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APPLICATION OF LEAN CONSTRUCTION TOOL (L.P.S) TO IMPROVE
LABOUR PRODUCTIVITY AT CONSTRUCTION SITE

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ABSTRACT

Indian construction industry still follows the primitive work pattern, which generates poor management in resources, waste management, over budgeting and schedule lagging.

To eliminate all the above mentioned issues, construction industries are now adopting sophisticated tools and techniques like lean construction tool (L.P.S). This paper includes the implementation of last planner system at site. After the implementation we observed the improvising effect in the area of labor productivity therefore, we can conclude that the L.P.S technique is better than the primitive project management approach.

Keywords: Last Planner System, Lean Construction Institute, Lean Construction, Weekly Work Plan, Building Information Modelling, Just – in- time and Project Evaluation Planning.

I. INTRODUCTION

In India, construction industry is the second largest industry after agriculture and services, according to XII Five (5) year plan (2012-2017) there are several proposals for construction works like roads, railway, seaports, airports, metro and smart- cities.

Lean construction system has been introduced as a new management approach to improve the productivity in the construction industry.

A. Definitions

Lean construction is a method to design production system to reduce the wastage of materials, time and efforts in order to generate the maximum possible outcome.

Lean: The main object is, to maximize customer value while minimizing wastage. Generally the meaning of Lean is creating more value for customers within limited resources.

Construction: Building construction is the process of preparation and formation of building and building system, which starts with planning, design, financing and continues until the structure is ready for occupancy.

Management: The organization and coordination of the activities of a business in order to achieve the defined objectives.

Last Planner System: it is a collaborative planning process that involves trade foremen or design team leaders (the last planner) during planning in greater and greater detail as the time for the work to be done get closer.

In UK it is known as: **Collaborative Planning.**

In USA it is known as: **Pull Planning.**



Fig 1. Last Planner System (Ref. 1)

B. History of Lean Management

. Lean manufacturing is not especially new, it derives from the Toyota Production System or Just-In-time production, Henry Ford and other predecessors.

Henry Ford: Although there are instances of rigorous process thinking in manufacturing all the way back to the Arsenal in Venice in 1450s, the first person who truly integrate an entire production process was Henry Ford.

Kiichiro Toyota: As Kiichiro Toyota, Taiichi Ohno, and others at Toyota observed this situation in 1930s, and more intensely just after **World War II**, they learned that a series of impel innovations might create the possibility to produce continuity in process flow and a wide range of variety in product offerings.

Lean today's: Today's big construction firm from U.S.A, U.K and China is easily accepting lean tools (L.P.S) at site. Construction firm are accepting it and getting benefits after its implementation. Most important some of the lean tools are in use from more than two decades throughout the world.

C. Objective of the study

. Identify tools and techniques of Lean Construction Tool. .

Identify the importance of L.C in Indian Construction Industry.

. Identify the impact on productivity of labors after the implementation of LPS in the Construction industry.

. Identify the terms, where LPS is different than the traditional Project Management Approach.

D. Need for Study

Due to the infrastructure development in the county, several construction firms are launching themselves in the market and labor productivity has been calculated annually 40-60%. Which can be increase by 60-70% by applying L.P.S at site for upcoming projects. Implementation of L.P.S is necessary, the main objective of lean management principle is "Drive more value by using less of resources."

II. LITERATURE REVIEW

Mossman Alan, 2013 has worked on LPS and analyzed almost 26 Cases and feedbacks on the site of U.K, where people were already using LPS. His published paper "Last Planner 5+1 crucial and collaborative conversations for predictable design and construction delivery" explains the importance, compilation and benefits of LPS implementation.

Amit Shankar Murje, in 2014 has elaborated that why Iean construction techniques is better than the traditional project management approach.

Thomas & Maloney have published in ASCE journal paper “Modelling Construction Labor Productivity” and discussed the formula to find out labor productivity in all different kind of site- situation.

In 2006 Aditi Javknedkar applied Lean Construction in concrete construction project, which introduced lean and last planner system in construction industry.

In 2005 Mr. O.Salem and J. Salomom implemented and assessed lean at construction site of Honda U.K and finished the case study.

III. RESEARCH METHODOLOGY



Fig 2.Sequence of Research Methodology

Stage I: Formulation of Objective of the study

Collection of references include journals, technical reports and books.

Stage II: Find out Importance of Lean Construction Technique in India

To address importance of lean technique in Indian construction industry.

