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Dynamic Scheduling For Short-Life Span Construction Projects In Indian Smes: A Simulation-Based Study

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ABSTRACT

The construction sector in India, especially among small and medium-sized businesses (SMEs), is critical to the country's economical progress. However, these SMEs often face the challenges of managing short-term projects with tight deadlines, restricted budgets, and changing resource availability. Traditional scheduling approaches, such as Gantt charts and the Critical Path Method (CPM), usually fall short of addressing these projects' dynamic and unpredictable character, resulting in inefficiencies, delays, and cost overruns. This study seeks to investigate the possibility of dynamic scheduling as an adaptable strategy that allows for real-time alterations to project plans in response to changing circumstances. The research creates a dynamic short project scheduling framework designed for short-term construction projects in Indian SMEs using simulation-based approaches. The study uses simulation methodologies to investigate the effects of dynamic scheduling on key performance metrics such as time management, cost efficiency, and resource utilisation. The research delivers practical insights that might improve project management techniques in the SME construction industry by comparing the results of dynamic scheduling to traditional approaches. The findings show that dynamic scheduling enhances project performance considerably by allowing project managers to reallocate resources, change schedules, and react quickly to unexpected occurrences. Furthermore, the study emphasises the importance of increasing SMEs' understanding and technical skills in order to promote the implementation of current scheduling technology. This research addresses a key vacuum in the current literature and provides practical solutions that construction SMEs can easily apply, resulting in increased operational efficiency and market competitiveness.

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Keywords: *Dynamic Scheduling, Short-Life Span Projects, Small and Medium Enterprises (SMEs), Construction Management, Simulation-Based Study*

1. INTRODUCTION

India's construction sector, especially that of Small and Medium-sized Businesses (SMEs), is vital to the country's economic growth. However, SMEs in the construction sector often face significant challenges, especially when managing short-life span projects characterized by tight deadlines, limited budgets, and fluctuating resource availability. Traditional scheduling methods, such as Gantt charts and Critical Path Method, often fail to accommodate the dynamic and unpredictable nature of these projects, leading to inefficiencies, delays, and cost overruns. This inefficiency not only affects project timelines but also impacts the overall profitability and sustainability of SMEs in the highly competitive construction market.

Dynamic scheduling, an adaptive approach that allows for real-time adjustments in project plans based on changing conditions, presents a promising solution to these challenges. Unlike static scheduling methods, dynamic scheduling incorporates flexibility, enabling project managers to reallocate resources, adjust timelines, and respond promptly to unforeseen events. Despite its potential benefits, the adoption of dynamic scheduling in Indian construction SMEs remains limited, largely due to a lack of awareness, expertise, and the perceived complexity of implementing such systems. Furthermore, existing literature on scheduling practices in the construction industry primarily focuses on large-scale projects, with minimal attention given to the unique needs and constraints of SMEs operating short-life span projects. This research attempts to overcome this gap by designing and assessing a simulation-based dynamic scheduling model specifically designed for short-life span construction projects in Indian SMEs. Through the use of simulation techniques, this research will explore the impact of dynamic scheduling on project performance, specifically in terms of time management, cost efficiency, and resource utilization. By addressing the key factors influencing the success of dynamic scheduling and comparing its outcomes with traditional methods, the goal of the study is to offer practical advice that will improve project management procedures in the small and medium-sized construction industry

The relevance of this research is in its potential. to offer practical solutions that can be readily implemented by construction SMEs, thereby improving their operational efficiency and competitive edge. Moreover, the findings could inform policymakers, industry leaders, and project managers about the benefits of adopting dynamic scheduling approaches, ultimately contributing to the broader development of the construction industry in India. This study not only aims to fill a critical research gap but also strives to support the growth and sustainability of SMEs by equipping them with advanced project management tools tailored to their specific needs. By exploring the application of dynamic scheduling through simulation, this research will provide a comprehensive analysis of how such methods can transform the management of short-life span construction projects, making them more adaptable and resilient in the face of industry challenges. The subsequent chapters will delve into the literature surrounding scheduling practices, outline the methodology for the simulation study, present the findings, and discuss their implications for both theory and practice in the construction management field.

Background of the Study

In recent years, the Indian construction sector has grown at an average annual pace of 9-11%, owing to an increase in both domestic and international manufacturing activities, as well as industrial growth. The current commercial and real estate projects being constructed in India have a combined market value of over $44 billion. Construction has increased across the country The government of India resolved to allow 100% foreign direct investment in the real estate and infrastructure. International businesses have committed to future investments totaling 3.9 billion euros. Given the importance of innovation to India's development and economic progress, the Indian president has proclaimed this decade to be the "Decade of Innovation," emphasising inclusive growth. If the building sector wants to take advantage of this expansion, its inefficiencies must be fixed (Nihas et al., 2015).

Overview of construction in Indian SMEs.

The construction industry is very important to India's economy. It employs a sizable proportion of the workforce, contributes significantly to the country's Gross Domestic Product, and is seen as a critical booster of the Indian economy's growth and development. This construction industry layout is very consistent throughout industrialized countries, with the proportion of small business activity being considerably higher in emerging nations. Due to their potential economic impact, SMEs (small and medium-sized enterprises) need to increase their quality and competitiveness to compete with or outperform their rivals. Small business management is often erratic and informal. For example, one of the most common methods of exchanging information is via informal face-to-face interactions between people, which means that there are often no recorded records. They usually lack project control and monitoring systems and have poorly defined project management roles and structures.

Small and medium-sized enterprises' unconventional project management techniques hinder growth and increase waste. In order to manage innovation and development in SMEs in a way that is specific to their requirements, project management will be used extensively (Giri et al., 2021)

1.3 Importance of dynamic scheduling in construction projects.

Dynamic scheduling is based on the assumption that changes to the schedule occur often throughout construction. Even little modifications in complicated projects may have serious repercussions, so making good judgements about adjustments is crucial. Making such selections is a really challenging undertaking. To make things easier, certain visualisation techniques are utilised, namely Gantt charts and network diagrams. However, because the current schedule does not account for earlier adjustments or the extent to which activity durations diverge from the original schedule, these methods are primarily intended for primary planning and are not very useful for plan updates. This contributes to poor evaluation of past changes during decision-making, which could lead to disastrous mistakes. The author created a Gantt chart modification that enhances decision quality by reflecting variations in activity duration from the initial schedule, or the dynamics of change. This modification substitutes stylised images of springs for the bars that show activities in the Gantt chart (Vadim, 2023).

1.4 Dynamic scheduling review Dynamic scheduling categories

Any of the aforementioned real-time occurrences might have a significant impact on the efficiency or the validity of a predetermined timetable, necessitating a full rescheduling of the project. Dynamic Scheduling (DS) specifies the approach for generating the initial baseline and responding to real-time events.

