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MINIMIZATION OF WASTAGE USING LEAN TECHNOLOGY IN CONSTRUCTION

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Abstract— **It is presumably that construction industries in India are facing the same generic problems/ wastes on construction activities which were also faced by their counterparts regardless those in developed countries or developing countries. However, the main problem in India (might be the same for most of other countries) is the lack of clear indicators on quantitative parameters to assess the extent of those problems/ wastes to have been impacted on the overall performance and productivity of local construction industries. To date, there have not been many well-documented quantitative studies and records on to process-related problems/ wastes which arisen on construction site in India. As a result of that, the introduction of the concepts and framework of new lean construction ideology are seen as an opportunity to address the existing problems in local construction industry and utilising concepts and framework of new lean construction ideology can then go further to formulate the extent of impacts of those problems/ wastes on a more structured and quantitative basis. Prior to assess the severity of the process-related problems/ wastes which existed in the construction processes for the local construction industries, the differentiation of traditional and new production/ construction concepts will have to be drawn prior to further investigation and evaluation on any project performances.**

New measurement parameters such as waste, value, cycle time or variability that was not covered under traditional concepts are to be introduced into this study; the local construction personnel will be subsequently examined with those new parameters to review the level of understanding and practicability in local construction industry compare to the requirements and the concepts set forth by lean construction philosophy.

This research is intended to verify and re-evaluated the status of existing productivity and performances on construction activities and processes for local construction industries. This is meant to have a clearer picture on how "lean" in local construction industry performed currently under the compilation of new measurement parameters particularly on waste and cycle time pertaining to the concepts and principles of Lean Construction

Index terms- **Construction, Project, Lean, Technology and Wastage.**

I. INTRODUCTION

Lean Construction had three initial sources of inspiration, the impacts of which has been bolstered by dissatisfaction with the practical accomplishments of project management. Koskela (1992) challenged the industry to apply the principles behind the revolution in manufacturing, and quickly initiated an effort to establish production management on a sound theoretical foundation. The third source took the form of an anomaly discovered by Ballard (Ballard & Howell, 1998): namely, that normally only about 50% of the tasks on weekly work plans are completed by the end of the plan week. This proved to be an uncomfortable fact for a philosophy of project management that relied on detailed centralized planning and the assumption that what should be done could be transformed into did through contract structures and contractual enforcement.

Construction industries worldwide have become notorious for under-performance in many aspects such as quality, safety, productivity and product delivery to planned budgets, programmes and client satisfaction. In general, a very high level of wastes/ non added value activities are assumed to exist in construction and it is difficult to measure all waste in construction. Several partial studies from various countries have confirmed that wastes in construction industry represent a relatively large percentage of production cost. The existences of significant numbers of wastes in the construction have depleted overall performance and productivity of the industry and certain serious measures have to be taken to rectify the current situation.

The chronic problems of construction are well known: low productivity, poor safety, inferior working conditions, and insufficient quality. Unlike manufacturing activities where the production activities are fundamentally governed and controlled under a rather routine process, construction activities are subjected to relatively wide range of variables and wastes factors throughout its information management and resource flow process as compared to manufacturing activities.

