

**IMPROVEMENT IN HIGHWAY PROJECT PERFORMANCE
USING LEAN CONSTRUCTION**

A

PROJECT REPORT

Submitted in partial fulfilment of the requirements for the award of the degree

of

MASTER OF TECHNOLOGY

IN

CIVIL ENGINEERING

With specialization in

CONSTRUCTION MANAGEMENT

Under the supervision

of

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STUDENT'S DECLARATION

I hereby declare that the work presented in the Project report entitled “**Improvement in highway project performance using Lean construction**” submitted for partial fulfilment of the requirements for the degree of Master of Technology with specialization in Construction Management in Civil Engineering at **Jaypee University of Information Technology, Wagnaghat** is an authentic record of my work carried out under the supervision of **Dr. Saurabh Rawat**. This work has not been submitted elsewhere for the reward of any other degree/diploma. I am fully responsible for the contents of my project report.

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/05/2019

CERTIFICATE

This is to certify that the work which is being presented in the project report titled “**Improvement in highway project performance using Lean construction**” in partial fulfilment of the requirements for the award of the degree of Master of Technology with specialization in Construction Management in Civil Engineering submitted to the Department of Civil Engineering, **Jaypee University of Information Technology, Wagnaghat** is an authentic record of work carried out by **Arun Kumar (172604)** during a period from July, 2018 to May, 2019 under the supervision of **Dr. Saurabh Rawat** Department of Civil Engineering, Jaypee University of Information Technology, Wagnaghat.

The above statement made is correct to the best of our knowledge.

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ABSTRACT

Highway project delivery of new and reconstructed facilities consumes too much time and total cost of the project. The purpose of this thesis is to gain a better understanding of highway project delivery and enhances the time performance, reduction in cost applying lean thinking. This work presents several advantages of lean implementation. Highway project can be improved using lean construction, as it focuses on higher project performance and reduction in delays which directly influence the total cost of the project. Highway project that are located in urban environment exhibit greater relative risk of duration escalation. The duration escalation increases exponentially with increase of project cost. Therefore, the objective of the thesis will be the reduction in duration escalation and the overall project cost. The questionnaire survey was done with total number of respondents as 25. 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. Primavera software is used to minimise the duration escalation and optimise the cost of the highway project.

Keywords :- Lean Construction, Planning and scheduling, Delay causes and factors, Relative Importance Index, Primavera software.

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LIST OF ABBREVIATIONS

BIM	Building Information Modelling
BrIM	Bridge Information Modelling
EVM	Earned Value Management
IGLC	International Group for Lean Construction
LC	Lean Construction
LPS	Last Planner System
LSS	Lean Six Sigma
TCQ	Time-Cost-Quality
VSM	Value Stream Mapping

CHAPTER 1

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;

- **Planning:** for defining criteria for completion and producing methods for achieving goals.
- **Control:** causing activities to work according to plan and re-planning.

1.2. The main principles of lean thinking are

1. 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.
2. Defining value according to what client wants.
3. 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.
4. 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.

5. 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.

1.4. What is Lean Construction?

Lean production is a “manner to design manufacturing structures to reduce waste of substances, time, and effort so one can generate the most feasible amount of value”. Designing a manufacturing gadget to gain the stated ends is simplest viable thru the collaboration of all venture contributors (proprietor, clients, Project Managers, last-user) at early levels of the task. This passes beyond the contractual association of layout/construct or constructability opinions wherein clients, and project managers, sometimes react to designs in place of informing and influencing the layout.

Lean construction acknowledges that preferred ends have an effect on the way to gain those ends, and that to be had method will have an effect on found out ends. Basically, lean construction ambitions to encompass the benefits of the Master Builder Idea.

Lean construction attracts upon the ideas of assignment-stage control and on the concepts that governs the manufacturing-degree projects. Lean construction renames that any a success project challenge will inevitably contain the interaction between assignment and production control.

Lean construction provides traditional construction management methods with: -

(1) Two vital and important dimensions for a main capital assignment delivery by way of requiring the necessary attention of fabric and statistics go with the value and flow era in a manufacturing device.

(2) Differing the project and manufacturing management (planning-execution-control) paradigms.

While lean production is similar to lean manufacturing in spirit, it is one of a kind in how it became conceived and how it is promoted. There may be a view that "model" of Lean manufacturing/manufacturing bureaucracy the basis of Lean production. The view with the beginning of lean construction arises particularly wanted for a manufacturing principle in construction company that have been determined inside the reliability of weekly manufacturing planning stage.

Getting the work to flow predictably and reliably on site construction requires the different alignment of the total deliver chain which is responsible for manufactured facilities such that the waste is minimized and value is maximized. With any such wide scope, it is true to mention that the tools discovered in Lean production and Lean manufacturing, as done via

Toyota and others, were tailored to be used within the completion of Lean production standards. TQM as well as six-sigma, determined their manner into lean construction. Further, strategies and tools observed in different areas, along with in social technological know-how and commercial enterprise, are developed in which they are used. The techniques and tools in construction control, such as work breakdown shape and CPM, and so on, also are applied in lean construction implementations. The construction work priority is to:

1. Keeping the work flowing so that the workers are always productive
2. Reducing inventory of tools and material and
3. Reducing the cost

The different unique methods and tools that were mainly given for lean construction are Lean Project Delivery System, Target Value Design, and the Last Planner System.

1.5. Lean Tools

1.5.1 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.

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.

1.5.2 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.

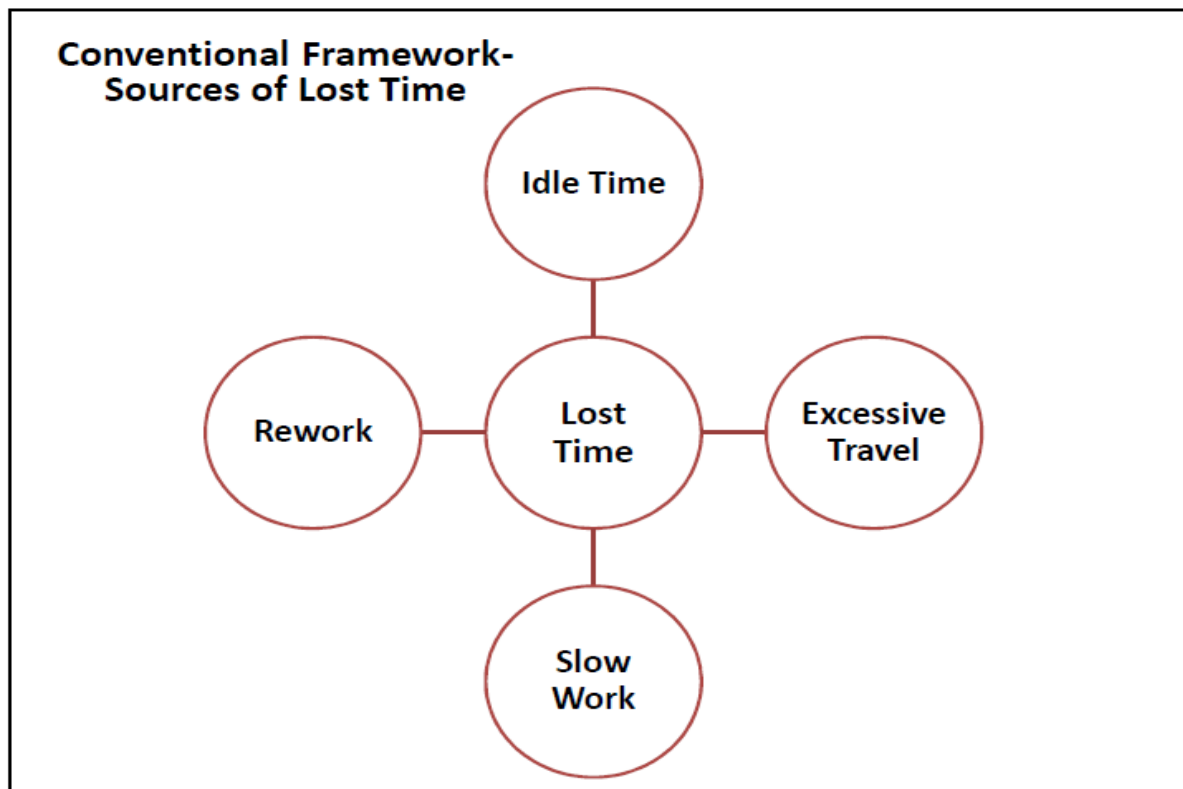


Figure. 1.1. Conventional Framework (Tomek et.al.(2017))

The Various Aspects of LEAN Construction

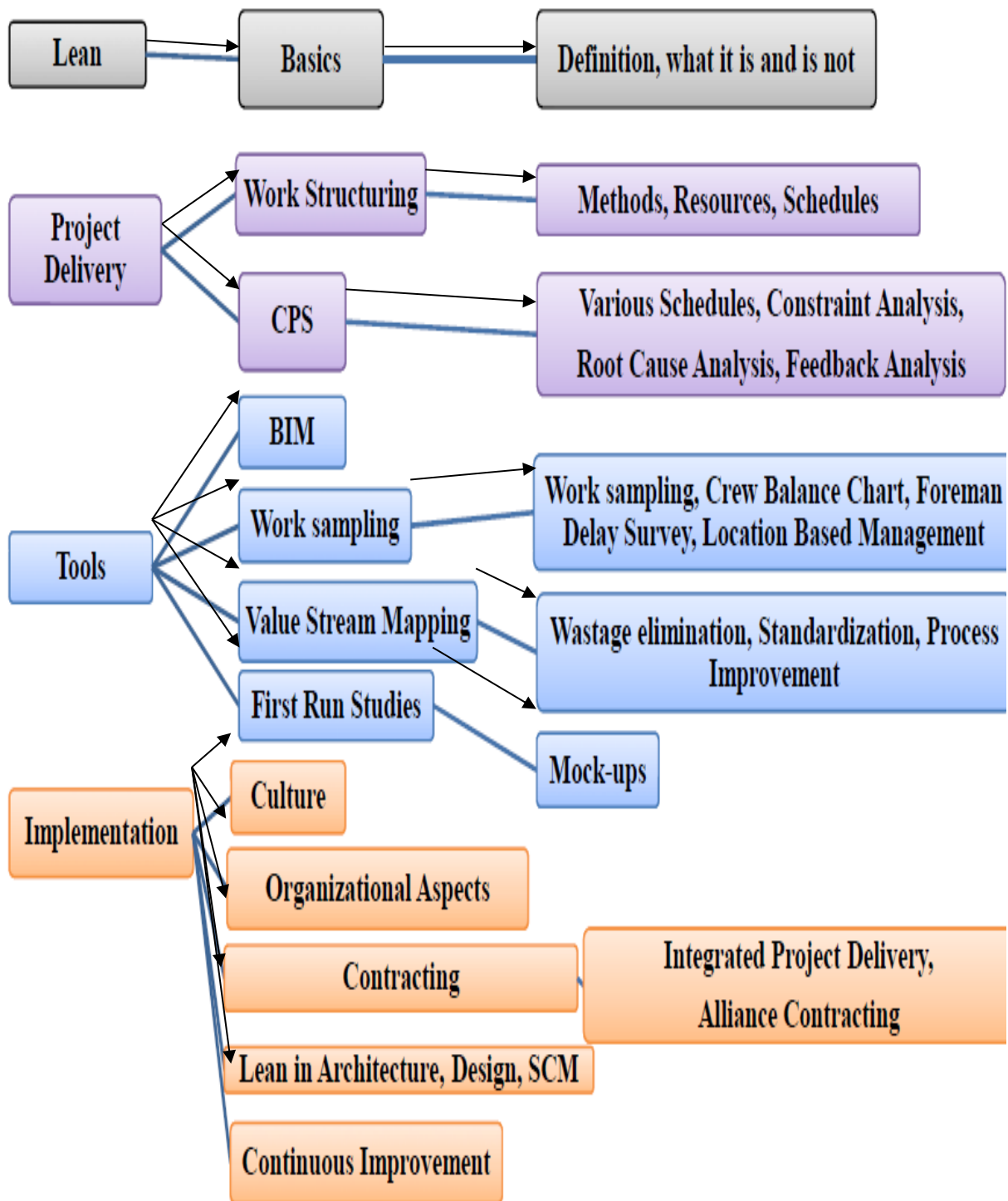


Figure. 1.2. Various aspects of Lean construction (Solis et.al.(2018))

CHAPTER 2

LITERATURE REVIEW

2.1. Historical background

The inspiration of lean production have been developed in post World war II Japan, when its production enterprise underwent a entire rebuilding. Ohno, leader manufacturing engineer, of Toyota motor corporation evolved some of the underlying ideas of lean production. At the time, the restricted uncooked materials and inadequate area for stock in Japan fostered an atmosphere wherein principles including lower in period escalation and discount in usual cost have become vital. Therefore, those steps have been termed as lean and employed within the manufacturing tactics within the employer, which shows the better overall performance with increase in first-rate.