Completely reactive scheduling

In this category, no baseline schedule is necessary, and real-time choices are made locally, at the resource level, with the next action to be performed by the resource chosen based on its priority (or predetermined criteria) from a list of tasks available for execution. The advantages of this technique may be immediately seen from the very minimal computing load needed for the analysis, in addition to the simplicity of explanation and comprehension of its ideas and principles by system users. This scheduling method, also referred to as "Dispatching" or "Priority Rule-based Scheduling," is mostly utilised in manufacturing for real-time scheduling of machine operations.

1.5 Challenges and Strategies for SME Competitiveness

Due to market globalisation, SMEs in India under significant pressure to meet international standards regarding cost, quality, delivery speed, and flexibility. Organisations feel limited in their ability to satisfy these market needs. Significant increases in technical, financial, economic, and personal hazards are caused by a lack of funding, a lack of technologically savvy abilities, and an inability to do a thorough information search. Under these circumstances, small businesses lack the time and committed experts necessary to study medium- to long-term investment options as extensively as they would want. SMEs often prioritise short-term competitiveness above the development and adoption of organisational and technical redesigns of business processes. Most SMEs have short term goals, thus they seldom invest in developing new platforms since they don't provide results right away.

Because of today's intense competition, companies need to succeed in several things at once without compromising on any of them, like creativity or client responsiveness. Businesses now have to meet higher performance criteria in a variety of areas, such as cost, productivity, quality, speed to market, or seamless operations, as a result of increased global competition. SMEs must meet a number of requirements, including as competitive pricing, high-quality products, low failure rates, and compliance. Additional challenges arise from supply chain integration including the effective use of IT technology.

To compete under the aforementioned challenges, SMEs need to develop effective strategies. A company's long-term goals, prospective goods and markets, and strategies for reaching those goals are all included in a competitive strategy. Organisations must periodically evaluate their manufacturing strategy in order to decide on investment, product structure, production configuration, and market priority. Improvement initiatives should be in line with the goals and objectives of operations. Compared to organizations with stagnant or decreasing revenue, high-growth companies focus more on external elements such as strategic direction, operational environment, and the use of e-commerce.

1.6 Identification of key issues in current scheduling practices for short-life span construction projects.

In the context of short-life span construction projects, which are characterized by tight timelines and rapid execution phases, current scheduling practices often face several critical challenges. One of the key issues is the lack of flexibility in traditional scheduling methods, such as Gantt charts and Critical Path Method (CPM), which can be too rigid to accommodate the frequent changes and uncertainties inherent in these projects. For instance, delays in material deliveries, unexpected site conditions, or changes in client requirements can disrupt the schedule, leading to cascading delays that are difficult to mitigate within a fixed schedule framework. Additionally, many construction teams rely heavily on manual scheduling and coordination, which can be time-consuming and prone to errors, especially when dealing with multiple overlapping tasks and dependencies.

Another significant issue is the inadequate integration of real-time data and communication between stakeholders, which hampers the ability to quickly respond to on-site developments. This often results in misalignment between the planned schedule and the actual progress on the ground, leading to inefficiencies and increased costs. Moreover, resource allocation in short-life span projects is often suboptimal due to the failure to accurately forecast the availability and productivity of labor, equipment, and materials. This can cause bottlenecks or idle times, further compromising the project timeline. Lastly, the lack of adoption of advanced scheduling tools and technologies, such as Building Information Modeling (BIM) and Artificial Intelligence (AI)-based predictive analytics, limits the potential for proactive schedule management and optimization, which are crucial for the success of projects with short durations. These issues collectively underscore the need for more dynamic, integrated, and technology-driven scheduling practices in the construction industry to better handle the unique challenges of short-life span projects.

1.7 Dynamic Scheduling Framework

In actuality, due to the dynamic nature of construction projects, the proposed pre-plan structure often changes. the unpredictable nature that makes project scheduling more difficult. The suggested conceptual framework is shown in Figure 3.2. Both controllable and uncontrolled factors are included in this. The factors within the project management team's control are referred to as controllable variables. This framework's controllable factors include the project's scope, work breakdown structure (WBS), team design, supplier chain, resources, performance, and goals. Additionally, uncontrolled variables are those that are beyond our control, such as fluctuations in the weather or the rate of inflation. In the suggested paradigm, this appears as an externality’s variable. Additionally, system dynamics is utilised to analyse cause-and-effect and stock and flow diagrams in order to comprehend the level of complexity involved in pre-plan scheduling. Systems thinking and system design are used to define the conceptual foundation for dynamic scheduling's design and execution. Project scheduling developed by engineers and practitioners may be made more realistic by using the conceptual framework suggested in this study. Thus, comprehending the dynamic scheduling components utilised to assess the degree of complexity is the goal of the project scheduling conceptual framework that has been developed. This is causing the flow of modifications with respect to the degree of complexity of the intended goal to be considered. The goal of the study is to reduce the schedule variation by focusing on these crucial aspects. However, depending on a particular scheduling strategy, this might encompass a wide variety of other goals. This relates to many internal and external stakeholders, constraints, and operational expectations for a completed plan.

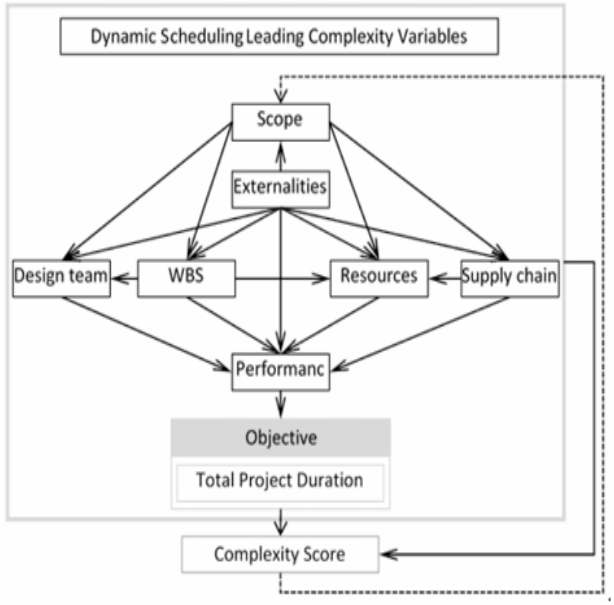

Fig.1. Dynamic scheduling for complexity control model

Source : (Shikhrobat et al., 2019)

Figure 1 suggested a model for dynamic scheduling's complexity control. A more accurate scope, a more optimistic estimate of the anticipated overall project time, knowledge about scheduling expectations that were not taken into account in the initial schedule and could alter in subsequent stages, and an expectation of the overall project length. By taking into account the complexity level built on both controllable and uncontrolled elements, the suggested framework may create a link between the intended goal and the reality of dynamic behavior of construction projects.