Stage III: Apply Lean Technique at Site

Apply lean Technique at site and find out the impact.

Stage IV: Survey, Feedback, Observation, Calculation.

Data collection from observation and questioner survey and lowest possible level in a whole range of one-off production calculation to find out labor productivity at construction site.

Stage V: Results and discussion

- . To identify the benefits of Lean implementation.
- . Collect suggestions from users.

IV. TOOLS AND TECHNIQUES

BIM (Lean Design),
A3, process design (Lean Design),
Offsite fabrication and JIT (Lean Supply),
Value chain mapping / Last planner system (Lean Assembly),
Visual site (Lean Assembly);
5S (Lean Assembly),

Daily crew huddles (Lean Assembly).

V. LAST PLANNER SYSTEM

On the basis of the research, Mr. Glenn Ballard and Greg Howell invented the last planner system to improve construction productivity in 1980s. It is “The Collaborative, commitment based planning system that integrates should-can-will-did planning (Pull Planning, Make-Ready plan, Look-ahead plan)with constraint analysis, weekly work planning based upon reliable promises and learning based upon analysis of PPC (Plan Percentage Completed) and reasons for variance.”



Fig 3. Mr. Greg Howell (Right) & Dr Glenn Ballard (Left) (Fig. Ref. Google)

And they said “Last Planner Manages the relationships, conversations and commitment which enables program and production planning decision to be made collaboratively at the lowest possible level in a whole range of one-off production settings.”



Figure 4. Implementation of L.P.S at site (Image source: Google)

A. Why should construction people choose L.P.S?

Technical and non-technical person both can use the L.P.S at site to achieve best performance in design and construction, to determine the schedule of work completion.

There are many reasons why any organization should adopt LPS (Including owners, designers and constructors)

- . To deliver projects more safely, on-time with less cost.
- . To build more predictable production program.
- . To reduce the stress/burden of project management team.
- . To improve the overall production process.
- . To increase the customer’s reliability by Just-In-Time delivery.

And on the basis of Case-Study reviewed papers there are some benefits like:

1. Smooth work flow.
2. Predictable work plan.

3. Reduces Cost.
4. Reduces delivery time.
5. Improves productivity.
6. Good collaboration/coordination with field personnel and subcontractors.
7. Helpful in monitoring.

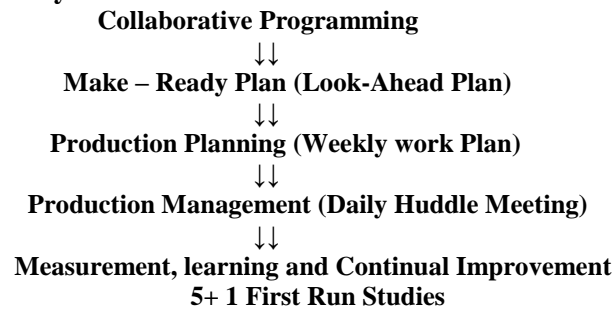
B. Is LPS only applicable in construction sector?

Glenn Ballard, in May 2012 at Nottingham Trent University in U.K has been reported that LPS can use in these fields also:

1. Production.
2. Software engineering.
3. Healthcare.
4. Development in the sector like Oil and Gas.

He said that “LPS works in all kind of situation where human coordination requires.”

C. Steps of Last Planner System



Last Planner System improves both design and construction, which gives project work flow, reliability and completion of work on time.



Figure 5. Steps of Last Planner System

1. Collaborative Programming:

- . Helps project team to increase the coordination by knowing each other, identify the problems within the project and reaches on the decision by mutual agreement to how to solve it, design and plan handovers.
- . Master planning and pull planning on the basis of overall project objectives and master scheduling plan to know what should be done next.

Benefits of Collaborative Programming:

- . Prepare each team member for action together from starting of project.
- . Sorts out sequencing as well as issues/difficulties to make smooth work flow.
- . Identifies unclear design details.
- . Builds commitment within each participants and reduces overall program period.

2. Make – Ready

- . Making tasks in the look ahead period ready so that they can be easily done whenever we want to do them.
- . Ensure that the work will be done when it is require to do.

Benefits of Make-Ready Process

- . Task or things are be ready for production or construction when requires.
- . Less wastage of material and equipment due to greater certainty of time.