In the past decade, the lean wondering is carried out in construction enterprise, wherein the lean construction is a mixture of realistic improvement and operational research in construction and design with an adaptation of lean practices and concepts to the give up to cease construction and design system. This technique attempts to manipulate and enhance production methods with minimal price and most value by means of thinking about customer's needs.

2.2. 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. They 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. This integration changed into done through the development of an established framework for

assessing lean creation maturity. Furthermore, has been proven through a validation involving a focal point organization and three interviews with preceding contributors of the examine that the tilt production adulthood model can measure the contemporary nation of lean construction maturity. Subsequently, the framework provides a unique possibility to improve the lean construction functionality in organizations because it gives a scientific and holistic evaluate of the current state and the strength and the weaknesses of lean construction maturity.

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.

Daniel E et.al.[2018] The purpose of this paper is to present the modern expertise surrounding social value and display how lean method supports social cost realisation in the transport of creation projects. The have a look at establishes that the modern-day level of consciousness on social fee continues to be low and the examine well-known shows the potentials of lean approach in supporting the shipping of social cost on construction ventures. The main aim of lean production is that to cast off waste and add value from the product right from design thru to the producing or production degree. This implies that the point of interest of lean manufacturing is not simply at the very last product, but also on the tactics that culminate within the development of the final product. The take a look at observed that there may be nevertheless no clear or single criterion for measuring social fee brought. consequently, the lean manufacturing technique have the capability to assist the shipping of social cost goals of creation tasks. The examine concludes that conceptualising the community and bodily environment around the production project the use of the tilt concept of consumer could aid social price realisations in the delivery of construction initiatives. This means the commitment to the transport of social fee on production tasks or establishments have to no longer be visible as a tick box exercising this is compliance pushed in view that there are other benefits inclusive of the business feel of doing it.

Tomek et.al.[2017] The objective of the paper is to fully analyse the benefits of prefabrication with respect to the traditional cast in lace 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.

Rivera et.al.[2017] BIM model and lean construction for planning work sports integrating constructing data modelling and lean production can improve the bolstered concrete bridging making plans technique, due to the possibility of handling the assignment information with BIM to achieve accurate enter statistics that benefits the application of lean production principles. The application of BIM to bridges is referred to as Bridge Information modelling (BrIM). This paper concludes the feasibility of jointly observe BrIM generation and lean construction philosophy, instead of the person use of BrIM fashions for planning strengthened concrete bridges. The combination of BrIM and lean creation enhance the effects of the assignment strategy planning stage early detecting problems and constraints, this selection has the visualisation and records management benefits supplied by using BIM which together with the utility of lean construction principles improve challenge planning and encourage waste discount. Reengineering a production manner applying the tilt creation philosophy concepts add value of fantastic benefit to stumble on disasters, which may be corrected and altered before beginning the construction of the project in place of for the duration of the development stage. In this manner, it's far feasible to lessen losses due to negative making plans and growth the understanding and fine of the construction planning. This new technique to generation management permits to enhance the planning approaches, including the estimation of each work quantities and budget and the elaboration of labour schedules.

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: developing price and disposing of waste; making plans and mutual co-ordination; on-site employer. Lean construction as Value stream Mapping (VSM), Last Planner System (LPS), and Visual Management (VM) have proven a exquisite capacity to enhance the conventional manufacturing machine thru waste discount, encouraging humans involvement, making sure a pull drift manufacturing, and merchandising of a continuous development philosophy.

Jadhav et.al.[2017] Materials constitute a major value issue for any industry. The overall price of mounted fabric can be 50% or more of the overall value. “Material management is described because the manner to offer right cloth at proper region at right time in right quantity so one can minimize the price of task” substances management is associated with making plans, exact quantity at proper vicinity in exact time which will schedule and coordinate the manufacturing activity in an integrative way for a commercial task. Effective management of material can reduce these expenses and contribute extensively to the fulfillment of the mission. Lack of stock can result in stock-ends, inflicting stoppage of construction, but a completely stock then again can bring about improved fee of production because of excessive price of sporting inventory Primavera software program is beneficial in pinnacle stage planning and it perfect for managing the complex info. Primavera is a laptop primarily based software used for making plans, scheduling, challenge creation, hobby codes, resource analysis and leveling, reporting overall performance and so forth. This software is hooked up with the aid of Primavera structures in which gives program and assignment management software program for the Engineering, architecture and production industry. Primavera software is used to plot, schedule, and control the proper strategic blend of tasks. it's also utilized in business enterprise to make informed venture, price and aid and in management selections.

Kazaz et.al.[2016] The study of thinking about the restrained resources, estimation of Time-cost-quality (TCQ) is a complicated problem. Consequently, to overcome those issues unique models had been brought. In these, models, distinctive processes have been used to estimate TCQ related records. Firstly, in continuous technique, it was assumed that the correlation among specific components will be expressed by way of non-stop capabilities. Secondly, in discrete method, production method, crew formation and group beyond regular time coverage have a few impacts on TCQ. However, the brand new methodology suggests that the

construction materials must be covered inside the aid usage formation, so that the 2 step method was added. On this take a look at, the aim was to define a brand new -step methodology to overcome the deficiencies determined. According to methodology, in first step, the outcomes of construction material on time, value and quality should be in comparison underneath identical crew formation and team coverage. The second step will simplest be started out if the planning engineer wants to make some changes on time and fee of the most beneficial time table. Consequently, only time and value of a project have to be optimized via thinking about alternative crew formation for every activity.

Heralova et.al.[2016] This paper deals with using of value engineering in highway projects. There are three essential motives on which the dual carriageway venture needs price engineering. First off, they do no longer attain the project desires. Secondly, project transport isn't always on time and finally, the price exceeds the price range limits. To lessen those hazards, the design degree in dual carriageway engineering is the key stage because it at once affects the whole challenge funding. Value engineering isn't a cost slicing technique; however it's miles an prepared effort which analyses the necessities of the venture for the cause of reaching the essential features at the lowest life cycle price. Value engineering can have many advantages along with, solve technical problems of complex tasks, advantage additional technical know-how, emphasis on green use of assets, enhance assignment overall performance and achieve price financial savings.

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 is an 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.

Gade et.al.[2016] This paper will suggest that a blended approach of Lean production techniques with Linear Programming as a probable technique to the trouble of overruns in construction projects. It's going to be searching for to have a look at how a combination of Lean construction strategies and a base software model of Linear Programming can follow to a construction task on the preliminary and intermediate strategy planning stage to overcome demanding situations associated with task overruns. Based totally on a literature overview and information collection it's going to look into if the mixture of Lean construction strategies and Linear Programming should bring about time and cost assurances in a construction challenge. Objective: to investigate to what quantity an aggregate approach of Lean construction concepts and Linear Programming should help remedy the trouble of overruns in time and costs in construction. Analysis: The studies work offers with the application of lean construction principles including closing planner system simply in time and so forth. At the first a part of the project after which the second component introduces formation of linear programming version base at the output of first component. The collective result of the aggregate is then measured. Task making plans and scheduling may be progressed in the early section of the assignment, which allows to avoid delays and failure of undertaking happening at a later stage. Improvement: The mixture of each is by no means used inside the production enterprise thus far, so this mission offers preliminary method to do so for small scale construction project first, and after a hit implementation, it can be implemented to the large scale construction undertaking.

Hamdar et.al.[2015] Lean construction purpose at minimizing waste and maximizing cost which can be related to cost, time and quality. these techniques are in line with sustainable construction procedures which target on decreasing the waste as well as consumption, emissions and many others. The objective of this paper is to maximize the fee of pavements by their performance, at the same time as minimizing wastes due to inefficient quality assurance/quality control (QA/QC). due to excessive value and prolonged time for the conduction of standard penetration test (SPT), it's far frequently not carried out. The drawback of that is that the volumetric houses aren't usually reliable indicators of asphalt concrete's overall performance. The long time overall performance is achieved with the aid of SPT result with correct performance. A benefit/cost evaluation of QA/QC strategies helps determine the foremost option for the assignment.

Ram et.al.[2015] This paper includes the examine on construction delay for highway projects as the growing complexity in modern-day infrastructure tasks, delays and overruns have

come to be commonplace records. Delays can cause many poor consequences as lawsuits between proprietors and contractors, extended charges, lack of productiveness and sales and contract termination. The main causes of delays in highway project are; put off environmental problems, due to land acquisition postpone in development charge, useless assignment, terrible site management and supervision, remodel due to mistakes, delay in approving design files, planning and scheduling, negative coordination among proprietor and other parties, financial closure and exchange order through customer. A number of those delays had been befall during Chennai Ennore port road connectivity project. The earned value management (EVM) is carried out for the not on time initiatives. This examine observed that the delay in land acquisition is the number one cause for delay in highway challenge. Consequently in case of delays, the EVM could be very useful in locating the probably final touch time for projects.

Nikakhtar .et.al.[2015] Waste within the production enterprise has been the problem of numerous studies tasks round the sector in current years. Researchers put in force many practices to lessen the quantity of waste within the production enterprise. The powerful strategies for lowering waste is utility of lean methods. Lean creation is a result of advent of a brand new form of construction management. Even though lean creation remains growing, its widespread standards, strategies and methods can already be applied. Waste minimisation is one of primary principles of lean questioning. In widespread, managers have a tendency to conceptualizing 'waste' as physical production waste, however lean thinking provides that there are sizeable wastes hidden in production methods (together with non-cost-adding sports and ready time). We purpose at checking the capacity of lean creation standards to lessen production method waste through a case have a look at (reinforcement method). Computer simulation is used to show the effects of lean principles software before the actual implementation. Outcomes show that special styles of wastes in a construction system can be minimised by adopting lean production standards the usage of computer simulation.

Locatelli et.al.[2013] This paper aims on how to address the troubles of creation projects that are not introduced on time and on price range and remodelling are commonly required to meet patron's need. The highway project overall performance may be executed through various parameters; as right education must be given to workers and allow them to apprehend the lean principles. The performance can't be carried out simply via the utility of lean ideas or tools however it is necessary to involve and inspire people at every degree to attain lean advantages. Delays in production ought to be reduced because it without delay affects the

value of the assignment. A discount in waste results in decrease the venture value due to the fact no value added sports are eliminated, as reworking in lean thinking way waste. The efforts spent in disposing of waste results in better fine. Customer involvement all through undertaking definition and layout phase leads to waste reduction as the focus can handiest be at the real purchaser desires and to expose its influences without delay. This paper concludes that the maximum commonplace blessings of Lean creation are shorter transport time and a better project overall performance because productivity of body of workers will increase, better coordination and conversation with suppliers and there's a minimization of remodelling and no value added activities.

Kumar et.al.[2013] This paper is based totally on a laboratory have a look at, wherein the copper slag is used as a alternative fabric for sand in pavement mixes. A mix of pavement quality concrete (PQC) have been prepared with 400kg/m³ of OPC by means of substituting different values 20%, 40%, 60%, 80% and 100% of copper slag in control mix. Then dry lean concrete (DLC) mixtures with 150mg/m³ of OPC and some blends of stone dirt with 20%, forty%, 60% and eighty% copper slag. However, the laboratory exams show that the compressive energy at 7 and 28 days became no longer tormented by inclusion of copper slag. However the increase in copper slag content material beyond forty% results in decrease in compressive power. Consequently, it changed into concluded that the mixing of stone dust with copper slag content material as much as 40% may be used for % and DLC.

Sarhan et.al.[2013] This paper emphasized that the ideas of lean questioning could lead the development industry's quest to improve best and efficiency. Although diverse counties international gained big advantages by way of using lean construction principles, there still seem to be constrained usage of lean in United Kingdom production enterprise. There appears to be many cultural and structural boundaries that are migrating towards its successful implementation. by means of no longer realising the elements that have an effect on the a success usage of lean construction, companies now no longer be able to realize what development strategies need to be done, whereas these efforts have to be focussed or which efforts should have first-rate outcomes. As there is a lack of adequate lean understanding or awareness. Lean construction efforts ought to prove to be extraordinarily profitable in construction enterprise. although numerous blessings can be won via adopting the tilt ideas. There appears to be a many cultural and structural limitations which might disturbs the development of creation companies toward achieving the tilt approach. The principle

obstacles identified are (i) lack of adequate lean understanding and awareness (ii) loss of upper management dedication (iii) cultural and person attitudinal issues.

Tezel et.al.[2013] Lean construction corresponds to the mirrored image of the production gadget developed on the Toyota corporation on the construction enterprise. Turkish contractors gives a huge portion of neighbourhood financial system and are essential global managers in contracting commercial enterprise. Lean construction primarily based studies and practice as the production control depend method for enhancing the effectiveness and performance of the construction enterprise are scarce amongst contractors. This paper gives the effects of a questionnaire provided to predict the lean conformance tiers of contractors and talk the consequences. The comparative weaknesses and strengths of the contractors for a lean creation initiative are provided. The findings in the paper may be used as start line to provide the practice and research in lean construction amongst contractors. A comparable sort of research may be repeated again to evaluate the lean conformance tiers in extraordinary areas and to assess the lean creation packages at one of a kind companies after the advent of lean production.