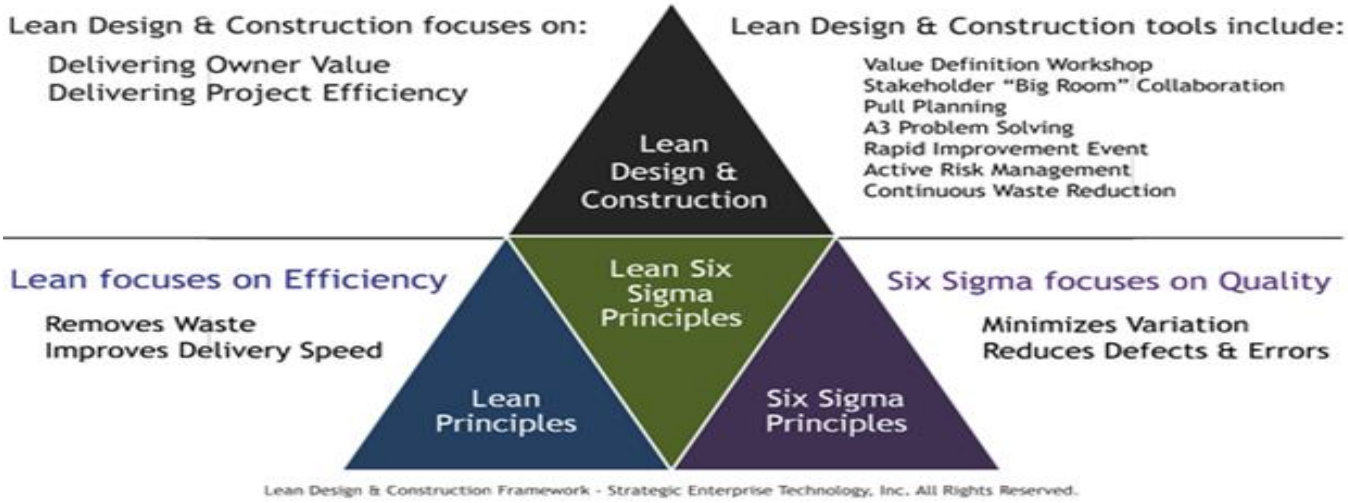

Fig. 1.1 Lean Six Sigma Principles

These variables and wastes generated in construction activities are mainly due to its large fieldwork component, the provisional nature of some of its organisations, and its intensive use of labour and non-stationary equipment and indeed, those construction peculiarities and variables will restraint the efficiency of the construction processes compared to those stationary & well-controlled manufacturing processes, but all of those peculiarities and variables can be overcome with the application of new flow design and improvements as well as new technologies adoption.

Therefore, the organisation, planning, allocation and control of these resources, processes and technologies are what finally determine the productivity that can be achieved.

II. PROBLEMS IN CONSTRUCTION & TRENDS IN IMPROVEMENT STRATEGY

A. Introduction

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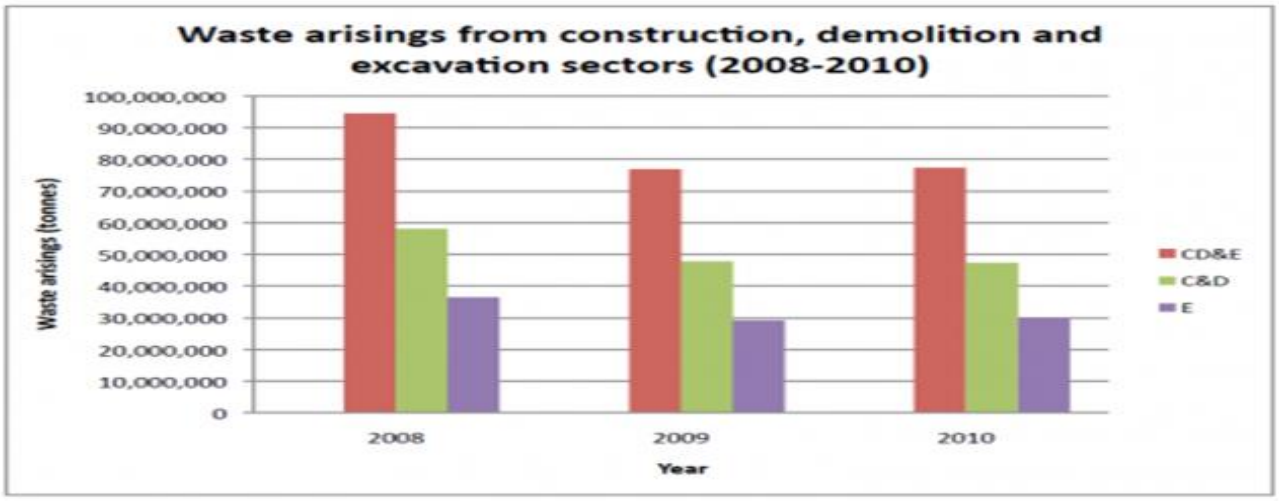

