

Identification and Ranking of Key Project Delays Using Relative Importance Index (RII): A Case-Based Survey Analysis

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Abstract- Highway infrastructure projects are often characterized by complex workflows, extended timelines, and cost overruns, frequently resulting from inefficiencies in traditional construction methods. Lean Construction, a methodology derived from Lean Manufacturing principles, emphasizes waste reduction, continuous improvement, and value generation for the client. This paper explores the application of Lean Construction principles to highway projects with the aim of improving overall project efficiency, reducing delays, and enhancing resource utilization. Through a review of existing literature and analysis of case studies, the study identifies key Lean tools—such as Last Planner System (LPS), value stream mapping, and just-in-time delivery—that have proven effective in streamlining construction processes. The findings suggest that integrating Lean Construction practices into highway projects can significantly improve coordination, minimize waste, and foster a culture of collaboration across all stakeholders. The paper concludes by recommending practical strategies for implementing Lean principles in the planning, execution, and monitoring phases of highway projects to achieve timely and cost-effective project delivery.

Indexed Terms- Lean Construction, Highway Projects, Project Efficiency, Waste Reduction, Last Planner System (LPS), Value Stream Mapping, Just-in-Time Delivery, Construction Delays, Resource Utilization, Infrastructure Development.

I. INTRODUCTION

1.1 General: -

Lean construction has the goal of better meeting customer needs while using less of everything. Lean

construction depends on production management concepts, the “physics” of construction. The end result is a new project delivery device that can be implemented to any form of production but is particularly suited for complicated, unsure, and brief projects. Waste is defined with the aid of the performance criteria for the manufacturing system because the failure to satisfy the numerous necessities of a consumer is waste. The approach for the construction of highway challenge via lean thinking keeps revolving through two aspects

1.2 principles of lean thinking: -

- Eliminate waste –waste is some thing that consumes sources without including value to the project. Waste may include mistakes, redundancies, revisions, work out of sequence or offerings that don't meet client needs.
- Defining value according to what client wants.
- Use the techniques that supply what client values in shortest feasible time –methods can be streamlined with the aid of identifying price circulate, on the way to supply the product in minimum time then putting off any technique that doesn't add value. A lean technique may additionally have as many as 60 percentage less activities than a traditional one.
- Pull don't push –the core of lean layout suggests starting with the goal and pulling closer to it only work wanted to perform the intention. Accomplish this requires making plans backward from the purpose to decide what each step in the procedure calls for from the step earlier than it. Later steps decide what the sooner steps should be and why they have to occur. Nothing must be finished that isn't always required with the aid of a later step inside the method.

- Pursue perfection by way of continuous improved methods –relentless checking of each assignment identifies their reasons and approaches to do away with them in subsequent initiatives.

1.3 Comparison between conventional construction and lean construction; Table 1.1

Conventional Construction	Lean construction
This method count on to haves scope modifications and design mistakes at some point of construction, a good way to be field engineered by way of construction groups.	Even as in this approach, layout product and construction manner together to keep away from design mistakes that leads to constructability troubles.
This empower managers to be the only planners.	This empowers manager to be the primary planners of strategies and stages and workers to be the final planners of operations.
This expect that decreasing fee in one piece will lessen cost of the complete project –the entire sum of its elements.	Although lean thinking treat complete mission as a system and use goal costing to gain project price reductions –the complete is greater than the sum of its parts.
This type of construction push for high local productiveness mistakenly questioning that that is a manner to obtain global performance.	This kind of construction push for high machine throughout that is the best manner to achieve global efficiency.
These are guided by the time-cost-quality tradeoff.	This challenges the time-cost-quality tradeoff through removing the supply of waste in the design/manufacturing strategies to provide better and more reliable workflow.
This manner of construction manage the system using schedules of price accruing elements –the ones on which the development payment are based totally.	Lean construction use schedules of price accruing elements as input to the planning and control of on site manufacturing operations.
Traditional construction don’t plan or control site manufacturing operations unless we have a look at deviation in focused value and time.	While lean production plan and control site production operations to preempt value accruing factors from going off centered time and cost.

