

# APPLICATION OF LEAN CONSTRUCTION PRINCIPLES IN AFFORDABLE HOUSING IN INDIA: A REVIEW

<sup>1</sup>Apoorva Vikram, <sup>2</sup>Sarthak Singh Rajput  
<sup>1</sup>Post Graduate student <sup>2</sup>Assistant Professor  
<sup>1</sup>Department of Civil Engineering, Integral University,  
<sup>1</sup>Lucknow, Uttar Pradesh, India

**Abstract:** The idea of integrating Affordability with Lean construction techniques itself is an innovation. In India we experience vividness and variety in all fields from science to cultures to tastes and communities. Housing is one of the most basic needs of survival. At the same time, we are facing an enormous depletion of our natural resources due to vast growth of population and unawareness among the users. Here comes the concept of Lean which relates directly to sustainability. All those materials, methods, techniques and practices which decrease the human efforts and at the same time reduce waste and utilize all those materials which enhance the sustainability and cost effectiveness are considered Lean. The idea of the propaganda of lean is to implement a whole new concept of 'changed thinking into lean thinking'. Lean begins from the mind-set and ends up into final results. These two are basically the two supporting pillars and everything in between is considered as the ladder steps. 'Lean' is not just a word rather it is a concept in itself. This concept although has been used since ages yet much needs to be incorporated in the real world and understood by the end users so that the idea behind successful implementation and achievement of sustainability and affordability is justified.

**Keyword:** Lean Principles, Affordability, Sustainability, Lean thinking

## 1. INTRODUCTION-

India, like most major emerging economies, has been witnessing accelerating urbanisation. As per the census of India in 2001, about 72% of the population lived in rural areas, and 28% in urban areas.

By 2011, these figures had changed to 69% rural population and 31% urban population. In fact, as per census 2011, for the first time since India's independence, the absolute increase in population was more in urban areas than in rural areas. According to estimates, around 600 million people are expected to make urban India their home by 2031, a whopping 59% growth over 2011. As an increasing proportion of India's population starts participating in its growth story, it brings with it mounting pressure on the existing infrastructure, which needs to at least keep pace with the growing demand, if not be ahead of the curve.

The current housing deficit in India stands at 19 million units, which, in the absence of any meaningful intervention, is slated to double to 38 million units by 2030. 95% of this deficit is around the EWS (Economically Weaker Sections) and LIG (Low Income Group) segments, which technically puts the figure at a staggering 18 million units in this category (approximately). While this number is huge, there is also a substantial chunk of upper end of LIG band and lower to middle end of MIG band, which we can say comprises 'the emerging middle class' who are also deprived of decent living conditions.

Nowadays, The Toyota Production System is known all around the World as a manufacturing management method and a lean construction and management tool to reduce waste during the production and increase the final product quality and value. The TPS is now understood as more than simple tools and management approaches, and it is described as the Toyota Way, a definition that encompasses all the philosophy behind the TPS. This philosophy started to be constructed since the early foundation, in the late 1880s, by Sakichi Toyoda, as a family business (Liker, 2004). Sakichi had a spinning and weaving machines business, and improved the systems by trial-and-error approach, moulding the concept of getting the hands dirty as a way to understand and improve the production, which is an important concept.

### 1.1. The most widely accepted Lean Principles are-

- a) Eliminate the waste.
- b) Precisely specify value from the perspective of the ultimate customer.
- c) Clearly identify the process that delivers what the customer values
- d) Eliminate all non-value adding steps.
- e) Make the remaining value adding steps flow without interruption
- f) Manage the interfaces between different steps.

- g) Let the customer pull – don't make anything until it is needed,
- h) Make it quickly.
- i) Pursue perfection by continuous improvement.
- j) Do not push your projects on customers.

### **1.2. Problems in implementing lean construction techniques-**

- Lack of awareness among people about the application of lean construction principles and techniques.
- Lack of successful and established examples of the implementation of these principles in Indian construction industry.
- Cultural hurdles like reluctancy among people to give up the deep rooted techniques and methodologies as well as hierarchical tendencies.
- Restrictions in the planning process and lack of consultancy.
- Lack of a trained, committed and reliable labour force with technological awareness and modern skills.