Fig. 2.1 Construction Waste

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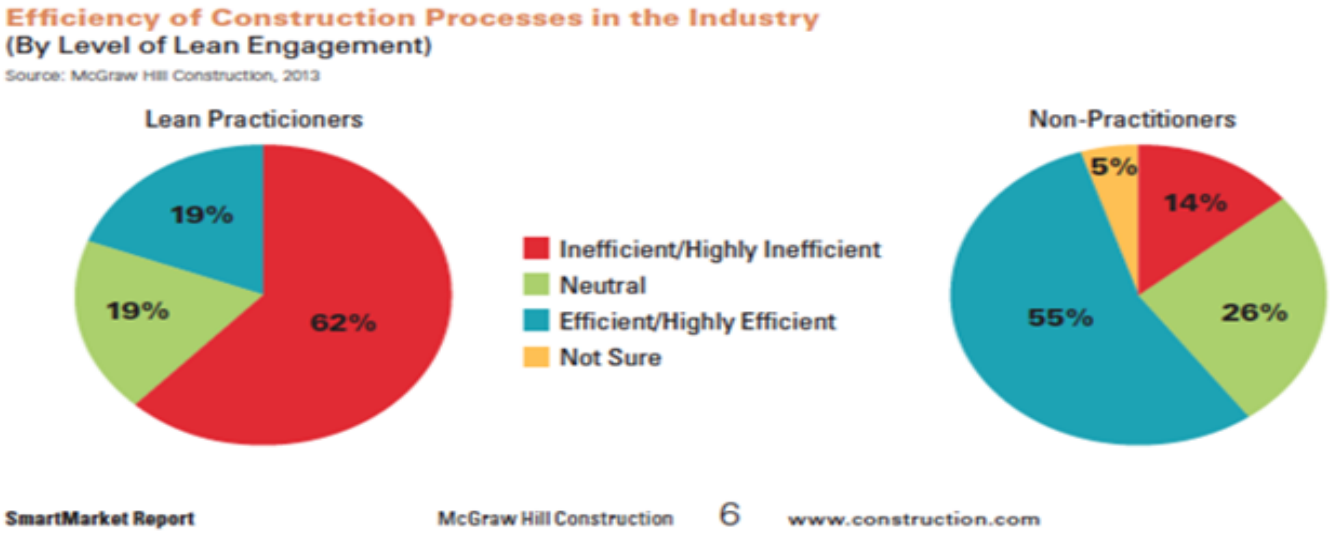

Fig. 2.2 Construction Process Efficiency

Table 2.1
Comparison Table for Manufacturing Production and Construction in the Field

	Start of manufacturing production	Start of construction in the field
What	Highly defined	Evolving as means refines ends
How	Highly defined. Operations plan is in great detail based on many trails. Primary sequence of many tasks is inflexible and the interdependencies are documented and analyzed. Positions in process determine required skills.	Partly defined but details un-examined. Extensive planning remains by hard logic but may change. Interdependencies due to conflicting measurements, shared resources, and intermediate products only partly understood. General craft skills to be applied in a variety of positions
Assembly Objectives	Produces one of a finite set of objects where details of what and how are known at the beginning of assembly	Make the only one. The details of what and how are not completely known at the beginning of assembly
Improvement Strategy	Rapid learning during the first units preparing for production line	Rapid learning during both planning and early sub-assembly cycles

B. Need for Lean Construction:

As construction industry gets competitive, thinking and applying Lean to Construction activity is critical to winning customers and ensuring profitability. The aim of Lean Systems is to design, produce and deliver products/services, which exceed customer expectations in terms of Cost/ Quality/Time/Performance.

The participants will be able to experience how different management concepts are integrated and can be applied to build a Lean Organization focused on Customer Value Creation. Develop insights into creating Lean Systems in a Construction project environment. Learn to discover and remove wastes in their organization, own jobs, and simplify processes. Cost reduction through process Simplification, inventory reduction, development of managers with acute awareness of creating customer value for top line growth.

Lean construction is a new way to manage construction. The objective, principles and techniques of lean construction taken together form the basis for a new project delivery process. Unlike current approaches to managing construction (including design-build) and programmatic improvement

efforts (Partnering and TQM), lean construction provides the foundation for an operations based project delivery system.

Waste is defined by the standard of perfection. Failure to meet the unique requirements of a client is waste, as is time beyond instant and inventory standing idle. The standard demands a new form of production management. Zero time delivery of a car meeting customer requirements, with nothing in inventory required that the rapid movement of each car down the line be tightly coordinated with the arrival of parts from supply chains.

Rework would have to be eliminated as it reduced throughput, the time to make a car from beginning to end, and caused workflow to be unreliable. Eliminating the unreliable workflow is the key to both throughput and minimizing inventory cost. Reducing the cost or increasing the speed of any one activity is likely to inject uncertainty into the flow of work and thus rarely contributes to increased throughput or lowest total cost. Rapid completion and low cost require high throughput resulting from matching the arrival of resources "Justified-in-time" with the flow of work.