1.8 Objective

The construction management expert has a variety of tools at their disposal to help them complete a project on schedule, within budget, and with the required quality as stipulated by the specifications and contract papers. These tools may be manual, but most depend on commercial software to save data management time as well as improve overall accuracy. These computer-based management alternatives also permit the study of choices that might enhance overall construction while using less resources and staff.

To use simulation-based models to provide an efficient dynamic scheduling framework for construction projects with limited lifespans in Indian SMEs.

To apply the Analytic Hierarchy Process (AHP) for prioritizing key project parameters and decision-making criteria.

To conduct questionnaire survey programming to optimize scheduling processes within a cement manufacturing company.

To evaluate the impact of dynamic scheduling and propose strategies for enhancing project delivery in small and medium-sized construction enterprises in India.

2. REVIEW OF LITERATURE

Dynamic scheduling is a critical aspect of project management, particularly in the context of construction projects with short life spans, where time, resources, and cost management are paramount. In Indian SMEs (Small and Medium Enterprises), the complexity and unpredictability of construction projects present unique challenges that demand innovative scheduling techniques. Traditional static scheduling methods often fail to accommodate the variability and uncertainties inherent in these projects, leading to delays, cost overruns, and compromised quality.

Babatunde Omoniyi Odedairo et.al (2024) This study. Projects, as accelerators for proactive change, provide a temporary and flexible framework for efficiently addressing complexity (or uncertainties) in a competitive business context. As a result, using an efficient project management framework, such as Dynamic Project Scheduling (DPS), is one way to deal with complexities while achieving organisational goals. DPS is a triangular interaction that includes baseline scheduling, schedule risk analysis, and project control while also allowing for schedule revision in response to changes and uncertainties. However, there is a scarcity of information on research that have examined the feedback processes among DPS components. The goal of this work was to use system dynamics to investigate the paradoxical interactions between these components. The amounts found in the DPS system were recognised and characterised. A causal loop diagram was created to depict the interactions

between these variables. Afterward, a Stock and Flow Diagram (SFD) was made to identify the inputs, states, and flow processes inside the DPS.

Vadim Undozerov (2023) The goals of this paper are to examine the theoretical underpinnings of dynamic scheduling in construction projects and make some suggestions for further research. It is well known that "static" scheduling receives much less attention than "dynamic" scheduling. However, research indicates that "dynamic" scheduling is most effective in the construction sector, particularly for intricate, large-scale projects. To meet the study's objectives, tasks such as (1) Addressing the issue of inadequate elaboration in scheduling dynamism and complexity within construction; (2) conducting a survey of the relevant scientific literature; and (3) proposing potential avenues for the advancement of dynamic scheduling theory have been accomplished.

Research techniques include analysis, synthesis, and a study of scientific literature. The study's findings include suggestions for the development of dynamic scheduling theoretical underpinnings in construction projects, including scheduling visualisation approaches based on the author's "spring chart" example. The findings are relevant because the created suggestions might be valuable to scholars in the area of project scheduling for a comprehensive investigation of the topic.

Jude Iloabuchi Obianyo et.al (2023) Construction scheduling is a complicated process with many factors, according to this study, which makes creating precise and effective schedules difficult. “Traditional scheduling approaches are based on human analysis and intuition, which are prone to errors and often fail to account for all important variables. This causes project delays, cost overruns, including poor project performance. Artificial intelligence models have shown the ability to improve construction schedule accuracy by including historical data, site-specific conditions, and other factors that traditional scheduling systems may ignore. This study employed soft-computing technologies to assess construction schedules and manage project operations in order to attain peak performance in the execution of building projects”. The artificial neural network and neuro-fuzzy models were developed utilising the construction schedule and project execution records of a two-story residential reinforced concrete framed building.

Izack Cohen et.al (2021) In this research, a project planner must pick a collection of tasks to undertake, identify their priority restrictions, and schedule them in accordance with temporal project requirements. For project types such as infrastructure construction and information systems development, we recommend a data-driven project planning strategy. In such projects, a substantial amount of tasks are repeated inside other organizational initiatives, which may be identical, yet each project is unique in its execution. Using historical data from similar projects, the suggested technique's first step is to learn a project network. The network that is exposed lessens the temporal constraints that are hidden in specific projects, exposing areas where scheduling and planning flexibility could be more beneficial.

Abdallah Lalmi et.al (2021) In this study, “the most popular project management style is the conventional plan-driven model, which is not necessarily the ideal approach to complex construction projects with several adjustments, where more agile techniques may be more appropriate. The purpose of this paper is to present a hybrid project management approach that draws on traditional project management approaches as well as agile and lean ones, as well that seeks to promote change, improve client interaction, and increase project value by incorporating the agile approach component to increase the likelihood of construction project success, and to eliminate waste by incorporating the lean approach component. The paper thoroughly examines the existing literature on different project management methodologies and proposes a hybrid project management model for construction projects.” It highlights and examines important conventional, agile, and lean approaches.

Neha Giri et.al (2021) The purpose and goal of this paper are to provide an overview of the construction industry and SME's in the construction area. One of the main features of the nation's economic development has been the extraordinary growth of small and medium-sized businesses (SMEs). It has boosted exports, employment, and the global GDP. Following market globalization and the pandemic 2020, SMEs have challenges in maintaining their market presence. The objective of this investigation was to make the relationship between the project's difficulty and the adoption of project management methods in small and unorganized enterprises in construction.

2.1 Research Gap

The research needs for "Dynamic Scheduling toward Short-Life Span Construction Projects in Indian SMEs: A Simulation-Based Study" is due to the limited study of adaptive and real-time scheduling strategies suited particularly for short-duration projects inside Indian SMEs. Current research often misses the particular issues that these firms confront, such as resource limits and short project schedules, requiring a targeted examination into simulation-based techniques that might improve scheduling efficiency for project results in this environment.

3. RESEARCH METHODOLOGY

The thesis' goals were realised by a literature study that identified existing scheduling methodologies and convenient solutions for various types of construction projects. Furthermore, the MS Project program was presented in detail using model interfaces. All information required for a scheduling project, such as tasks, start and completion times, task connections, and durations, was detailed, and the process of establishing them in both applications was shown with examples.

The major aim for explaining both MS Project was to make the differences, shortcomings, and benefits obvious and understandable. A matrix table was created to represent the functionality of these two software products.

The nature of the project, its intended use, and the management and control needs of the organisation or organisations involved determine the names and numbers of the stages that make up a project life cycle. These phases are usually consecutive and occasionally overlap. The life cycle provides a fundamental structure for project management, regardless of the specific tasks completed. “All projects, regardless of size or complexity, may be mapped to the life cycle framework shown below. a) Begin the project b) Organize and prepare c) Carry out the project work d) Document and give over the project & closeout. This generic life cycle structure is often encountered when engaging with top management or other organizations who are less familiar with the project's primary elements. This high-level perspective may give a shared framework for comparing initiatives, even if they are diverse in character.”

