

Lean Labour in AEC Industry: From Theory to Implementation



Siba Prasad Mishra, Saswat Mishra, Mohammed Siddique

Abstract: *The architecture, engineering and construction (AEC) industry, in India is flourishing due to urbanization, industrialization and modernization. The orthodox concept of construction was design-bid builds method or Integrated Project Development methods have been replaced by “lean construction” concept. The lean concept adaptation in AEC is contemporary to the socialistic working tool of the Anthropocene epoch during mid of 20th century. The studies on lean concept is highly relevant in the present social and ecological prospective which promote environmental sustainability, labour manager coordination and collaboration. The lean concept can enhance production and productivity in construction industry through effective implementation of lean labour management. The concept emphasizes on coordination, collaboration, team spirit with humane approach to labour management. The concept results in lowering cost, reduction and elimination of wastage, higher level of motivation, retention of workforce, innovation and implementation of result oriented management practices and achieving customer’s delight. The Takt time and last planners system is to be introduced with lean labour. The construction works on its flow processes require the value stream such as 6M’s (Men, Material, Machines, Methods, Mother Nature (environment) and Measurement), working under 5T’s principle (transparency, teamwork, technology, time, which shall lead to transformations) to be implemented within the AEC sector from grass root to top.*

Keywords: *Anthropocene, Lean Construction, Lean Labour, Last Planner System, Takt-time*

I. INTRODUCTION

The architecture, engineering and construction (AEC) industry is gradually undergoing transformation due to increasing population and the need for human settlements, urbanizations, and infrastructural requirements etc. The three major factors affecting the AEC are “land”, “capital” and “labour”. The last factor, “labour” play pivotal role as they directly influence the construction industry. The labour force mainly consisting of skilled, unskilled, semi-skilled are key instruments to the construction activities as they have bearing

on productivity. Labour being major cost component of build projects strategic implementation of lean construction, a new paradigm and especially lean labor to achieve the objective of efficiency. The concept of “lean” thought was borrowed from Toyota, Japan after World War II contemporary of the Anthropocene epoch and its socialistic approach. The lean concept was introduced by Lauri Koskela in 1993

Lean is a culture in which people use tools to continuously solve problems like lean thinking, lean labour, lean concreting etc.. The factors focused in lean labour are the labour component of the construction project lack of lean thinking, awareness and understanding, cultural and human attitude issues, work stress, proper planning, training and educational, communication between labour and contractor or subcontractors, financial and sociopolitical issues added with top management commitment. The construction project environment is volatile 4 U’s (Unexpected, unstable, unknown challenges, uncertain), lack of status, information and predicting outcome, complex (too many links, variables and processes) and ambiguous (too many lessons to be learned, experiments and implications of output).

The lean labour ideology focuses on reduction of construction waste, application of lean labour practices, planning, reliability, and performance improvement, strategic management by identifying critical nodes, modeling to save time, skill, mechanism and goal achievement Fig-1. Lean construction is designing structure systems to curtail waste of resource materials, tools, time, and energy to produce the optimum possible results. Lean Construction (LC) applies same philosophies as per lean production by reducing waste and enhancing quality, productivity and effectiveness in construction.

II. LITERATURE REVIEW

Koskela-2000 introduced the production theory for construction based on field studies later the management principle such as Transformation, value and flow (TVF) theory) was developed (Bertelsen et al. 2002 and Koskela et al., 2002). Drawings of structures and products have been improved but design part is less advanced in last 40years (Li et al 1998 and Love et al 2000). The lack of upgrading of construction industry are due to industry breakup, absence of trust among key contributors, the orthodox construction processes, craft-oriented philosophy, strict regulations, safety problems, and less innovation (Javkhedkar, 2006). The most convincing part of lean concept is empowering employees which mobilize, motivate and inspire them without resistance to adapting the changes (Inji S., 2013).

Manuscript received on February 10, 2020.

Revised Manuscript received on February 20, 2020.

Manuscript published on March 30, 2020.

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The end users are apathetic to understand Lean construction potentialities but get the value of it (Marhani et al., 2012). Last planner system in the construction under LC technique is not well understood by project managers and do not get result of the system (Chamberlin et al., 2017). Shang Gao (2014), reported that

lean construction lags the concept of long term thinking, lean culture, multi-layer subcontractors and issues related to partnership associated with managerial and organizational concerns. Olatunji (2008) compartmentalized the related barriers in lean construction of Nigeria as skills and facts, management, Government, Attitude, resources and logistics which are the stepping stones in construction Industry. Abdulla et al and Mossman (2009), reported that the shortfall in implementation of lean construction are absence response, communication, focus and pledge from the apex management, snags in picturizing the notion of LC appliqué.

The lean upgradation must stress upon the labour management approaches to augment labor exploitation which will result in healthier labour performance. (Thomas et al. 2003). Defaulting lean implementation and noncompliance to labor values like wages and duty timing have impact on social performance, construction productivity and safety norms resulting in unhealthy labor relations (Greg et al., 2017). Lean architecture, inadequate training and orthodox managerial approach also affect construction productivity. Work progress reduces wastes in construction, increases labor efficiency and improves project enactment. The poor labor management fetches the unreliability, inefficiency and meager loyalty to work progress, (Zhang et al., 2017). The construction industry in India is following orthodox work culture and work pattern generating weak organization in achieving goals like obtaining resources, cost effectiveness, instilling least waste, excess budgeting and lagging in schedule (Verma et al., 2017). Loktu E., 2018, introduced the Takt-time planning in lean construction for a conflict less, continuity in construction flow.

The preindustrial period:

During preindustrial period (Post Holocene Period i.e upto 17th century), different construction activities were less but individualistic due to expertise of a specific caste, religion, place etc..So construction activities like palaces, monuments, temples, mosques, and other antiquities were region or zonal concentric but unique and costly. Plenty of unskilled workers were used on bethi (without wages) were the major section of the workforce with limited skill to serve the kingship.

The post Industrial period:

The pre-Anthropocene period (postindustrial era) construction activities were plenty, standardized with repetitive activities. Most of the construction activities depend upon the skilled or semiskilled workers. Gradually mechanization, and special handy gadgets producing multiple special products of similar identity and look used for fixing, decorating in construction industry unlike one specialist show in preindustrial period.

Anthropocene Period:

The Anthropocene epoch succeeded the Holocene epoch in India from 1945 (Mishra S. P. 2017) During the Anthropocene; the construction activities became more

efficient with emphasis on reducing waste , idle time, and with enhanced safety and security only based upon the lean thinking concept. The products resulted have demanded excellence, flawless, least inventories, minimum prices, eclectic varieties, alluring, strong & durable. Lean makers have focused unble materials, labours, machineries and finally value added flow processes without the ecosystem.