Construction and manufacturing differ significantly in the physical features of the end product. In manufacturing, finished goods generally can be moved as a whole to retailers or end customers. Construction, on the other hand, deals with larger units that cannot be transported. Additionally, the construction industry has three other features that distinguish it from manufacturing: Onsite production, one-of-a-kind projects, complexity, temporary multi organization and regulatory interventions as discussed earlier. The combined effect of these features of construction is uncertainty. The manufacturing process makes it possible to reduce uncertainty by increasing control over the process itself. A steady state is desirable in order to increase efficiency through repetition. In construction projects, significant uncertainty exists throughout the project. Weather conditions, soil conditions, owner changes, and the interaction between multiple operations can produce unique circumstances, which could be as critical as the planned activities and have a significant impact on project cost.

This topic will emphasis on study of implication of lean techniques on wastage control of a construction project in which specific lean construction elements will be tested. Each technique will be evaluated in terms of its impact on the performance of the project. Based on the findings of the study, a new "lean assessment tool" will be proposed to quantify the results of lean implementations. The assessment tool evaluates lean construction elements: Last planner, increased visualization, huddle meetings, first-run studies, five S's and fail-safe for quality, increase in pre-manufactured products in construction, Value Stream Mapping, Target Value Design, cluster groups, and building information modelling (BIM), A3 Reports, Weekly Work Plans, and Plus Delta.

III. LEAN CONSTRUCTION TOOLS

A. Last Planner:

- **Reverse Phase Scheduling**

All subcontractors were encouraged to chart their schedule on a wall display using Post-it notes. Subcontractors could see how their planned schedules affected the completion time of a particular phase of the project. Within a few weeks, planners started to rely on reverse phase scheduling to estimate activity durations instead of going back to the original master schedule.

- **6-Week Look-Ahead**

The project manager was not familiar with the look-ahead schedule, so the research team prepared the first look-ahead schedules. Once the project manager realized that the look-ahead schedule could provide an updated picture of the project assignments to be completed, he started to prepare it regularly. The project manager focused the constraint analysis on material issues.

- **Variance Analysis**

Cost variance was the only performance indicator at the start of the project, so it was difficult to introduce the variance of assignments as a meaningful performance measure. When assignments were not completed on time, the project manager provided the immediate cause, e.g., weather conditions or scheduling. By the end of the study, the project manager was able to identify the root causes of variances and set action plans to deal with delays.

- **Percentage Plan Completed Charts**

The research team prepared percentage plan completed _PPC_ charts at two levels: project and subcontractor. Subcontractors were concerned about their weekly PPC value, so they tried to improve the quality of their own assignments. During the study, the project staff prepared the PPC charts and posted them in the site trailer.

B. Increased Visualization:

- **Commitment Charts**

The GC's vice president addressed the project personnel to emphasize the importance of their safety to the company. The attendees were asked to give examples of how to maintain safety practices on a job site. At the end of the presentation, a commitment pledge was signed by all employees and posted in the trailer throughout the project.

- **Mobile Signs**

The project personnel provided their input on the design of the safety signs. After a brainstorming session, mobile signs were designed and later posted on various areas of the site. Most of them used colourful and funny expressions to attract the attention of all people on the job site.

- **Project Milestones**

The project personnel were not regularly informed of completion dates at the beginning of the study. Once the signs were designed, completion dates were plotted and posted floor by floor throughout the project. At the end of the study, most workers stated that they felt more involved in the execution of the project.

C. Huddle Meeting:

- **All-Foreman Meetings**

An informal meeting of all project foremen was replaced with the weekly work plan meeting, which focused on the completion of assignments during the following week. The discussions during the meetings addressed overlapping activities and identified potential problems on the job site. Actions agreed to at the meetings were recorded in minutes and were reviewed the following week.

- **Start-of-the-Day Meetings**

Project personnel met at the beginning of each workday for 5 to 10 minutes to review the work to be done that day. Scheduling, safety, and housekeeping were the most common issues to arise during these meetings Based on job surveys, at least 67% of the workers found value in the meetings. More than 42% of the workers provided some feedback during the meetings. Most of them stated that they are more likely to talk directly to their foremen during that time of the day.