3. Production Evaluation & Planning :

- . Regular Production evaluation and meeting planning is involve throughout the project in Last Planner System.
- . This meeting is weekly and known as weekly work plan meeting.
- . Beneficial in monitoring current activity at site.
- . Each last planner leader proposes a construction program for his team In P.E.P meeting and they identifies if there is any inter-dependencies between their proposals like resources, equipment and reduces the burden of over-committing by distributing each task within team members.

WORK SCHEDULE : WEEKLY

WEEK BEGINNING	COMPANY							DEPARTMENT	
EMPLOYEE NAME	WORK ASSIGNED	MON 3/4/17	TUES 4/4/17	WED 5/4/17	THUR 6/4/17	FRI 7/4/17	SAT 8/4/17	SUN 9/4/17	HOURS

Figure 6: Weekly Work Plan Format

Benefits of PEP meeting in the context of Last Planner:

- . Try to maintain relationship between supplier and team leaders through reliable promises, commitment and implementation.
- . Maintains commitment by doing their task, and focuses on what can really be done.
- . They work together every week for the improvement and learn from their own and other's experience.

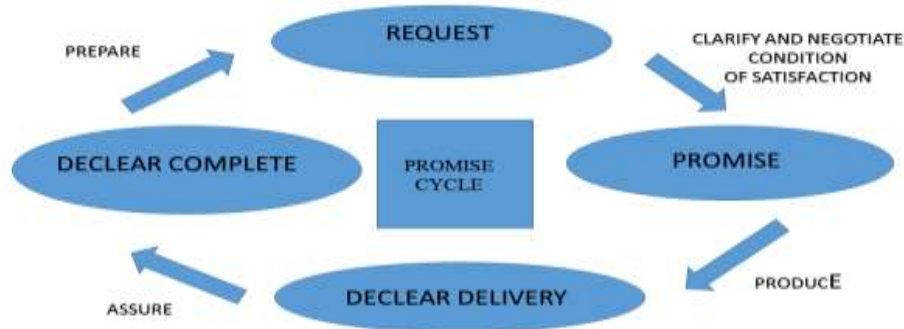


Figure 7. Promise Cycle of L.P.S

4. Production Management

- . Collaboratively monitoring of production to keep activities on track.
- . Helps to adjust plans in the light of new information/data according to the percentage (%) of work completed actually and what is expected, means re-scheduling.
- . Construction is a social process, coordination, conferences on telephone between the contractors so that manage/arrange the equipment/resources so that tomorrow's work will be start on the time in spite of last minute adjustment and this is the responsibility of project manager for the set-up and brief meeting or conversation and it takes not more than 15 minutes.

5. Measurement, Learning & Continual improvement

- . Learning together is all about improving project, planning and production process.
- . At the end of the task executed at site by measurement we can get to know the reason for variance and they try to reduce in next activity and this is called continual improvement.
- . And learning elements, encourages learning from success and reduces repeated failures.
- . Last planner measures the predictability of work delivery – percentage of promises completed on time and at the end of PPC meeting, team members get motivation to do next week activity for more satisfaction.
- . After using LPS in U.K and U.S, construction industry institute reported the correlation between the PPC and productivity on engineering construction project, they observed changes in productivity and profitability with the PPC around 75%-90%.

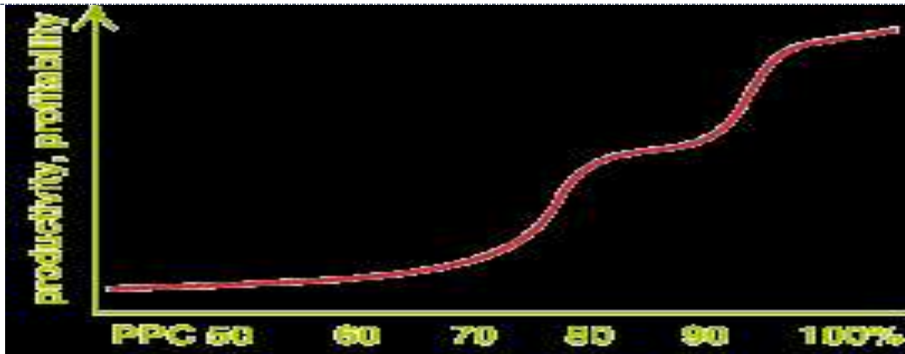


Figure 8: Correlation between PPC and Productivity (Mossman)

There are various reasons which team member faced while its execution on site, so that the reason and type of problem occurring find out by Pareto chart, Cause and effect diagram or by any other Quality Control tool.