II. LEAN TOOLS

2.1 Integrated Project Delivery

The usage of IPD, task individuals can overcome key contractual and organizational troubles. The IPD method to contract the aligns challenge goals with the thinking of key individuals. IPD mainly depends on transparency, participant selection and continuity dialog. Production customers may take into account thinking their contracted strategies to proportion greater completely inside the blessings. The IPD technique creating an enterprise with the potential to use Lean project delivery (LPD) practices and concepts.

2.2 Integrated Lean Project Delivery (ILPD):-

The technique targets to dispose of waste around the construction projects, through evaluating of preliminary making design and plans, and examining of construction approaches to are expecting in which and when waste material occurs, which is eliminated using the lean tools in IPD technique. An ILPD is a multi-venture settlement that specified the use of lean production as provided inside the Lean project transport device. The difference is there because the integrated project delivery(IPD) is simplest referred to the multi-venture party agreement irrespective of what methods are used.

2.3 Last Planner System

The commitment, collaborative-primarily based planning method that integrated the planning (pull planning, make-gear up, look ahead making plans) with constraint analysis, weekly paintings making plans primarily based upon dependable guarantees, and mastering primarily depend upon evaluation of % (plan percentage complete) and giving reasons for variance. Customers including clients, construction groups or owners, uses the LPS to reap good performance in layout and production via elevated programme /schedule predictability (i.e. work is finished as and when said earlier). LPS is a device of associated elements, and advantages come while all are applied together. It is primarily depend on easy paper forms, so it is able to be administered the usage of paper, pencil, eraser and photocopier. LPS starts with collaborative programming/scheduling enticing the different project providers from the starting. Risk analysis ensuring that drift is constructed in where it will satisfactory guard application predictability and integrity.

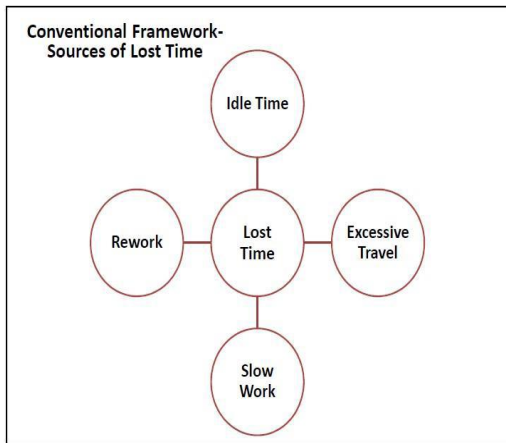


Figure. 1.1. Conventional Framework (Tomek et.al.(2017))

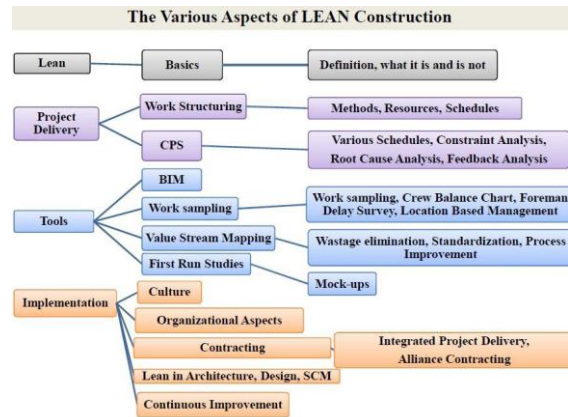


Figure. 1.2. Various aspects of Lean construction (Solis et.al.(2018))

III. LITERATURE REVIEW

Rajput et.al.[2018] This paper enhances that Lean implementation is a project to cope with untrained staff, wrong web page control and protection elements in creation. The paper gives many blessings of lean implementation. usually, the tilt construction targets to lessen the waste by way of unpredictable workflow, whereas the waste can be defined in exclusive classes; as defects, delays because of awaiting upstream sports to complete before some other job can begin unnecessary shipping of cloth, over allotted system or fabric on website, twist of fate on website online. In northern India, delays in creation tasks occur in most advanced ventures, whether or not honest or complicated. A capability solution for the problem of deciding the influences of basic achievements is to calculate on construction undertaking is extended pre undertaking arranging. This benefit incorporate elevated benefit, lessened danger and advanced exceptional. The assessment continues the Indian production enterprise is profoundly divided, as an example, inclusive of NHAI, as the reality that maximum ventures aren't any long lasting connections among the transient employees and customers. The have a look at located that four performance parameters; namely, fine, productivity, profitability and venture control ought to be applied and it's miles critical for effecting place of job subculture modifications and mind-set changes.

