A critical appraisal of traditional methods of construction progress monitoring

Muhammad Sami Ur Rehman and Muhammad Tariq Shafiq
Department of Architectural Engineering, United Arab Emirates University, Al Ain, United Arab Emirates
Fahim Ullah
Department of Surveying and Built Environment, University of Southern Queensland – Springfield Campus, Springfield Central, Australia, and
Khaled Galal Ahmed
Department of Architectural Engineering, United Arab Emirates University, Al Ain, United Arab Emirates

Received 1 March 2023
Revised 8 May 2023
Accepted 18 June 2023

Abstract

Purpose – The purpose of this study is to investigate the current construction progress monitoring (CPM) process in relation to the contractual obligations, how project management teams carry out this activity in the field and why teams continue to adopt the current method. The study aims to provide a comprehensive understanding of the current monitoring process and its effectiveness, identify any shortcomings and propose recommendations for improvements that can lead to better project outcomes.

Design/methodology/approach – The study conducted semi-structured interviews with 28 construction management practitioners to explore their views on contractual requirements, traditional progress monitoring practices and advanced monitoring methods. Thematic analysis was used to identify existing processes, practices and incentives for advanced monitoring.

Findings – Standard construction contracts mandate current progress monitoring practices, which often rely on manual, document-centric and labor-intensive methods, leading to slow and erroneous progress reporting and project delays. Key barriers to adopting advanced tools include rigid contractual clauses, lack of incentives and the absence of reliable automated tools. A holistic automated approach that covers the entire CPM process, from planning to claim management, is needed as a viable alternative to traditional practices.

Research limitations/implications – The study's findings can inform researchers, stakeholders and decision-makers about the existing monitoring practices and contribute to enhancing project management practices.

Originality/value – The study identified contractually mandated progress monitoring processes, traditional methods of collecting, transferring, analyzing and dispensing progress-related information and potential incentives and points of departure towards technologically advanced methods.

Keywords Construction progress monitoring, Contractual obligations, Performance improvement, Construction industry, Process effectiveness, Project management

Paper type Research paper

1. Introduction

Construction project is a specific type of project that involves the design, planning and execution of the construction of buildings, structures and other physical assets. The management of such projects involves the process of planning, organizing and overseeing the execution of a project, including the coordination of resources and the management of timelines and budgets (Ika and Saint-Macary, 2012). One of the key aspects of construction project management is the development of a detailed project plan, which outlines the scope, timeline and budget for the project. This plan is used to guide the project team in the

Built Environment Project and Asset Management

2044-124X
DOI 10.1108/BEPAM-02-2023-0040

execution of the project and to track progress over time. The project manager is responsible for overseeing the project plan and making any necessary adjustments to ensure that the project stays on track and within budget (Sami Ur Rehman *et al.*, 2022a, b). To complete the construction project on time, achieve expected time-related goals and stay aware of the status of the project at any given time, construction project management teams conduct continuous worksite inspections throughout the lifecycle of the project; usually termed as ‘construction progress monitoring’ or ‘construction progress tracking’ (Mantel and Meredith, 2009). Construction progress monitoring (CPM) is a critical part of construction project management, as it allows the project team to identify and address any issues that may arise during the project. This can include issues related to the schedule, budget, or scope of the project, as well as problems related to the quality of the work or the safety of the construction site. Another key aspect of CPM is that it feeds this information into project control processes enabling project team to take corrective action for any drift in project progress. Project monitoring and control are responsible for safeguarding the project from any delays, cost overrun. CPM typically involves regular inspections of the construction site and the use of tools such as Gantt charts, project management software and progress reports to track progress and identify areas for improvement (Sami Ur Rehman and Shafiq, 2022).

Construction project delays are a common problem in the industry, and they can have a significant impact on the overall success of a project (Sami Ur Rehman *et al.*, 2022a, b). According to estimates, more than 80% of construction projects experience some level of delay. Delays can be caused by a variety of factors, such as changes in project scope, poor communication, inadequate planning and unforeseen site conditions (Doloi *et al.*, 2012). CPM is responsible for identifying and addressing potential delays before they occur. This includes tasks such as creating detailed project plans, setting realistic deadlines and developing effective communication channels between all stakeholders. This activity resulted in a baseline project schedule which serves as a measuring stick throughout the project’s lifecycle and variances are measured against the actual progress of the project (Vanhoucke, 2012). Despite these efforts, many construction projects continue to experience delays. According to a study by McKinsey, the construction industry is one of the least productive sectors in the world. The study found that construction productivity has remained stagnant for the past several decades and that many construction projects are still plagued by delays and cost overruns (Changali *et al.*, 2015). One of the main reasons for this is that project managers often lack the necessary skills and experience to effectively manage construction projects. According to a study by the Project Management Institute, only 64% of project managers have a formal education in project management and many of those lack experience in the construction industry. Another reason for the high rate of project delays is the lack of standardization and consistent project management practices in the construction industry (Ali and Kidd, 2014). Many projects are managed using different methodologies and tools, which makes it difficult for project managers to compare their progress with others and identify best practices. Furthermore, the access to untimely information for project control, disconnect between project monitoring and control processes and monitoring information often being delayed and trapped in current document-centric manual process are among the key issues as reported by the existing knowledge (Ekanayake *et al.*, 2021; Omar and Nehdi, 2016; Sami Ur Rehman and Tariq Shafiq, 2021).