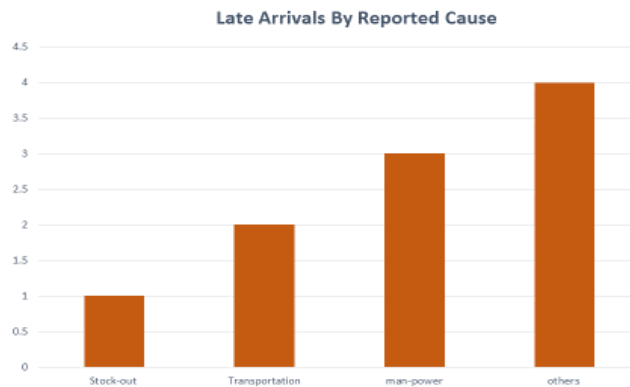


Figure 9: Pareto chart for causes of late arrivals materials to the site

+1 First Run Studies

The first run study is integral part of LPS, FRS is used to learn about the sequence so that it can be improved and done more safely, completed to the required quality, FRS is based upon Plan-Do-Check-Act cycle.

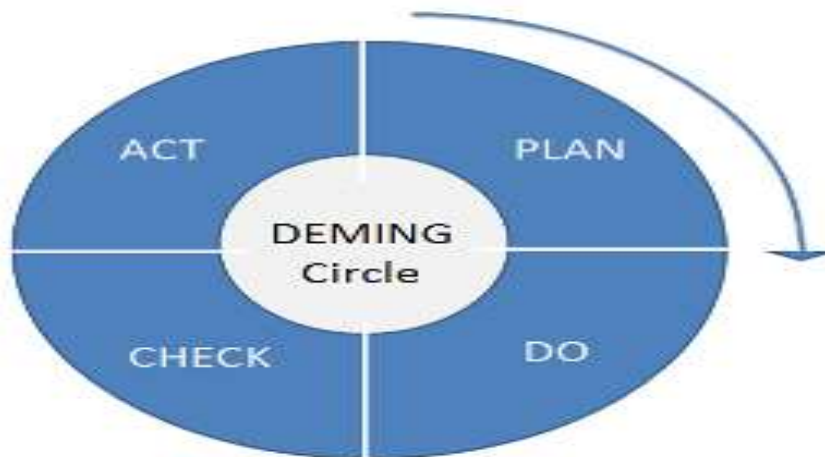


Figure 10: Deming P-D-C-A Cycle

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VI. CASE – STUDY : IMPLEMENTATION AT SITE

In India , there are very few sites who actually use Last Planner System at site, the other tools like Building information modelling ,A3 Report for documentation work , Just in Time , these are already in use at construction site .

So the challenges is to implement L.P.S at site and to know that how much it is useful by taking feedback through each employee.

That’s why we have been chosen a construction site in Pune (India) and the details are:

- Apply Last Planner System (LPS) at Site.
- Site name – Suvaranrekha
- Type of Building- Commercial (7 Floor)
- Location – Prabhat road , Pune (INDIA)
- Project started – Feb 2012 , Finish – Dec 2016



Figure 11. Images of construction site

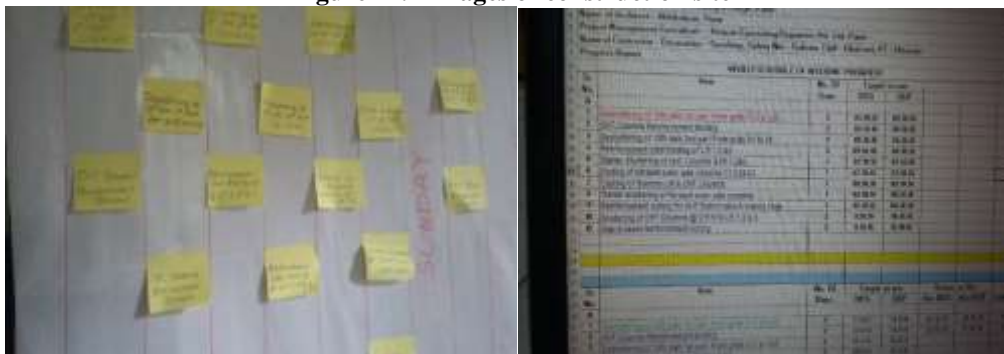




Figure 12. Apply last planner system at site

OBSERVATION / FINDING

By the implementation on construction site, taking feedback by questioners survey as well as observation