D. First-Run Studies, Plan, Do, Check, Act:

- **Plan**

Two assignments were selected with input from the foreman, superintendent, and project manager: installing bumper walls and construction joints. Bumper wall installation was chosen because it is a high-cost activity, and construction joint installation was selected because of its high variability.

- **Do**

Assignments were documented with video shooting and productivity studies. One flaw in the documentation was that most of the input came from the foreman instead of from the crew. The crew was focused exclusively on the completion of the task. The description of the activities could have been more detailed with input from the crew.

- **Check**

The work performed was checked in a formal meeting attended by the project manager, the foreman, and the crew. The research team led the meetings, looking for potential improvements and learning opportunities. Most of the participants tried to give their best suggestions as to what could be improved for the next repetition of the assignment.

- **Act**

Ideas suggested during the meetings were tested by the same crew, with support from the project manager and the foreman. The results showed more than 38% reduction in the cost of crash walls and 73% reduction in the cost of construction. Joints after the studies were completed. The actions implemented included new methods, changes in the composition of the crew, and a better sequence of activities.

E. Five S's

- **Sort**

The first level of housekeeping consisted of separating material by reference and placing materials and tools close to the work areas with consideration of safety.

- **Straighten**

Next, materials were piled in a regular pattern and tools were placed in gang boxes. Each subcontractor took responsibility for specific work areas on the job site.

- **Standardize**

The next level included the preparation of a material layout design. The layout contained key information of each work activity on the job site. The visual workplace helped locate incoming material, reduce crane movements, and reduce walking distance for the crews.

- **Shine**

The next step consisted of keeping a clean job site. Workers were encouraged to clean workplaces once an activity had been completed. A housekeeping crew was set to check and clean hidden areas on the job site.

- **Sustain**

The final level of housekeeping sought to maintain all previous practices throughout the project. At the end of the project, this level was not fully achieved, in part because project personnel did not view housekeeping as a continuous effort. They had to be reminded frequently of housekeeping practices.

Fig. 3.1 Planning Levels

F. Fail-safe for Quality:

- **Check for Quality**

An overall quality assessment was completed at the beginning of the project. Most quality issues could be addressed by standard practices, and it seemed there was little room for improvement. During the execution of the project, however, some critical items appeared. A new vibration method for shear walls was suggested and implemented by the superintendent of the project.

- **Check for Safety**

Safety was tracked with safety action plans, i.e., lists of main risk items prepared by each crew. Potential hazards were studied and explored during the job. Most hazards, such as eye injuries, falls and trips, and hearing loss, have standard countermeasures; however, in practice, workers have to be reminded of safety practices.

G. Value Stream Mapping:

A powerful lean tool, designing the relationships and dependencies between the owner, designers, and construction was a necessary first step to produce a functional group. What information was needed and when did the designers need to supply it to the constructors for them to continue their work? What information did the constructors need to feed back to the designers to input the constructability factors, and when? Who communicates to whom and by what method? How are conflicts resolved? When do the owner and GC have to approve competed work? These are all very important questions that Value Stream Mapping can help answer in a systematic fashion.

H. Building Information Modelling:

BIM is another tool to make the project more efficient. Drawing the building in a virtual environment and performing clash detection between architectural, structural, and building systems in the virtual model is more efficient than finding and correcting the issues in the field. This eliminates waste, thus meeting a core requirement of Lean Construction.