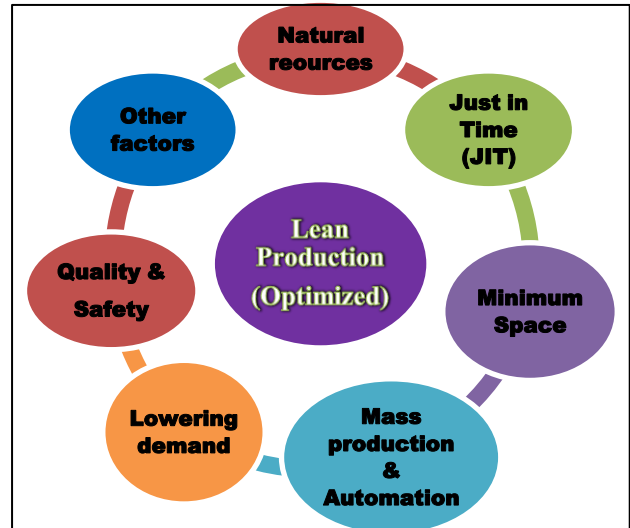


Figure 1: The lean production (TQM) introduced by Toyota Motors in 1950' (Aziz et al., 2013)

III. LEAN CONCEPT

The lean concept in AEC structures is based on value, value-stream, low wastage, productive flow, pull and perfection. The value in construction industry relies upon waste reduction, projecting continuous perfection in the process by considering customers satisfaction. Once customers choice is fixed, funding is provided, the project works on flow processes necessary for value stream such as 6M's (Men, Material, Machines, Methods, Mother nature (environment) and Measurement,) working under 5T's principle (transparency, teamwork, technology, time, which shall lead to transformations) and shall be measured by 7C's (cause and effect diagram, check sheet, control chart, histogram, Pareto chart, scatter diagram, run chart and finally the flow chart). Lean construction demands waste reduction related to material, labour basing upon defects, over production, waiting, transport, non-utilization of talent, motion, inventory and over processing and above all management attitude. Work process flow is essential in lean construction to have a continuous and un-interrupted work flow which is only possible by proper sequencing of activities. Planning and scheduling results in bringing the contractors, controlling staffs, quality control, risk managers in the same boat to reach the goal with proper communication, collaboration and team spirit. Perfection is taught by innovation in methodology, introducing new machineries, advanced skilled work group culture of continuous improvement and accomplishment.

A. Concept of Lean Labour :

Lean labour is considered as an antidote to idle labour and underutilized labour. The lean labour is based on the lean thinking concept, wastage reduction planning at right time, and right place and reorganizing work place. The construction sector faces the problem of skill hands due to inappropriate training, employer and employee’s attitude, improper method, methodology and tools, non-usage of PPE’s , poor or no-construction

equipment’s and scanty supervising and supporting staffs. The lacks in lean labour accounts for division of labour classes like labour needed for all category of activities, specific groups of activities (Semiskilled), and a specific activity. For a better construction site management the SIS method (Short-interval scheduling) and Bautex Wall System (reduced materials, fewer steps, less labour, faster schedule and simpler process) should be encouraged.

B. Traditional BIM Vs Lean Construction:

The out-of-date design-bid-build(DBB) or integrated project delivery (IPD) methods should be replaced by BIM collaborative technology which has been proved most safe and cost effective (reduce cost from 48% down to 2%) <https://blog.plangrid.com/2019/12/how-to-save-money-in-construction-project-phase/.BIM> (buildings modeling method)

is digitally modeled by computers (launched by Dassault (INNOVIA), or Techno strut LLC or BENTLEY) that facilitates in the planning, design and scheduling construction representing the physical or functional features of a place used for decision making in construction sector. IPD relies on mutual respect, trust, benefit and reward, collective innovations, involvement of key work force, fixing goal early, intensified planning, modern technology, appropriate hierarchy, good leadership, well planned, resourceful contractors, and finally at low cost which is lagged mostly by DBB method. The BIM- BAM (Building assembly modeling)-BOOM (Building owner operator model)methods are the basics of lean construction Blending well-judged, cooperative and collaborative thoughts with the IPD can result the lean concept of construction(Ilozor et. al., 2012, Christian et al., 2014).

C. Traditional Vs Lean construction:

One of the dependable and probably better way is lean construction, which optimizes cost, waste and labour by unanimous work initiation and flow continuity. The lean concept can be applicable to labour and time of work is called lean labour which is dependent of time optimization called Takt-time Table -1

Table 1: Gowth of build Concept from DBB to IPD to lean construction in 21st Century

[1] Functions	[2] Design-bid-build (DBB) method	[3] integrated project delivery (IPD) or (BIM)	[4] Lean construction
[5] Processes	[6] Design Bid Build, Design build, CM at risk, Turnkey Project delivery	[7] 3-D geometry models (Dassault, Bentley, Techno) are developers	[8] IPD combined with lean concepts of thinking, lean labour, lean concrete etc
[9] Important functions	[10] Contacts/ agreements/ contracts (Piecemeal)	[11] Mutual respect and trust (IT based tool) combined effort	[12] constant flow Production, all involved, team work
[13] Goal	[14] only transformation (Cheaper is better)	[15] Transformation and value culture	[16]TFV (Transformation, Flow & Value cohort)
[17] Process	[18] linear, discrete, separated and knowhow as per need	[19] concurrent, multifaceted, knowledge, high skill added initially	[20] output and design resulted simultaneously
[21] Key features	[22] More litigation, inside and out side	[23] less litigation	[24] Least Litigation
[25] Design ideas	[26] Totally split, Often fails (Owner at risk of design)	[27] Cohesive & collaborative, At times unsuccessful	[28] Least fragmented, Rarely unsuccessful
[29] Operating system	[30] Transactional, command and control	[31] Activity based flow centered	[32] Relational and flow centered
[33] Team work	[34] less team work, Decision at higher specialist level	[35] Compact and integrated team from entry level	[36] Lower to top managers participate as team work
[37] Planning systems	[38] Not coordinated	[39] At times coordinated	[40] Mostly Coordinated
[41] Cooperation/ Innovation	[42] Specialists involved, better innovation, less cooperation	[43] collectively stand and shared equally	[44] Work smarter, solve critical loci well managed untidily
[45] Good strategy	[46] Timely completion is the only strategy	[47] collectively managed with Mutual benefit and reward	[48] Last Planner & users interest respected
[49] Agreements	[50] Essential, contractors competence is work efficiency	[51] BIM modelling use contract where needed	[52] Lean construction rarely need contracts

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[53] waste/ Reward and penalties	[54] Individual, imposed, less effort, increased level of wastes	[55] Since computer modeled the team is blamed or praised, some waste occurs.	[56] value generation and waste reduction, Team work, no reward or penalties
[57] Risk attached	[58] Discretely managed, owners and contractor's risk	[59] Jointly achieved, &owner and contractor share	[60] Mutually shared &all risks and benefits shared
[61] Life cycle stages	[62] Designed initially, few works life cycle changes	[63] Changes at strategic points	[64] Last planner method rarely changes
[65] Users interest	[66] Less seen	[67] Standardized, at times seen	[68] Given first importance
[69] Supply chain /lead time	[70] Through market and sales dept. efficiency	[71] Better than traditional construction methods	[72] Systematically managed
[73] Buffers/ inventories	[74] very high	[75] As scheduling is don, it is less	[76] Negligible or Just in Time (JIT)
[77] Transportation and traffic delays	[78] Very high	[79] As scheduling is done, It is less	[80] Negligible or Just in Time (JIT)
[81] Communications	[82] Paper based	[83] Auto CADD, #-D models	[84] BIM+ Lean concept

Source: <https://www.kronos.in/products/workforce-management> Matthews and Howell (2005)

D. Lean concept in Industry and construction:

Lean production is the concept in industries which is different in present AEC industries due to varying workplace, seasonal and climate, short span work period, work pressure, repetitive nature, drawing and design, responsibility and built environment. Industry is based on mass production where labours and their skill in unidirectional where in lean construction includes various nature of work and the category of labour force are different.

E. Takt Time:

The Labour tool, the Takt-time is planning to engage the workforce compartmentalized properly and establishing continuous flow at work place. Takt time creates uninterrupted work progress with an advantage of unanimous effort at the bottleneck points without conflicts. Keeping the labourers to work incessantly enhances productivity. All the three groups (owner, management and workforce) are the key for work structure and strength in lean construction. The lack

of vocational skill, adequate training, working environment, risky policy decisions, migration and immigration, change and disparity in wage structure, and present young workers are bottlenecks of lean labour. The implementation of Takt time shall use learners with skilled workers for smooth management of work. The main causes of work structure for delay in construction industry are absence of optimization, altered requirements during construction, delay for decision, working drawing & designs, improper work methodologies and lack of management call for disorder in lean construction and Takt-time looks to the lacunae.

F. Waste Elimination:

Waste elimination in lean construction relies on construction information, components and materials, workers, equipment, space, time, past and present connected activities, meteorological, political, social and economic strategies Fig -2.

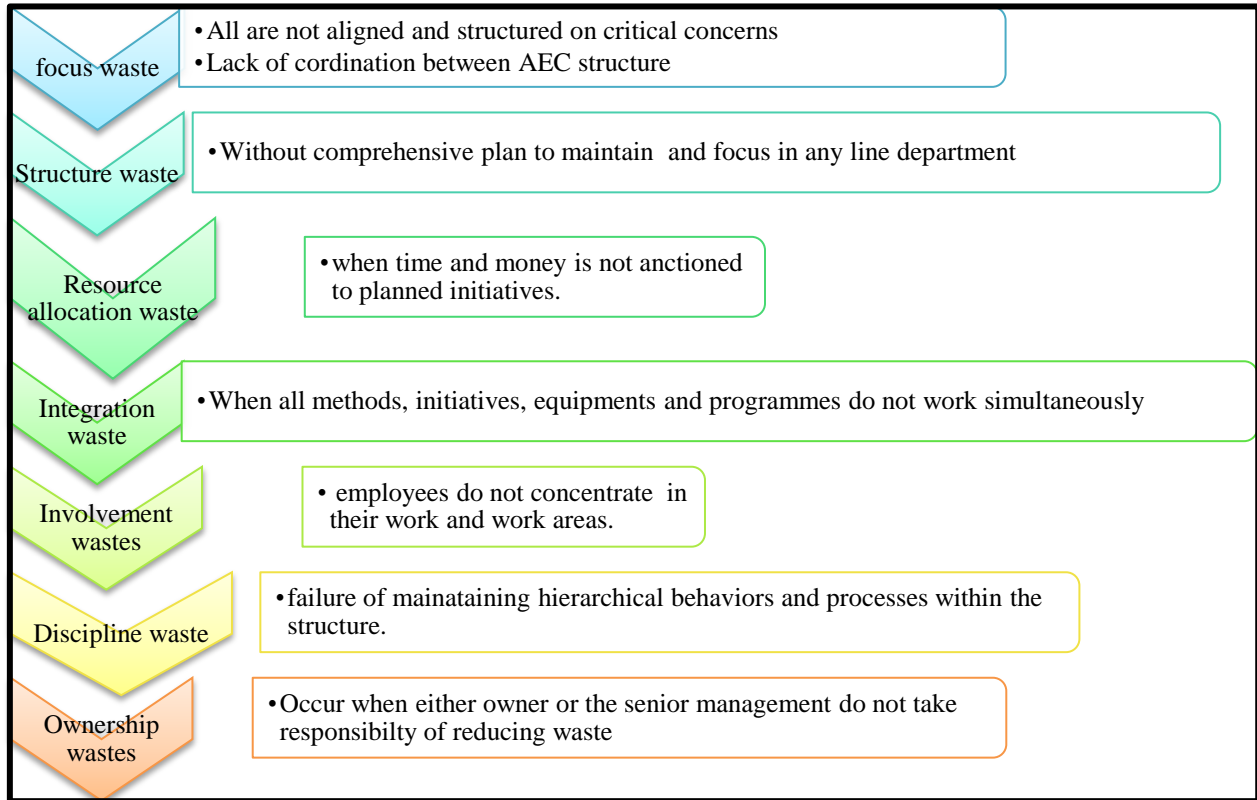


Figure 2: The type of wastes in lean labour and causes of occurrence

G. Last Planner System (LPS):

The last planner system (LPS) is one of the common planning tools developed by Ballard G., 2008. LPS system employs planning or work scheduling (Material and labour) at the last moment when the activity is just to commence. In the process all milestones are equally weighted and planning is multifaceted. Emphasis is equally shared between the work force and all levels of management. Regular meetings (may be for a small period) is to be organized where in managers, supervisors and workforce should participate. Follow up for any deviation or error with reasons must be reported. The changes are immediately implements leading to continuous work flow and creating least wastes. The last planners should use a team to plan and execute, find root cause of problems before work commencement with a long term solution without recurrence and finally reward the problem solver.

H. Lean Labour Management:

The concept of lean labour is a trendy topic since 1910. Only by disciplining the work force of the organization the construction industry shall never flourish. Adaptation lean methodologies, lean labour concept, lean attitude can improve the setup. According to Gordon G. 2004 the well trained workforce in a particular activity are more productive as they identify the waste easily. The idle time is reduced by these lean labour groups so that more work is done at the same investment. But change of work place and breaking the team shall affect the value. However labour wages must be alluring, regular and sync with market. The middle man involvement such as contractors or subcontractors must be reduced to augment skill, performance and safe work environment. Kaizen's 5'S (Sort, Straighten, Scrub, Standardization and Sustain implementation in construction labour activities can increase productivity with least waste in

labour force. Paying salaries through checks also improvise the activities at work place. Improvement can also be accomplished by implementation of work flow and work schedule with lean planning. Gordon also opted for last planner or SMED (Single Minute Exchange of Die) concept to cop the work progress by labour variability daily. The matching workers and their demand, taking operational decisions as per labour at hand can improve the SMED tool.

I. Strategy of Lean Labour:

Revolutions in the construction setup of an organization following lean labour principle don't materialize overnight. Lean labour methodologies can surge the power in the workers, and develops organizational behavior from senior leaders to workers on the occupation and results in operational excellence. Through last planners schedule and maintaining ethics continuously the work group can bring upheavals.

Indemnification: The work force should indemnify, defend and hold a mutually agreeable harmless group having 3.3.1 requisite licensees, successors, related and affiliation to the respective job and satisfied with their offer, owner and management both lower and higher category. They should be aware of any and all obligations, judgments, losses, demands, claims, damages, penalties, interest, costs and expenses of any kind.

Safety and Risk: The awareness of risks and causes of accidents suffered by any person or persons and knowledge of PPE's, arising in course of work, acts, or omissions. He should point out the negligence or willful misconduct within the work premises on breach of representations, warranties and obligations hereunder.

Insurance and Fire: All workers should be insured and possess their policy endorsements and insurance certificate and firefighting clearances prior to joining the worksite for their safety.

Check Payment: The regular payments of wages through bank increase transparency and reduce the middle man's interest and worker-owner relationship increases.

Healthy work environment: All labours are required to be provided with adequate health assistances along with their family

Social, Political and Regional: The work force must be well protected from social, political and regional conflicts which should be ensured by the owner.

Dispute Resolution: The management and the workers should agree that in case of all disputes or disagreements of any nature pertaining to work must be binding with federal court of law/arbitration in harmony with the laws of Labour department as per provision of the agreement. Disagreeable by any of the parties should take the shelter of law.

Professionalism and liberty: The performance of the working group should be in a professional manner not deviating to work practices. Liberty should be given to the worker for any improvement. Any contravention about workforce should be viewed by rules, laws, statutes, and any regulations of the federal regulatory agencies.

Confidentiality: The employees and the workers should assign to provide and shall guard the strictest Confidentiality and must not disclose to others about the methodology, progress and knowhow of any kind. Company's confidential information should not be disclosed even the worker leave the work and after the contract period.

Labour assessment: The cost of performance is worker to be done as a quarantine check and wages to be paid in accordance to the performance. The work wise data set needs to be prepared to have a lean labour concept. The payment should not be based on the number of years the labour has worked but on his performance, waste elimination and output.

Authority and Authenticity: The work group should have authority over the nature of work and change of authentic work force should not entertain. Any additional changes or amendments to the Agreement must be conveyed by the senior management to the work group in time.

Strict/tightness coupled with action by learning: The workplace management through strict adherence to work and time schedule shall train the inept labour's to learn by action, coping with the technique, schedule and time adherence.

Optimization of Indirect Labour: Indirect labour's like cleaning and clearing workers, supporting staffs were considered value less expenses in old traditional construction activities. The lean construction tools under modern methods capture more work hours for skilled labours and have mammoth impact on the process cost during optimization.

Maintenance of Parallel Labour MRP: The MRP and time clocks should maintain a parallel secondary data source on

call complying absentees and urgencies as per last planner's schedule.

J. Lean Labour Tricks:

Increased business rivalries, razor-thin margins, entry of new players and the unreasonable discount in product (flats and shops), unprofessional conducts and intense competition have brought the construction sector to a critical edge. Lean labour only can face the challenges of constraints of time frame and meet consumer's satisfaction. The lean labour introduction only can fill the gap between the demand and supply by augmenting efficiencies of labours.

Green construction is the adaptation of pollution free, energy efficient and minimization waste technique has been attained by continuous research and design of processes. Green construction also aims at conservation of Mother Nature and non-renewable natural resources for future generations. The popular concept can saves unusable costs, and encourages further research for the AEC group. The AEC group should try for green construction by lean driving, lean labour setups, Internet of things (IOT). They should stress upon long real time data, forecasting through soft and stochastic modeling, continuity in work flow and process control, prioritizing the users demand, owner's margin through implementation of lean labour. The razor thick concept of saving labour in construction Industry is done by properly sequencing activities, waiting for instruction and instruments, optimizing movement of workers and materials, defective and ineffective works (labour's skill, physical, morale and salary problems), idle labours (ineffective gadgets, haul roads, interferences, unserviceable machineries)), design and omissions, reworks, poor workforce involvement and collaboration with contractor and management, unnecessary work and undesired outputs are the non-value adding activities where the lean labour concept nose-dives. Adequate steps are to be taken to identify and reduce wastage of labour.

IV. METHODOLOGY

The methodology of the exploration is collection of primary data from sites and secondary data from literature review. The primary data is collected from the owner, contractor, sub-contractors and site workers. The secondary data from books, manuscripts and case studies of construction sites are collected from electronic media and different books which reveals that the adaptation of lean labour concept has led to higher productivity, less waste and work flow without disruption with a harmonious work environment without accidents and less risk in management. The basic methodologies employed are given in the flow chart below Fig 3.

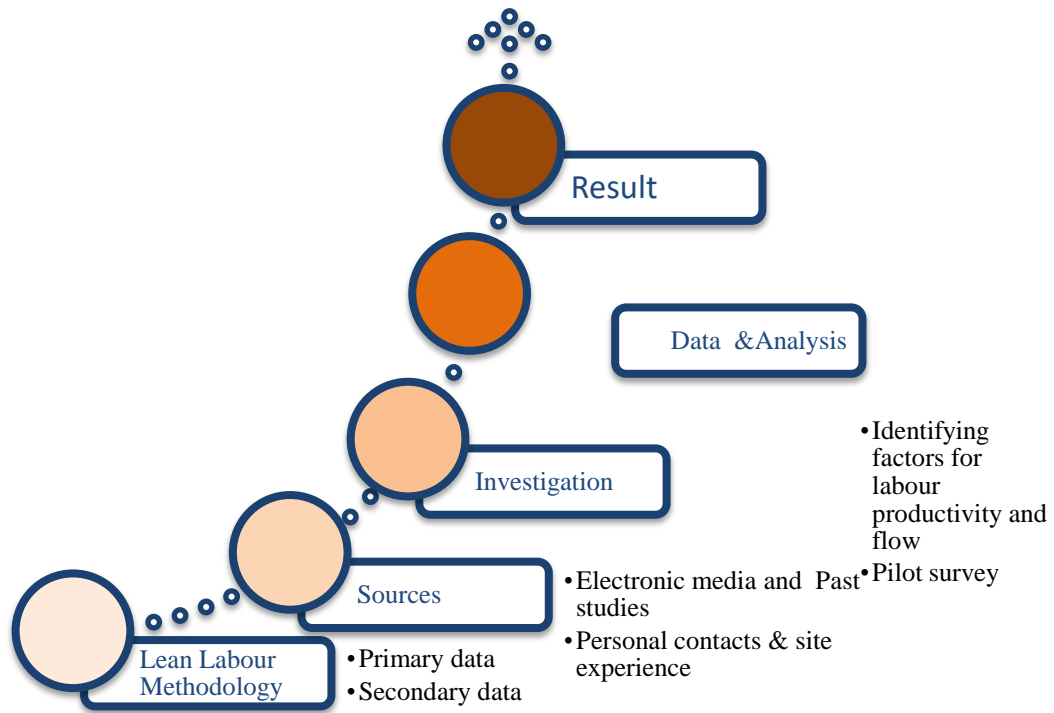


Figure 3: The methodology of lean labour concept in lean construction, the present study

A. Lean Labour Thinking Methodologies:

In a lean construction framework, the lean labour concept deals with total quality management (TQM) employing the existing workforce, timely execution adhering to schedule framed, contemporaneous methodologies of construction, value based management, reengineering (process redesign), visual hierarchy of organization, workforce involvement and finally the total productive maintenance based on costumers value design, value stream, value pull and value flow (Womack and Jones (1996). Eiji T. et al., 1949 during visit to Ford Industry, Detroit, identified even flaws in labour activities like process, movement, inventory, transport, waiting, over processes and production, defective wastes, erroneous methodologies and stock handling which affect lean labour processes. Lean practices (Construction, labour or thinking) differ in different companies and progress chart on use of lean principles leading to lean work environment enhancing work safety and reduce risks.

The activity flow in each branch of WBS structure is to be decided by suitably deciding by CPM, PERT chart to eliminated delayed and repeated activities. A suitable scheduling is to be adopted by construction of BAR chart for the MS project or DASSAULT and many other systems.

The measuring tools for the effective implementation of lean labour in the project can be done by 7C’s cause and effect diagram, check sheet, control chart, histogram, Pareto chart, scatter diagram, run chart and finally the flow chart). Apart from these IT technology, the value stream can be maintained by 6M’s (Men, Material, Machines, Methods, Mother Nature (environment) and Measurement,) working under 5T’s principle (transparency, teamwork, technology, time, which shall lead to transformations).

B. Hindrances for Lean Labour Options:

The hindrances in lean labour option are lack of improvement and wellbeing of the industry professionals, labour, manufacturers, suppliers, contractors and craftsmen. The unsettlement of socio-economic and political issues, poor labour relations and disputes in the labour sector, non-assurance of public safety and job security, unhealthy environment and many others under built environment are the flaws of lean labour concept. The lean labour concept also fails under poor leadership, demotivated and aged work force, unskilled and inexperienced workforce and ineffective team players.

C. Labour Deployment:

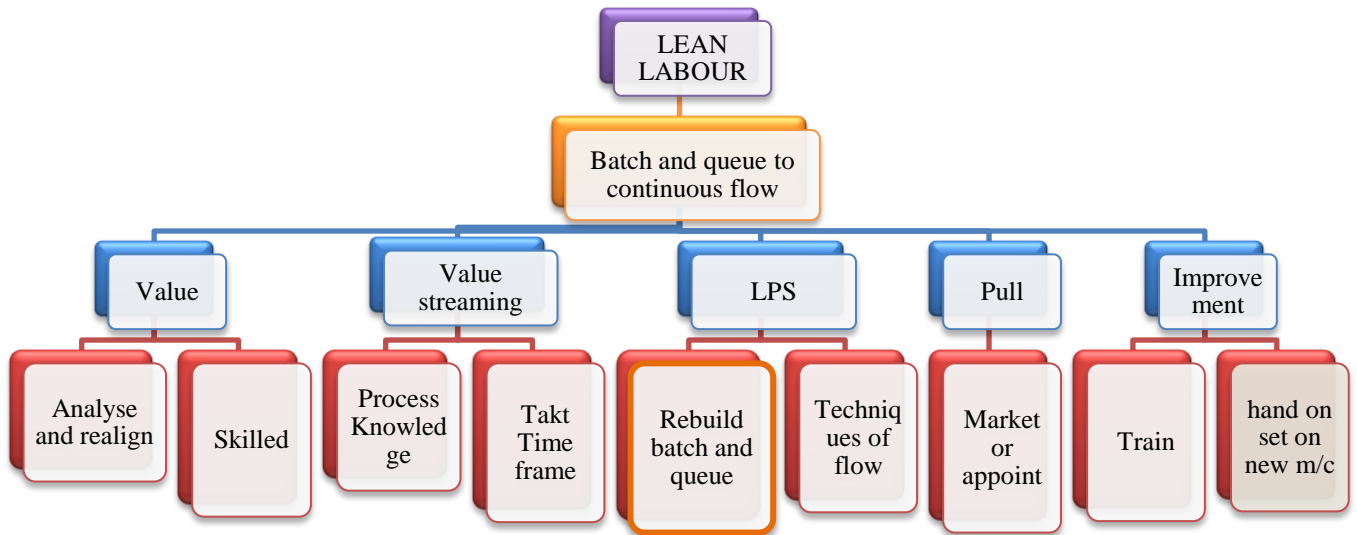


Figure 4: The batch and queue process of continuous flow in Lean labour concept

The deployment of labour should be done after careful considerations like continuous analysis of work force foresee future, consensus slow decisions but fast implementations, develop leadership, challenge, fellow feeling and respect among the workforce, fix workload, quality compliance, problem identification, adequate labour deployment to avoid overproduction. Standardization of task, transparent management, continuous innovations and adoption of tested methodologies by eliminating overburden, unevenness, injuries, accidents and idle time shall promotes lean labour Fig. 4. In her work, Koskela proposed a set of eleven principles for the design and management of production systems in construction. These principles are: 1. Reduce the share of non-value-adding activities; 2. Increase output value through the constant consideration of customer requirements; 3. Reduce variability; 4. Reduce cycle time; 5. Simplify by minimizing the number of steps, parts, and linkages; 6. Increase output flexibility; 7. Increase process transparency; 8. Focus the control on the complete process; 9. Build continuous improvement to the process; 10. Balance flow and conversion improvements, practice benchmarking; and 11. Continuously improve the process. The wastes generated by the lean labours are waiting, idle, transportation, inventory, excess processing and excess movement within the work space (Ali et al, 2012).

According to Koskela, the lean construction researcher had offered 11 eleven methods of principles to design and administrate built environment. They are: moderating the non-value-adding events, enhancing build output value incessant consideration of customer’s demand, Reduce inconsistency; cycle period, curtailing steps and activities, parts, and linkages. The other lean labour gears are increase in yield flexibility, process transparency, emphasis on the control on process, incessant improvement in the build process, flow and erection methodologies, practice of bench marking etc. The wastes generated by the lean labours are waiting, idle, transportation, inventory, excess processing and excess movement within the work space (Ali et al, 2012)

V. DISCUSSION

The lean labour in construction industry can be productive and efficient under the conditions like value added activities through value added planning and implementation, Improving work method by implementing lean technique, eliminating non added vale activities, and by choosing appropriate lean tools. The improvement can be achieved by analyzing data from literature and past experiences and evaluating impact.

A. Factors Affecting Lean labour:

The impediments of lean labour are futile management directives, focusing on quantity of yield but not on workmanship, Growing of specialism, Substantial Completion etc.. The lean labour does not allow sluggish adaptation to innovations, poor benchmarking (no quality and productivity), risk prone, unsafe workplace and work culture, more unskilled labours, orthodox technology, workforce shortage, poor management strategies, less wage and delayed payment ethos, impeccable coordination and finally inertness of management to the principle of rewards and punishments.

B. Controlling Labour Wastes:

The cultivation of lean labour can be done by WBS, re-schedule the tasks (for the next few days), order material deliveries and accordingly plan the workforce, limit socializing and schedule daily breaks, monitor the weather and document, update the critical path developed, fix responsibilities, assign Matrix, allocate the schedule for rework, retesting and renovating Radhika et al 20-17). Indian construction sector has gaps to compete modern industry by following the primitive work knowledge and pattern, poor employees working conditions (EWC), which spawns poor management in resources, waste management, over budgeting and schedule lagging.

The ‘making do’ (Koskela 2004), are wastes when the work initiated without planning, scheduling and non-availability of drawing and design but works are available and without knowing all available resources. Non response, non-listening adamant and senile workers cause more waste than the organized well educated/trained workers/operators. The lean labours should nurture the skill of listening and art of response.

Implementing 6M’s: 6M’s in Six Sigma (5M1P) can control the construction progresses are man, machine, material, method and Mother Nature and the measurement is a parameter. Other’s may be new techniques (mind power), Management and finally the money (financing) cannot be neglected. The labour (Man) plays pivotal role as untrained labours has more impact the other five M’s in build process.

Implementation of 5T’s: To achieve continuous and work perfection putting right man at right place at right time is essential by maintaining transparency, teamwork, technology, time, which shall lead to transformations. The other way of expressing 5T’s can be Technology, Technique, Tactics, Talent and tracking can give efficient optimized labour productivity and work progress.

The roots of lean labour are solid coordination and collaboration between all project participants from a labour to the CEO, commitments project participants, optimization and tightly complying with the schedule under strict quality control. Lean labor can help builders progress the technique they bring into line the employees with user’s claim. Scheduling submissions of component to the personnel management solution site, the shift engineers is to verify with the recommended mix of concrete workers and their skills in executing the construction activities. Simultaneously there can be overall work progress and cost targets. The efforts can also relief to curtail overtime costs or alternate work forces who can fill a gap.

C. Labour Waste and Equipment:

The waste in construction sector is directly related to equipment’s and presently all the activities are mechanized, to reduce labour waste the initiative are queuing tasks, safe work settings, testing, servicing, repairing or diagnostic of all construction equipment’s before commencement of the activities, Less labours by employing more hoisting equipment’s, and cultivating the culture of safe and riskless accomplishments.

Lean labour concept need efficient labour procurement and work Plan: defining criteria for success. Labour control: should comply to plan, schedule and trigger learning and revised phase scheduling to keep revolving throughout the project. Lean labour should implement leadership commitment and is sustained with a culture of continuous improvement in waste control, time control and cost control and simultaneously augmenting productivity. On study of different projects construction of high-rise buildings, dams, powerhouses, highways, the labour force should be well organized considering the following facts (Gambatese et al., 2014) Fig. 5.



Fig 5: The implementation of the lean labour concept in Construction industry

D. Workspace Management:

The in-house construction work approach should be such that clean workspace, proper illumination, zero confusion about workplace (minimum leads and Lift), least movement and safe steps, and in-situ decisions, least fall hazard improves morale at work place. All works should be standardized so that workers are not confused in discriminating work sequence, normal course of action, no overproduction, and knowledge about the work. Continuous workflow, zero idle time and waste, work of repetitive nature to commit errors like labour waste, accidents. Working in high altitudes adequate PPE’, controlled environment, stress on workers comfort, less movement, alarm and alert system during crisis.

Application of Kaizen (A Sino-Japanese word) concept refers to ongoing events that unceasingly advance all activities of a project by introducing some small changes. It include all workforces from the CEO to the line workers to involve all to promote the activities safely, riskless, looking ahead, planning, analyzing constraints, clearing backlogs, pull schedule, decision making short term plan as the last planner, clearing variances. For lean labour concept a small curtailment in different work timings (move, wait, set up and process time) can keep the work flow continuous and interrupted with keeping in view the quality, risks and safety of the workforce.

The last planners aims at planning and scheduling with communicating decision by repeated in house meetings, by identifying tasks and events, the projected simple work flow, possible safety standards. They should clearly demark about the labour involvement in the activities during the short term planning includes form site engineers, supervisors, work invigilation staffs, and subcontractors to have smooth work progress without any interruptions. At least the last line should know clearly what they are going to do. In addition lean labour management should practice accident prevention measures through safety standards, temporary dependable skilled workforce, demarcation of duties and responsibilities of all, training about technology advancements, cultivating punishments and rewards, and timely labour skill developments programme and hand on practices to make them apt in the work processes (Radhika et al., 2017)

The author contradicts the fact that hiring and retaining them as long-term workforce of varied, devoted staffs whose desires and associations are nurtured, the efficient dedicated working group are fast problem-solving in the construction industry.

E. Work Structuring:

Work structuring determines how the work of a system is structured in terms of how resources are organized down to the design of operations. If the work structuring is not properly managed during construction it leads to poor quality, rework and large variations in work flow. LPS methodology (Last Planner System) which is a concerted planning method that contains from engineer in charge to team leaders (called last planners) involve themselves in planning more and more as the activity starts. They decide the process, amount involvement of labours or workforce by analyzing the depth of work in progress (Verma A. et al., 2017). To achieve lean labour concept the workouts are workflow controls, labour's work safety, weekly work plan, % plan complete (CCP), increased visualization (Visits, CCTV, inspections etc.), daily tool box (huddle) meeting, critical assignment studies, Fail Safe for Quality and labour scheduling etc.. The last planner meeting, memos and minutes, various forms of schedules, action tasks with duration, actual completion dates, constraints in six-week look ahead, reasons for not completing assignments, and the results of interviews are also essential.

At present under declining prospective, it is extremely tough to compete in the manufacturing industry today, lean labor can help. With lean labor, manufacturers can acquire a proven way to gain new efficiencies, reduce and control costs, and increase overall productivity. In turn, this allows them to focus on revenue-generating activities, strengthen the bottom line, and increase their overall competitive advantage Salem et al 2005; More et al 2016. Lean Labour concept is feasible for success under good project leadership, improved management of hierarchy, eliminating or minimizing defective work and warranting passable cash flow. To achieve high margins, pressures imposed in construction sector by cutting costs, rise in rivalry from existing co-constructing agencies, and new players in the segment have made it tough to survive in the cutting edge of the industry. Hence lean construction demands to increase productivity, efficient cost control measures, optimization labor procurement and management to withstand under pressure, new vendors and competitive estate dealers. Lean improvement initiatives in construction industry should concentrate more on work force management strategies to expand labor utilization that will inculcate better labor performance.

F. Monitoring lean labour:

The lean labour can be monitored through organization commitments, safety planning and training, pre-project planning and scheduling, pre-task planning, safety awareness, workers indulgence in work, efficient subcontract management, risk and accidents/investigation and reporting, regular drug/Alcohol testing and finally reward and penalties.

VI. CONCLUSION

A good lean labour practice should encourage the work break down structure, MRP, fixing of responsibility chart, flow continuity chart, upgradation, pull production control and

quality function deployment of labour force. The lean labor culture in the organization like AEC needs to be promoted for achieving the management objectives efficiently and effectively. The present day modern management practices lay due emphasizes on human approach to maximize human return from the human capital saving at nano scale concept. The lean labour requires improvements, saving, perfection, and optimization in construction labour sector through implementation of 6M's and 5T's.

Table 2: Eight tools for implementation and evaluation of lean labour in construction industry

Sl No	The thumb rules for lean labour	The processes
1	Implementing 6M's: Six Sigma (5M1P)	Control the construction progresses are man, machine, material, method and Mother Nature and the measurement is a parameter. Other's may be new techniques (mind power), Management and finally the money (financing) cannot be neglected. The labour (Man) plays pivotal role as untrained labours has more impact the other five M's in build process Nasim SRM, 2014
2	Implementation of 5T's	To achieve continuous and work perfection by the lean labour it is essential for putting right man at right place at right time is essential by maintaining transparency, teamwork, technology, time, which shall lead to transformations. The other way of expressing 5T's can be Technology, Technique, Tactics, Talent and tracking can give efficient optimized labour productivity and work progress.
3	Implementation of 6S	The 5S system in maintaining lean labour: Sort (Keeping materials tools and labours for the ongoing activity only at work place which are essential), Setting (keeping the tools, materials and labour systematically one after the other for continuous work flow), shiny and Systematic (orderly and clean workplace to avoid labour waste and accidents), Standardize (standardization of work achievement and hierarchy), sustainability (Creating innovative and creative practices with timely audit and punishment and rewards). Any one or a combination of handling labour strategies can optimize productivity, reduce waste and hinder redundancy in work flow.
4	Measuring lean labour by 7C's	The lean labour output is measured by 7C's (cause and effect diagram, check sheet, control chart, histogram, Pareto chart, scatter diagram, run chart and finally the flow chart).
5	5W1H method for lean labour	The lean labour output is measured by 7C's (cause and effect diagram, check sheet, control chart, histogram, Pareto chart, scatter diagram, run chart and finally the flow chart).
6	5W1H method for lean labour	The 5W are (When, Where, Who, What, Why), and 1H is (How): when and where the work is to be executed, who will do the work, what work is to be done and the worker should know why the work is being done and finally how the worker shall do the work.

7	5's for disciplined worker and workplace	For a disciplined work place the labour force should be organized, clean the site immediately, possess work perfection, well ordered and well mannered, systematic and sustained
8	3K's and 3M's	For an unpleasant working condition for workers in Japanese Toyota system use to avoid Kiken (unsafe), Kitsui (difficult) and , Kitanai (dirty). Similarly the lean labour should avoid Muda ((avoid waste), Mura (uneven works) and Muri (over laden with work)

Along with above seven thumb rules, a good lean labour practice should encourage the work break down structure, MRP, fixing of responsibility chart, flow continuity chart, upgradation, pull production control and quality function deployment of labour force. The lean labor culture in the organization like AEC needs to be promoted for achieving the management objectives efficiently and effectively. The present day modern management practices lay due emphasizes on human approach to maximize human return from the human capital saving at nano scale concept. The lean labour requires improvements, saving, perfection, and optimization in construction labour sector through implementation of 6M's and 5T's. To save waste and productivity the tips are keeping inventory updated, regular record keeping and data analysis with necessary corrections and organize labour for continuous work flow.

REFERENCES

1. Abdullah S., Razak A. A., Bakar A.H. A. and Sarrazin2 Moh. I, (2009). Towards Producing Best Practice in the Malaysian Construction Industry: The Barriers in Implementing the Lean Construction Approach, Conference: International Conference on Construction Industry 2 (ICC12),
2. Ali S. A. A., Arun C., (2012). Time waste and delays in construction projects, A state of the art report, communication II, NICMAR- journal of construction management, 27(4), 63-73
3. Aziz, R. F., Hafez S. M., (2013). Applying lean thinking in construction and performance improvement, ELSEVIER, Alexandria Engineering Journal, Vol- 52(4), P P- 679-695, <https://doi.org/10.1016/j.aej.2013.04.008>
4. Ballard, G., (2008). The Lean Project Delivery System: An Update. Lean Construction Journal; 49(2); 1-19
5. Bertelsen S., Koskela L.,(2002). Managing the three aspects of production in construction, in: Proceedings of the 10th Annual Conference of the International Group for Lean Construction, Gramado, Brazil, 2002.
6. Betelsen Sven, (2004). Lean construction: where are we and how to proceed, Lean construction Journal. Pp- 46-69
7. Chamberlin K. S., Asadi S. S.and Chaitanya D. S., (2017). Evaluation of latest trends and
8. Christian T. Bo, Harty J. (2014). Implementing BIM and IPD: Focused on Refurbishment Projects in the Norwegian Construction Industry. Report is a part of my Bachelor of Architectural Technology and Construction Management at KEA – Copenhagen School of Design and Technology, pp. 1-35
9. EinarLoktu, (2018). Lean construction, takt time planning. http://apppm.man.dtu.dk/index.php/Lean_construction_takt_time_planning 17 November 2018
10. Gambetese John, Pestana Catarina, 2014. Connection between Lean Design/Construction and Construction Worker Safety. Final report, CPWR Small Study No. 13-10-PS, Oregon State University, [https://www.cpwr.com/sites/default/files/publications/GambateseL](https://www.cpwr.com/sites/default/files/publications/GambateseLeanandSafetyFinalReport.pdf)eanand SafetyFinalReport.pdf
11. Garrido, JS, Pasquire C., Thorpe T. (20). Value in Construction from a Lean Thinking Perspective: Current State and Future Development , Proceedings for the 17th Annual Conference of the International Group for Lean Construction, pp-281-294
12. Gordon Gregg, (2005). Lean Labor: A Survival Guide for Companies Facing Global Competition
13. Greg Distelhorst, Jens Hainmueller, Richard M. Locke (2017). Does Lean Improve Labor Standards? Management and SocialPerformance in

- the Nike Supply Chain. Management Science, Vol- 63(3): PP-707-72, <https://doi.org/10.1287/mnsc.2015.2369>
14. H. Li, P. Love, (1998). Visualisation of building interior design to reduce rework, in: Proceedings of Second International Conference on Information Visualisation, London, UK, 1998, pp. 187–191.
15. Howell, G. and Lichtig, W. (2008). “Lean Construction Opportunities Ideas Practices” Speech presented to the Cascadia LCI “Introduction to Lean Design” Workshop, Seattle, WA, Sept. 15, 2008.
16. Ilozor B. D., Kelly D. J. (2012), Building Information Modeling and Integrated Project Delivery in the Commercial Construction Industry: A Conceptual Study , Journal of Engineering, Project, and Production Management, 2012, 2(1), 23-36
17. Inji Salihi., (2013). How to Change a Traditional Construction Company to Lean”, Dept. of Civil and Environmental Engineering. Div. of Construction Management Chalmers University of Technology, Goteborg, Sweden, pp 32-40.
18. Javkhedkar A., Song L., (2006). Applying lean construction to concrete construction projects, Masters Thesis, University of Houston, 1-33
19. Koskela L., Huovila P., Leinonen J., (2002), Design management in building construction: from theory to practice, Jr. of Construction Research, Vol-3 (1),, pp. 1-16
20. Love P., Mandal P., Smith J., Li H., (2000). Modeling the dynamics of design error induced rework in construction projects, Construction Management Economics, Vol-18 (5), , pp. 567-574
21. Marhani, MohdArif and Adnan, Hamimah and Baharuddin, HarEinur and Esa, Mohd Reza and Hassan, Ahmad Arzlee (2012). Dependency of foreign workers in Malaysian construction industry / MohdArifMarhani ... [et al.]. Built Environment Journal, 9 (1). pp. 39-50. ISSN 1675-5022
22. Mohd Arif Marhani, AiniJ aapar, Nor Azmi Ahmad Bari (2012), “Lean Construction: Towards enhancing sustainable construction in Malaysia”, ASIA Pacific International Conference on Environment-Behaviour Studies Giza, Egypt, 31 Oct. - 2 Nov.,pp 87-98
23. More V. D., Charhate S., and Sinha M.,2016. Lean Construction Techniques in Indian
24. O. Salem, J. Solomon, A. Genaidy, and M. Luegring (2005). “Site Implementation and Assessment of Lean Construction Techniques” Lean Construction Jr. Vol 2 (2) October 2005, pp 1-21.
25. Oladiran Joshef Olatunji, (2008). Lean -in- Nigerian construction: State, barriers, strategies and “Go-to-Gemba” approach, Olatunji, J.O. (2008). Proc. 16th IGLC, Manchester, England. Proceedings for the 16th Annual Conference of the International Group for Lean Construction People, Culture and Change, pp-1-11.
26. Radhika R, Sukumar S.,(2017). An overview of the concept of lean construction andthe barriers in its implementation, International Journal of Engineering Technologies and Management Research, Vol. 4, No. 3(2017), 13-26.DOI: 10.5281/zenodo.478010
27. Ramya G., Vidjeapriya R., (2018). Study on construction labour productivity using lean principles, International Journal of advance research science and Engineering, IJARSE, Vol-7(2), pp-257-266
28. Shang Gao& Sui Pheng Low (2014). The Toyota Way model: an alternative framework for lean construction, Total Quality Management & Business Excellence, 25:5-6, 664-682, DOI: 10.1080/14783363.2013.820022
29. Thomas H. R., Horman M. J., Minchin R. E., and Chen D., (2003). Improving Labor Flow Reliability for Better Productivity as Lean Construction Principle, Journal of Construction Engineering and Management, Vol- 129 (3), DOI: 10.1061/(ASCE)0733-9364(2003)129:3(251)
30. Verma A., Angalekar S.S., Khandare M., (2017). Application of lean construction tool (1.p.s) to improve labour productivity at construction site, International journal of engineering sciences & research technology, (IJESRT), Vol- 6(6): June, 2017, PP- 287-291, DOI: 10.5281/zenodo.809172
31. Womack JP, and Jones DT., (1996), Lean Thinking: Banish Waste and Create Wealth in Your Corporation. Simon & Schuster, New York. Second Edition, 2003
32. Zhang Lianying, Chen Xi, SuoYongqing, (2017). Interrelationships among critical factors of work flow reliability in lean construction, Jr. of Civil Engineering and Management, Vol- 23(5):PP- 621-632, <https://doi.org/10.3846/13923730.2016.1217921>