Shehata et.al.[2012] Exact control of resources in production tasks can yield good sized financial savings in cost and time. As construction is the labour extensive industry, this paper gives attention on labour productivity within the creation enterprise. This have a look at considers the modern country of the artwork troubles as relevant to difficulty. It cover the development labour productiveness aspects, definitions, elements, measurements affecting it, special techniques were used for modelling strategies and measuring it. This look offers a guide for many important steps required to enhance creation labour productivity and task overall performance. It could also improves the general performance of production tasks through the usage of the concept of lack of productiveness dimension for production productivity claims. the main conclusion drawn is that there is no trendy definition of productivity and any modern-day misunderstandings about productiveness appear from as a minimum non-standard terminology. a hard and fast of graphs for factors affecting labour productivity became provided that can assist improve labour productivity and assignment performance.

Hosseini et.al.[2012] Waste in the construction had been the problem of numerous studies project around everywhere in recent years. Researchers implement exceptional strategies to lessen quantity of waste in production industry. The effective strategies is software of lean

methods to production industry. Lean production is a end result of the creation of the new shape of manufactured control. Whereas lean production is still growing, the widely wide-spread ideas, tools and techniques of lean production can be applied. Waste discount that allows you to enhance overall performance is one of primary principles of lean thinking. In standard, task managers generally tends to conceptualize “waste” as physical waste, but there are noticeable wastes inside the construction methods that are “non value-adding activities” by using lean production principle. This paper, the waste amount of creation techniques in any layout has given through discrete occasion primarily based on lean questioning method. Outcomes show that development procedures have excessive potential of optimization via using the computer simulation and lean construction approaches.

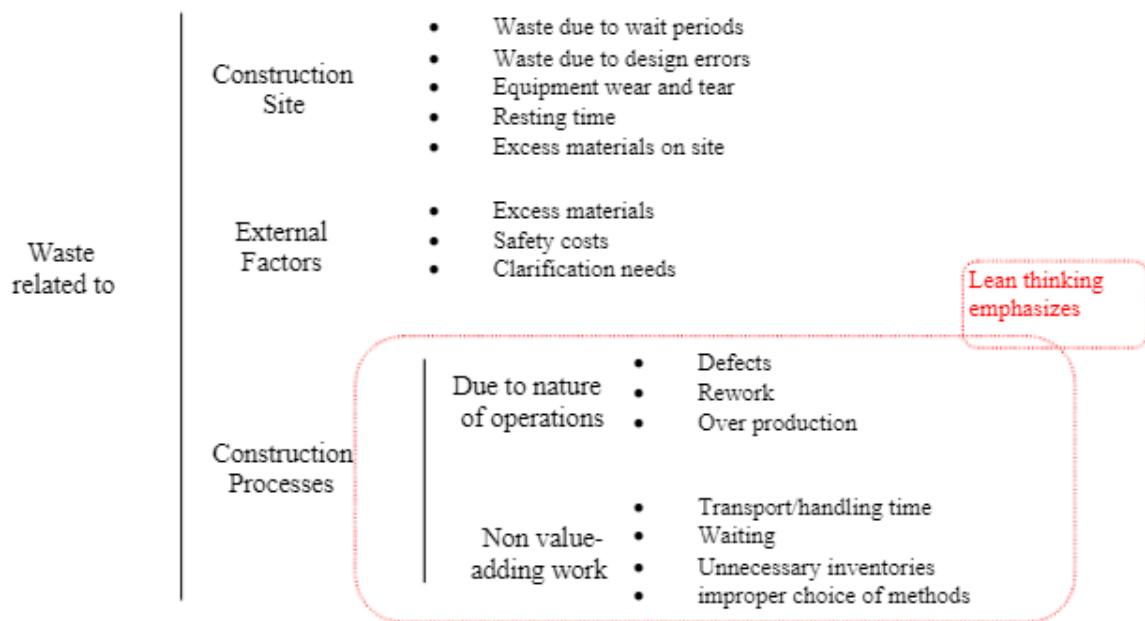


Fig. 2.1.Waste categorisation considering lean thinking approach (Hosseini et.al.(2012))

Zimina et.al.[2012] Goal costing is an effective management approach that had been utilized in construction for many years to gain cost predictability all through new product development. Adopting this method promises advantages for development enterprise as it is struggling to elevate the range of a hit effects and actuality of challenge shipping in terms of quality , cost and time. Target value layout is the control method that gives the fine methods of goal costs and adapting them to peculiarities of construction. The method of target price layout is delivered primarily depend on the outcomes of motion research finished on 12 production initiatives within the USA. It is shown that systemic application of goal value

layout leads to large implementation of venture overall performance the very last value of projects became on common 15% less as of the marketplace price. The construction enterprise has strategies that have similarity with elements of goal cost design system or use the equal terminology, e.g. goal value contracts and partnering, fee planning, and so on. Following an exploration of the variations and similarities goal value design is provided as a shape of goal costing for creation that gives a more reliable course to a success mission consequences.

Porwal et.al.[2010] Plan non reliability is real problem in production enterprise because the construction industry is fragmented and every venture is precise, scheduled put off is a commonplace phenomenon. ultimate planner gadget has turn out to be a famous tool the various lean creation network to stabilise work waft and make plans extra dependable. However, LPS customers and mentors document severe challenges with improvement and use of this tool. The main aim of this research paper was to identify the demanding situations faced with the aid of creation professionals throughout the use and implementation of LPS at each organization and venture tiers. The study shows that resistance to trade , lack of training, absence of human capital and lack of management in implementing and the usage of LPS are foremost challenges, amongst others. Even though LPS is widely used in course of the sector, it's miles new to various construction professionals. Development of LPS usage strategies and schooling could be crucial steps within the a success improvement and use of LPS at organization and challenge degrees. Strong management and control dedication to improvement are also important for bringing alternate for tremendous result and non-stop improvement.

Hofacker et.al.[2008] The rapid LCR is a completely unique and smooth model to evaluate the fine and degree of leanness of a construction assignment. A standardized framework permits to mix qualitative assessment thru statement together with quantitative evaluation. A labeled assessment scheme is proposed within the equal version, to without difficulty visualize and interpret the score consequences. The degree of lean construction software is hereby distinguished between (lowest possible initiatives, tasks with none lean construction understanding, low quality and tremendously wasteful) and (highest possible level). This standardize score model may be implemented to all types of production projects and within exceptional geographic contexts. One hour of creation site go to and any other half of hour for the analysis is needed to adopt the rating. The goal for the development of this rating model were to keep the LCR version on a macro scale and to provide a entire framework for

the evaluation, visualisation of outcomes and type into standardize LCR classes. An applicant of LCR version can speedy gain a standardized belief of the exceptional and alertness diploma of lean principles. This really displays whether or not the development undertaking is in line with a precise approach to cognizance on cost generation and waste discount.

Ansell et.al.[2007] This paper entails the resurfacing and deep patching of two 4 lane carriageways and the supply of concrete safety to eight bridge piers. At some point of the development degree, analysis constituted of 3 sports; constraints evaluation, delay evaluation and buffer analysis. The constraints analysis involved the usage of a chart in an excel spread sheet to become aware of the guidance that turned into required to make prepared sports planned to begin in the subsequent four weeks. Secondly, in the delay analysis, prior to weekly assembly, a two week plan become organized primarily based at the programme which turned into updated weekly. If the pastime had not been finished on time, a reason for the postpone became required. Even as, in buffer evaluation, software program turned into used to analyse penetration into the buffer because the challenge progressed. The lean wondering manner used on h highways renewals scheme has been mentioned in terms of programming, analysis and overview, which includes problems in producing and maintaining a buffered programme, advantages of weekly constraints, planning and put off evaluation and usefulness of numerous output from the technique. Understanding those differences and displaying how lean tools and techniques may be followed to present full capacity in a toll road context, is fundamental to creating assist for lean on this environment.

Lapinski et.al.[2006] Facility owners and venture groups frequently struggle to interact “green” or “sustainable” necessities on constructing tasks and may incur extra venture fees as a result. even though “investments” in excessive overall performance constructing capabilities can be given again through the operational saving, the project transport methods presently followed via maximum projects are provided with process waste. Lean manufacturing standards were verified to lessen waste and enhance procedure overall performance in especially complicated development and production environments. Adopting these lean concepts, the paper reports a look at that diagnosed the presence of waste and value in a sustainable building undertaking. The investigation also focused on South Campus Facility, which acquired U.S. inexperienced building the Council’s leadership in strength and Environmental design with Gold certification at a challenge fee equal to a traditional facility. thru put up hoc procedure-based totally analysis, perception approximately what added waste and cost in sustainable task shipping at Toyota become received. The outcomes additionally

identify similarly development opportunity to Toyota's shipping process. For company owners and the structure construction enterprise, the results gives insights about a way to economically and efficiently deliver sustainable facilities.

Wolbers et.al.[2005] The intention of this paper is to explore how the construction management framework (CMF) can attain its objectives to offer quality fee and continuous development in comparison to standard methods of procurement. On an operational stage, lean creation has been identified as one manner of supplying best price in the CMF. This paper determine how lean thinking lends itself to the middle objectives of the brand new way of life that the toll road company are promoting. It will don't forget how lean construction can improve exceptional value within the CMF, with the aim that the want for further studies may be diagnosed. Lean production has been acknowledged as a tool for improving methods and adding value by means of both the toll road organisation and production management network. Evidence of using lean thinking in different sectors of creation has proven there are advantages to be made from applying lean ideas to highways. At the same time as selection of suitable procurement techniques theoretically allows realisation of best cost and continuous development, it's far suggested that it's far on the operational level that capacity financial savings are most easily regarded and recovered. Lean creation has been diagnosed as the biggest opportunity stage and evidence of making use of lean questioning standards from production to the development environment advocate blessings can be executed.

Arbulu et.al.[2004] This paper proposes a method to implement the management to deliver methods in construction using lean standards and strategies. The goal is to assure on time transport of materials and information to task sites as a most value and minimum cost for the very last client. The first mean for reaching this goal is to provide supply control functions with lesser waste; e.g., low demand and deliver reliability, massive inventories not had to soak up variability, and bodily waste. The paper provides deliver complexity in production with a purpose to higher apprehend in which positive styles of wastes are originated. The approach proposes the usage of a web-based totally device based totally on the closing Planner gadget to implement making plans reliable so the demand variability is lowest, the use of regional logistics facilities for providing of materials to on sites, the use of strategies to pull decided on materials on a simply-in-time foundation, and a hyperlink among manufacturing manage and fabric management strategies on site. It additionally gives the importance of minimizing cloth lead instances with emphasis on pre-meeting practices and

standardization so delivery systems are more effective. It concludes highlighting the maximum vital challenges for the implementation of this approach.

Yang et.al.[2001] Having resources paintings constantly has lengthily been the goal for scheduling repetitive initiatives. Waste in repetitive projects is located when labour and system's are ready, being idle because the previous resources have now not finished their jobs. In contrast to the frenzy gadget method used by traditional CPM, we endorse a pull gadget scheduling gadget to put off unforced idleness in repetitive tasks. We use the time period pull in making use of repetitive scheduling thoughts to Lean construction in a new manner. The scheduling gadget is capable of model general repetitive initiatives with the aid of relaxing impractical assumptions posted via preceding models and affords a computational set of rules to generate planned and as constructed graphical schedules. A computer software, repetitive undertaking planner is incorporated and a real pipeline task is applied to demonstrate the utility. The pull system scheduling system can function a practical tool in the direction of continuous work glide. The emphasis of this studies is the elimination of waste in the making plans and execution section, in an effort to maintain non-stop workflow. Real challenges emerge when labour and equipment; (i) pass certain work places (ii) trade progress directions (iii) work for multiple activities (iv) break up and reunite all through development (v) perform at extraordinary production quotes (vi) require travel or wreck time.

Howell et.al.[2001] The connection between capability utilization, wait time and version is properly understood in production enterprise wherein the relationships are stated as fundamental laws. This paper explain this idea and its implications for construction and will project the contemporary view that time and cost must always be in tension. This paintings display that decreasing version in paintings go with the flow will improve performance and that the ensuing improvement may be carried out to lowering period/ price. This take a look at indicates the connection among capability utilization, wait time and paintings flow variability within a manufacturing gadget and the "time –value exchange off" skilled in production. The impact of lowering version in this change-off has been shown on the enterprise facet, proprietors and contractors ought to query their not unusual sense assumptions and prevent pushing for max labour utilization or for doing every bit of work as quickly as possible. Instead they ought to paintings to lessen work go with the flow version for you to improve assignment overall performance.

2.3. Summary of Literature Review

1. From the above results and discussions we have concluded that with using the lean techniques over conventional construction, there is a reduction in consumption of materials, time period and cost of the project.
2. The above study focuses on usage of lean construction philosophy as this can benefit from a very big margin to improve the organizational management system especially on the level of these fields: Planning and mutual coordination, Creating value and eliminating waste and Site organization.
3. Primavera software is very helpful and vital in any organisation for effective planning and management.