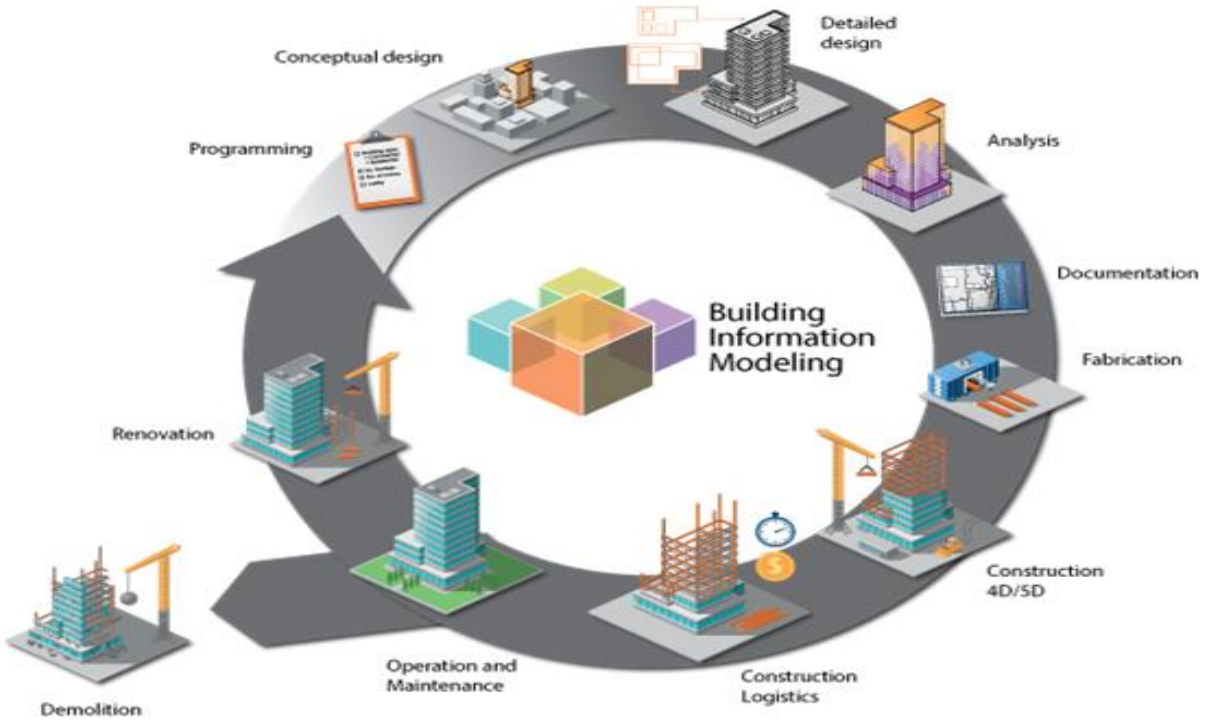

Fig. 3.2 BIM in Construction Project

I. A3 Report:

The A3 process, another lean tool, is a structured report used to solve a problem, report project status, propose a policy change, or make a purchase. The name A3 refers to A3-size paper (11.69 in. by 16.54 in.). The objective is to fit all the necessary criteria on one page of A3 paper to present to for approval. A good A3 report will have a description of the current condition, root cause analysis, target condition, implementation plan, follow-up plan and result report.

IV. CONCLUSION

In this paper, we had analysed the general perceptions of construction industry and how the lean construction tools can be used to improve the implementation of these activities particularly in managing construction wastes. As mentioned in this paper, we developed a process improvement tool using lean construction which are executed it in different sites. We received an overwhelming response from the construction team and they found it very effective tool that can be implemented in the site.

The following are the advantages that we found by using our tool

- Very Simple and easy to use
- Better way to convey the information about a problem to the top management
- Easy to understand from the top to bottom of the construction pyramid
- No additional cost is required for the implementation
- Qualitative improvement could be able to achieve in few days of implementation
- Reduction in the overall cost of the activity
- Reduction in overall time of the activity
- Better communication with various stakeholders of the project
- Members/ Stakeholders will be empowered in decision making to make it successful
- Each member of the construction supply chain will be aware of its influence on the overall project
- Materials and components can be selected to meet the best needs of supply chain discipline
- Just In Time (JIT) can be implemented
- Purchase department will focus on ‘Pull’ Purchase i.e., purchase to cater the current demand
- It focus on delivering the value desired by the owner, which primarily leads to the principle ‘Customer is the King’
- It is a continual improvement/pursuit of perfection involving everyone in the system
- Inefficiency and waste in the use of labour and materials will be eliminated
- Reduction of accidents in the site
- Proper synchronisation of activities can be done much effectively than using planning softwares
- Better clarification can be ensured among various stakeholders for project implementation
- It can be used for the process improvement of any activities irrespective of its nature and size.

- We can put an end to **'JUST DO IT'** policy of implementing activities

Lean Construction which was developed in the mid-1980s had a more formal start with the first meeting of the International Group for Lean Construction in 1993. 'Lean Construction' has developed and reached mature stage in countries such as Denmark, US, Chile, Brazil, Peru, Germany, UK, Australia and Sweden. HCC is implementing Lean Construction for their water supply irrigation project in Andhra Pradesh. This is the first of its major kind in the field of Lean Construction in India. Other construction majors in India such as Shapoorji Pallonji, Essar, and Oberoi are trying to implement Lean Construction for their projects in India.

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