CPM has been widely addressed in scientific research, with numerous studies and articles published on the subject. These studies have focused on various aspects of construction progress monitoring, including the use of technology, the role of project management, and the impact of delays on construction projects. One area of research that has received significant attention is the use of technology in CPM. Studies have examined the use of various technologies, such as building information modeling (BIM), drones and sensor networks, to improve the accuracy and efficiency of progress monitoring (Omar and Nehdi, 2016).

Other studies have looked at the use of advanced analytics and machine learning algorithms to analyze data from construction projects and identify potential issues before they occur (Sami Ur Rehman *et al.*, 2022a, b). Further research endeavors have explored how project managers can use progress monitoring to identify and address issues, such as delays and cost overruns, that may arise during the construction process (Hegazy, 2013). Additionally, research has been conducted on how effective communication and collaboration among stakeholders can enhance the effectiveness of existing techniques. Despite the considerable research efforts, there still exists a knowledge gap that presents a holistic overview of the entire process and addresses the potential of available techniques to facilitate and improve the process throughout the lifecycle of the project. This gap is due to the lack of understanding of the current process of CPM, prevailing methods being conducted on construction sites, the type of data being collected, the effectiveness of the collected progress information and its impact on curbing project delays. Therefore, this research study aims to identify the current process of CPM, the methods being used on construction sites, the type of data being collected and to assess the effectiveness of the collected progress information and its impact on curbing project delays. Also, this research is interested in assessing the extent of implementation of advanced tools and techniques, as identified by the research over the decades, into actual execution practices. Lastly, understanding the motivation and perspective of the industry behind using the prevailing techniques and possible points of departure from traditional methods towards technologically advanced techniques.

2. Literature review

Nearly 3 decades ago, Davidson and Skibniewski (1995) identified that the manual data collection process to conduct CPM is slow, inaccurate and produces a vast amount of paperwork. To explain the process further, this was stated that progress associated with any construction activity is measured using traditional manual data collection, such as supervisors filling timesheets for workers, filling out templates for progress recording and reporting, collecting paper documentation like delivery notes, etc. This study concluded that the traditional manual data collection process was slow, inaccurate and no longer effective to monitor the construction progress and get the accurate status of the project. Navon (2005) also discussed that traditional progress monitoring methods comprise of slow and inaccurate manual progress data collection from the worksite. Also, the key to accurate and proactive decision making is extensive and well-organized progress data, however, neither construction companies nor project managers afford to collect such an extensive data by utilizing their efforts and resources (Kopsida *et al.*, 2015). Instead, project managers continue to rely on time-consuming and expensive methods of data collection and make decisions based on inaccurate and erroneous information which results in more costly and complex corrective measures (Alizadehsalehi and Yitmen, 2019). A recent study (Sami Ur Rehman and Shafiq, 2022) confirmed these findings that prevailing CPM techniques are still relying on paper-based data collection and dissemination of information through verbal and email-based mediums by using photos/videos as evidence. Moreover, the construction industry professionals agreed that such information involves manual labor, lacks accuracy, time consuming and difficult to analyze or understand the progress information. Despite the availability of Enterprise Resource Planning (ERP) and other specialized extranets, up-to-date and accurate progress information remains elusive.