2.4. Objectives

Improvement in highway project performance using Lean construction.

- 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.

CHAPTER 3

METHODOLOGY

3.1 General

Applying lean thinking to enhance the highway project performance by finding waste and eliminate it, which will help in reduction of time and cost.

The methodology of this work will help to assess the current state of highway project delivery focussing on real parameters comparison between conventional and lean construction. In the above study, first we study the different parameters such as, time, cost and material around which the total project revolves. Then, we apply the lean principles on these parameters which will benefit the project construction compared to conventional construction.

3.2 Collection of data of a real time project

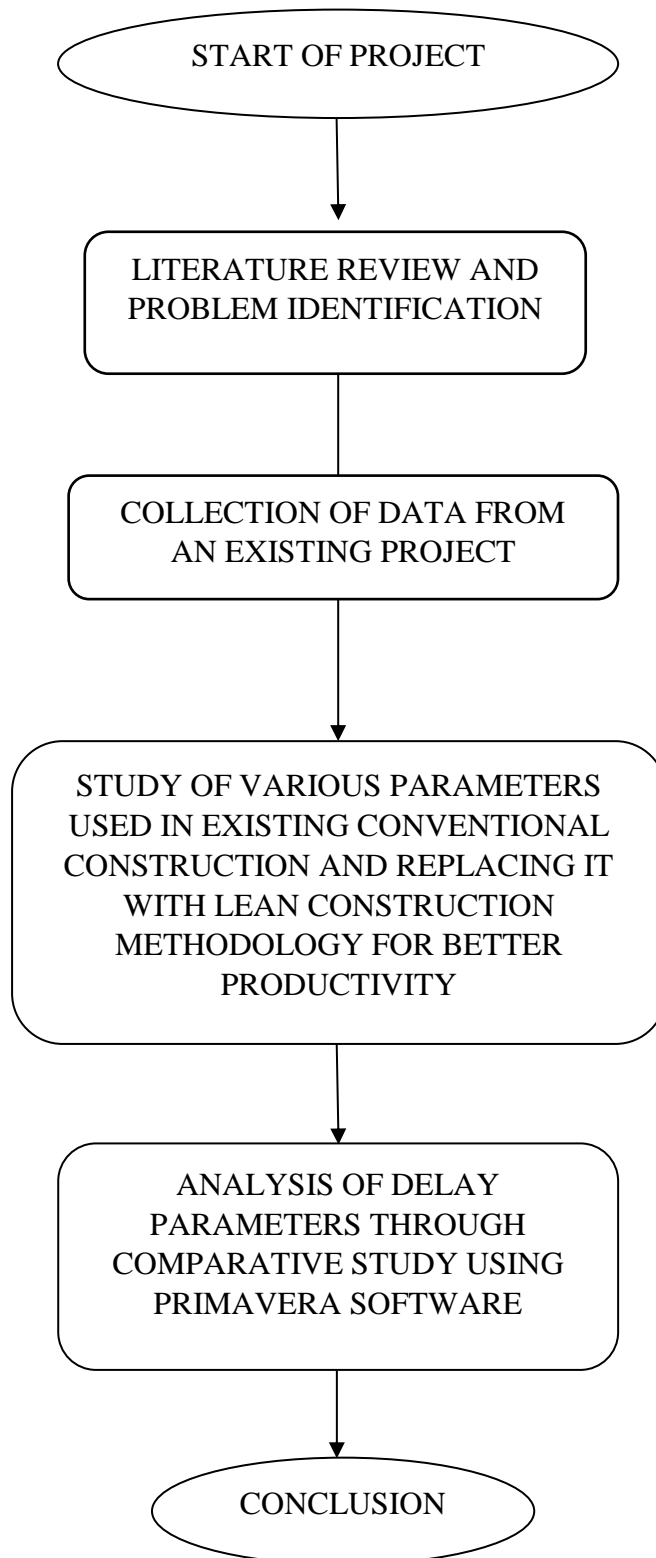
As firstly we acquire the data for a highway that has already been constructed using traditional ways, then we carry out the comparative analysis on time, cost and material used in the project with the lean construction.

Secondly, we will study the delay parameter which affects the time and overall cost of the highway project performance.

3.3 Time-cost analysis using Primavera software

We will validate the highway performance through lean construction using the Primavera software. Primavera is a computer based software used for planning, scheduling, project creation, activity codes, resource analysis and levelling, reporting performance etc.

Sequential Methodology Chart



3.4. Methodology of Proposed work

3.4.1. To carry out comparative analysis on parameters of time, cost and material both in conventional and lean construction,

- The growing context of globalization completely will boom strain on businesses to enhance their performances. Currently, the lean philosophy starts to combine into the development area. As a manner to enhance the performance of the production device, Lean production philosophy modified into added as a new method of production tasks manage. On this art work, we are primarily based at the trendy and maximum reliable researches performed on this region that permits you to behaviour a rigorous comparative study of techniques used inside the conventional construction with the strategies and tools inspired by means of lean introduction philosophy. The comparative observe specializes in the 3 following criteria: growing value and doing away with waste; planning and mutual coordination; site organization.

- **Conventional construction**

- (i) Creating value and eliminating waste**

The conceptual engineering of traditional creation industry focuses best on the stairs of conversion or processing sports activities and neglects the non-value-brought activities, which ends up in an uncontrolled variability of manufacturing. The most important factors of producing within the construction sites are wastes. Leaders of conventional creation assignment seek in most instances to clear up the production variability via using incorporating more belongings in an effort to increase the reliability of operations that create added rate, so that it will increase spending of agencies that take the chance of making an investment in the advent of latest technology regularly out of control in place of trying to pick out the real assets of wastes.

- (ii) Planning and mutual co-ordination**

Conventional planning model extra than 50% of scheduled responsibilities aren't completed on time. Most of the time, an unused entity (undertaking supervisor) dictates 'what to do' and 'when' to the rest of the stakeholders in the undertaking. indeed, the undertaking manager realizes the overall planning “master time table” based totally at the project statistics and the focused objectives, fundamental to a temporal kingdom of what “need to” be accomplished with out taking into

consideration of neither the intrinsic truth of the website on line of production nor the functionality of agencies to satisfy their missions. “Traditional,” push planning system is illustrated in figure 2.

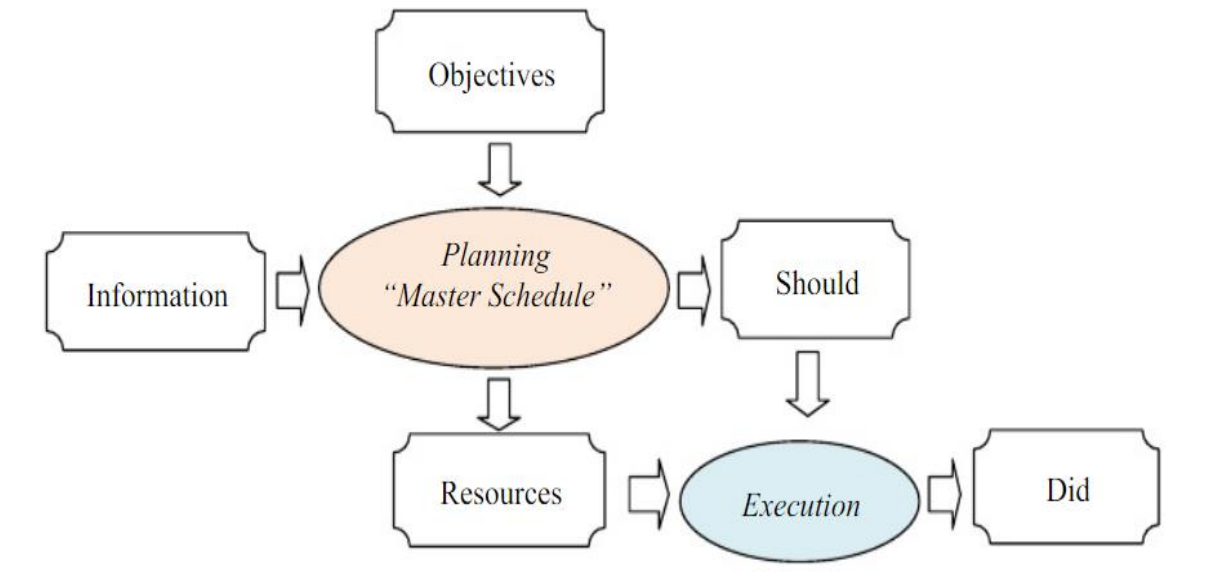


Fig. 3.1 - A push planning system (Howell et.al.(2001))

(iii) Site organization

In an aggressive market with more and more shorter closing dates and several contractors operating within the same vicinity, the control of organizational level will become more and more complicated. Certainly, maximum of the conventional manufacturing sites are poorly prepared places. Bad visualization and business enterprise are taken into consideration many of the crucial causes of injuries on the net website of introduction. In line with the studies, most people of production projects, that have an unorganized web site of manufacturing, are characterized with the aid of cost overruns and delays. Inside the traditional control, the construction websites gift a totally high stage of risk for the group of workers, in particular within the absence of visual management, and the presence of numerous stakeholders on site, appearing varied sports simultaneously.



Fig.3.2 - Poorly organized construction site

- **Lean construction**

- (i) **Creating value and eliminating waste**

Value stream Mapping “ VSM ” is taken into consideration the numerous maximum used Lean introduction equipment for the identification of the assets of wastes. VSM is composed in growing a visible map of the flow of substances and statistics from providers to consumer. the number one purpose is to perceive the wonderful responsibilities of the technique analysed and to distinguish among them into classes: people who create Value Added (VA) and those without No Value Added(NVA), which lets in figuring out the assets of wastes that have to be removed for objective to convert the cutting-edge method right into a future method more optimized.

- (ii) **Planning and mutual co-ordination**

“Master Agenda” is used to decide crudely the principle actors, the sequences of constructing further to the milestones which ought to be executed at some stage in the step “phase planning”, each company, represented through a foreman, will attempt to adjust the time desk in keeping with the activities for which it is able to have interaction. At the end of this phase, the making plans will become now not best greater faithful to the fact of the paintings, but the most essential are that it includes sequences and intervals of duties no longer imposed, which they had been deliberate in collaboration with all members; individuals that are without delay answerable for the supervision of the work on site production.

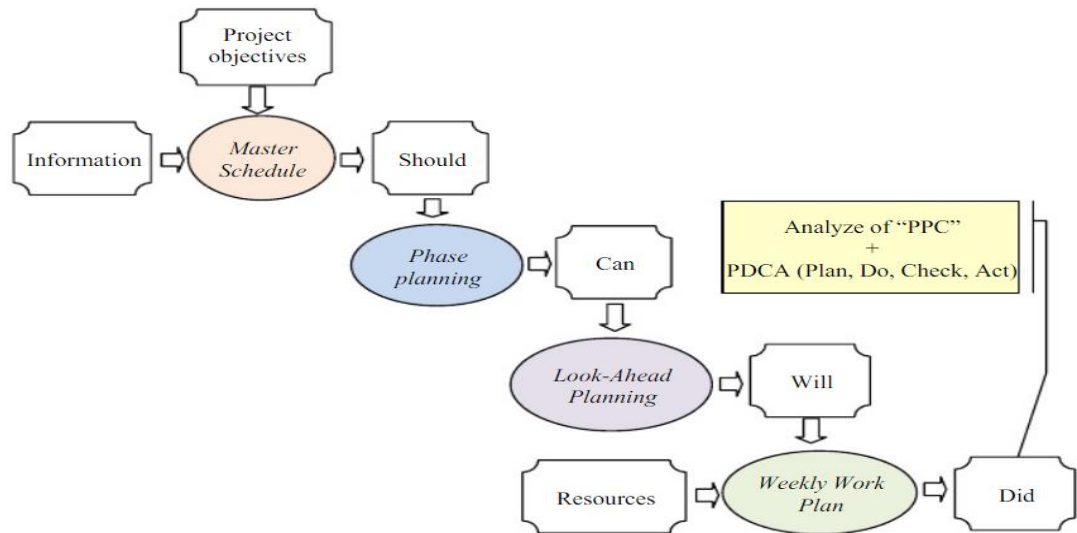


Fig. 3.3 - Scheme of planning in Lean construction (Howell et.al.(2001))

(iii) Site organization

Visual management helps to make the improvement device transparent, easy and relaxed for all stakeholders on internet page. Virtual billboards, signs and symptoms of safety and graphical dashboards of PPC facilitate the construction technique and boom the overall performance of verbal exchange between the coordinators of the undertaking, which make the internet site of creation extra secure and more obvious. Figure 5 indicates the usefulness of seen control for organisation and transparency of creation projects. So, we have got each material/device recognized the use of seen signs and symptoms and signs and symptoms smooth to understand with the useful resource of labour which enables to restriction needless displacements/moves and boom the transparency of the drift.



Fig. 3.4 - Site organization based on visual management

- **Case study**

As an example of the tilt precast pavement era and conventional method, this task organized through the Virginia branch of Transportation in fall 2009, that illustrates its ability thoroughly. The goal changed into to rehabilitate the forty-12 months-old exit ramp from dual carriageway I-66 to U.S. no.50 in Virginia, United States of America, with the precast concrete pavement systems. It changed into a five million project to replace distressed pavement slabs in a excessive-traffic region outdoor Washington D.C., i.e. a heavy-site visitors place.

Traditional restore with cast-in-situ concrete could have required approximately one hundred days with website online traffic congestion from lane closures, but the precast slab technique allowed closure of one lane at a time for approximately 35 nights of labour and made all lanes available for rush-hour visitors. Every night's cycle included the elimination of the prevailing concrete, steorage and grading of the roadway sub-base, and schooling and location of the brand new pavement slabs.

These are its essential benefits over the conventional solid-in-vicinity approach:

- Higher pace of construction works to reply the need to cut the time of visitors waft hindrance.
- Better and strong excellent due to higher managed production process within the devoted facility and the benefits of pre- and publish-tensioning.
- Long-time period durability thanks to the better satisfactory material used.
- Much less frequent maintenance of the crucial elements of the network – highways' pavements and bridges.
- Higher good value effectiveness due to mass production of all standardized factors (especially pavement panels and bridge elements) and achieved financial system of scale.

3.4.2. To assess the delay parameters of a highway project

(i) Questionnaire Design

Based on the literature review, a closed ended questionnaire was designed considering the objective of the study. The questionnaire consist of the general information of the respondent.

(ii) 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.

(iii) 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:

$$RII = \Sigma W / (A \times N);$$

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).

(iv) List of major causes of delays in a project

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

Table 3.1.

S. No.	Type of Delays	NS	SS	MS	VS	ES	RII
	Factors related to Owner						
1	Poor communication and coordination	2	5	7	7	4	0.648
2	Delay in approving drawings and material	10	10	3	2	0	0.376
3	Delay in revising and approving design documents	0	7	8	5	5	0.664
4	Change orders by owner during construction	2	5	7	7	4	0.648
5	Deliver in progress payments	0	4	8	8	5	0.712
6	Delay to furnish and deliver the site	10	8	7	0	0	0.376
7	Slowness in decision making process	4	5	10	5	1	0.552
8	Conflicts between joint ownership of the project	5	6	10	3	1	0.512
9	Suspension of work by owner	4	5	5	8	3	0.608
10	Delay due to land acquisition	0	2	10	5	8	0.752
	Factors related to Contractor						
11	Poor site management and supervision	0	5	10	5	5	0.68
12	Improper construction method implementation	5	5	5	5	5	0.6
13	Delay in sub contractor work	2	10	5	5	3	0.576
14	Ineffective planning and scheduling of project	0	5	6	10	3	0.691
15	Difficulties in financing project	5	5	8	6	1	0.544
16	Conflict in subcontractors schedule in execution of project	8	5	7	3	0	0.443
17	Rework due to errors	0	5	8	10	2	0.672

18	Conflict between contractor and other parties	5	8	7	5	0	0.496
19	Inadequate contractors work	4	5	10	6	0	0.544
	Factors related to Consultant						
20	Inefficient data collection and survey before design	10	9	6	0	0	0.368
21	Un-use of advanced Engineering design software	12	10	3	0	0	0.28
22	Conflicts with other parties and financial problems	13	10	2	0	0	0.312
23	Unclear and adequate drawings	8	10	4	3	0	0.416
24	Delay in approving major changes in the scope of work	5	10	5	0	0	0.32
25	Poor communication and coordination	4	4	4	4	4	0.6
26	Inadequate experience of consultant	6	7	5	7	0	0.504
27	Mistakes and discrepancies in design documents	10	5	5	3	0	0.408
28	Delay in producing design documents	8	8	5	4	0	0.44
	Factors related to Material						
29	Delay in material delivery	3	6	5	5	4	0.608
30	Late procurement of material	8	8	5	2	0	0.408
31	Shortage of construction material in market	10	10	3	0	0	0.339
32	Change in material type during construction	5	6	7	7	0	0.528
33	Damage of sorted material while they are needed urgently	8	5	8	3	1	0.472
34	Delay in manufacturing special building materials	10	5	5	5	0	0.44
35	Problem with material transport and processing at site	4	5	4	8	4	0.624
36	Quality problem with procured material	10	6	6	0	0	0.363

37	Procuring undesired and unwanted material instead	10	5	5	5	0	0.44
	Factors related to Equipment						
38	Lack of advanced and hi-tech equipment	5	6	7	5	0	0.504
39	Unavailability of special equipment	4	9	8	2	2	0.512
40	Difficulty in transporting equipment	5	5	5	5	5	0.6
41	Wrong kind verity of equipment	8	4	4	6	2	0.533
42	Lack of heavy equipment when needed	12	4	6	2	0	0.383
43	Low level of equipment-operator's skill	10	6	4	3	0	0.4
44	Low productivity and efficiency of equipment	4	5	6	8	0	0.556
45	Equipment's breakdown	0	10	5	8	2	0.616
46	Shortage of equipment	10	5	4	3	0	0.4
	Factors related to Labour						
47	Labour shortage	5	8	5	7	0	0.512
48	Working permits of labour	10	8	5	0	0	0.356
49	Personal conflicts among labours	2	8	10	5	0	0.544
50	High labour wages	3	8	9	4	0	0.516
51	Low producivity level of labours	5	5	10	5	0	0.52
52	Labour strikes at site	4	5	5	5	0	0.515
53	Labour safety problems	0	10	10	5	0	0.56
54	Labour exodus	5	10	6	4	0	0.472
55	Labour health problems when working in hazardous areas	8	9	5	1	0	0.391
	External Factors						
56	Environmental Issues	0	2	11	7	5	0.72
57	Accident during construction	4	5	9	7	0	0.552
58	Traffic control and restriction at job site	0	8	8	7	0	0.591
59	Change in govt. regulation and laws	8	5	5	7	0	0.488
60	Delay in providing services from utilities	4	5	8	4	4	0.592

61	Delay in performing final inspection and certification	4	8	8	0	0	0.44
62	Civil unrest and public strikes	6	5	4	8	2	0.56
63	Effect of subgrade and ground condition factors	4	5	9	7	0	0.552
64	Delay in obtaining permits from municipality	10	5	5	3	0	0.408

(v) 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.

Table 3.2.

Type of Delays	RII	Ranking
Delay due to land acquisition	0.752	1
Environmental Issues	0.72	2
Deliver in progress payments	0.712	3
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 revising and approving design documents	0.664	7
Poor communication and coordination	0.648	8
Change orders by owner during construction	0.648	9
Problem with material transport and processing at site	0.624	10
Equipment's breakdown	0.616	11
Suspension of work by owner	0.608	12
Delay in material delivery	0.608	13
Improper construction method implementation	0.6	14
Difficulty in transporting equipment	0.6	15
Poor communication and coordination	0.6	16
Delay in providing services from utilities	0.592	17
Traffic control and restriction at job site	0.591	18

Delay in sub contractor work	0.576	19
Labour safety problems	0.56	20
Civil unrest and public strikes	0.56	21
Low productivity and efficiency of equipment	0.556	22
Effect of subgrade and ground condition factors	0.552	23
Accident during construction	0.552	24
Slowness in decision making process	0.552	25
Inadequate contractors work	0.544	26
Difficulties in financing project	0.544	27
Personal conflicts among labours	0.544	28
Wrong kind variety of equipment	0.533	29
Change in material type during construction	0.528	30
Low productivity level of labours	0.52	31
High labour wages	0.516	32
Labour strikes at site	0.515	33
Labour shortage	0.512	34
Unavailability of special equipment	0.512	35
Conflicts between joint ownership of the project	0.512	36
Inadequate experience of consultant	0.504	37
Lack of advanced and hi-tech equipment	0.504	38
Conflict between contractor and other parties	0.496	39
Change in govt. regulation and laws	0.488	40
Labour exodus	0.472	41
Damage of sorted material while they are needed urgently	0.472	42
Conflict in subcontractors schedule in execution of project	0.443	43
Delay in producing design documents	0.44	44
Delay in manufacturing special building materials	0.44	45
Procuring undesired and unwanted material instead	0.44	46
Delay in performing final inspection and certification	0.44	47
Shortage of equipment	0.4	48

Low level of equipment-operator's skill	0.4	49
Unclear and adequate drawings	0.416	50
Mistakes and discrepancies in design documents	0.408	51
Late procurement of material	0.408	52
Delay in obtaining permits from municipality	0.408	53
Labour health problems when working in hazardous areas	0.391	54
Lack of heavy equipment when needed	0.383	55
Delay to furnish and deliver the site	0.376	56
Delay in approving drawings and material	0.376	57
Inefficient data collection and survey before design	0.368	58
Quality problem with procured material	0.363	59
Working permits of labour	0.356	60
Shortage of construction material in market	0.339	61
Delay in approving major changes in the scope of work	0.32	62
Conflicts with other parties and financial problems	0.312	63
Un-use of advanced Engineering design software	0.28	64

(vi) Findings

The top ten significant causes of construction delays regarding road infrastructure projects are: (i) Delay due to land acquisition; (ii) Environmental issues; (iii) Delay in progress payment; (iv) Ineffective project planning and scheduling; (v) Poor site management and supervision; (vi) Rework due to errors; (vii) Delay in approving design documents; (viii) Poor coordination between owner and other parties; (ix) Change order by clients; and (x) Problem with material transport and processing at site.

All the delay causes will affect the progress of the project as per their significance and occurrence. As per the parties involved in the project, consultant as a mediator has a lesser role in construction delay. Excusable delay can be compensated as per the contract terms and condition and the extension of time (EoT) can be granted for the projects.

3.4.3. PRIMAVERA

Primavera is a computer based software used for planning, scheduling, project creation, activity codes, resource analysis and leveling, reporting performance etc. this software is established by Primavera Systems in which provides project and program management software for the Architecture, Engineering and Construction industry.

Primavera software is used to Plan, schedule, and manage the right strategic mix of projects. It is also used in organization to make informed project, cost and resource and in management decisions.

A. Use of primavera software

1. Project Structure
2. Project Creation
3. Work Breakdown Structure
4. Relationship And Constraints
5. Activity Codes
6. Resource Analysis And Levelling
7. Tracking The Project Progress
8. Reporting Performance
9. Precedence Diagramming
10. Representing Project Schedules
11. Resources Optimization Techniques
12. Schedule Compression Techniques
13. Check in & Check out
14. Reflection

B. Methods in Primavera

1. EPS (Enterprise Project Structure)
2. OBS (Organization Breakdown Structure)
3. WBS (Work Breakdown Structure)

This lets in planner, venture managers, planning controllers and lots of different experts to have get right of entry to the challenge facts in just one touch of the button.

1. It includes optimization of resources available for holding stock of diverse materials.

2. Lack of stock can lead to inventory-outs, causing stoppage of production, but a very excessive stock on the other hand can bring about accelerated price of production because of excessive cost of sporting stock.
3. Hence optimization of stock have to ensure that stocks are neither too low nor too high. Inventories like completed merchandise, work-in-progress, additives, uncooked substances, shops, spares, and so on. account for 80% or extra of running capital in a number of the representative industries studied in the past.
4. It would appear that any effort put in towards clarification of inventories can result in an appreciable saving. for example, a scientific machine of manage can reduce funding in inventories appreciably, from time to time by as lots as 50% or even more.
5. Then the same process will be carried out using the software. Then the results came out will be compared. After comparison we will find out whether the software is effective than the manual techniques. If the software is effective then it can be used for the ongoing project structures and future proposed structures so as to reduce their estimated cost and time.
6. It offers you an idea of challenge agenda and records of cost discrepancy.
7. You may hold track of performance of venture and might view beyond performances.
8. Use of Primavera lets in superior verbal exchange between organizations. Furthermore growing, dealing with, and understanding of project will become simpler.
9. It allows you breakdown tasks and sports with out problem.

3.4.4. Collection of data of a Highway project

Widening and strengthening of State Highway 10 (Theog-Kotkhai-Kharapathar) road in Shimla district of Himachal Pradesh as shown in table 3.3.

Table 3.3.

Name of Highway Project	SH-10(Theog-Hatkoti Highway)
Contract value	Rs22,85,16,436
Length of Highway	10.5 km
Start of work	1 st February, 2018
End of work	5 th February 2019

The given duration for the project was 370 days, which is then rescheduled using Primavera software in which total number of days are reduced.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1. Top ten significant causes of delay

Total 25 responses have been collected from the engineers and contractors and relative importance index has been ranked according to the ranking given.

Table 4.1. given below shows the ranking of top ten significant causes of delay as per delay related factor; type of delay and RII value.

Table 4.1

S.No.	Type of Delays	RII	Related Factor
1	Delay due to land acquisition	0.752	Owner
2	Environmental Issues	0.72	External
3	Deliver in progress payments	0.712	Owner
4	Ineffective planning and scheduling of project	0.691	Contractor
5	Poor site management and supervision	0.68	Contractor
6	Rework due to errors	0.672	Contractor
7	Delay in revising and approving design documents	0.664	Owner
8	Poor communication and coordination	0.648	Owner
9	Change orders by owner during construction	0.648	Owner
10	Problem with material transport and processing at site	0.624	Material

4.2. Processing of Time duration data in Primavera

The table below contains different activities for a highway project for which the revised schedule for completion period is prepared by the contractor and then the completion period is processed using Primavera software.

Table 4.2

Activity ID	Activity Name	Completion of Revised Schedule	Completion as per Primavera
Stretch B/W 21+300 To 22+500			
A1	Road Way Excavation (Length=1200m)	7-Apr-18	4-Apr-18
A2	Protection Wall	18-May-18	9-May-18
A3	Subgrade	14-May-18	14-May-18
A4	GSB	29-May-18	18-May-18
A5	WMM-1 st	1-Jun-18	21-May-18
A6	WMM-Top	5-Jun-18	24-May-18
A7	DBM	7-Jun-18	26-May-18
Stretch B/W 22+500 To 23+700			
A8	Road Way Excavation (Length=1200m)	13-Apr-18	9-Apr-18
A9	Protection Wall	27-Apr-18	21-Apr-18
A10	Sub Grade	30-Apr-18	23-Apr-18
A11	GSB	1-May-18	24-Apr-18
A12	WMM-1 st	2-May-18	25-Apr-18
A13	WMM-Top	3-May-18	26-Apr-18
A14	DBM	4-May-18	27-Apr-18
Stretch B/W 23+700 To 24+300			
A15	Road Way Excavation (Length=600m)	26-Feb-18	17-Feb-18
A16	Sub Grade	1-Mar-18	21-Feb-18
A17	GSB	3-Mar-18	23-Feb-18
A18	WMM-1 st	5-Mar-18	26-Feb-18
A19	WMM-Top	10-Mar-18	7-Mar-18
A20	DBM	13-Mar-18	9-Mar-18

	Stretch B/W 24+300 To 24+900		
A21	Road Way Excavation (Length=600m)	26-Feb-18	17-Feb-18
A22	Retaining Wall	4-Apr-18	17-Mar-18
A23	GSB	6-Apr-18	20-Mar-18
A24	WMM-1 st	9-Apr-18	23-Mar-18
A25	WMM-Top	12-Apr-18	27-Mar-18
A26	DBM	15-Apr-18	30-Mar-18
	Stretch B/W 24+900 To 26+700		
A27	Road Way Excavation (Length=1800m)	24-Apr-18	17-Apr-18
A28	Sub Grade	30-Apr-18	24-Apr-18
A29	GSB	3-May-18	27-Apr-18
A30	WMM-1 st	6-May-18	1-May-18
A31	WMM-Top	9-May-18	4-May-18
A32	DBM	12-May-18	8-May-18
	Stretch B/W 26+700 To 27+300		
A33	Road Way Excavation (Length=600m)	14-Feb-18	13-Feb-18
A34	Sub Grade	20-Feb-18	28-Feb-18
A35	GSB	22-Mar-18	2-Mar-18
A36	WMM-1 st	23-Mar-18	3-Mar-18
A37	WMM-Top	24-Mar-18	3-Mar-18
A38	DBM	26-Mar-18	4-Mar-18
	Stretch B/W 27+300 To 29+800		
A39	Road Way Excavation (Length=2500m)	26-May-18	19-May-18
A40	Sub Grade	7-Jun-18	25-May-18
A41	GSB	10-Jun-18	28-May-18
A42	WMM-1 st	14-Jun-18	31-May-18
A43	WMM-Top	17-Jun-18	3-Jun-18
A44	DBM	21-Jun-18	6-Jun-18
	Stretch B/W 29+800 To 31+800		
A45	Road Way Excavation (Length=2000m)	9-May-18	4-May-18
A46	Sub-Grade	16-May-18	12-May-18
A47	GSB	19-May-18	16-May-18

A48	CSUS	21-May-18	18-May-18
A49	WMM-1 st	23-May-18	21-May-18
A50	WMM-Top	25-May-18	23-May-18
A51	DBM	27-May-18	25-May-18
	Culverts		
A52	Box Culverts	29-May-18	28-May-18
A53	Pipe Culverts	19-May-18	16-May-18
A54	Slab Culverts	20-Jun-18	18-Jun-18
	Minor Bridge Approaches		
A55	Minor Bridge 21+295 & Approaches	22-Jun-18	20-Jun-18
A56	Minor Bridge 23+250 & Approaches	17-Nov-18	4-Oct-18
A57	Minor Bridge 25+120 & Approaches	25-Jun-18	22-Jun-18
A58	Minor Bridge 26+696 & Approaches	18-Nov-18	3-Oct-18
A59	Minor Bridge 28+738 & Approaches	20-Feb-19	31-Dec-18
A60	Minor Bridge 30+642 & Approaches	12-Jun-18	11-Jun-18
	Bituminous Concrete		
A61	Stretch From 17+170 To 18 +370	20-Mar-18	3-Feb-18
A62	Stretch From 21+180 To 21+740 (Ex. Bridge & Bridge Approaches)	22-Mar-18	6-Feb-18
A63	Stretch From 22+600 To 32+000 (Ex. Bridge & Bridge Approaches)	11-May-18	5-Apr-18
A64	Stretch From 32+000 To 42+550 (Ex. Bridge & Bridge Approaches)	21-Sep-18	26-Jun-18
A65	Stretch From 44+410 To 44+850	30-May-18	29-May-18
	Traffic Signs & Road Marking		
A66	Traffic Signage & Km Stones	18-Nov-18	20-Oct-18
A67	Road Marking	20-Feb-19	1-Dec-18
	Other Misc. Work		
A68	V-Drain	25-Jul-18	1-Jul-18
A69	U-Drain	8-Jun-18	8-Jun-18
A70	Retaining Wall	13-Jul-18	8-Jul-18
A71	MBCB	21-Sep-18	26-Jun-18

	Bridges		
	Minor Bridge@21+295		
A72	A2 Casting of 7th Lift	8-Feb-18	8-Feb-18
A73	A2 Casting of 8th Lift	25-Feb-18	16-Feb-18
A74	A2 Casting of 9th Lift	4-Mar-18	24-Feb-18
A75	A2 Casting of 10th Lift	18-Mar-18	5-Mar-18
A76	A2 Casting of Final Lift	25-Mar-18	13-Mar-18
A77	A1 & A2 Casting of Abutment Cap	6-Apr-18	27-Mar-18
A78	A2 Casting of Pedestal	9-Apr-18	30-Mar-18
A79	Staging & Shuttering For Bottom Slab	29-Apr-18	23-Apr-18
A80	Soffit And Web	15-May-18	11-May-18
A81	Casting of Top Slab	30-May-18	29-May-18
A82	Construction of Dirt Wall At A1 & A2 Side	8-Jun-18	8-Jun-18
A83	Fixing of Expansion Joint	12-Jun-18	11-Jun-18
A84	Misc. Works (Approach Slab And Crash Barrier)	30-Jun-18	27-Jun-18
	Minor Bridge@23+250		
A85	A1 Casting of 13th Lift	26-Feb-18	17-Feb-18
A86	A1 Casting of 14th Lift	20-Mar-18	7-Mar-18
A87	A1 Casting of 15th Lift	28-Apr-18	4-Apr-18
A88	A1 Casting of 16th Lift	19-Apr-18	24-Mar-18
A89	A1 Casting of 17th Lift	4-May-18	11-Apr-18
A90	A1 Casting of Abutment Cap	2-Jun-18	19-May-18
A91	A1 Casting of Final Lift	3-Jun-18	16-May-18
A92	A2 Casting of 14th Lift	6-Jun-18	27-Mar-18
A93	A2 Casting of 15th Lift	13-Apr-18	4-Apr-18
A94	A2 Casting of 16th Lift	1-May-18	19-Apr-18
A95	A2 Casting of 17th Lift	18-May-18	4-May-18
A96	A2 Casting of Final Lift	6-Jun-18	19-May-18
A97	A2 Casting of Abutment Cap	23-Jun-18	3-Jun-18
A98	A2 Casting of Pedestal & Bearing Fixing	29-Jun-18	18-Jun-18
A99	Staging & Shuttering	27-Jul-18	23-Jun-18

A100	Casting of T Girder	20-Aug-18	18-Jul-18
A101	Casting of Deck Slab	9-Oct-18	12-Sep-18
A102	Construction of Dirt Wall At A1 & A2 Side	29-Oct-18	20-Sep-18
A103	Fixing of Expansion Joint	5-Nov-18	24-Sep-18
A104	Miscellaneous Works	8-Nov-18	9-Oct-18
	Minor Bridge@24+120		
A105	A1 Casting of 8th Lift	7-Feb-18	7-Feb-18
A106	A1 Casting of 9th Lift	14-Feb-18	13-Feb-18
A107	A1 Casting of 10th Lift	1-Mar-18	21-Feb-18
A108	A1 Casting of Final Lift	7-Mar-18	28-Feb-18
A109	A1 Casting of Abutment Cap	23-Mar-18	10-Mar-18
A110	A2 Casting of 9th Lift	21-Mar-18	8-Mar-18
A111	A2 Casting of 10th Lift	28-Mar-18	16-Mar-18
A112	A2 Casting of Final Lift	4-Apr-18	24-Mar-18
A113	A2 Casting of Abutment Cap	19-Apr-18	11-Apr-18
A114	Staging & Shuttering Between A1 & A2 For Deck Slab	19-May-18	16-May-18
A115	Casting of Deck Slab	2-Jun-18	3-Jun-18
A116	Construction of Dirt Wall At A1 & A2 For Deck Slab	11-Jun-18	10-Jun-18
A117	Fixing of Expansion Joint	14-Jun-18	13-Jun-18
A118	Miscellaneous Works	28-Jun-18	25-Jun-18
	Minor Bridge@25+696		
A119	A1 Casting of 7th Lift	9-Feb-18	9-Feb-18
A120	A1 Casting of 8th Lift	27-Feb-18	19-Feb-18
A121	A1 Casting of 9th Lift	7-Mar-18	28-Feb-18
A122	A1 Casting of 10th Lift	22-Mar-18	9-Mar-18
A123	A1 Casting of 11th Lift	30-Mar-18	19-Mar-18
A124	A1 Casting of 12th Lift	7-Apr-18	28-Mar-18
A125	A1 Casting of 13th Lift	15-Apr-18	6-Apr-18
A126	A1 Casting of 14th Lift	23-Apr-18	16-Apr-18
A127	A1 Casting of 15th Lift	1-May-18	25-Apr-18

A128	A1 Casting of Final Lift	9-May-18	4-May-18
A129	A1 Casting of Abutment Cap	21-May-18	18-May-18
A130	A1 Casting of Pedestal & Bearing Fixing	24-May-18	22-May-18
A131	A2 Casting of 7th Lift	12-Jun-18	11-Jun-18
A132	A2 Casting of 8th Lift	21-Jun-18	19-Jun-18
A133	A2 Casting of 9th Lift	30-Jun-18	27-Jun-18
A134	A2 Casting of 10th Lift	10-Jul-18	5-Jul-18
A135	A2 Casting of 11th Lift	19-Jul-18	13-Jul-18
A136	A2 Casting of 12th Lift	22-Sep-18	28-Jul-18
A137	A2 Casting of 13th Lift	30-Sep-18	7-Aug-18
A138	A2 Casting of 14th Lift	8-Oct-18	16-Aug-18
A139	A2 Casting of 15th Lift	16-Oct-18	25-Aug-18
A140	A2 Casting of Final Lift	24-Oct-18	4-Sep-18
A141	A2 Casting of Abutment Cap	1-Nov-18	13-Sep-18
A142	A2 Casting of Pedestal & Bearing Fixing	4-Nov-18	17-Sep-18
A143	Staging & Shuttering Between A1 & A2 For Deck Slab	22-Oct-18	1-Sep-18
A144	Casting of Deck Slab	30-Oct-18	11-Sep-18
A145	Construction of Dirt Wall At A1 & A2 For Deck Slab	6-Nov-18	19-Sep-18
A146	Fixing of Expansion Joint	9-Nov-18	22-Sep-18
A147	Miscellaneous Works	27-Nov-18	13-Oct-18
	Minor Bridge@28+738		
A148	A1 Casting of 1st Lift	2-Mar-18	12-Feb-18
A149	A1 Casting of 2nd Lift	12-Mar-18	23-Feb-18
A150	A1 Casting of 3rd Lift	22-Mar-18	7-Mar-18
A151	A1 Casting of 4th Lift	1-Apr-18	19-Mar-18
A152	A1 Casting of 5th Lift	11-Apr-18	30-Mar-18
A153	A1 Casting of 6th Lift	21-Apr-18	11-Apr-18
A154	A1 Casting of 7th Lift	1-May-18	23-Apr-18
A155	A1 Casting of 8th Lift	11-May-18	4-May-18
A156	A1 Casting of 9th Lift	21-May-18	16-May-18