Gangyan Xu et.al.[2018] Prefabricated construction has turn out to be an increasing number for the latest years, as given its advantages together with greater

production speed, decrease cost, stepped forward quality. Prefabricated production refers back to the practicing of manufacturing constructing elements in a manufacturing facility and then joining them on site. To make the work flow the operations of prefabricated production and various technologies have been brought. Whereas, due to its challenge primarily depends characteristic and the involvement of severe medium and small corporations, the adoption of records technology is diverse and inadequate among SMEs, thereby hindering the development of performance of pre-fabricated creation. Thinking about those troubles and aiming at figuring out lean pre-fabricated production, this paper gives an incorporated cloud primarily depends upon net of factors (IoT) platform via exploring the method of cloud asset. Its operational model had been worked out to permit SMEs so to undertake IoT patterns flexibly and economically. With considerable blessings on efficiency, best, fee and environment, prefabricated creation has no longer most effective attracted growing interest from practioners international, but additionally obtained authorities supports to revolutionize enterprise.

Nesensohn et.al.[2018] Embedding lean production in an company normally requires many changes and is a difficult endeavour. In particular whilst transformations take location it will become vital to degree the present day kingdom of the maturation procedure. Hence there may be a requirement for businesses with the intention to demonstrate in which they may be of their lean creation journey. There may be an increasingly high quality fashion inside the enterprise to put into effect lean construction and searching for the required development goals. Consequently, knowledge about lean production maturity and the capacity to degree the current country of adulthood as well as supporting organisations round the arena of their ameliorations in the direction of greater maturity in lean creation will become vital. It's also feasible to state that the integration of maturity fashions and lean construction to a framework allows companies to measure their modern-day state of lean construction adulthood.

Solis et.al.[2018] Lean and six sigma were identified as revolutionary strategies that may be used to convert a company's management practices to a more recent

degree. This paper fills the distance by investigating primary limitations, blessings and opportunities of Lean and six sigma. Six sigma is a theory method and quality practices aimed to help undertaking design and executions deliver increased enterprise consequences inside the form of less time, much less waste and less fee. The principle precept of lean task management is turning in is turning in greater price thru the discovery and removal of embedded cloth or process waste. Lean six sigma (LSS) is a commercial enterprise development method that integrates two unique control philosophies. Lean and six sigma complementing every other to enhance project control methods by reducing non-efficient time and other wastes. The 2 models are outstanding catalysts of change as stand-alone techniques, however have a ability to emerge as a very vast and effective tool if contained together. At the same time as, if six sigma is carried out without lean, the gadget would lack tools and shape to derive the process closer to excessive fee and waste reduction. Similarly, if lean is adopted without six sigma, the system will need a approach to persuade it in the direction of excessive cost savings and variability reduction.

Sarhan et.al.[2018] This paper concludes the growing frame of expertise has been rising from International Group for Lean Construction (IGLC) community, with regards to synergies among lean creation and sustainability. Both are looking for to reduce waste and maximise price, but via exceptional methods and views. The maximum common mistake, is a device centered framework for integration, which overlooks the conceptual variations among these initiatives. The intention of this take a look at is to review the development made in expertise the linkages and inconsistencies between the 2 projects, through carrying out a vital systematic literature evaluation and synthesizing the findings of lean creation and sustainability. Three most important obstacles in tactics to lean creation have been identified;

(i) the predominance of a confined patron focused perspective of value, (ii) the limited awareness on the management of product lifestyles cycle requirements, (iii) the winning conceptualisation of waste, which does not account for environmental and social impacts. but, important obstacles have been related to methods to sustainability construction; (i) the over

reliance on formal 'green overall performance certifications', which limits possibilities for sustainability improvement, (ii) techniques to sustainability in architecture and construction that anticipate fixed enter output members of the family. Tackling those recognized flaws and exploiting the opportunities for future studies accrued through this study ought to sincerely assist to transport the research agenda ahead and probably cause sustainable upgrades in exercise.