Project management functions vary depending on the project, but as a general rule, five essential functions of project management are followed in every project execution to ensure a smooth project completion. “a) Planning b) Organising c) Staffing and allocating resources d) Directing or leading e) Managing. There must be a clear operational plan to lead the whole project.” The plan must incorporate and integrate the project's three components: scope, budget, and timeline. Too frequently, planning focusses just on the timetable, disregarding the critical components of money and scope. This method begins with the work breakdown structure. Planning, scheduling, and regulating begin at the start of the project and continue throughout its life until completion.

3.1 Data collection

To evaluate the present state of utilizing Primavera and Microsoft Project in construction projects, the researchers gathered massive amounts of data from both software users in Indian SMES. The data collection approach is based on 80 respondents creating a survey in the form of a questionnaire, since this method allows for the gathering of a huge amount of data from a range of software users in several regions and industries. The researcher utilized an online questionnaire created using Google Forms. Google Forms is a tool for collecting user data through a customized quiz or survey. After that, the information is collected and immediately moved to a spreadsheet. The researcher delivers the questionnaire link to a group of engineers at an Indian SME Following the receipt of the data, the questionnaire data is statistically analyzed using the Statistical Package for Social Sciences, Version 23 (SPSS).

Concept of scheduling activities and resources in the framework of the 3M method (Main, Material, and Machinery), as it applies to the issue of dynamic scheduling for short-life span construction projects in Indian SMEs.

3.2 Analysis of questionnaire responses:

A questionnaire was created to conduct a comparative study of different organizations in terms of organizational structure, business type, owner/entrepreneur data, project details, and so on. There are several questions on the questionnaire form. The first four questions focused on the respondent's construction industry characteristics, primary kind of job, designation, and work history. Other questions addressed the current circumstance and contrasted Microsoft Project with.

3.2 Dynamic Scheduling:

With or without the existence of constrained project resources, the baseline scheduling entails the construction of a schedule outlining the start and end times of each project activity. To identify the vulnerable areas of the baseline schedule and ascertain the potential impact of uncertainty in the various activity estimations on the project goal, an additional step called risk analysis is necessary.. These two dimensions may be seen as preliminary measures to help the project control phase as the project progresses, guiding the corrective action procedure when the project encounters difficulties. Dynamic scheduling is the merging of baseline schedule, risk management, and project control.

3.3 Steps of dynamic scheduling:

Here are some key steps for implementing dynamic scheduling:

Define scheduling objectives and constraints

Gather real-time data on resources, tasks, and priorities

Use algorithms to generate optimal schedules based on current conditions

Monitor execution and collect feedback

Dynamically adjust schedules as needed

3.4 Analysis Tools:

In the research titled "Dynamic Scheduling for Short-Life Span Construction Projects in Indian SMEs: A Simulation-Based Study," various statistical tools and techniques will be employed to analyze the simulation data and derive meaningful insights into the scheduling performance.

4. ANALYSIS

4.1 AHP analysis

A set of axioms that accurately define the issue environment form the foundation of the analytical hierarchy process (AHP). Problems involving multi-criteria decision-making (MCDM) are frequently resolved using the AHP. AHP is a method of decision-making that rates different options according to a wide range of criteria. This method establishes a primary objective and arranges all of the requirements in a hierarchical diagram to assist in reaching it. It is predicated on the ability of the right-eigenvector to provide accurate or approximation weights and the well-defined mathematical structure of consistent matrices. It could be regarded as a descriptive and prescriptive framework for making decisions. Its validity is based on the fact that aware decision makers (DMs) have accepted and used the AHP results in hundreds (now thousands) of real-world applications. As a result, AHP is the most widely used decision-making process in the world. Before reaching the final comparison matrix, which ranks and compares the alternatives, the AHP technique generates a series of matrices by comparing alternatives (in pair-wise mode) in relation to a criterion. There is a lack of understanding among academics and practitioners regarding the ELECTRE and TOPSIS decision-making methodologies, which have been available in the literature to address the issue of multi-criteria analysis. However, by analysing their dependencies and driving factors, ISM has been used in many research to describe a problem or issue by establishing a relationship between particular objects or aspects. To improve understanding of the system, an AHP technique may be used to quantify linkages and assess the importance of different items/elements. By determining the connections between the variables and evaluating how strongly they affect one another, DEMATEL ranks the criteria in order of importance. AHP's evident appeal to DMs, flexibility, and error-finding capabilities set it apart from other multi-criteria approaches. The first step in the AHP decision-making process is to divide the issue into a hierarchy of issues that will be examined in the study. These hierarchical arrangements make the problem easier to understand and simplify its representation. Each element's relative ability to fulfil the goal is shown by the numerical priority that the technique produces for each element. Without standardised measures, AHP could be able to help with modelling risky and unpredictable scenarios. SCM, engineering/design, green supplier selection, education, healthcare, and management are just a few of the fields in which the AHP methodology has been used in a number of decision-making situations. The word "analysis," which refers to the process of breaking down a material or abstract item into its component parts, is derived from the first word in the name of AHP. We must come up with a way to synthesise across several dimensions since complicated, crucial decision scenarios, forecasts, or resource allocations often contain too many variables for people to intuitively synthesise.

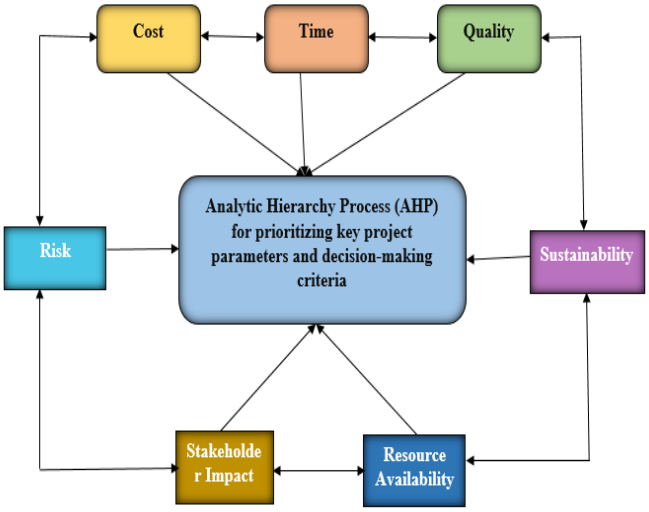

Fig.2. AHP model formulated

Table 1. Preference Scale used

Numerical Value	Verbal Judgment	Explanation
1	Same Importance	Two components each make an equal contribution to the goal.
3	Moderate Importance	One factor is marginally favored over another by judgement and

		experience.
5	Strong Importance	There is a strong preference for one element over the other.
7	Very Strong Importance	The dominance of one element is evident in practice; it is highly favored.
9	Extreme Importance	One element is given the highest grade of affirmation by the evidence.
2, 4, 6, 8	Intermediate Values	Used to express shades of preference between the above rankings.