Based on the inherent shortcomings of traditional CPM techniques many research studies have emphasized an automated CPM (ACPM) process, experimented with a multitude of latest technologies and proposed a plethora of technologically advanced tools and techniques to achieve the highly sought after automation for the CPM process. Navon (2003) presented an automated project performance control model to verify if project performance indicators can be automatically measured and controlled. The model was aimed at collecting high-quality data to compare the planned vs actual progress of the construction project. This timely information is vital for project management teams to take corrective actions when needed and reduce the damages caused by discrepancies. Navon and Sacks (2007) conducted a research study to test the desired functionality of ACPM techniques against the one in the current construction practice. This study also highlighted the potential benefits of automated data collection, i.e. saving cost and time invested in collecting data and updating the schedule and the possibility of updating the schedule frequently – possible even daily. This early evidence of the potential of ACPM encouraged the researchers to further explore this domain. Omar and Nehdi (2016) reviewed the available literature and summarized the methods and techniques available for ACPM. This study analyzed the technologies from three distinct perspectives: (1) collection of as-built data, (2) organization of as-built data and (3) analysis of as-built data. Furthermore, several available technologies were also identified and categorized, i.e. (1) Enhanced IT tools, i.e. multimedia, email and handheld computing; (2) Geospatial technologies, i.e. barcoding, radio frequency identification (RFID), ultra-wide band (UWB), geographic information system (GIS) and global positioning system (GPS); (3) Imaging, i.e. photogrammetry, videogrammetry, laser scanning and range images and (4) augmented reality (AR). This study concluded by discussing the potential of various technologies and stating their limitations. Furthermore, guiding further research efforts into exploring avenues toward the adoption of these technologies. Recently, Sami Ur Rehman *et al.* (2022a, b) identified the process for computer vision (CV)-based CPM which comprises four sub-processes i.e., (1) data acquisition (2) information retrieval (3) progress estimation and (4) output visualization and discussed the available techniques for each sub-process along with their advantages and limitations. This review study also provided a comparative insight into the traditional CPM techniques and CV-based CPM and discussed the potential of such technologically advanced methods for replacing the slow and error-prone traditional CPM techniques. However, Mostafa and Hegazy (2021) argued that these research studies are catered toward addressing the academic audience rather than construction professionals, which has been identified in a recent study conducted by Sami Ur Rehman and Tariq Shafiq (2022), that reports that the majority of construction practitioners are unaware of the availability of such advanced tools for an effective CPM process let alone their capabilities or implementation protocols.

Despite years of research in improving the effectiveness of construction processes and identification of technologically advanced techniques, a recent study by Keyvanfar *et al.* (2021) reported that manual, slow, costly and ineffective traditional practices are still prevailing in the industry and there seems to be little or no sight of it ever being replaced by advanced techniques. Why is this so? To understand the mismatch between the academic research and actual construction execution practices, this research study took a step back and aimed at exploring the existing processes being observed during the execution of construction projects and understanding the reasons behind the continued utilization of such methods and techniques despite their obvious disadvantages. An apparent reason behind this continued usage is the contractual obligations which does not allow for the integration of technologically advanced techniques into existing practices or at the very least does not encourage or appreciate such innovations hence discouraging the potential users from experimenting with such techniques, improving along the way and resultantly implementing them. This phenomenon has been identified by Matthews *et al.* (2015) who attempted to re-engineer the existing process to allow for a real-time progress monitoring data collection and reporting from the worksite. However, the study identified that since the existing processes were certified to ISO 9001 and there was a distinct reporting protocol linked with such certification, which impacted the ability of newly re-engineered process to collect the desired data from the on-going construction project and its effectiveness be compared to the existing CPM process. Therefore, firstly this study explored the contractually mandated process and how contractual terms are being translated into further action plans. Then understood the sub-process involved in this, i.e. progress data collection, data reporting, data transfer, data analysis and progress status reporting to concerned stakeholders. Lastly, this study explored the motivation behind continued usage of such practices, bottlenecks associated with traditional methods and desired modifications into it and discussed the possible point of departure from existing practices towards more advanced and automated techniques, as pointed out by Sami Ur Rehman *et al.* (2022a, b). In line with this aim, this study is designed to answer three research questions to gauge the views of the project management teams working in the construction industry:

RQ1. What is the current construction progress monitoring process as per the contractual obligations?

RQ2. How are the project management teams conducting this activity in the field and getting the desired information?

RQ3. Why do the project management teams continue to adopt the current method and what could be the possible point of departure?

3. Methodology

The research design of this research study follows the guidelines provided by Saunders' research onion. According to the concept of the research onion, the research design follows multiple layers of the onion, starting from the research philosophy, then the research approach, research strategy, time horizon and data collection and analysis methods (Saunders *et al.*, 2009). This research study was carried out under the stance of interpretivism, which suggests that social action is essential if analyzed from the standpoint of the participant (Tracy, 2019). Further, an inductive research approach was used because it allowed moving from specific observations to broader generalizations. This research approach started from specific observations and measurements, began to detect patterns, formulated some tentative hypotheses that can be explored, and finally ended up formulating general conclusions and theories (Arthur, 1994). After peeling away the research philosophy and research approach, the research study used a qualitative research design that utilized semi-structured interviews to explore the views of construction project management teams. This design allowed the researchers to collect rich and detailed data about the participants' experiences and perspectives regarding the use of CPM techniques in construction projects. Due to the limitation of the time and the nature of this exploratory research study, a cross-sectional approach was adopted to address the time horizon associated with this study. The cross-sectional approach allowed for the study to be conducted in a snapshot of time rather than elongated observations over an extended period (Kulatunga *et al.*, 2007), as interviews were conducted with various construction project teams within a specific time frame.