Tomek et.al.[2017] The objective of the paper is to fully analyse the benefits of prefabrication with respect to the traditional cast in place construction method. Prefabrication of any shape issue off website during motorway creation consequences a lower in time and price compared with traditional forged in place techniques. The precast pavement panel or bridges are greater long lasting as they are forged and cured in a managed surroundings and also gives greater manage over consistency of the concrete blend. This facilitates in acceleration of bridge production all through motorway initiatives. As a study become undertaken in Virginia, USA, where the 40 year vintage go out ramp from dual carriageway needed rehabilitation with high visitors vicinity. Traditional repair might have required one hundred days but the pre-solid slab allowed closure of 1 lane at a time and the paintings is completed in 35 nights simplest. Consequently, prefabrication provides higher pace and balance, long time sturdiness, less renovation of toll road bridges and pavements.

Bajjou et.al.[2017] The improving context of globalization day by day will increase stress on the construction corporations so as to promote their performance if you want to withstand to the levels of competitiveness inside the worldwide marketplace. It had turn out to be ineluctable to provide for introducing a brand new alternative which is capable of creative development to the traditional manufacturing device. This paper relates especially to the maximum applicable management strategies in production company and particularly, the lean creation. To begin with, we will focus on the main traits of construction enterprise compared to the manufacturing enterprise in accordance to 3 stages: on-site construction, one in every of a kind tasks, and complexity. However, we can awareness our focus on

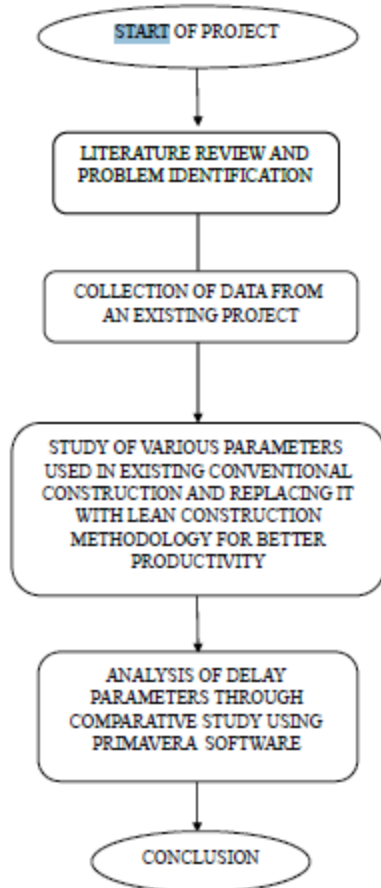
the principle assets of waste in production enterprise. Finally, a comparative examine can be achieved to show the attentiveness of the lean construction equipment inside the merchandising of conventional creation in particular at the extent of the following elements.

Jeong et.al.[2016] Value stream mapping is a beneficial tool to discover waste and improvement regions. It has emerged as a desired way to aid and enforce the lean method. When lean ideas are properly installed and have vast applicability in production, their extension to data generation remains restrained. This paper presents the implementation of VSM in a lean IT development initiative. It includes mapping the modern-day activities of the firm and figuring out opportunities for development. After numerous interviews with employees who're currently worried within the system, cutting-edge state map is ready to reveal the proposed improvement motion plans. The achievements of VSM implementations are reduction in lead time, cycle time and resources. VSM is a standardized manner of documenting methods and data flows as they're and applying a scientific way to analyse these tactics in order to perceive various waste and goal particular regions for improvement. The first step to enforce VSM is to draw a current country map. The value stream map of present day procedure is created and identifies distinct sorts of value brought in addition to non-price introduced activities on this stage.