- Optimum use of resources
- Reduce waste
- Transparency
- Time save
- Avoid dispute

VII. EFFECT ON THE PRODUCTIVITY OF LABORS:

Calculation

A. Labor productivity = Output / Labor cost

B. Labor productivity = Output / Work-hour

C. Labor productivity = Labor cost / Output

OR = Work hours / Output

D. Performance factor = Estimated unit rate / Actual unit rate

1. For plastering work

Per day work done by the labor = 10 m² (quantity of material)
(8 hour)

Area covered = 100 ft²

No. of person = 1 skilled labor + 1 unskilled labor + 1 helper

Cost for 1 day = 500 + 350 + 300
= 1150

- a. Labor productivity = $100 / 1150 = 0.086$ ft²/Rs.
After applying L.P.S = $110 / 1150 = 0.095$ ft² / Rs.
- b. Labor productivity = $100 / 8 = 12.5$ work/hr
After applying L.P.S = $110 / 8 = 13.75$ work/hr
- c. Labor productivity = $1150 / 100 = 11.5$ Rs/ ft²
After applying L.P.S = $1150 / 110 = 10.45$ Rs/ft²
- d. Performance factor = $10.45 / 11.5 = 0.9$
After applying L.P.S = $11.5 / 11.5 = 1$

2. Brick work in foundation and Plinth level with cement mortar

Quantity = 1.25 m³ / day

Work done by mason

Payment for 1 day to mason = 1150 /-

After applying L.P.S work done = 50 ft³

Quantity = 1.4 m³/day

- Labor productivity = $45/1150 = 0.04$ ft³/Rs.
After L.P.S = $50/1150 = 0.043$
- Labor productivity $45/8 = 5.6$ ft³/hr
After L.P.S = $50/8 = 6.25$ ft³/hr
- Labor productivity = $1150/45 = 25.6$ Rs./ft³
After L.P.S = $1150/50 = 23$ Rs./ft³
- Performance factor = $23/25.6 = 0.9$
After L.P.S $25.6 / 25.6 = 1$

Table 1. Productivity of labor for plastering work

For plastering work			
	About	Before L.P.S	After L.P.S
By equation A.	Labor productivity	0.086 ft ² /Rs.	0.095 ft ² /Rs
By equation B.	Labor productivity	12.5 ft ² /hr.	13.75 ft ² /hr
By equation C.	Labor productivity	11.5 Rs./ft ²	10.45 Rs./ft ²
By equation D.	Performance factor	0.9	1

Initially mason was covering 12.5 ft² per hour plastering and after applying LPS the productivity improve by 13.75 and initially we were paying 11.5rs./ft² and after applying LPS we are paying 10.45 for the same area. So productivity increase and per ft² payment is also reduce as compare to previous.

Table 2. Productivity of labor for brick work

For Brick work			
	About	Before L.P.S	After L.P.S
By equation A.	Labor productivity	0.04 ft ³ /Rs.	0.043 ft ³ /Rs
By equation B.	Labor productivity	5.62 ft ³ /hr.	6.25 ft ³ /hr
By equation C.	Labor productivity	25.6 Rs./ft ³	23 Rs./ft ³

By equation D.	Performance factor	0.9	1
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Initially labor was covering 5.62 ft³ per hour brick work and after applying LPS the productivity improve by 6.25 and initially we were paying 25.6 Rs. /ft³ and after applying LPS we are paying 23 for the same area. So productivity increase and per ft³ payment is also reduce as compare to previous.

VIII. DISCUSSION OF RESULTS AND RECOMMENDATIONS

By applying lean construction tool (L.P.S) at site, the labor productivity observed by 10 to 12% as compared to previous. Exp. For plastering it improves 12.5 ft²/hr to 13.75ft²/hr and performance factor 0.9 to 1. Same as for brick work and other construction work. So it is practically beneficial for the optimizing resources and improve labor productivity at construction site.