To meet the research aims, and considering the nature of the research questions, this research employed semi-structured in-depth interviews to understand and map the existing progress monitoring process and explore the problems associated with traditional construction progress monitoring processes from the standpoint of the construction project management teams. The in-depth interviews are an open-ended and discovery-oriented method to obtain detailed information and insights regarding a specific topic (Boyce and Neale, 2006). Lastly, a thematic analysis approach was selected to analyze the data collected through semi-structured in-depth interviews. More specifically, inductive thematic analysis was employed to identify various themes and code them without any pre-existing coding frame or preconceptions (Braun and Clarke, 2006).

4. Sample demographic profile

The interviewees were selected using purposive sampling, which involves choosing participants who can offer rich and relevant data for the research questions. The sample includes 28 mid-career civil engineers in planning roles. This methodology did not use a predetermined sample size, but rather aimed to reach data saturation, which is the point where no new themes or insights emerge from the data (Fusch and Ness, 2015). All the interviewees were planning engineers with experience spanning from 6 to 10 years with an average of 8 years of experience within the construction industry. Approximately half of the interviewees were graduates of civil engineering with a Bachelor of Civil Engineering degree and the other half held a Master of Science degree in a related domain. Furthermore, all the research participants were working for large-scale contracting organizations in multiple countries, i.e. Qatar, United Arab Emirates (UAE), Pakistan, Norway, Denmark, United States of America (USA), Canada and Australia. In this study, 28 participants were interviewed, with data saturation being reached after 18 interviews. An additional 4 interviews were planned to confirm emerging themes, bringing the total to 22. However, during the 19th interview, a new theme emerged related to the use of a tailor-made ERP system for progress information reporting. To ensure that no new themes emerged, 9 more interviews were conducted.

5. Results and discussion

5.1 Current progress monitoring process

Participants reflected on the current progress monitoring process being adopted in the construction industry in their respective regions. They were asked to provide their input on contractual obligations and requirements from the client regarding the project's progress monitoring and tracking throughout its lifecycle. Emerged themes include: (1) contractual obligations, (2) project management plan (PMP), (3) preparing for progress monitoring and reporting process and (4) progress data types. These sub-themes reflect the factors that shape the planning and preparation phase of the current progress monitoring process, which determines the type and quality of data that will be collected, analyzed and reported throughout the project lifecycle.

5.1.1 Contractual obligations. All the participants indicated that the construction industry is following The International Federation of Consulting Engineers (FIDIC) contracts. The FIDIC Red Book is the standard construction contract form for all projects. In these contracts, FIDIC sub-clause 4.21 (Progress Reports) obliges the contractors to submit a "comparison of actual and planned progress" as part of the progress reports. It also requires a contractor to submit details in monthly progress reports. Also, the participants indicated that FIDIC sub-clause 8.3 (Program) and sub-clause 8.6 (Rate of Progress) oblige the contractor to revise the program if it is not consistent with the agreed baseline program submitted at the time of the contract. However, most of the participants indicated that client organizations do not implement FIDIC clauses in their pure form, and these clauses are often modified to suit the client or project needs. Along with general conditions derived from the FIDIC contract form, special conditions of the contract are also being incorporated into the contract to cater to the requirements that are peculiar to that specific contract or necessitated by that specific project. Generally, in the construction industry, contractors are required to submit a weekly report, a bi-weekly summary report, and a detailed monthly report to convey the progress information of a construction project to all the primary stakeholders involved throughout the lifecycle of the project. The contents of these reports and follow-up meetings are driven by the PMP translated from the contractual obligations specified in the construction contract.

5.1.2 Project management plan (PMP). All participants indicated that PMP contains guidelines on how to conduct the progress monitoring process throughout the lifecycle of the project. Apart from containing vital information and definition on how a project is going to be executed by laying out an executive summary, project scope and deliverables, project schedule, project resources, risk and issue management plan and communication management plan, it is also an official reference document for the planning engineer to design further tools and procedures to efficiently conduct the progress monitoring and reporting throughout the lifecycle of the project. The communication management plan in the PMP presents a communication strategy that comprises a hierarchy and a procedure to report progress-related information. These procedures further provide guidelines regarding the type of reports, frequency of reports, templates and required contents or type of information from progress reports. Also, a detailed PMP contains the guidelines for physical periodic meetings to discuss the progress of the project, the information may comprise the purpose/agenda, type, frequency and participants of those meetings. The planning department takes the guidelines provided in the PMP and designs its processes accordingly to fulfill the requirements of the progress monitoring and reporting process as obligated through the contract. However, many participants mentioned that sometimes the contract document or PMP does not contain detailed information on the progress monitoring and reporting process then the requirements from this process are discussed and agreed upon during the kick-off meetings with the client or its representative consultant.

