content analysis is to summarise the informational elements of the data (Altheide, 1987 & Sandelowski, 2000). As per the request of the respondents, the company names and respondent names are anonymised.

## DATA COLLECTION AND ANALYSIS

For data collection, a web-based survey form using Microsoft Forms was created and sent to the willing participants with the following questions (as referred to and modified by Forbes et al., (2021)). Further, the last question was added to seek inputs on measures to be taken for accelerating lean implementation, considering the benefits of lean implementation.

- How did your company get started with lean? And why?
- How did you personally become involved with lean implementation?
- How are you training your employees/subordinates? What do they read? What games/simulations do they play? Any other innovative way of training your employees?
- How much time does your organisation devote to training employees for Lean? Is training a "one-time" or "recurring"?

- To what extent do you train your trade partners (subcontractors/labourers/clients/suppliers/any other)? Who among your trade partners should be trained more and why?
- Has lean been incorporated into your company's guiding principles/values/processes? If so, how?
- Any other suggestions for accelerating lean implementation in India?

Regarding the academicians, the objective is to identify the teaching efforts in Lean construction. Therefore, the following questions were asked:

- Students at which level (Undergraduate/postgraduate) you teach and at what level they should be taught Lean! Why?
- What do the students read? What games/simulations do they play?
- Any other suggestions for accelerating lean implementation in India?

A total of ten industry professionals and five academicians responded to the survey. The details of the respondents from the construction companies are provided in Table 1. The industry respondents' experience in lean ranges from 0.5 to 7 years, and their total experience ranges from 2 to 16 years.

Table 1: Details of the respondents from the industry

Company	Respondent Id	Designation	Work Experience (in Years)	Experience Practicing Lean (in Years)	Company Core Market	Company Type
A	1	Project Manager	13.0	0.5	Buildings	Owner/Client
B	2	Regional Lean Manager	8.0	7.0	Buildings, Malls, Airport	Consultant (PMC)
B	4	Planning Manager	16.0	4.0	Buildings	Consultant (PMC)
C	3	Planning Engineer	6.0	6.0	Infrastructure	Contractor
C	6	Senior Engineer	7.0	2.0	Infrastructure	Contractor
D	5	R&D Engineer	2.0	2.0	Infrastructure & Buildings	Contractor
E	7	Assistant Manager	5.5	1.5	Infrastructure	Contractor
E	8	Assistant Manager	7.5	2.0	Buildings	Contractor
E	9	Assistant Manager	4.5	1.0	Buildings	Contractor
F	10	Deputy Manager	2.0	2.0	Buildings	Contractor

Similarly, academicians' details are provided in Table 2, along with the institute they teach. The academicians are teaching lean construction from a minimum of 3 to a maximum of 10 years. Further, the academicians in the range of assistant professors, professors, and heads of the university, from four different institutions have provided the inputs for the survey. Further, in Table 3, the details of the case study companies are provided. It can be inferred that lean implementation started in 2008. The companies are long-standing, with more than fifty years of existence in the construction industry.

Table 2: Details of the respondents from the academia

Academia ID	Academia Type	Respondent	Designation	Overall Experience (in Years)	Experience in Teaching Lean (in Years)
Academia A	University	1	Professor	22.00	6.00
Academia B	Institute for	2	Professor	40.00	10.00
Academia B	Postgraduation	3	Assistant Professor	14.00	3.00
Academia C	University	4	Head	35.00	10.00
Academia D	Engineering College	5	Assistant Professor	15.00	3.00

Table 3: Details of the Companies with Lean Implementation

Company	Company Category	Lean Implementation in India	Brief Description
A	Owner/Client	2022	Set up in 1953 as an infrastructure construction firm to undertake the construction of government projects. In 1986 the company diversified and ventured into private real estate development.
B	Consultant (PMC)	2007	100+ years old US-based construction company providing Project Management Consultant Services in India.
C	Contractor	2008	One of the well-known companies in the Infrastructure sector, namely, marine structures, surface transport, Oil& gas, hydro & underground, and urban infrastructure. Set up in 1959
D	Contractor	2013	It was started as a small contractor in 1956 to construct irrigation systems in southern India. In its 66 years, the company has grown in scale and strength, covering all infrastructure and residential projects in India.
E	Contractor	2008	Buildings vertical of a construction company founded in 1938, regarded as a professionally managed Indian multinational construction company engaged in Technology, Engineering, Construction, and Infrastructure Projects.
F	Contractor	2010	It was established in 1865, offering 'turnkey solutions', from 'concept-to-commissioning' across the entire spectrum of urban infrastructure.

## EFFORTS OF CONSTRUCTION COMPANIES FOR LEAN IMPLEMENTATION

The case companies' lean implementation journey and the respondent answers based on the qualitative content analysis have been summarised in the below sections.

### **Lean journey commencement**

The lean journey has begun in client organisation company A, aiming to increase productivity. The consultant organisation company B, being a US-based organisation, has lean in its operational standards. The operational standards provide standard work breakdown structure, procedures, workflows, and templates that standardise our work across projects and regions/countries.

The contracting organisations C, D, E, and F have different reasons for lean implementation. Company C has begun lean due to emphasis on early completion of the projects. The primary motivation for Company D to begin the lean journey is to get information transparency among stakeholders on the project's progress. Company E has targeted wastage reduction, rework and thus cost reduction, for which lean is being implemented at project sites. Company F adopted lean to reduce hidden costs and optimise the construction activities' timeline. Further, it is to be noted that ILCE has acted as a facilitator-cum-catalyst for lean implementation in the contractor companies, namely C, D, E and F. While companies C, E, and F are founding charter members of ILCE from 2008, Company D joined ILCE in 2013 as they became aware of lean construction through a professor at Indian Institute of Technology, Madras (IITM).

The reason for respondents' involvement in lean implementation is majorly the management decision and part of roles and responsibilities. However, there are a few exceptions. Respondents 8 and 9 from company E are selected for the company's Lean implementation program. The lean implementation process in company E is as follows: 1. Select a site for lean implementation, 2. Identify lean champion(s) in the specific site, 3. Provide the documents and access to the lean repository (use cases), 4. Be at the site for a week to check and correct the implementation, 5. Obtain weekly/monthly reports to see the improvement and benefits.

Respondent 10, from company F, is part of a lean journey because of doing the course on "Lean project delivery" during the postgraduation in construction management, and Respondent 5 has done the final year project on Lean Construction, which has fetched the role of "Lean Coordinator" at company D.

To summarise, motivation for lean implementation by case companies is to gain cost and time savings, and the driving force is top management. Further, lean tools used for productivity improvement, waste reduction, and increased transparency about the progress.

### **Lean training for the employees**

Company A's training efforts are minimal as they are in the very early stage of lean implementation. Currently, only one training is conducted for two employees in LPS so that they can implement it. However, the company management plans to take up further training based on the success of LPS implementation.

Respondent 2 from company B was given stepwise training initially with an emphasis on what precisely lean is for commencing the journey with willingness. There are training modules for employees at basic and advanced levels. Further, company B has a University Knowledge Network for different sets of training conducted online and in person.

Company C uses Silent Squares simulation and E-Learning courses on Lean to train employees. Company E has two different training programs for Lean Champions and the project team separately and is provided at the start of lean implementation at a project level. The various tools and processes that have been fixed to be implemented are explained to the employees through these two training programs with the help of the company's case studies from other similar projects. Company F has engaged only selected employees with the National Programme on Technology Enhanced Learning (NPTEL) based Introduction to Lean Construction course conducted by Prof. Koshy Varghese and Prof. Raghavan N from IITM.

Compared to all the companies, Company D, though it started its lean journey in 2013, five years later than companies C, E, and F, has developed a specific training plan as follows:

employees take the NPTEL "Introduction to Lean Construction: Module 1 - Basics" course which is mandatory, followed by internal training with their Lean experts (employees whose experience in Lean implementation is more than five years) in a virtual mode with the help of presentations and case studies from the company project sites. Further, Company D has a "Villego" Simulation Kit, which was outsourced from "The Change Business- UK", a Lean Consultancy, for the Last Planner System.

Concerning the training frequency, the common aspect of all these companies is that the management encourages these employees to attend the training workshops and conferences held by ILCE. However, the in-house training frequency as per the respondents is based on the need of the hour at the site level rather than a recurring and scheduled event, except for company C where the training frequency is once a quarter for everyone. Further, as part of its lean implementation program, Company E imparts training whenever a new member joins the program.

Overall, the efforts on employee training towards Lean Construction differs for each company. Only one of the case companies has a defined training plan and one has defined training frequency whereas all others treat training employees as per the need of the hour.

### **Lean training for trade partners**

The trade partners for the construction companies are trade partners (subcontractors, workers, clients, and suppliers). The training for the trade partners is significantly less across the companies. Companies A, C, and F currently do not have any training programs for trade partners. However, the respondent from company A feels that there should be a particular focus on training workers. The respondents from companies C and F believe sub-contractors are to be trained to introduce the benefits of implementing the lean.

Company B trains the trade partners, at-least on weekly mass training. Company D has yet to train the external project players (sub-contractors, clients, suppliers, and consultants). However, training the workers on Lean tools like 5S (Sort, Set in Order, Shine, Standardize, and Sustain) & 3P (Production Preparation Process) with sign boards in *their regional language*. Further, Company E trains the workers through the lean champions and site engineers involved in the specific activity in which lean is implemented. Further, the respondents from company E feel that all the workers, including subcontractor's supervisors, are to be trained, and even the material suppliers/ vendors should also be provided virtual training as they do not visit the site.

As the current training efforts are targeting internal employees, training trade partners is limited. At this juncture, the respondents opine that subcontractor supervisors, subcontractors, and workers are to be imparted lean training for maximising the benefits.

### **The Lean as part of the organisation's guiding principles/values/processes**

The company's approach to adding lean to the existing systems is different. Company E has incorporated lean management as a section in the project quality plan (PQP), which makes adopting tools and practices an auditable point. Moreover, this enables the project teams to adopt these practices. At Company C, mainly 5S, root cause analysis (RCA), LPS and Value Stream Mapping (VSM) are strictly implemented at construction sites to improve project activities continuously. Company D has done mandatory training for all employees on Lean construction with a well-defined training plan.

Further, Company D has made Lean implementation one of the key results indicators (KRI) of the employee performance appraisal system. Further, Company F has incorporated LPS as an integrated part of IMS (Integrated Management System) processes. Company B has incorporated the pre-construction phase as part of the project management plan so that the implementation during the construction phase can be made easy and handy. Company A, being in the initial stages of implementation, has yet to plan for now but is interested in adding it to the company's process, provided LPS implementation is successful.

The approach to incorporate Lean into company's existing policies is different by the companies. Each have chosen a different approach as explained above. However, it is interesting to note that Lean is being injected into the companies existing process one way or other. Table 4 provides the summary of the lean implementation, teaching and training efforts, ways of introducing into companies existing process illustrating the similarities and differences across the companies.

Table 4: Summary of Training Efforts of the Construction companies

<b>Company</b>	<b>A (Client)</b>	<b>B (Consultant)</b>	<b>C (Contractor)</b>	<b>D (Contractor)</b>	<b>E (Contractor)</b>	<b>F (Contractor)</b>
<b>Company Lean journey</b>	Productivity improvement	Operational standard	Early completion	Information transparency on project progress	Wastage and rework reduction	Hidden costs reduction and optimising time
<b>Respondent's lean journey</b>	Management decision	Part of the roles and responsibility	Management decision	Project work on Lean Construction	Lean Implementation team	Course on Lean project delivery
<b>Training employees</b>	Very limited training so far	Corporate university – basic and advanced levels	Silent Squares simulation and E-Learning courses	Well-defined mandatory training plan & Villego	Two programs – for Lean champions and the Project team at the start of the project	NPTEL course for the selected employee
<b>Time devoted to training</b>	Nil	Need basis	Quarterly	Need basis	Need basis	Need basis
<b>Trade partners trained</b>	None	Mass training for all trade partners	None	Workmen	Workmen	None
<b>Lean in Company processes</b>	None	Project management plan	5S, VSM, RCA, LPS mandatory	Mandatory training and lean implementation as KRI	Project Quality Plan for Audit	LPS as part of IMS

## EFFORTS OF ACADEMIA FOR LEAN TEACHING

The respondents representing the four academic institutions have provided their inputs on how they have been contributing to the lean implementation, and the summary of the teaching efforts, and the resources used for teaching are provided in the sections below.

### Lean teaching for students

The students at Academia A are being taught at the postgraduate level with a subject titled "Lean Construction". Further, the course is being delivered as an elective, which the students choose. However, the respondent from Academia A feels the course could be introduced as a

higher-level elective at the final year undergraduate level. Moreover, the university has made a collaboration with UK based university for a project titled Collaborative Online International Learning (COIL) project to create awareness about lean and sustainability. Similarly, Academia B also offers a course on Lean construction at the postgraduate level, except that it plans to make it a core/compulsory course.

Academia C offers courses in the built environment. The builders/developer organisations have been provided with training on saving materials and time costs. In this process, the institute started adding topics on lean construction, which the builders/developer organisations accepted well. Therefore, Academia C has been teaching lean construction practices as an elective in two of their master of business administration programmes for the last five years. Academia D offers all engineering courses. However, the institute has started offering specialisation in Lean Construction Technology as part of the graduate-level civil engineering course. The Lean construction courses are delivered in the third and final year of the bachelor of engineering course.

One out of the case academic institutions has introduced Lean Construction at the undergraduate level, whereas rest of the institutions have been teaching at the postgraduate level. Further, the course at postgraduate level is being offered as an elective as an alternative construction project management method.

### **Resources used for Lean teaching**

Training the students at academia A and B is based on the concepts in the textbooks on lean, journal papers or online material. Further, games involving card games, aeroplane games, and pattern development games are used for teaching Lean Construction. Occasionally role-play games are used to simulate the construction scenarios. At Academia B, the students are given lean concept theory linked with practical application through case studies. Further, Academia A and B have hosted ILCC conferences and engaged students as volunteers, encouraging them to see the practical application of Lean Construction. Multiple lean awareness exposure games and lean software are used to train and teach the students at Academia C.

Overall, games, books, journals and case studies are major part of the resources used for teaching.

### **SUGGESTED MEASURES FOR ACCELERATING LEAN IMPLEMENTATION IN INDIA**

Lean was introduced to India fifteen years back by IITM and ILCE in 2008-2009 (Raghavan et al., 2014). However, the number of contracting parties reporting lean implementation is less compared to the number of construction companies in India. Considering the advances in technology adoption requirements, there is a need to fast-track the lean implementation (ILCE (n.d)). Therefore, the respondents, being lean trainers and lean implementers, were asked to provide their suggestions for accelerating lean implementation in India.

The measures suggested by the respondents are: 1. Marketing in the industry by showcasing the success stories and their positive outcomes with the Tier II & Tier III contractors, 2. Devising Lean construction-based courses jointly by construction companies and educational Institutes, 3. Integrated Project Delivery (IPD) or Relational contracting approach for construction project delivery. 4. Engaging with public policy decision-making authorities more frequently for mandating Lean Construction - Introducing lean implementation as a prequalification criterion, 5. Improve Lean knowledge and awareness of clients in India, 6. Introduction of the lean rating and lean certification, 7. Sharing of incentives with the trade partners for promoting lean adoption, 8. Increasing the training of frontline workers and supervisors, and 9. Use of computer simulations to enable the selection of lean tools for better decision-making and implementation. Further, majority of these measures are considered as enablers of lean construction (Bayhan et al., 2019 & Moradi, Sormunen 2013)

In this context, the role of organisations is crucial for conducting specific training dedicated workshops and monitoring their incremental progress over a period. ILCE has been connecting the industry and academia by conducting ILCC conferences at the academic institutes to promote Lean in India. Further, academia should also bring in a compulsory course (rather than as an elective) on lean construction in undergraduate and postgraduate courses for all disciplines, so that lean awareness is ensured at the entry level of the construction industry.

## CONCLUSIONS

The study has used multiple research methods to understand the efforts of industry and academia towards lean education and training in India. A total of fifteen respondents from six companies and four educational institutes have provided valuable inputs on how lean is being implemented and the training and teaching efforts. It has been observed that the primary motive for lean implementation is to get cost and time savings, and the top management is driving the lean implementation. Therefore, creating further awareness and marketing Lean should attract more construction companies to adopt lean.

The company's approach towards implementing Lean in existing company procedures is varied. However, all the approaches presented in this study can be referred to by the companies in developing countries and adapt to which one best fits their organisational setup. Further, the true success of Lean implementation is possible only when there is a significant cultural change brought among all the project stakeholders, focusing on suppliers/vendors, subcontractor supervisors, and frontline workers.

There is a need to show the clients the potential benefits of Lean by contractors and advocate implementation beyond contractual obligations. It would eventually have significant benefits for all the stakeholders in the Construction Ecosystem. The research is helpful to both researchers and practitioners to gain further insights on lean implementation and teaching/training in India and is a source of information for the potential construction companies wishing to implement Lean construction.

## LIMITATIONS AND FUTURE WORK

The number of respondents from each company/institute is limited. There could be construction companies not presenting at the conferences, not joining the ILCE, but implementing Lean on a full scale. Therefore, a survey of nationwide construction companies will facilitate further understanding. While the research has obtained data saturation representing each organisation, increasing the number of respondents from each organisation, conducting qualitative interviews, and longitudinal studies would provide further insights into the teaching and training efforts and validate the suggested measures for accelerating lean implementation in India.

## ACKNOWLEDGMENTS

We want to thank ILCE, and all the construction companies, academicians and survey participants for their valuable input in this research work. We also thank the anonymous reviewers for their review, which has helped in the overall improvement of the research paper. We would also like to thank IGLC for providing this opportunity.

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