IV. OBJECTIVES

- To carry out comparative analysis on parameters of time, cost and material both in conventional and lean construction.
- To assess the delay parameters of a highway project.
- To validate highway performance through lean construction using Primavera

V. METHODOLOGY



VI. RATING CRITERIA

To identify the degree to how much respondents agree or disagree on the severity of these causes based on their experience and knowledge, a 5-point Likert Scale is designed.

The ratings of scale from 1 to 5 are:

- 1-Not Significant(NS): 0% delay contributing factors;
- 2-Slightly Significant(SS):: < 35 % delay contributing factors;
- 3-Moderately Significant(MS):: 35 –60% delay contributing factors;
- 4-Very Significant(VS):: 60 –75 % delay contributing factors; and
- 5-Extremely Significant(ES):: > 75 % delay contributing factors.

The respondent have to rate a particular cause based upon the above scale. The reasons for using Likert Scale are: it is most universal method and is easily understood; response is easily quantifiable; makes

question answering easier on the respondent; quick, efficient and inexpensive method; and high versatility.

VII. DATA ANALYSIS

Relative Importance Index (RII) is adopted for ranking the delay causes as per their significance as it is simple and most widely used for finding the significant factors and ranking of the same. It is a regression based statistical tools. The formulae used for calculating RII is:

$$RII = \Sigma W / (A \times N); \text{ where, } 0 \leq RII \leq 1$$

Here, W = Weight given to each cause by respondent, ranges from 1 to 5;

A = Highest weight i.e. =5 (in this case); and

N= Total number of respondent = 25(in this case).

VIII. LIST OF MAJOR CAUSES OF DELAYS IN A PROJECT

The table given below shows the number of delays categorized in seven different category to which number of responses are assigned according to the questionnaire data conducted

S. No.	Type of Delays	N	SS	M	V	E	RII
Factors related to Contractor							
1	Poor site management and supervision	0	5	10	5	5	0.68
2	Delay in sub-contractor work	2	10	5	5	3	0.576
3	Ineffective planning and scheduling of project	0	5	6	10	3	0.691
4	Conflict in subcontractors schedule in execution of project	8	5	7	3	0	0.443

5	Rework due to errors	0	5	8	10	2	0.672
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IX. RANKING OF DELAY FACTORS ACCORDING TO RELATIVE IMPORTANCE INDEX (RII)

With the use of Relative Importance Index, the ranking of delays are conducted and then the highest value obtains the top rank.

Type of Delays	RII	Ranking
Ineffective planning and scheduling of project	0.691	4
Poor site management and supervision	0.68	5
Rework due to errors	0.672	6
Delay in sub-contractor work	0.576	19
Conflict in subcontractors schedule in execution of project	0.443	43

X. TOP THREE SIGNIFICANT CAUSES OF DELAY

Total 03 responses have been collected from the engineers and contractors and relative importance index has been ranked according to the ranking given. Below table shows the ranking of top 3 significant causes of delay as per delay related factor; type of delay and RII value.

S.No.	Type of Delays	RII	Related Factor
1	Ineffective planning and scheduling of project	0.691	Contractor
2	Poor site management and supervision	0.68	Contractor
3	Rework due to errors	0.672	Contractor

CONCLUSION

This study aimed to identify and rank the most significant delays affecting project performance using the Relative Importance Index (RII) method. Based on the data collected through a structured questionnaire survey involving three respondents, five key delay factors were identified and systematically evaluated. The application of the RII method allowed for the prioritization of these delays according to their impact, providing clear insights into which issues most critically affect project timelines.

The findings underscore the importance of proactive delay management and the need for targeted interventions to mitigate the most impactful factors. Although the limited sample size constrains the generalizability of the results, the study offers a valuable framework for assessing project delays in similar contexts. Future research involving a broader range of stakeholders and larger datasets is recommended to enhance the reliability and applicability of the results across the construction industry.

The above study identifies the 05 number of delays which is then ranked using the Relative Importance Index. The RII value gives us the delays which are more significant in the project by giving higher value to that delay. The study is based on the questionnaire survey conducted which includes the response of 03 respondents.