5.1.3 Preparing for progress monitoring and reporting process. After reviewing the Bill of Quantities (BOQ), detailed design drawings and specifications and a summary of major milestones, a planning engineer set out to prepare a detailed schedule, cash flows and manpower histogram along with other secondary requirements, e.g. shop drawings log, procurement tracking log, No Objection Certificate (NOC) and other statuary approvals log, etc. The detailed construction schedule formed after careful review and consideration of contractual documents is known as a baseline schedule and it must be submitted and approved by the client or its representative consultant before the start of any project. Throughout the lifecycle of the project, the planning engineer tracks the as-built status of the project by comparing it with the approved baseline and submitting the required progress reports based on this information for further review by the client or the consultant. Any variations will be discussed in follow-up meetings and the contractor will be asked to take necessary measures to keep the project on track and ensure its completion within the agreed project duration.

5.1.4 Progress data types. Data types correspond to the type of information incorporated into the baseline schedule and this information will be used to devise the project tracking and reporting strategy throughout the lifecycle of the project. The baseline schedule can be as simplistic as the basic critical path method schedule which only considers early start and early finish dates, durations, milestones and percent completion of each activity in the project plan. However, none of the participants indicated its use in the industry. All participants agreed that most of the projects are practicing progress monitoring and reporting by utilizing a basic lump sum cost-loaded schedule for each activity. Costs associated with each activity are derived from the BOQ and the percent completion status for each activity will give a rough estimate regarding the as-built completion of the project. However, this practice does not give realistic and accurate information regarding the status of the project, and it sometimes misleads the project management team and other stakeholders. Furthermore, all participants agreed that the most efficient method to track the progress of the project is through a resource-loaded schedule by incorporating estimated manhours and other resource-related information into the baseline schedule. Also, all participants indicated that tracking through a resource-loaded schedule requires skilled planning engineers, additional costs and further dedicated efforts on behalf of the contractor.

5.2 Current progress monitoring practices

Participants reflected on the existing practices to conduct the construction progress monitoring process on their projects. They were asked to provide information regarding existing progress monitoring practices from data collection from the worksite to data entry into project management tools, from analyzing the as-built data to submission of the required reports. Emerged themes include (1) data collection from the worksite, (2) data transfer and analysis, (3) project scheduling tools and (4) progress reporting to project stakeholders.

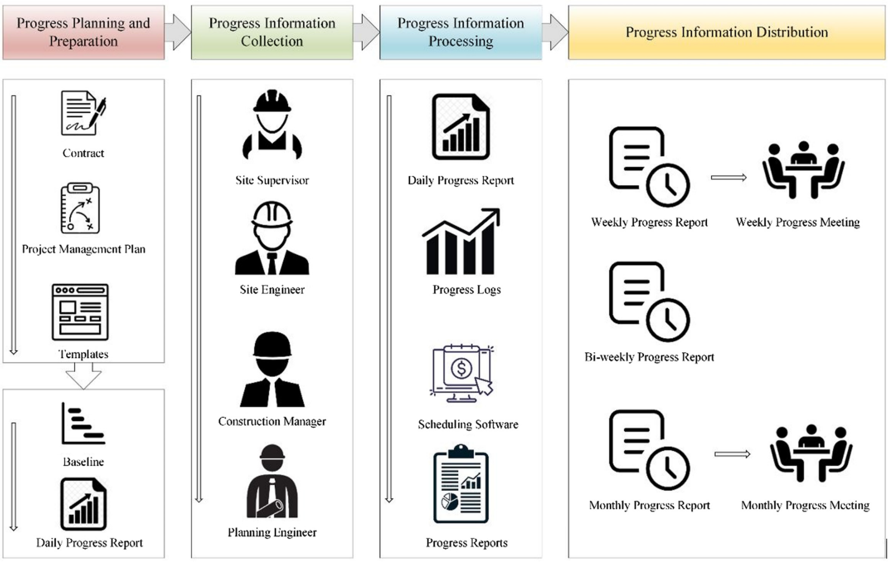
5.2.1 Data collection from the work site. The participants have identified several terminologies for data collection tools, i.e. progress proforma, progress layout, progress status template, progress reports, etc. Although participants mentioned different terminologies, they all agreed on a common and standard terminology that is being used for the data collection tool, i.e. Daily Progress Reports (DPR). These DPRs can have different templates based on contractual and organizational requirements. However, participants agreed that all these DPRs generally collect activity names, actual start date, actual completion date, percent complete, earned manhours, equipment deployed and other progress-related information as required by the planning engineer. Usually, the planning engineer will extract the information of as-planned activities from the baseline schedule for that specific week and transfer that to the DPR template and progress-related information will be collected by the supervisor from the worksite through observations and subjective assessment of the as-built status by filling out the provided template. The site supervisor hands these reports over to the site engineer and after confirming the information, the site engineer submits these reports to the construction manager for approval. After approval from the construction manager, these reports reached the planning department for further review and analysis.