A157	A1 Casting of 10th Lift	31-May-18	28-May-18
A158	A1 Casting of 11th Lift	10-Jun-18	8-Jun-18
A159	A1 Casting of 12th Lift	20-Jun-18	20-Jun-18
A160	A1 Casting of 13th Lift	2-Jul-18	30-Jun-18
A161	A1 Casting of 14th Lift	13-Jul-18	10-Jul-18
A162	A1 Casting of 15th Lift	25-Jul-18	20-Jul-18
A163	A1 Casting of 16th Lift	3-Aug-18	28-Jul-18
A164	A1 Casting of 17th Lift	11-Aug-18	4-Aug-18
A165	A1 Casting of 18th Lift	20-Aug-18	11-Aug-18
A166	A1 Casting of 19th Lift	28-Aug-18	18-Aug-18
A167	A1 Casting of 20th Lift	5-Sep-18	25-Aug-18
A168	Abutment Cap	17-Sep-18	4-Sep-18
A169	A2 Raft	17-Mar-18	7-Mar-18
A170	A2 Casting of 1st Lift	27-Mar-18	13-Feb-18
A171	A2 Casting of 2nd Lift	6-Apr-18	24-Feb-18
A172	A2 Casting of 3rd Lift	16-Apr-18	8-Mar-18
A173	A2 Casting of 4th Lift	26-Apr-18	26-Mar-18
A174	A2 Casting of 5th Lift	6-May-18	6-Apr-18
A175	A2 Casting of 6th Lift	16-May-18	24-Apr-18
A176	A2 Casting of 7th Lift	26-May-18	5-May-18
A177	A2 Casting of 8th Lift	5-Jun-18	17-May-18
A178	A2 Casting of 9th Lift	29-May-18	15-May-18
A179	A2 Casting of 10th Lift	25-Jun-18	21-Jun-18
A180	A2 Casting of 11th Lift	5-Jul-18	3-Jul-18
A181	A2 Casting of 12th Lift	12-Jul-18	11-Jul-18
A182	A2 Casting of 13th Lift	19-Jul-18	19-Jul-18
A183	A2 Casting of 14th Lift	27-Jul-18	26-Jul-18
A184	A2 Casting of 15th Lift	4-Aug-18	2-Aug-18
A185	A2 Casting of 16th Lift	13-Aug-18	9-Aug-18
A186	A2 Casting of 17th Lift	21-Aug-18	16-Aug-18
A187	A2 Casting of 18th Lift	29-Aug-18	23-Aug-18
A188	A2 Casting of 19th Lift	6-Sep-18	30-Aug-18

A189	A2 Casting of 20th Lift	14-Sep-18	6-Sep-18
A190	Abutment Cap A2	26-Sep-18	16-Sep-18
A191	Staging & Shuttering	19-Nov-18	12-Oct-18
A192	Slab	16-Jan-19	1-Dec-18
A193	Miscellaneous Works	18-Feb-19	29-Dec-18
	Minor Bridge @ 30+642		
A194	Excavation For A2 Side	12-Feb-18	11-Feb-18
A195	PCC in A2 Side	14-Feb-18	13-Feb-18
A196	Foundation For A2 Side	17-Mar-18	3-Mar-18
A197	A2 Casting of 1st Lift	22-Mar-18	9-Mar-18
A198	A2 Casting of 2nd Lift	27-Mar-18	15-Mar-18
A199	A2 Casting of 3rd Lift	1-Apr-18	21-Mar-18
A200	A2 Casting of 4th Lift	6-Apr-18	27-Mar-18
A201	A2 Casting of 5th Lift	11-Apr-18	2-Apr-18
A202	A2 Casting of 6th Lift	18-Apr-18	10-Apr-18
A203	A2 Casting of 7th Lift	23-Apr-18	16-Apr-18
A204	A2 Casting of Final Lift	28-Apr-18	21-Apr-18
A205	A1 & A2 Casting of Abutment Cap	8-May-18	3-May-18
A206	A1 & A2 Casting of Pedestal & Bearing Fixing	13-May-18	9-May-18
A207	Staging & Shuttering Between A1 & A2 For Deck Slab	8-May-18	3-May-18
A208	Casting of Deck Slab	23-May-18	21-May-18
A209	Construction of Dirt Wall At A1 & A2 Side	30-May-18	29-May-18
A210	Fixing of Expansion Joint	2-Jun-18	1-Jun-18
A211	Miscellaneous Works	20-Jun-18	22-Jun-18

The total number of days using rescheduled data was 370 days, which is then reduced using Primavera Software and the final completion period is 333days.

4.3. Processing of cost analysis in Primavera

The table below contains different activities for a highway project for which the revised schedule for completion period is prepared by the contractor and then the completion period is processed using Primavera software.

Table 4.3

Activity ID	Activity Name	Cost as per Revised Schedule (Rs.)	Cost as per Primavera (Rs.)
		22,85,16,436	23,90,87,636
	Stretch B/W 21+300 To 22+500		
A1	Road Way Excavation (Length=1200m)	480210	501000
A2	Protection Wall	4005500	4105500
A3	Subgrade	22100	25100
A4	GSB	2000203	2100503
A5	WMM-1 st	2350000	2405000
A6	WMM-Top	2770000	2805000
A7	DBM	3310210	3320200
	Stretch B/W 22+500 To 23+700		
A8	Road Way Excavation (Length=1200m)	480210	501000
A9	Protection Wall	4005500	4105500
A10	Sub Grade	22100	25100
A11	GSB	2000203	2100503
A12	WMM-1 st	2350000	2405000
A13	WMM-Top	2770000	2805000
A14	DBM	3310210	3320200
	Stretch B/W 23+700 To 24+300		
A15	Road Way Excavation (Length=600m)	240000	310000
A16	Sub Grade	12500	15000
A17	GSB	1005430	1155000
A18	WMM-1 st	1190700	1250600
A19	WMM-Top	1400500	1550000

A20	DBM	1640400	1730500
	Stretch B/W 24+300 To 24+900		
A21	Road Way Excavation (Length=600m)	240000	310000
A22	Retaining Wall	1960600	15000
A23	GSB	1005430	1155000
A24	WMM-1 st	1190700	1250600
A25	WMM-Top	1400500	1550000
A26	DBM	1640400	1739500
	Stretch B/W 24+900 To 26+700		
A27	Road Way Excavation (Length=1800m)	715400	850900
A28	Sub Grade	38000	480000
A29	GSB	3010200	350600
A30	WMM-1 st	3565100	3760000
A31	WMM-Top	4210500	4550000
A32	DBM	4950500	5070500
	Stretch B/W 26+700 To 27+300		
A33	Road Way Excavation (Length=600m)	240000	310000
A34	Sub Grade	12500	15000
A35	GSB	1005430	1155000
A36	WMM-1 st	1190700	1250600
A37	WMM-Top	1400500	1550000
A38	DBM	1640400	173950
	Stretch B/W 27+300 To 29+800		
A39	Road Way Excavation (Length=2500m)	1050600	1260900
A40	Sub Grade	49500	55600
A41	GSB	4560300	4678900
A42	WMM-1 st	5570300	5750800
A43	WMM-Top	6470200	6670200
A44	DBM	7350800	7540700
	Stretch B/W 29+800 To 31+800		
A45	Road Way Excavation (Length=2000m)	805000	90800
A46	Sub-Grade	40000	50000

A47	GSB	3570300	3760800
A48	CSUS	1011000	1112000
A49	WMM-1 st	4400500	4570800
A50	WMM-Top	5213100	5345600
A51	DBM	5940500	6089600
	Culverts		
A52	Box Culverts	9955000	11060800
A53	Pipe Culverts	5898400	5898000
A54	Slab Culverts	1865000	1865000
	Minor Bridge Approaches		
A55	Minor Bridge 21+295 & Approaches	6132600	6435800
A56	Minor Bridge 23+250 & Approaches	6132600	6132600
A57	Minor Bridge 25+120 & Approaches	6856800	6858000
A58	Minor Bridge 26+696 & Approaches	5565900	6565000
A59	Minor Bridge 28+738 & Approaches	6678900	7078000
A60	Minor Bridge 30+642 & Approaches	7517000	7521000
	Bituminous Concrete		
A61	Stretch From 17+170 To 18 +370	2150500	2867800
A62	Stretch From 21+180 To 21+740 (Ex. Bridge & Bridge Approaches)	1078600	1205000
A63	Stretch From 22+600 To 32+000 (Ex. Bridge & Bridge Approaches)	1078600	1205000
A64	Stretch From 32+000 To 42+550 (Ex. Bridge & Bridge Approaches)	1156600	1459000
A65	Stretch From 44+410 To 44+850	1078600	1176900
	Traffic Signs & Road Marking		
A66	Traffic Signage & Km Stones	55000	60000
A67	Road Marking	1098700	1160700
	Other Misc. Work		
A68	V-Drain	2500000	3000900
A69	U-Drain	18900	20800
A70	Retaining Wall	19870500	20500500

A71	MBCB	2150500	2345600
	Bridges		
	Minor Bridge@21+295		
A72	A2 Casting of 7th Lift	150800	198700
A73	A2 Casting of 8th Lift	150800	198700
A74	A2 Casting of 9th Lift	150800	198700
A75	A2 Casting of 10th Lift	150800	198700
A76	A2 Casting of Final Lift	150800	198700
A77	A1 & A2 Casting of Abutment Cap	199600	204500
A78	A2 Casting of Pedestal	199600	204500
A79	Staging & Shuttering For Bottom Slab	550800	578900
A80	Soffit And Web	150800	198700
A81	Casting of Top Slab	960200	1078900
A82	Construction of Dirt Wall At A1 & A2 Side	110000	130000
A83	Fixing of Expansion Joint	110000	130000
A84	Misc. Works (Approach Slab And Crash Barrier)	199600	204500
	Minor Bridge@23+250		
A85	A1 Casting of 13th Lift	150800	198700
A86	A1 Casting of 14th Lift	150800	198700
A87	A1 Casting of 15th Lift	150800	198700
A88	A1 Casting of 16th Lift	150800	198700
A89	A1 Casting of 17th Lift	150800	198700
A90	A1 Casting of Abutment Cap	199600	198700
A91	A1 Casting of Final Lift	150800	204500
A92	A2 Casting of 14th Lift	150800	198700
A93	A2 Casting of 15th Lift	150800	198700
A94	A2 Casting of 16th Lift	150800	198700
A95	A2 Casting of 17th Lift	150800	198700
A96	A2 Casting of Final Lift	150800	198700
A97	A2 Casting of Abutment Cap	150800	198700
A98	A2 Casting of Pedestal & Bearing Fixing	199600	204500

A99	Staging & Shuttering	530800	589900
A100	Casting of T Girder	299700	345680
A101	Casting of Deck Slab	900800	1098700
A102	Construction of Dirt Wall At A1 & A2 Side	101000	156000
A103	Fixing of Expansion Joint	101000	156000
A104	Miscellaneous Works	199600	204500
	Minor Bridge@24+120		
A105	A1 Casting of 8th Lift	150800	198700
A106	A1 Casting of 9th Lift	150800	198700
A107	A1 Casting of 10th Lift	150800	198700
A108	A1 Casting of Final Lift	150800	198700
A109	A1 Casting of Abutment Cap	199600	204500
A110	A2 Casting of 9th Lift	150800	198700
A111	A2 Casting of 10th Lift	150800	198700
A112	A2 Casting of Final Lift	150800	198700
A113	A2 Casting of Abutment Cap	199600	198700
A114	Staging & Shuttering Between A1 & A2 For Deck Slab	530800	567900
A115	Casting of Deck Slab	900800	990000
A116	Construction of Dirt Wall At A1 & A2 For Deck Slab	101000	156000
A117	Fixing of Expansion Joint	101000	156000
A118	Miscellaneous Works	199600	204500
	Minor Bridge@25+696		
A119	A1 Casting of 7th Lift	150800	198700
A120	A1 Casting of 8th Lift	150800	198700
A121	A1 Casting of 9th Lift	150800	198700
A122	A1 Casting of 10th Lift	150800	198700
A123	A1 Casting of 11th Lift	150800	198700
A124	A1 Casting of 12th Lift	150800	198700
A125	A1 Casting of 13th Lift	150800	198700
A126	A1 Casting of 14th Lift	150800	198700

A127	A1 Casting of 15th Lift	150800	198700
A128	A1 Casting of Final Lift	150800	198700
A129	A1 Casting of Abutment Cap	199600	204500
A130	A1 Casting of Pedestal & Bearing Fixing	199600	204500
A131	A2 Casting of 7th Lift	150800	198700
A132	A2 Casting of 8th Lift	150800	198700
A133	A2 Casting of 9th Lift	150800	198700
A134	A2 Casting of 10th Lift	150800	198700
A135	A2 Casting of 11th Lift	150800	198700
A136	A2 Casting of 12th Lift	150800	198700
A137	A2 Casting of 13th Lift	150800	198700
A138	A2 Casting of 14th Lift	150800	198700
A139	A2 Casting of 15th Lift	150800	198700
A140	A2 Casting of Final Lift	150800	198700
A141	A2 Casting of Abutment Cap	199600	204500
A142	A2 Casting of Pedestal & Bearing Fixing	199600	204500
A143	Staging & Shuttering Between A1 & A2 For Deck Slab	530800	567800
A144	Casting of Deck Slab	900800	1090800
A145	Construction of Dirt Wall At A1 & A2 For Deck Slab	101000	156000
A146	Fixing of Expansion Joint	101000	156000
A147	Miscellaneous Works	199600	204500
	Minor Bridge@28+738		
A148	A1 Casting of 1st Lift	150800	198700
A149	A1 Casting of 2nd Lift	150800	198700
A150	A1 Casting of 3rd Lift	150800	198700
A151	A1 Casting of 4th Lift	150800	198700
A152	A1 Casting of 5th Lift	150800	198700
A153	A1 Casting of 6th Lift	150800	198700
A154	A1 Casting of 7th Lift	150800	198700
A155	A1 Casting of 8th Lift	150800	198700

A156	A1 Casting of 9th Lift	150800	198700
A157	A1 Casting of 10th Lift	150800	198700
A158	A1 Casting of 11th Lift	150800	198700
A159	A1 Casting of 12th Lift	150800	198700
A160	A1 Casting of 13th Lift	150800	198700
A161	A1 Casting of 14th Lift	150800	198700
A162	A1 Casting of 15th Lift	150800	198700
A163	A1 Casting of 16th Lift	150800	198700
A164	A1 Casting of 17th Lift	150800	198700
A165	A1 Casting of 18th Lift	150800	198700
A166	A1 Casting of 19th Lift	150800	198700
A167	A1 Casting of 20th Lift	150800	198700
A168	Abutment Cap	199600	204500
A169	A2 Raft	150800	198700
A170	A2 Casting of 1st Lift	150800	198700
A171	A2 Casting of 2nd Lift	150800	198700
A172	A2 Casting of 3rd Lift	150800	198700
A173	A2 Casting of 4th Lift	150800	198700
A174	A2 Casting of 5th Lift	150800	198700
A175	A2 Casting of 6th Lift	150800	198700
A176	A2 Casting of 7th Lift	150800	198700
A177	A2 Casting of 8th Lift	150800	198700
A178	A2 Casting of 9th Lift	150800	198700
A179	A2 Casting of 10th Lift	150800	198700
A180	A2 Casting of 11th Lift	150800	198700
A181	A2 Casting of 12th Lift	150800	198700
A182	A2 Casting of 13th Lift	150800	198700
A183	A2 Casting of 14th Lift	150800	198700
A184	A2 Casting of 15th Lift	150800	198700
A185	A2 Casting of 16th Lift	150800	198700
A186	A2 Casting of 17th Lift	150800	198700
A187	A2 Casting of 18th Lift	150800	198700

A188	A2 Casting of 19th Lift	150800	198700
A189	A2 Casting of 20th Lift	150800	198700
A190	Abutment Cap A2	199600	204500
A191	Staging & Shuttering	530800	657800
A192	Slab	900800	1097900
A193	Miscellaneous Works	199600	204500
	Minor Bridge @ 30+642		
A194	Excavation For A2 Side	199600	204500
A195	PCC in A2 Side	199600	204500
A196	Foundation For A2 Side	299700	324500
A197	A2 Casting of 1st Lift	150800	198700
A198	A2 Casting of 2nd Lift	150800	198700
A199	A2 Casting of 3rd Lift	150800	198700
A200	A2 Casting of 4th Lift	150800	198700
A201	A2 Casting of 5th Lift	150800	198700
A202	A2 Casting of 6th Lift	150800	198700
A203	A2 Casting of 7th Lift	150800	198700
A204	A2 Casting of Final Lift	150800	198700
A205	A1 & A2 Casting of Abutment Cap	199600	204500
A206	A1 & A2 Casting of Pedestal & Bearing Fixing	199600	204500
A207	Staging & Shuttering Between A1 & A2 For Deck Slab	530800	657800
A208	Casting of Deck Slab	900800	1097900
A209	Construction of Dirt Wall At A1 & A2 Side	101000	156000
A210	Fixing of Expansion Joint	101000	156000
A211	Miscellaneous Works	199600	204500

The total cost using rescheduled data was Rs. 22,85,16,436 which is then optimised in Primavera Software and due to the reduction in total number of days, there is a increase in the total cost and the final cost is Rs. 23,90,87,636.

CHAPTER 5

CONCLUSION

5.1. Conclusion

The above study identifies the 64 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 25 respondents. Then the highway project data is processed using Primavera software in which the duration escalation is reduced and the total cost of the project is optimised. The total number of 37 days were reduced using the Primavera software which affects the total cost of the project as well.

5.2. 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.

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ANNEXURE

Following is the data processed in Primavera Software using the completion period and the given total cost of the project,

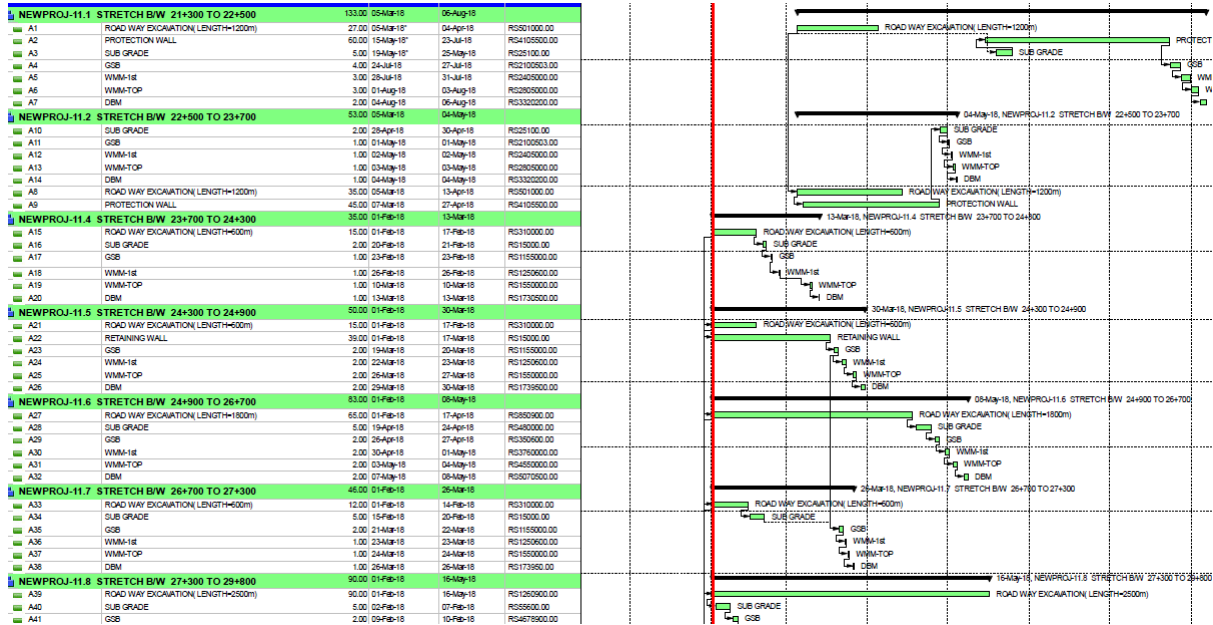


Fig. 6.1. Rescheduling using Primavera Software



Fig. 6.2. Rescheduling using Primavera Software

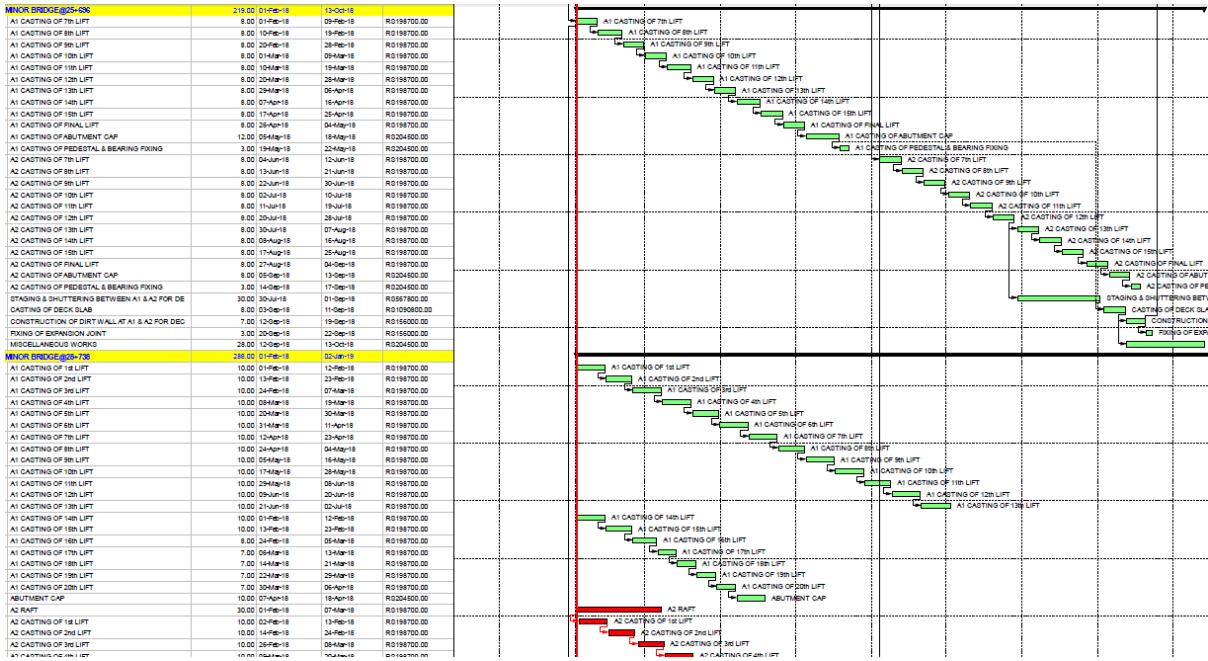


Fig. 6.3. Rescheduling using Primavera Software

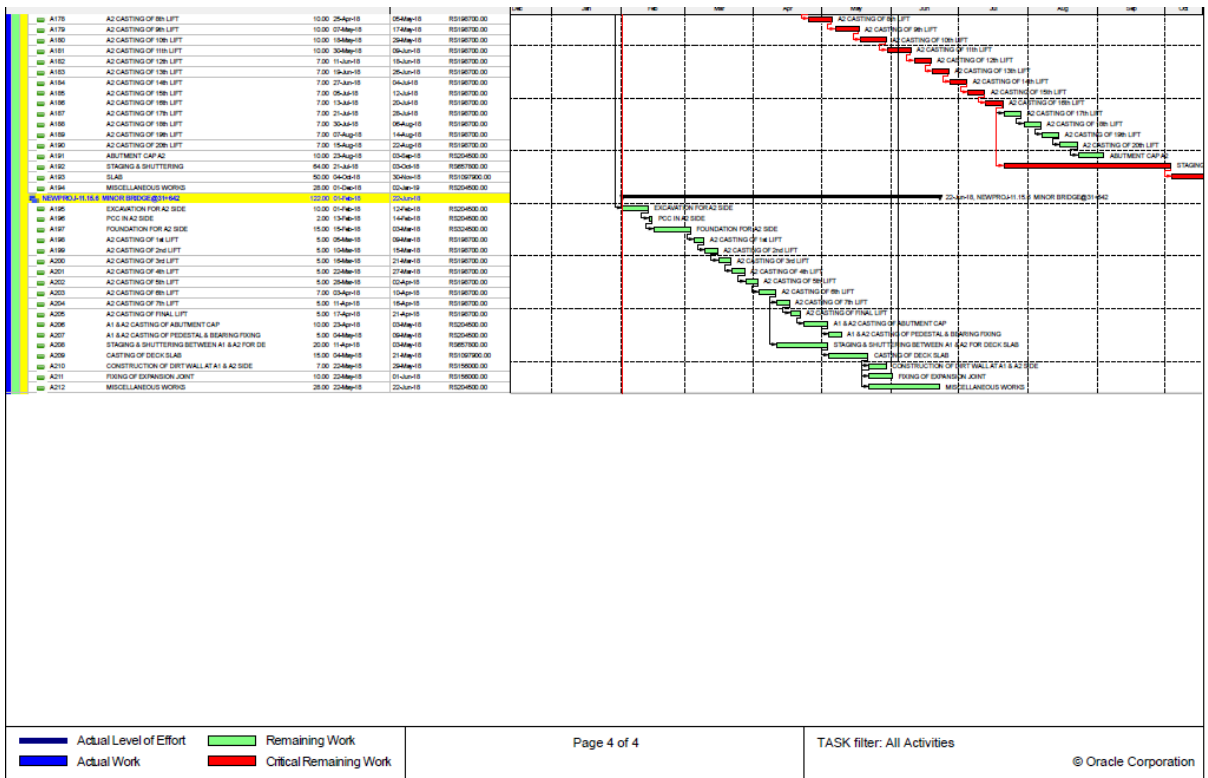


Fig. 6.4. Rescheduling using Primavera Software