(Yunus, 2013)

Table 2. Considered Factors for AHP

	Cost	**Time**	**Quality**	**Risk**	**Stakeholder Impact**	**Resource Availability**	**Sustainability**
Cost	1	3	3	4	9	8	9
Time	0.333333	1	3	0.333333	5	3	5
Quality	0.333333	0.333333	1	3	3	4	3
Risk	0.25	3	0.333333	1	3	4	3
Stakeholder Impact	0.111111	0.2	0.333333	0.333333	1	0.333333	0.333333
Resource Availability	0.125	0.333333	0.25	0.25	3	1	3
Sustainability	0.111111	0.2	0.333333	0.333333	3	0.333333	1
Sum	2.263889	8.066667	8.25	9.25	27	20.66667	24.33333

The provided table offers a comprehensive analysis of various criteria essential for project evaluation, including Cost, Time, Quality, Risk, Stakeholder Impact, Resource Availability, and Sustainability. Among these, **Cost** emerges as the most significant factor, influencing several other criteria. Its high scores, particularly in Stakeholder Impact (9) and Resource Availability (8), indicate that financial considerations heavily dictate project outcomes and stakeholder satisfaction. In contrast, **Time** has a lower overall importance but still holds relevance, especially in relation to Stakeholder Impact (5). This suggests that while timely project execution is crucial, it does not overshadow cost considerations.

Quality occupies a middle ground, being moderately important in relation to Time and Risk, which underscores its necessity in achieving project objectives. However, its impact is less pronounced compared to Cost and Stakeholder Impact. The **Risk** factor reveals a complex interplay with Resource Availability, achieving a score of 4, suggesting that risk management is critical for effectively utilizing resources within a project.

Conversely, **Stakeholder Impact** receives lower scores overall, highlighting its reduced significance compared to the other criteria, despite its role in influencing Cost and Resource Availability. Finally, **Sustainability** is identified as the least impactful criterion, as evidenced by its consistently lower scores across the board. Nonetheless, it remains interconnected with Cost and Resource Availability, indicating that sustainable practices can influence financial and resource-related decisions.

In summary, the analysis underscores the intricate relationships among these criteria in project management. It is evident that prioritizing Cost is vital, followed by considerations of Time and Quality. The interplay between Risk, Resource Availability, Stakeholder Impact, and Sustainability emphasizes the need for a holistic approach to project evaluation, where

multiple factors are considered to achieve successful outcomes.

4.2 Questionnaire survey analysis

The questionnaire survey study intends to gain valuable insights from industry experts on current scheduling methods, challenges, and goals in construction project management, with a focus on small and medium-sized firms (SMEs). The survey is on understanding the limitations of traditional scheduling approaches, the utilisation of current tools, and the critical aspects that influence project success. By analysing replies, this study hopes to uncover important pain areas and possibilities for creating a dynamic scheduling framework adapted to the unique needs of SMEs. The findings provide a data-driven framework for solving practical challenges and improving project management procedures.

Survey Link: https://forms.gle/5treRzTGuugG2Mrk9

4.2.1 Demographic questions

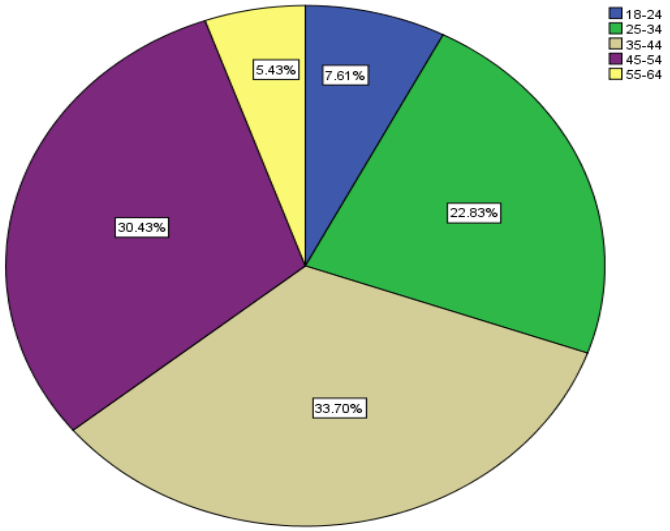

Fig.3. Age group wise Distribution

The study on dynamic scheduling in short-life span construction projects in Indian SMEs found that the age group of 35 to 44 years old accounted for the majority of the respondents, which accounts for 33.7% of the sample, followed by the 45-54 age group at 30.4%. The 25-34 age group makes up 22.8%, while younger respondents aged 18-24 constitute 7.6%, and older respondents aged 55-64 comprise only 5.4%. This distribution suggests that middle-aged professionals, particularly those between 35 and 54 years, are the most involved in these construction projects.

What is your gender?

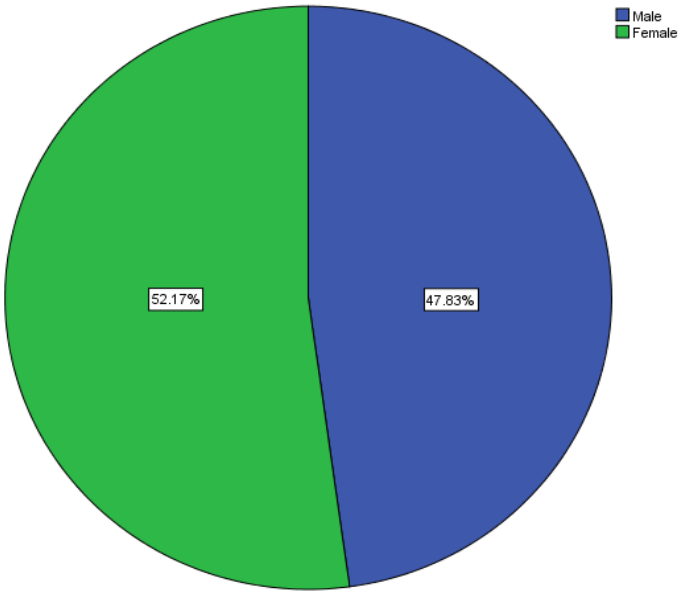

Fig.4. Gender Group Wise Distribution

The gender distribution among respondents is relatively balanced, with a slight majority of females are 52.2% as we compared to 47.8% males. This indicates a near-equal representation of both genders in the sample, suggesting gender diversity in the workforce involved in short-life span construction projects in Indian SMEs.

How much years of experience do you have?

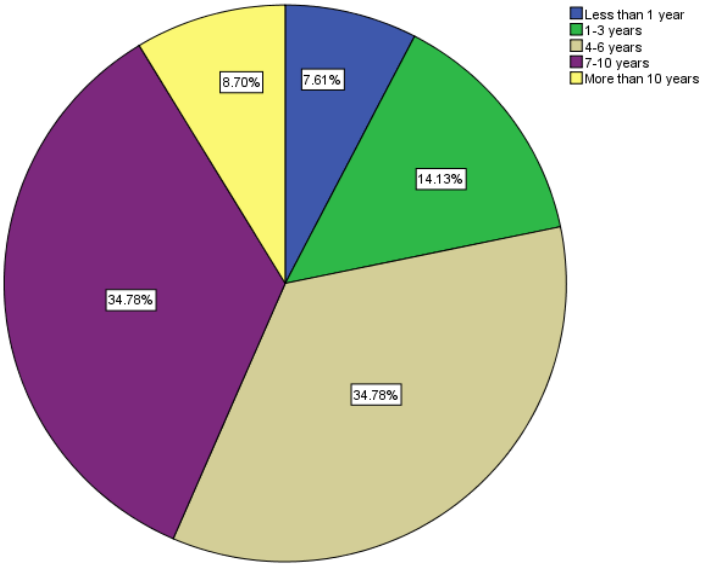

Fig.5. Years of Experience in Current Industry

The experience levels of respondents in their current industry reveal that a significant portion has 4-6 years (34.8%) or 7-10 years (34.8%) of experience, indicating a workforce with a moderate to substantial level of industry expertise. A smaller percentage has less than 1 year (7.6%) or more than 10 years (8.7%) of experience, while those with 1-3 years make up 14.1%. This distribution suggests that most respondents are in the mid-stage of their careers in the industry.

What size is your company?

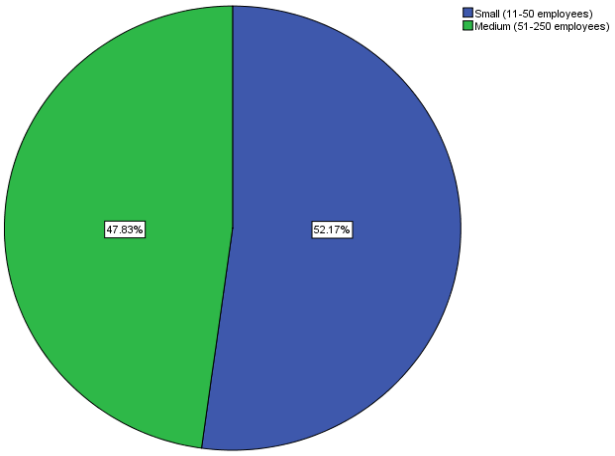

Fig.6. Company Size

The company sizes of respondents show a nearly even split, with 52.2% working in medium-sized businesses (51-250 employees) and 47.8% in small businesses (11-50 employees). The study's emphasis on the dynamic scheduling issues in construction projects within these firm sizes in India is reflected in this distribution, which shows a balanced representation of small and medium companies (SMEs).

4.2.2 Questions based on objectives

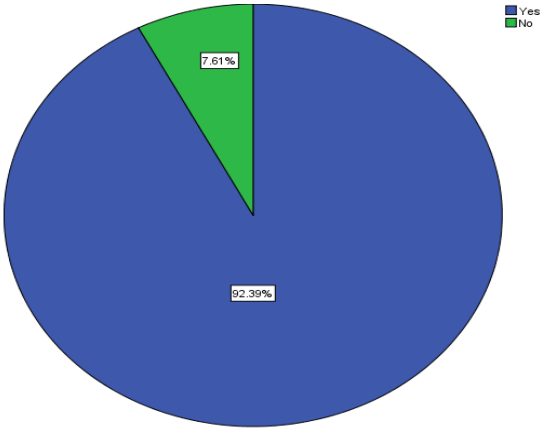

Fig.7. Have you ever used any project management tools or software?

A significant majority of respondents (92.4%) have used project management tools or software, indicating widespread adoption of digital tools in managing construction projects within Indian SMEs. Only 7.6% have not used such tools, suggesting that experience with project management software is common and likely essential in this industry.

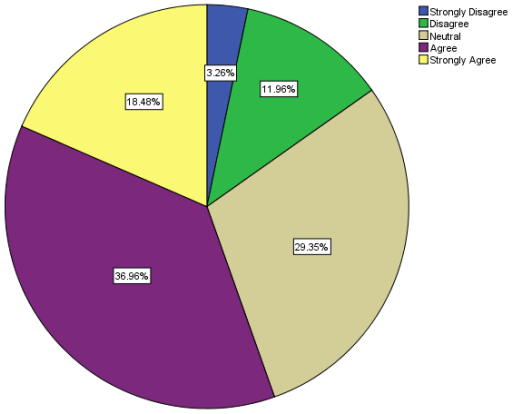

Fig.7. Dynamic scheduling can help complete short-life span construction projects on time.

The responses indicate that most participants view dynamic scheduling positively for timely project completion in short-life span construction projects, with 37.0% agreeing and 18.5% strongly agreeing. A significant portion remains neutral (29.3%), while a smaller group disagrees (12.0%) or strongly disagrees (3.3%). This suggests that dynamic scheduling is generally regarded as beneficial, though some respondents are less certain about its effectiveness.

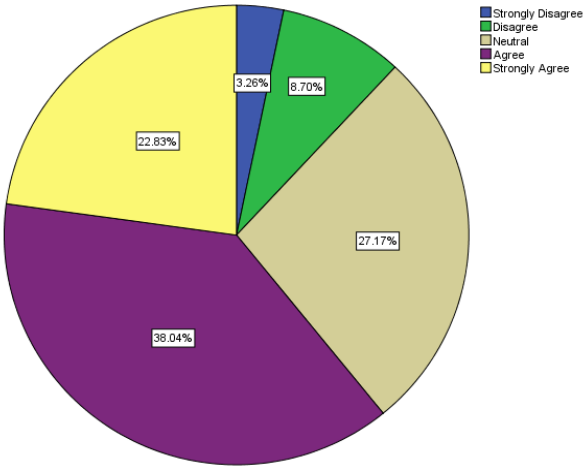

Fig.9. Short-life span construction projects need specialized scheduling methods to succeed.

A majority of respondents (38.0% agreeing and 22.8% strongly agreeing) believe that specialized scheduling methods are

crucial for the success of short-life span construction projects. However, 27.2% remain neutral, and a smaller portion disagrees (8.7%) or strongly disagrees (3.3%). This suggests that while many recognize the importance of specialized scheduling, there is still some uncertainty among a portion of the respondents.

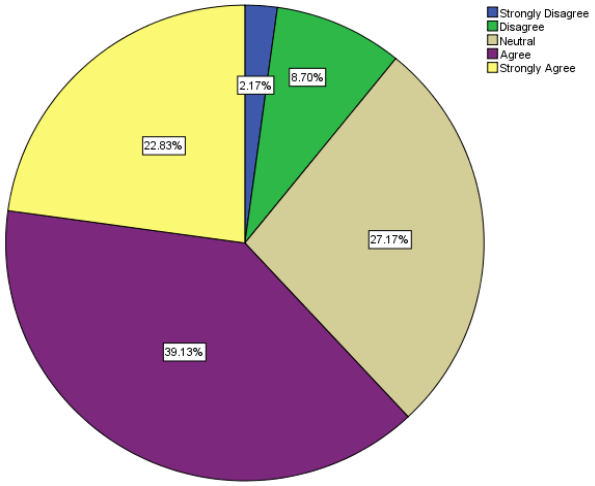

Fig.10. AHP is useful for prioritizing key aspects of construction projects.

The majority of respondents (39.1% agreeing and 22.8% strongly agreeing) believe that the Analytic Hierarchy Process (AHP) is useful for prioritizing key aspects of construction projects. However, 27.2% remain neutral, and a smaller portion disagrees (8.7%) or strongly disagrees (2.2%). This suggests strong support for AHP's utility in project prioritization, with some uncertainty among a few respondents.

4.2.3 One-way anova test

Table 3. ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
AHP is useful for prioritizing key aspects of construction projects.	Between Groups	2.017	4	.504	.506	.731
	Within Groups	86.635	87	.996		
	Total	88.652	91			
Using AHP helps to make better decisions during project planning.	Between Groups	7.480	4	1.870	2.269	.068
	Within Groups	71.683	87	.824		
	Total	79.163	91			
AHP can simplify the process of ranking project priorities.	Between Groups	5.795	4	1.449	1.688	.160
	Within Groups	74.683	87	.858		
	Total	80.478	91			
AHP provides a clear structure for comparing project criteria.	Between Groups	2.045	4	.511	.580	.678
	Within Groups	76.683	87	.881		
	Total	78.728	91			
Decision-making in construction projects improves when AHP is applied.	Between Groups	5.771	4	1.443	1.469	.219
	Within Groups	85.479	87	.983		
	Total	91.250	91			

Regarding the application of AHP in construction project management, the one-way ANOVA findings show that there are

no significant differences between the groups for any of the claims. All of the assertions' p-values, which range from 0.068 to 0.731, are more than the conventional significance criterion of 0.05, suggesting that the variations in responses across different groups are not statistically significant. This means that participants' opinions on the usefulness of AHP, its ability to prioritize key aspects, and improve decision-making, among other factors, do not differ significantly across the groups. Thus, AHP's impact is perceived similarly by the respondents regardless of their group affiliation.

4.2.4 Regression

Table 4. Summary of Model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.171[a]	.029	-.027	.27021
a. Predictors: (Constant), It is easy to understand project timelines when using Microsoft Project., Microsoft Project helps reduce mistakes in scheduling tasks., Microsoft Project helps organize the schedule of construction projects., Using Microsoft Project makes scheduling more efficient in a cement company., It helps manage the resources and timeline of construction projects better.				

With a R value of 0.171, the regression analysis findings demonstrate that the model has a weak correlation and little predictive ability between independent and dependent variables. The model only explains 2.9% of the varience in the dependent variable, according to the R Square value of 0.029.

Additionally, the Adjusted R Square value of -0.027 states that the model does not improve upon a simple mean model and may not provide significant insights. The standard error of the estimate is 0.27021, indicating a moderate level of prediction error. This suggests that while the selected predictors related to Microsoft Project's impact on construction scheduling have some influence, they do not strongly predict the outcome in this case.

Table 5. ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.188	5	.038	.515	.764[b]
	Residual	6.279	86	.073		
	Total	6.467	91			
a. Dependent Variable: Have you ever used any project management tools or software?						
b. Predictors: (Constant), It is easy to understand project timelines when using Microsoft Project., Microsoft Project helps reduce mistakes in scheduling tasks., Microsoft Project helps organize the schedule of construction projects., Using Microsoft Project makes scheduling more efficient in a cement company., It helps manage the resources and timeline of construction projects better.						

The ANOVA findings indicate that the entire model is not statistically significant since the p-value (0.764) is substantially greater than the standard significance level of 0.05. This implies that the independent variables, including various aspects of Microsoft Project, do not significantly explain the variation in the dependent variable, "Have you ever used any project management tools or software?" The F-value of 0.515 indicates a weak association between predictors and the dependent variable. The sum of squares for the regression (0.188) is much smaller than the residual sum of squares (6.279), reinforcing the conclusion that the model does not adequately predict the use of project management tools.

5. DISCUSSION

5.1 Findings

The Cronbach's Alpha score of .765 indicates good internal consistency for the 27 items used in the survey, suggesting that the items are reliable for measuring perceptions related to project scheduling and management tools.

Respondents consistently agree that dynamic scheduling is valuable for timely completion and reducing delays in short-life span construction projects within SMEs, as reflected in high mean values across relevant survey items.

There is strong support for simulation-based models as a useful tool in the planning process for short-life span construction projects, particularly in improving decision-making.

Findings indicate that specialized scheduling methods are necessary for short-life span construction projects, reinforcing the demand for tailored approaches in project scheduling.

Microsoft Project is seen as beneficial in organizing construction schedules, reducing scheduling errors, and enhancing efficiency, although its impact on scheduling outcomes was not statistically significant based on regression analysis.

Regression results show a low R-squared value of .029, suggesting that Microsoft Project's features—such as ease of timeline understanding and resource management—do not significantly predict overall use of project management software.

The ANOVA results indicate that the features of Microsoft Project do not have a statistically significant effect on whether respondents have used project management tools, as shown by a p-value of .764.

Kruskal-Wallis test results show no significant difference in perceptions of Microsoft Project's utility across various job roles, indicating that views on project management software are relatively consistent regardless of job title.

One-sample t-tests show that respondents strongly agree that the ability to easily change schedules improves project success, especially in SMEs where flexibility is beneficial for project delivery.

Respondents believe that flexible work plans are beneficial for teams in small construction companies, which supports the value of adaptability in resource-constrained environments.

The findings indicate that respondents perceive dynamic scheduling as a key factor in reducing delays in construction projects for SMEs, which could improve project delivery times.

Across all items related to dynamic scheduling and flexibility, high mean scores suggest a positive perception among respondents regarding strategies that allow adjustments and adaptability in project management.

5.2 Suggestions

Future research should include other popular tools, such as Primavera and Trello, to gain a more comprehensive understanding of how various software tools influence project scheduling and management.

Including a larger and more diverse sample of participants, particularly more non-users of project management tools, can help achieve more generalizable results and enhance the robustness of comparisons.

Expanding the study to include industries beyond construction, such as IT or manufacturing, could reveal valuable insights into sector-specific needs and the versatility of project management software.

Future studies should consider collecting objective data on project outcomes (e.g., time, cost, and quality metrics) to validate self-reported benefits and establish clearer links between software use and project performance.

Conducting the study across different regions or countries could provide insights into how cultural and regional factors impact the use and effectiveness of project management tools.

Future research should control for project complexity and team experience to better isolate the impact of project management tools from other influential factors.

Implementing a longitudinal design would allow researchers to track changes in perceptions and tool effectiveness over multiple project phases, offering a deeper understanding of long-term benefits and limitations.

5.3 Limitations

The study focused primarily on Microsoft Project, which may not capture the range of functionalities provided by other project management tools. This limits the generalizability of findings to other software with different capabilities.

The number of respondents who have not used project management tools was quite small, making it challenging to draw significant conclusions from comparisons between users and non-users.

The results might not be applicable to other industries with differing project management requirements because they only look at the construction sector, particularly small and medium-sized businesses (SMEs).

The reliance on self-reported data could introduce bias, as responses may reflect individual perceptions rather than objective effectiveness or actual project outcomes.

If the study was conducted in a specific region, this may impact the external validity of the findings, as construction project management practices can vary widely by region.

6. CONCLUSION

A major force behind economic growth, the construction industry makes significant contributions to GDP expansion,

infrastructure development, and employment creation. In this industry SMEs are crucial, particularly in developing countries. However, SMEs confront various challenges when managing construction projects, particularly those with short life cycles, which are marked by tight schedules, limited budgets, and changing resource availability. This study proposed a dynamic scheduling framework adapted to the unique demands of Indian SMEs, using simulation-based approaches and modern project management tools, to address these challenges. The major focus of this study was to provide a complete framework for dynamic scheduling, allowing for real-time modifications in project timeframes and resources to manage the inherent unpredictability's of construction projects with short lifespans. The goal of the study was to evaluate the shortcomings of traditional scheduling tools like Gantt charts and the Critical Path Method (CPM) which often lack the flexibility to deal with dynamic and unexpected situations. Furthermore, the study investigated the use of simulation tools such as Analytic Hierarchy Process (AHP) to prioritise project parameters, optimise resource allocation, and enhance decision-making.

This study also acknowledged the specific challenges that SMEs in India confront, such as restricted access to modern tools, a lack of technical experience, and dependence on manual scheduling procedures. By focussing on these pain spots, the study hoped to provide realistic and scalable solutions that SMEs could use to improve their project management skills. The methodology adopted in this research combined theoretical and empirical approaches to address the research objectives comprehensively. The study started with a thorough analysis of current literature to identify research gaps and provide the theoretical groundwork for dynamic scheduling. Key themes covered were scheduling strategies, project management challenges in small and medium-sized enterprises, and the promise of simulation-based approaches. The empirical phase included gathering data via questionnaires sent to industry experts working in SMEs. These surveys gave essential insights into the present state of scheduling practices, the challenges associated with introducing dynamic scheduling, and the main project criteria that needed to be prioritised. Statistical tools were used to analyse survey results, resulting in a solid and data-driven knowledge of the problems at hand. To address these challenges, the study used simulation approaches, including MSP and AHP, to create and evaluate the dynamic scheduling framework. This enabled the examination of alternative scheduling situations, the identification of bottlenecks, and the assessment of the framework's efficacy in improving project results.

The analytical part of the study produced considerable results, highlighting the benefits of dynamic scheduling over conventional techniques. Simulations indicated that dynamic scheduling allows for real-time modifications, enabling project managers to adapt quickly to changes in project circumstances. For instance, it facilitated the reallocation of resources during unforeseen delays and optimized task sequences to prevent cascading disruptions. The use of the AHP technique improved the framework by offering an organised way to prioritising project criteria. Cost, time, and quality appeared as the most significant elements impacting project results, with resource availability and risk management regarded as secondary but equally essential aspects. The results emphasised the interdependence of these characteristics, as well as the significance of a comprehensive scheduling strategy. Furthermore, the study highlighted the practical advantages of incorporating MSP into project management procedures. MSP's ability to manage various baselines and give rich visualisations of project dynamics was very useful in monitoring progress, finding deviations, and making educated choices. This highlighted the need of using modern tools and technology to expedite project management procedures in SMEs.

The findings of this study have far-reaching consequences for the construction sector, especially for SMEs trying to stay competitive in a hard market climate. By using the suggested dynamic scheduling framework, SMEs may significantly increase project efficiency, cost management, and resource utilisation. The capacity to flexibly change schedules decreases the danger of delays and cost overruns, thus increasing the overall success rate of short-term projects.

The study also has important implications for governments and business leaders. Policymakers might use the data to create targeted training programs, subsidies, and awareness campaigns that encourage SMEs to use advanced scheduling methods. The suggested framework may be used by industry leaders to include dynamic scheduling into their project management methods, supporting innovation and resilience in the construction sector.

While this study presents a potential framework, it is not without limits. The focus on SMEs within a specific geographical context—India—may limit the generalizability of the findings to other regions or industries. Furthermore, although simulation-based methodologies are useful, they need further validation via real-world case studies to properly verify the framework's applicability and efficacy. Another noteworthy difficulty is SMEs' lack of understanding and technical experience with modern scheduling technologies. To overcome this hurdle, industry players must work together, including via training programs and the development of user-friendly products customised to the requirements of SMEs.

The foundation for further investigation and advancement in the field of dynamic scheduling is laid by this study. Future studies could examine how to enhance the proposed framework's predictive power and real-time adaptability through the incorporation of advanced technologies include the Internet of Things, machine learning , and artificial intelligence .

Extending the study to include large-scale construction projects or other sectors might give more insights and confirm the framework's adaptability.

Furthermore, creating case studies that illustrate real-world applications of the dynamic scheduling framework would provide

practical proof of its advantages and promote broader adoption. Finally, developing collaborations between SMEs and technology suppliers may assist bridge the gap between invention and implementation, allowing SMEs to fully realise the benefits of dynamic scheduling.

Finally, this study presents a complete and effective framework for dynamic scheduling in short-life span construction projects, addressing the specific challenges encountered by Indian SMEs. The study shows how real-time adaptation may increase project efficiency, cut costs, and maximise resource utilisation by using simulation-based approaches and modern technologies. The results highlight the need of using creative scheduling strategies to overcome the difficulties of current construction projects. As SMEs continue to play an important part in India's economic development, providing them with good project management tools is both a strategic priority and a road to long-term progress. This study is a key step in revolutionising project management processes in the SME construction sector, providing a paradigm for adaptation, efficiency, and resilience in the face of industry challenges.

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