FUTURE SCOPE

The Relative Importance Index is very useful for ranking the number of delays, so that the important factors of delay can be known easily. The Primavera software is widely used for highway projects as the different activities can be arranged in a particular manner where the relationships can be given to the different activities. Through this the lean construction can be achieved as the duration escalation or the total cost can be reduced

REFERENCES

[1] Rajput, S.S. and Sharma, P.K., 2018. Enhancement of Highway Project Performance

- using Lean Construction Method. *International Research Journal of Engineering and Technology (IRJET)*, Volume: 05, Page no. 1760 to 1767.
- [2] Xu, G., Li, M., Chen, C.H. and Wei, Y., 2018. Cloud asset-enabled integrated IoT platform for lean prefabricated construction. *Automation in Construction*, 93, pp.123-134.
- [3] Ochieng, D.E., Nesensohn, C., Bryde, D., Fearon, D. and Hackett, V., 2018. Assessing Lean Construction Maturity. *Proceedings IGLC-22* page no. 1157 to 1168
- [4] Fernández-Solís, J.L. and Gadhok, N., 2018. Comparative Analysis of Lean and Six Sigma in Building Construction: Benefits, Obstacles and Opportunities. *Journal of operations management* Page no. 1 to 11.
- [5] Sarhan, S., Elnokaly, A., Pasquire, C. and Pretlove, S., 2018. Lean construction and sustainability through IGLC community: A critical systematic review of 25 years of experience. *Proceedings 26th Annual Conference of the International Group for Lean Construction (IGLC)*. Page no. 1 to 10.
- [6] DANIEL, E. and PASQUIRE, C., 2018. Creating social value within the delivery of construction projects: the role of lean approach. *Engineering, Construction and Architectural Management*. ISSN 0969-9988
- [7] Tomek, R., 2017. Advantages of Precast Concrete in Highway Infrastructure Construction. *Procedia Engineering*, 196, pp.176-180.
- [8] Sánchez-Rivera, O.G., Galvis-Guerra, J.A., Porrás-Díaz, H., Ardila-Chacón, Y.D. and Martínez-Martínez, C.A., 2017. BrIM 5D models and Lean Construction for planning work activities in reinforced concrete bridges. *Facultad de Ingeniería*, 26(46), pp.39-50.
- [9] Bajjou, M.S., Chafi, A. and En-Nadi, A., 2017. A comparative study between lean construction and the traditional production system. In *International Journal of Engineering Research in Africa* (Vol. 29, pp. 118-132). Trans Tech Publications.
- [10] Jadhav Shubham and Deshmukh, Y.R., 2017. Comparative Study Between Conventional Techniques and Software analysis Of effective material management and inventory control. *International Research Journal of Engineering and Technology (IRJET)*, Volume: 04, Page no. 1198 to 1202.
- [11] Kazaz, A., Ulubeyli, S., Er, B. and Acikara, T., 2016. Construction Materials-based Methodology for Time-Cost-quality Trade-off Problems. *Procedia engineering*, 164, pp.35-41.
- [12] Heralova, R.S., 2016. Possibility of using value Engineering in highway projects. *Procedia engineering*, 164, pp.362-367.
- [13] Jeong, B.K. and Yoon, T.E., 2016. Improving IT process management through value stream mapping approach: A case study. *JISTEM-Journal of Information Systems and Technology Management*, 13(3), pp.389-404.
- [14] Gade, R.J., 2016. A Proposed Solution to the Problem of Construction Industry Overruns: Lean Construction Techniques and Linear Programming. *Indian Journal of Science and Technology*, 9, p.25.
- [15] Hamdar, Y., Kassem, H., Srouf, I. and Chehab, G., 2015. Performance-Based specifications for sustainable pavements: A lean engineering analysis. *Energy Procedia*, 74, pp.453-461.
- [16] Ram, A. and Paul, D.P., 2015. Study on Construction Sequence Delay for Road Infrastructure Projects. *IOSR Journal of Mechanical and Civil Engineering (IOSRJMCE)*, eISSN, pp.2278-1684.
- [17] Nikakhtar, A., Hosseini, A.A., Wong, K.Y. and Zavichi, A., 2015. Application of lean construction principles to reduce construction process waste using computer simulation: