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A COMPREHENSIVE STUDY OF THE LINEAR SCHEDULING METHOD IN CONSTRUCTION PROJECT MANAGEMENT

Mehendale Aditya Prasad

Research Scholar, Department of Civil Engineering, Vikrant University, Gwalior, M.P

Dr. Manoj Sharma

Research Supervisor, Department of Civil Engineering, Vikrant University, Gwalior, M.P

ABSTRACT

Repetitive tasks are a common component of several projects, including highway, pipeline, and high-rise skyscraper construction. Here, we offer the Linear Scheduling Method (LSM), a way to plan out such tasks. Lines with constant or variable slopes plotted on two axes, distance versus time, and represent the repetitive activities in an LSM schedule. It is possible to display discrete activities at the right places at the right times and then refer to a network schedule for more information. An example of a real-world roadway construction project is used to demonstrate the Linear Scheduling Method. In this article, we take a close look at the Linear Scheduling Method and all its uses, benefits, drawbacks, and principles as they pertain to managing construction projects. The research looks at how LSM saves time and money by avoiding wasteful delays, minimizing disagreements over resources, and keeping process consistent across different project sites. Limited flexibility, reliance on sequential operations, and LSM's applicability largely for repeating linear projects are some of the difficulties discussed in the article that might arise from using LSM. By improving planning, optimising resources, and controlling the project effectively, LSM is a dependable and efficient scheduling method that may boost the performance of construction projects.

Keywords: Linear Scheduling, Construction, Project; Resource, Time Management

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I. INTRODUCTION

In order to accomplish the goals of a construction project, a series of interconnected tasks must be performed. Along the course of a construction project's lifetime, several management issues could arise that make it difficult to accomplish the project's goals. An issue that arises frequently is the availability of resources. Both the availability and affordability of resources are frequently obstructed. So, managing resources is crucial for project scheduling. Construction managers must master the art of resource management in order to accomplish their projects on time and under budget. This includes not just personnel, but also equipment, supplies, and schedules.

In order for resource management to be efficient, it is necessary to optimise the consumption of resources in addition to ensuring that resources are assigned to all activities. However, managing resources becomes more challenging when there are few resources to keep the project on track. Thus, it is essential for construction project scheduling to have a comprehensive and complete resource calendar that matches the activity schedule.

Any competent project manager will tell you that efficiently scheduling a linear construction project (LCP) is no easy feat. Diverse locations may pool their resources in a sequential or parallel fashion for this sort of project. In order to complete a project within the agreed upon time frame, avoid wasting resources, and keep work moving forward in different parts of the world, the management must allot sufficient resources. During the implementation of LCPs, conflicts over resource usage can arise if the allocation of confined shared space is not properly coordinated. Accordingly, LCP schedules take into consideration not just the time and space limitations of activity resource movement, but also the precedence constraints of activities [8]. Since CPM places an emphasis on scheduling according to precedence connections between activities, it is not well-suited to monitor work continuity for LCPs [9]. But, linear scheduling (LSM) is better suited to scheduling linear construction projects since it allows for effective monitoring of work continuity.

When trying to attain optimal scheduling efficiency, minimizing idle resources is one strategy to consider. Any resources that have been mobilized but are not currently being used are considered idle resources. Although they are not in use, resources that are sitting idle nonetheless have expenses like rent, depreciation, and upkeep. Optimizing scheduling is achieved by reducing the amount of time and resources that are idle, which in turn reduces

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the amount of money that is wasted on non-productive activities.

A road repair project involves applying the same sort of road maintenance to several sections of road. Incorporating the road network maintenance project as an LCP is accompanied with this quality. This means that LSMs are a good fit for scheduling purposes. However, conventional LSM isn't up to the task of handling road network repair projects because of its unique features.

In conventional LSM, crews are the means by which labour is accomplished. Based on the continuity of work, linear construction project scheduling is efficient because it employs the assumption that various types of work need distinct teams. Projects to maintain road networks, which involve a variety of heavy machinery, are not going to be able to leverage this. The crew, in the context of classical LSM, is a group of tools that work together to accomplish a task. These tools can be classified as either primary or supporting equipment, depending on their function. To finish one kind of activity, you may require the same piece of supporting equipment to do another. This means that the profile of work continuity and the profile of equipment allocation continuity are differentiated. In light of this fact, we provide a method of resource allocation we term "equipment combination and configuration" (ECC), which involves breaking the team down into smaller parts known as subcontractors. A linear scheduling model for construction projects is proposed by the authors, based on the linear scheduling method with ECC concept (LSM-ECC). This model aims to minimise equipment idle time at the sub-crew level.

Conventional LSM necessitates that engineers specify the order in which LCP's repeated units will execute. When planning sequential or serial linear construction projects, engineers typically have little problem determining which repetitive units to start with. In most cases, however, each section of road in a road network maintenance project is typically quite accessible, therefore the order in which maintenance work is performed on each segment is rather flexible. Consequently, in order to plan efficiently, engineers need to consider which section of road to construct first. The solution to this difficulty lies in an optimisation model that can advise engineers on the optimal order to execute road segments in order to achieve effective scheduling. Ideally, the model may even recommend non-sequential or parallel execution options.

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II. ADVANTAGES OF THE LSM IN PROJECT MANAGEMENT

For projects like highways, railways, pipelines, and tunnels—which involve repetitive activities done along a continuous path—the Linear Scheduling Method (LSM) is an invaluable tool for project managers. In order to plan, monitor, and control project activities, it offers a structured approach. Here are some of the main benefits of LSM:

1. Improved Clarity and Faster Project Execution

Project teams can easily grasp the process because to LSM's presentation of actions in a rational and sequential sequence. Reduced confusion and improved coordination are the results of clearly defined beginning and ending points for each job. Productivity is increased and project execution is accelerated by this methodically planned strategy.

2. Effective Visualization and Progress Monitoring

A strong suit of LSM is the ability to visually depict project operations in relation to time and place. Project managers can maintain tabs on the project's status, pinpoint any setbacks, assess the team's performance, and make quick choices thanks to this visual approach.

3. Enhanced Communication and Coordination

Through the provision of an easily comprehensible schedule, LSM enhances communication among project stakeholders. Managers, contractors, and team members can all see clearly defined roles and how they relate to one another, which improves communication and collaboration.

4. Optimized Project Scheduling

Project schedules can be optimized using the Linear Scheduling Method, which involves arranging activities in the most efficient sequence. Project performance and completion time are both enhanced by the elimination of needless delays and interruptions and the maintenance of a continuous workflow.

5. Efficient Resource Utilization

Throughout a project's lifespan, LSM encourages efficient use of resources (human and mechanical). Improved efficiency and cost management are outcomes of less downtime, less disputes over scarce resources, and a more evenly distributed workflow.

6. Flexibility and Adaptability

Unanticipated events or revised needs frequently cause project conditions to evolve. With LSM, you can easily change plans and reorder activities when more data becomes available. Because of this flexibility, project managers can efficiently react to changes while keeping the project on track with minimal setbacks.

7. Better Time and Cost Control

Better management of project time and budget may be achieved with the help of LSM by ensuring a continuous process and reducing delays. Reducing the likelihood of budget overruns and project delays, early identification of scheduling issues allows for the prompt implementation of corrective actions.

8. Improved Decision-Making

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III. DISADVANTAGES OF THE LSM IN PROJECT MANAGEMENT

While the Linear Scheduling Method (LSM) serves as a proficient instrument for the planning and administration of recurring linear projects, it possesses certain constraints. Comprehending these drawbacks aids project managers in assessing the appropriateness of LSM for a certain project. The primary constraints are outlined as follows:

1. Limited Flexibility

LSM is less adaptable to sudden changes since it adheres to a predetermined sequence of operations. Changes to the design, lack of resources, or unanticipated events can force a complete rescheduling of the project, which would have a devastating effect on the workflow.

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2. High Dependency on Task Sequencing

The procedure is very dependent on the previous steps being completed successfully. When one activity is postponed, it might have a domino effect on other tasks and eventually the project as a whole.

3. Difficulty in Handling Unforeseen Delays

A linear schedule isn't always the best way to deal with unforeseen circumstances like bad weather, broken equipment, lack of materials, or unavailable workers. The time and effort put into a project might take a hit when these unexpected problems arise.

4. Increased Complexity in Large Projects

There are more activities and interdependencies when a project is larger and more complicated. Keeping a linear timetable up-to-date for large-scale projects may be challenging and requires constant vigilance and adjustments.

5. Limited Suitability for Dynamic and Agile Projects

For projects where tasks tend to be repetitive and predictable, LSM works well. It doesn't work as well in settings where duties are constantly changing, like research projects or software development, when more adaptable planning methods are needed.

6. Reduced Focus on Overall Project Objectives

Team members may focus on getting their duties done because LSM is all about doing things in a systematic order. This has the potential to diminish teamwork and obscure the bigger picture of the project's aims and objectives.

7. Challenges in Resource Reallocation

Within a linear schedule, it can be challenging to reassign labour, equipment, or materials while the project is being executed. Several interdependent tasks may need to be adjusted in response to changes in available resources, which can impact the efficiency of the project.

8. Not Suitable for All Types of Projects

The Linear Scheduling Method is particularly advantageous for endeavours that have recurring tasks along a linear trajectory, like roadways, pipelines, trains, and tunnels. It is not well-suited for initiatives characterised by significant variability, irregularity, or intricate processes.

IV. TIME EFFICIENCY OF LSM

Temporal efficiency is a vital element of project management in roadway building. The implementation of Linear Scheduling Methods (LSM) has demonstrated significant benefits in minimising project delays via optimised scheduling. In contrast to conventional scheduling techniques like Critical Path Method (CPM) or Program Evaluation and Review Technique (PERT), LSM offers a transparent depiction of sequential tasks along a linear route, allowing project managers to pinpoint possible bottlenecks and coordinate activities efficiently. Through the utilisation of a time-distance framework for task mapping, LSM reduces downtime between activities and guarantees constant production rates across the project.

A major contribution of LSM is its capacity to enhance the synchronisation of tasks through sequential methodologies. For example, in roadway development, activities like excavation, paving, and finishing must advance in a sequential order over the project area. Conventional approaches frequently neglect the spatial interdependencies among these activities, resulting in overlaps, disruptions, and postponements. LSM, conversely, guarantees the proficient management of these dependencies by synchronising work schedules with their spatial necessities. This optimised scheduling minimises the chances of resource conflicts and enhances coordination among project teams.

Empirical data from the Tamil Nadu road initiative demonstrates the time-efficient capabilities of LSM. In this initiative, LSM was utilised to organise construction tasks for a 50-kilometer roadway. Through the application of LSM, the project team successfully diminished the total timeframe by 20% in contrast to analogous initiatives that depended on CPM. The approach's emphasis on output rates and buffer zones facilitated ongoing advancement, despite unforeseen setbacks. For instance, notwithstanding significant precipitation, LSM’s integrated buffers guaranteed that subsequent operations remained unaffected, allowing the project to adhere to its timeline. This instance illustrates how LSM's capacity to adjust to real-time circumstances enhances its exceptional time efficiency.

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V. COST EFFICIENCY OF LSM

In contrast to traditional scheduling methods, LSM exhibits superior cost efficiency, a crucial statistic. A primary characteristic of LSM is its ability to assist project managers in optimising resource allocation, encompassing people, equipment, and materials through enhanced planning. The allocation of resources aligned with the project's linear progression is assured by LSM, unlike CPM and PERT, which sometimes lead to resource overlaps and underutilisation. The specific allocation leads to a decrease in overall project expenses and a reduction in waste.

Minimised exertion and rework resulting from redundancy is a significant advantage of LSM. Mistakes requiring rectification increase both time and financial expenditure on personnel and materials when employing conventional methods due to insufficient coordination among successive tasks. LSM addresses this issue by clearly illustrating task dependencies, ensuring that all elements are organised before progressing to the subsequent phase. By postponing the arrival of paving crews until the grading teams completed their segment, LSM successfully minimised rework associated with surface grading in the Tamil Nadu road initiative. Besides curtailing costs, this approach improved the overall quality of the project.

Further substantiation of LSM's economic benefits relative to traditional techniques is offered through comparative analysis. In contrast to techniques such as CPM or PERT, projects employing LSM generally achieve cost reductions of 15-20%. Optimal resource utilisation, reduced idle time, and diminished occurrences of task redundancy account for these financial benefits. The road initiative in Tamil Nadu successfully conserved approximately INR 1.5 crore through the implementation of LSM, primarily by optimising equipment utilisation and minimising material waste. These findings underscore the financial benefits of employing LSM in roadway construction initiatives.

The economic efficiency of LSM is improved by its focus on buffer management. By employing buffer durations between tasks, LSM mitigates the probability of delays caused by factors such as meteorological disturbances or machinery malfunctions. To maintain the project's timeline and financial constraints, these buffers act as a safeguard. Due to its proactive risk management technique, LSM surpasses traditional methods and is thus a more cost-effective option for linear construction projects.

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VI. CONCLUSION

The Linear Scheduling Method (LSM) is a proficient approach for organising recurrent linear building endeavours. Despite its constraints in managing unforeseen alterations and non-linear initiatives, LSM continues to be an essential instrument for enhancing building project efficacy. Incorporating LSM with contemporary digital technologies can significantly improve its effectiveness and facilitate successful project execution.

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