5.2.2 Data transfer and analysis. Once the planning engineer receives the approved DPRs, the data will be transferred to the draftsman or quantity surveyor for progress layouts and the planning engineer updates progress logs using the information provided through DPRs. Most of the participants indicated that these progress logs are being maintained using Microsoft (MS) Excel software and the information is being transferred to the designated project scheduling software for further analysis at the end of the reporting cycle, i.e. 7 days. During the analysis the planning engineer analyzes planned vs actual cumulative progress, planned vs earned manhours and machine-hours, critical path and status of floats in the schedule. Most of the participants indicated that the planning engineer also performs necessary amendments to the project schedule to absorb any delays during the current reporting cycle to complete the project within the agreed duration.

5.2.3 Project scheduling tools. All the participants mentioned that Primavera P6 is the most widely used project management software in the construction industry. Usually, the Primavera file or the PDF version of the complete schedule and a work breakdown structure (WBS) summary is required as a part of the weekly or monthly progress report from the client or consultant as part of the progress monitoring and reporting process on the project. Moreover, a few participants also mentioned that MS Project is another project management software being frequently used for schedule updates and reporting. However, the participants indicated that MS Project is not as comprehensive as Primavera P6 and is mostly used on small to medium size projects where progress monitoring and reporting requirements are not stringent. One participant also mentioned the use of MS Excel for progress monitoring and reporting to clients and consultants as no specific software requirements were mentioned in the contract. One of the participants also mentioned the use of a tailor-made Enterprise Resource Planning (ERP) platform to convey progress-related information in terms of cost to the contractor’s higher management.

5.2.4 Progress reporting. The participants indicated four different types of reports involved in the progress monitoring and reporting process. First, a DPR is being used as a primary tool to collect progress information from the worksite and is being disbursed among concerned departments within the contractor's organization. Second, a weekly progress report which comprises detailed progress information, i.e. cumulative percent progress vs cumulative actual progress, cumulative variance, summary WBS, weekly percent planned vs percent actual, financial status, manpower histograms, look ahead weekly or bi-weekly plan and summary of floats among other required information. All participants agreed that weekly reports are the most detailed among others regarding the communication of progress-related information. Third, bi-weekly reports comprise a general overview rather than detailed information, i.e. a summary of physical and financial progress among other information, i.e. perspective views, project information, building plans/drawings, the status of quality assurance and control and photographs of actual construction. Last, a monthly report comprises detailed progress information, i.e. S-curves, overall project progress, monthly percent planned vs percent actual, variance analysis, planned vs actual quantities, detailed progress information, look ahead plan and progress-related bottlenecks among other necessary project-related information.

Figure 1 summarizes the identified construction progress monitoring process through a series of semi-structured in-depth interviews with construction practitioners. The overall process can be divided into four distinct phases, i.e. progress planning and preparation, progress information collection, progress information processing and progress information distribution. In the first phase of the process, planning for progress monitoring will be done by following the obligations laid down in the contract and translated into and communicated through a PMP to the planning department. This process yields all necessary templates required to perform the monitoring process throughout the lifecycle of the project. The distinct outcome of the first phase is the baseline schedule. In the second phase, progress-related information is collected from the worksite through the involvement of various project management cadres. In the third phase, a detailed analysis is performed from taking data from DPRs to creating progress logs and from updating the scheduling software to creating



Source(s): Figure by authors

Figure 1. Overview of existing construction progress monitoring process

necessary progress reports. In the final phase, periodic progress reports will be distributed among stakeholders and discussed through progress meetings.

5.3 Continued usage and departure from existing practices

Participants discussed the reasons behind the continued usage of existing practices despite their drawbacks. The study also explored advanced methods and techniques and gathered participant perspectives on the possible benefits of adopting such techniques, as well as the obstacles that hinder their implementation. Emerged themes are (1) motivation behind the continued usage of traditional techniques, (2) incentives for adopting advanced methods and techniques and (3) barriers to the adoption of advanced progress monitoring methods and techniques.

5.3.1 The motivation behind the use of existing methods. 5.3.1.1 Contractual requirements. The current process of progress monitoring and reporting in the construction industry, although manual, slow and labor-intensive, appears to fulfill the requirements set by the client or consultant. However, when considering the potential benefits of advanced methods, such as increased accuracy and efficiency, the existing process may have drawbacks and limitations that could be addressed by exploring alternative approaches. By staying under the umbrella of prevailing contractual requirements the existing system can be improved significantly to provide accurate and precise progress-related information. Most of the participants agreed that the suggested improvement is dependent on the resources deployed specifically for the progress monitoring and reporting process in terms of human, cost, and equipment. The more dedicated efforts are towards improving the existing process from the client and contractor alike the more efficient, accurate and precise the outcome will be. Furthermore, all the participants indicated that the key motivation behind the use of existing methods of progress monitoring and reporting is the requirements from the client through the contract.

5.3.2 Potential incentives for advanced methods. 5.3.2.1 Automated or real-time progress updates. All the participants indicated the need for advanced methods for construction progress monitoring and reporting which may comprise several automated systems that can provide automated or even real-time progress updates without the need for labor-intensive manual tasks.

5.3.2.2 Accurate forecasts and risk management. Several participants agreed that such systems will help project management teams to get accurate forecasts and can efficiently predict the outcome. Furthermore, a few participants also indicated the integration of these systems with cost and risk management tools to efficiently assess and quantify potential risks and their associated costs.

5.3.2.3 Reduced time and human resources. One of the participants also mentioned the potential reduction of time and human resources involved in the existing process and the elimination of subjective assessment of the completed tasks by the site supervisor or engineer.

5.3.2.4 Effective project control and delivery. Most of the participants agreed that technologically advanced tools will be beneficial for project management teams to effectively control various aspects of the project and deliver them within the agreed time and cost.

5.3.3 Barriers to adopting advanced methods. 5.3.3.1 Lack of clients' knowledge. In response to the identification of key barriers to the adoption of advanced progress monitoring and reporting techniques, all participants indicated that the lack of clients' knowledge about such technologically advanced systems is the major barrier in this regard. This is translated into the absence of the requirement for the use of these advanced methods on construction projects. Since it is not required by the client and is not mandated by the construction contract, no contractor will invest the required resources towards the implementation of advanced systems on their projects.

5.3.3.2 Lack of contractors' knowledge. Moreover, a few participants also identified a lack of knowledge of the contractor as well. The contractors' higher management has no idea about the availability and capabilities of such systems.

5.3.3.3 Lack of skilled individuals. Furthermore, participants also listed the lack of skillful individuals in the market with the required skill set to efficiently implement such technologically advanced systems and reap the offered benefits.

5.3.3.4 Lack of availability of advance systems. One of the participants also mentioned that there are very limited options available for such advanced progress monitoring and reporting systems with certain capabilities and drawbacks. These might not cater to the dynamic nature of various types of construction projects and a bespoke system might work on building construction projects and not on infrastructure projects. A contractor with a diverse portfolio will always be busy making certain tweaks to such systems for every project scenario which will again require additional resources on top of the initial investment to procure and implement the system.

5.3.3.5 High costs. One of the participants also mentioned that another barrier to adopting advanced methods is their high costs compared to traditional methods.

Construction project planning, monitoring and control does not simply comprise of the progress data collection from the worksite throughout the project lifecycle. This is a holistic process which spans across all phases of a construction project, i.e. initiation, planning, execution and closing out. As identified by this research, before the execution of the project all contractual requirements are first translated into a comprehensive project management plan which further directs the project planning and control protocols. Initial planning corresponds to various cost, time and productivity estimates and hence the submission of an accurate baseline schedule whereas the project control comprises of measuring work progress, cost and schedule control, forecasting at completion and schedule updating (Hegazy, 2013). As identified by previous researchers (Davidson and Skibniewski, 1995; Matthews *et al.*, 2015; Navon, 2005; Omar and Nehdi, 2016), this study also concluded that the use of manual, labor-intensive and document-centric process still prevails in the construction practices of today. Despite years of research into automating the progress monitoring and reporting process through the introduction of advanced data acquisition techniques (Omar and Nehdi, 2016), automated analysis methods (Mostafa and Hegazy, 2021) and modern progress reporting and visualization tools (Ekanayake *et al.*, 2021); the construction industry largely seems to stay away from adopting technologically advanced tools and techniques.

The prevailing construction progress monitoring process is purely driven by the contractual obligations of the owner/client of the project. Generally, clients are simply following the standard form of the contract, either put forward by the FIDIC or the New Engineering Contract (NEC), which are often modified to suit their specific requirements. Usually, the client aims to achieve the planned objectives of a construction project at the lowest possible cost. Therefore, the special modifications within the terms of standards contracts may cost additional effort on the part of all stakeholders because they need to accommodate those special requests by going an extra mile away from their routine process. This is the primary cause of the continued practice of traditional practices not only for construction progress monitoring but in all processes during construction execution. However, some studies have suggested that the implementation of intelligent contracts in the construction industry could allow for the integration of more effective or technologically advanced tools to improve operational efficiency and potential cost savings (Mason, 2017).