## **2. LITERATURE REVIEWS-**

“Sustainability through low cost housing” is a study by Ar Manisha saxena and Ms Shruti Sharma, based on some works of low-cost housing and their influences on architecture. Sustainable and low-cost is now a trend in architecture, there are many of the projects which are truly based on low cost techniques which was used by Sir Ar. Laurie baker and some architects still working on it. Aim of the study is to lighten up the latest techniques which they used in their projects, and his principles and selection of materials. Now a day, people think urban and a lavish life style, with affordable and ecological friendly living. The study aims at sustainability of low-cost works of different architects through, their principles of cost reduction and techniques. All sorts of materials are used to clad a structure to achieve the ‘look’, stone cladding for a ‘natural look’, or sometimes even for the ‘sustainable look’. In this lost world, very few architects are concerned about depleting natural resources, issues of conservation of energy, the carbon foot print of the built environment and other related issues, Of the few concerned architects, some have been inspired or at some point have looked at baker for his philosophy, practice and works. This literature influences on the utility of such resources for architectural beauty of a structure which would not deplete the limited resources available for the forthcoming generations. The idea is not to beautify the structure but to justify its existence for all. Baker believed in applying vernacular principles to modern construction technology. He mentioned that we need to take forward by adding modern technology to that which has already been accomplished by our ancestors and contribute to it instead of contradicting it. Natural locally available materials were preferred over modern materials. These included materials like brick which were locally made. The choice of these materials stemmed out from the need to be honest and use minimal energy. Baker used techniques observed by improving on them, he applied vernacular principles to modern construction techniques, as the traditional methods often had apt solutions to current day problems faced in construction.

Another research work by the honours students in Construction Management, University of the free state, South Africa, reveals how the utilisation of low cost construction materials can help in enhancing the viability, life and quality of structures. Several materials have been used and different techniques are imparted by these students to design the structures such as-Moladi technology- It involves easy to use plastic panels that are interconnected to make a plastic structure/form of any length and height for the different walls of a building. The reinforcements, pipes, electrical installation, door- and window openings are cast before the concrete is cast into the walls. It takes approximately 4 hours to set up the plastic mould and about two hours to fill it with a special blend of concrete. The walls are left to dry overnight (15 hours) and the formwork then removed. The formwork can be used up to 50 times and can then be recycled for other components.

Speedwall building systems- Initially started in 1991, speedwall construction technology provides manufacturing of the systems floor, wall and roof panels on site by a mobile panel manufacturing machine. The panels are constructed from fireproof isolation and steel mass, and then a mixture of concrete sand is sprayed over the wall. A 35m<sup>2</sup> house will require about 40 panels to be constructed. Construction times are up to 12 times quicker than conventional construction approaches. One onsite panel manufacturing machine is capable of producing 240 panels per day and can be erected in situ within minutes. Speedwall structures are cheaper to build, and are known for high energy efficiency which reduces energy costs, a benefit to low-cost houses.

Hydraform interlocking bricks- In 1988 Hydraform developed an interlocking building block machine which hydraulically compress soil (earth), mixed with cement into solid blocks which fit into one another. When cured, the soil cement blocks can be dry-stacked. For building houses, a strip footing foundation build with Hydraform blocks is used eliminating the use of mortar in 70% of the building structure with no need for concrete or steel columns. The unique dry-stacking building system uses mortar in the first few courses and the top 3-4 courses – the rest of the structure is dry-stacked which make wall construction easy to done by anyone. The dry-stacking method represents savings (approx 30%) in time and construction costs making Hydraform machines ideal for remote sites where transport, cement and sand costs are high.

Modular and timber construction- In South Africa, timber homes were re-introduced as an alternative to conventional brick and mortar homes in the sixties. The timber frame walls panels with doors and window frames built into panel openings are manufactured on site or pre-manufactured in panels, and then raised and fitted onto the floor platform of the building. Builders Trade Depot supply quality standard modular timber homes of 41m<sup>2</sup> or 53m<sup>2</sup>, as a complete unit, including wall and ceiling lining, cornice and skirting, wall and floor tiling, plumbing and electrical fittings, windows, doors and kitchen and bedroom units. The houses are delivered in stages to suit the contractor/clients progress. In terms of environmental and cost aspects, manufactured timber components contain approx 14% per cent embodied energy, in comparison to bricks, blocks and concrete with 80% and steel at 95%. Better insulation, means a smaller heating system and lower heating bills.

A study by Mr. Norman Bodek brings forward the concept of lean production. Lean is fundamentally empowering all workers to be partners in your continuous improvement efforts. You ask them to make their work easier and more interesting. You challenge them to grow every day on the job. You ask them to cut costs, to improve safety, to improve quality and reduce the time line to deliver superior products and services to their customers. There are two barriers to advancing lean manufacturing; one is just living in the old paradigm where we don't ask workers to be involved in creative problem solving. "Keep your brains at home," was the subliminal sign over the factory's front door." And secondly is the incredible resistance to change, the "not invented here syndrome." Yes, you can "always," find reasons not to do something. Most people are experts in this. His work involves implementing all those ideas in the management of work and workers through which work can be done more efficiently and in lesser time.

Mike Sondalini talks about Value Stream Mapping and its advantages involved in reducing waste thus streamlining the processes. In VSM we follow a process from start to finish monitoring and measuring what happens within, and between, each process step. For each process step we record the variety of resources used in the step, the amount of their usage and the range of times each resource is in use as a block of information specific to that step. The measured variables are collected together in a 'variable block'. From the information collected during data gathering the process is drawn as a flow diagram showing the times and resources used at each step and the time delay between each step. This diagram is called the 'current state map'. The non-value-adding actions and resources are analysed to find where they can be minimised through time-saving and cost-saving improvements. A secondary benefit of timing the process steps and measuring the rate of throughput is identification of the bottleneck step(s). The bottlenecks can be redesigned to lift their capacity and so increase the output rate of the whole process. The reengineered process is drawn on a new flow chart known as the 'future state map'. It shows all the steps and information flows in a redesigned, simplified and more efficient process.

Abhigana E. Desai and Maharishi J. Shelat also performed a study on Value stream Mapping to justify its effectiveness in the construction process as a lean construction methodology. Low productivity is a chronic problem in construction industry. One way to increase the productivity is to reduce the non-value adding activities. Productivity improvements achieve higher cost savings with minimal investments. Value stream mapping has been used as a lean construction tool to help reduce the non-value adding activities in construction projects and increase the productivity. Improvement opportunities can be seen more effectively by using and implementing Value Stream Mapping.

A study by Gregg Howell brings about the methods and techniques Lean thinking is a new way to manage construction. Many people object on first exposure because lean thinking appears to be the application of a manufacturing technique to construction. One response to the arguments that "construction is different" is to make construction more like manufacturing through greater standardization. They took the opposite view as they believed the goals of lean thinking describe the management of dynamic projects. But objections to lean in construction are hardly a surprise as lean was indeed developed in manufacturing, and individual tenets appear either already in practice or incomprehensible.

The goals of lean thinking redefine performance against three dimensions of perfection:

- (1) a uniquely custom product,
- (2) delivered instantly, with
- (3) nothing in stores.

This is an ideal that maximizes value and minimizes waste. The goals demand a new way to coordinate action, one that is applicable to industries far removed from manufacturing.

The principles of lean thinking and production: (1) Stopping the Line, (2) Pulling Product Forward, (3) One-Piece Flow, (4) Synchronize and Align, and (5) Transparency, are techniques which support the goal. Implementation requires a deeper understanding of the goals and techniques. Some go astray by comforting themselves that they are already doing some or most of it, while those who believed going in that lean is about manufacturing want their money back. This paper explains the implications of the goals and key production principles, and how when taken together they result in a different way to manage construction. Implementing lean in construction then becomes a matter of developing and acting on this new knowledge. Simply put, but still only partly comprehensible in current thinking, lean is a value seeking process that maximizes value and continually redefines

perfection as described above. Moving toward this form of perfection, requires more than a change in procedure, it requires changing the way we think about and do construction. This paper first explains lean construction by exploring the essential differences between lean and current practice, then explores the underlying nature and implications of lean thinking. The paper closes with implementation advice based on this new understanding.

### 3. LITERATURE SUMMARY –

Table.1: Lean implementation tools and their benefits identified by different Researchers

NO	TITLE	TOOL APPLIED	BENEFITS DERIVED
1.	Sustainability through low cost techniques in india.	Baker's concepts of architecture and use of local materials.	Sustainability, cost-effectiveness, innovation.
2.	Alternative Construction methods for low cost housing.	Moladi technique, Speedwall building system, hydraform interlocking bricks, modular construction, straw bale construction.	Utilisation of non-conventional resources, green building materials, pollution abatement, sustainability
3.	Lean Construction- A promising future for MSUs.	Lean production, workflow control, work structuring, production control, last planner system.	Elimination of non-value adding activities, stream lining of the processes, time saving.
4.	Advances in construction- lean construction for productivity enhancement and waste minimisation.	Safety first, skill development, energy efficiency, recycling of waste, upgraded machinery.	Lesser accidents, labour efficiency, energy efficiency, cost saving.
5.	Value stream mapping- as a lean construction tool.	Value stream mapping	Elimination of non-value adding activities, time effective, cost effective.
6.	Implementing lean construction- understanding and action.	Lean thinking, lean manufacturing, JIT, Synchronisation, one piece flow, transparency till the end user.	Targets the end users, nothing stored as buffer, minimisation of waste, quality product, delivered instantly.
7.	Site implementation and assessment of lean construction techniques.	Last planner system, reverse phase scheduling, weekly work plan, Percent plan complete, daily huddle meetings, 5s process.	Behavioural change, employee involvement, total involvement, improvement in process, timely checks.
8.	Benefits of lean construction for affordable housing.	Toyota Production System, lean manufacturing, variability reduction.	less waste, reduction in time construction, improvement in the quality of social housing construction and profitability to the constructors.
9.	Lean implementation in construction industry.	Daily progress report, last planner system, critical success factors, work sampling, time and motion study, value stream mapping.	Effective communication, waste minimisation, right design, motivation and training, management support.
10.	A Dynamic WBS: going beyond scope management.	Work breakdown structure.	Assignment of right work to the right worker, qualitiveness , better output, time efficient, cost saving, better resource utility

### 4. CONCLUSION-

This study is an initiative to develop a better thought process among people including all the stakeholders from the builder to the labour, the architect as well as the house owner about the utilisation of all those processes which will bring about a change in the environmental conditions, the resource buffers, sustainability conditions as well as aesthetics and finances of the country. The idea is to uproot the deep rooted cultures of the Indian society in context of the utility of resources, the processes involved and

implementation of construction practices which have been performed by our forefathers since ages and are continuing to deplete the natural resources and the environment as well.

Carbon footprints can almost be eradicated by utilising these techniques and materials of construction. We just need to widen our approaches and mind-set to step into this new era of innovation and revival. Some of the suggested methods and techniques would be-

- Last Planner System (LPS)
- Value Stream Mapping (VSM)
- Waste Minimisation
- Reverse Phase Scheduling (RPS)
- Percent Plan Complete
- Daily Hurdle Meetings
- Work Breakdown Structure (WBS)
- Just in Time technique (JIT)
- Utilisation of alternative construction materials
- Energy efficient designing
- Involvement of top management
- Improvising labour skills
- Questionnaire surveys to the top builders of UP

*\*all the above techniques to be applied on a live project of affordable housing units.*

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