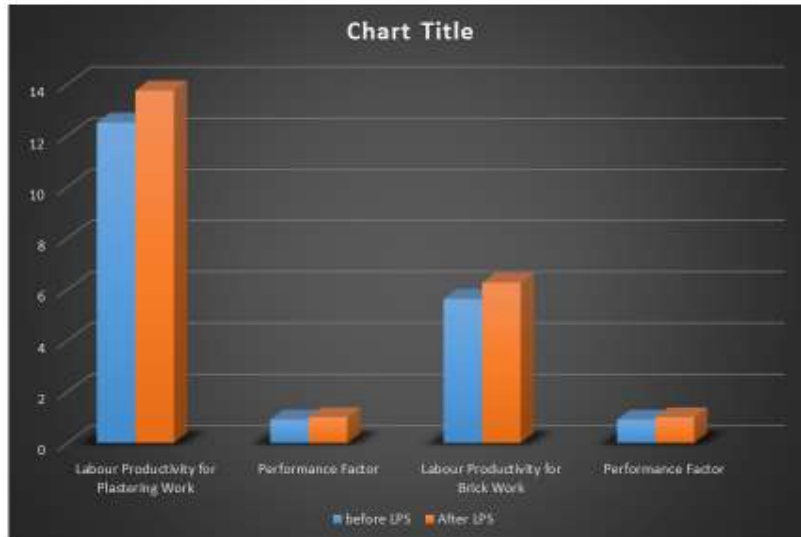


Figure 13. Before and after applying LPS

With and without LPS



Fig 14. Without last planner system

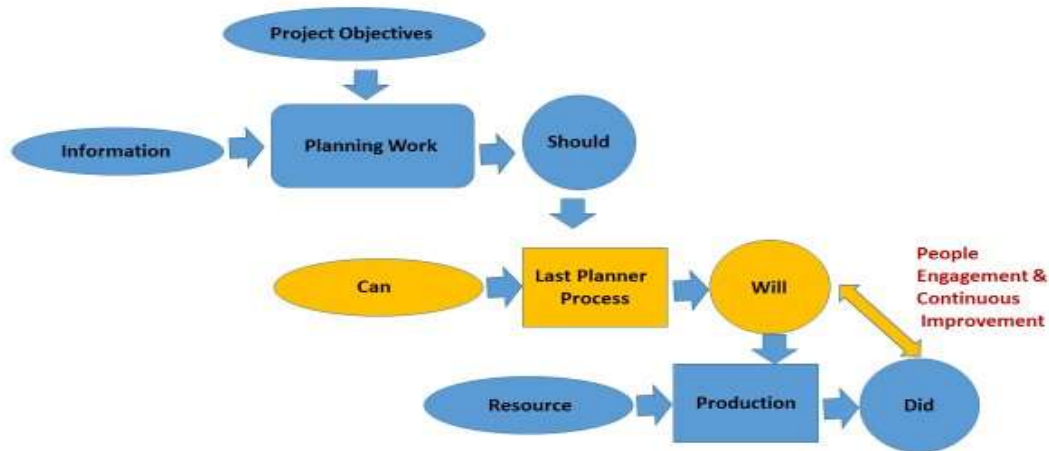
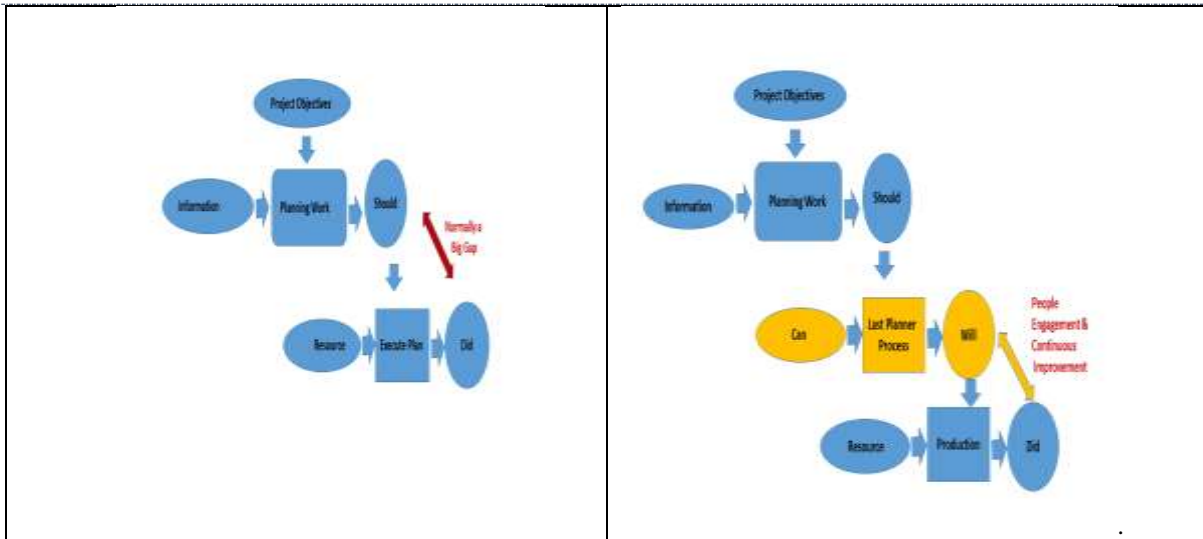


Fig 15.After applying last planner system

IX. IN WHICH TERMS IT IS DIFFERENT THAN THE TRADITIONAL PROJECT MANAGEMENT APPROACH:

Traditional Construction Management	Lean Construction Management
1. Customer is not involving in planning stage.	Customer, Client, Owner, Contractor, Project Manager everyone involve from starting.
2. This is Push Techniques focus to increase productivity of each activity even if this may be causes of rework, reduce customer satisfaction.	This is Pull Techniques, main focus is on the proper flow of activities with reduce error or rework and consideration of customer’s requirement and satisfaction.
3. It does not consider adjustment because of the isolated environment and only Project Manager Work as a boss, so there are no suggestion or ideas come from the participants.	This system’s capacity absorb the variation, because of feedback loop, learning and continual improvement and rapid system response.
4. Traditional construction management does not pay attention to continuous improvement.	And this approach tries to make continuous improvements.
5. Construction management decision rights cantered to one person that is call project manager.	And in Lean construction, decision power making is distributed in all those who are involved.
6. It does not consider transparency in between the customers, managers and labors.	It tries to increase transparency between the customers, managers and labors.



X. CONCLUSION / BENEFITS OF L.P.S IN LABOR PRODUCTIVITY BY FEEDBACK & IMPLEMENTATION

We have successfully applied L.P.S at site, and after analysis of 3 month we have observed by questioner survey and feedback on construction site and the benefits are -

- Transparency in scheduling
- Avoid waste of resources
- Proper monitoring and improve labor productivity from 40 % - 60% to 60% - 70%
- Easy to planning the next activity
- Efficient use of time
- Less dispute due to clear vision / planning
- Project was successful, met overall deadlines for completion, did not use contingency and shared savings resulted.
- Owner was pleased with the process efficiency, increased user input during design and final product.
- Team had well documented “lessons learned” for next project.

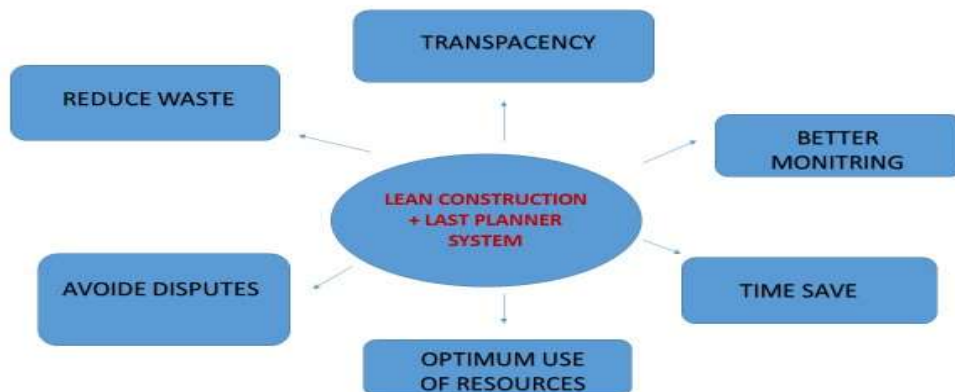


Fig 16. Benefits of L.P.S



XI. LIMITATION

Participants: Large construction companies are ready to implement after giving training or small workshop, but the small and medium companies are not much interested to use it.

No – one – size – fit – to – all: All firms are not fit in the guidelines or the way of Toyota production system, so all firms operate their works differently that's why all firms do not accept easily.

Takes time: it is not gives result in short term basis, implementation and then result takes time, overall it requires time, efforts, engagement of employees to make planning and get together within a week.

Implementation: Implementation of L.C is easy in Production System but is very tough to implement in construction sector.

XII. REFERENCE

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