Furthermore, this study identified that the construction progress monitoring process is a complicated process which requires multiple data inputs involving several project actors. The completion status of any specific activity depends on multiple data types, i.e. actual start date, actual finish date, percent completion and earned manhours. Despite many proofs-of-concept and several field demonstrations in various countries, no automated system has been widely adopted or proven to provide the level of information required by construction teams for effective progress estimation and further decision-making to deliver the project within its contractual duration. Similarly, Omar and Nehdi (2016) also agree that the acquisition of a complete dataset and the integration across different construction areas will enable the integration of such technologies within traditional construction management practices. As identified in this research study, along with different data types that are being collected from the work site, the data reporting times also vary throughout the industry. Usually, the clients require the contractor to submit a detailed monthly report to analyze the progress of the project for their financial or other administrative purposes. However, the reporting time within contracting organizations varies from daily to fortnightly reporting. This poses another limitation to effective decision making by project management teams and hinders successful project management. Hegazy (2013) highlighted the potential of getting progress monitoring data daily for an effective project management. Moreover, many studies have presented the automated project performance control for construction projects solely based on the idea of gathering and analyzing the progress information daily and automatically to ensure the speed and accuracy of collected information and resultantly effective project management and control to ensure timely delivery of the project (Matthews *et al.*, 2015; Navon, 2005). Furthermore, building upon this idea, recent review study by Sami Ur Rehman *et al.* (2022a, b) discussed the potential of collecting, retrieving, analyzing and visualizing the progress information through CV-based CPM and presented an overview of available tools and techniques along with their advantages and limitations. However, as this study identified, the project management teams are already getting the information from the work site daily through DPRs, but why this information is not adequate to facilitate necessary decisions to avoid project delays?

However, none of the studies ever discussed the idea of getting progress information at this pace and what do they do with such information from the perspective of project management teams and decision-making capabilities. This leads to another shortcoming in the current method which is nonexistence of reasonable mechanism or protocol for the collected progress information. There is no mechanism in place to analyze, process and take necessary corrective actions if any delay has been identified through DPRs to steer the project away from potential delays. There are superficial checks in place; however as per the interviewees those checks are far from sufficient to make use of the information available daily or in real time for that matter. Since such reporting methods are internal, clients do not have the luxury to get such information until it is too late for them to do anything useful rather than just accepting the situation and directing the contractor to update the schedule and revise and resubmit the baseline with new completion dates or resources necessary to achieve the target completion of the project. This lack of effective mechanism will also affect the decision-making despite the availability of real-time progress information. So, the question is not only to get the information as accurate as possible automatically but also to address the lack of mechanisms to deal with such information and propose effective techniques to make use of such information otherwise the availability of real time progress information will not be as effective as research studies claim at this point.

Lastly, most of the interviewees highlighted the lack of incentive to adopt modern technology to improve project management processes, especially the CPM process, which is not a new debate as discussed by a plethora of research studies. However, this is not entirely true because of the lack of knowledge of the industry practitioners regarding the availability of technologically advanced techniques in the realm of ACPM as identified by Sami Ur Rehman and Tariq Shafiq (2022). On the other hand, those who knew the availability of such techniques also pointed towards another critical factor which is the capabilities of the available techniques regarding the CPM process. As highlighted by

Sami Ur Rehman *et al.* (2022a, b) that majority of currently available tools and techniques demonstrated their abilities in a controlled environment and with only selected construction feature therefore the lack of capability of the ACPM technologies also hinders their integration into the mainstream traditional project management practices as well.

6. Research implications

This research provides a comprehensive overview of the current progress monitoring process in the construction industry, highlighting gaps and limitations in existing methods. These methods include manual data collection, subjective assessment, inaccurate forecasts and the lack of effective decision-making and corrective actions. The study identifies factors that influence the adoption of advanced methods and techniques, such as contractual obligations, client requirements, knowledge and skills and the availability and capabilities of automated systems. The research suggests that integrating intelligent contracts and automated systems can improve operational efficiency and cost savings in construction projects by providing integrated progress information for proactive management. Additionally, the study highlights the need for further investigation and experimentation to determine the feasibility of advanced progress monitoring methods. Furthermore, this study is a pivotal point for research on automated progress monitoring in construction projects. It provides insight into the real problems and challenges of the industry, which will help researchers steer future research in this domain. Overall, this research serves as a benchmark for future studies and comparisons, providing valuable insights for advancing progress monitoring in the construction industry.

7. Conclusion

For the past three decades, the published research has been reporting on the manual nature of CPM methods being followed in the construction industry. Moreover, research efforts have been proposing technologically advanced tools and techniques to improve the efficiency of the existing CPM method or entirely replace the traditional techniques with automated ones. Despite such efforts, the construction industry seems reluctant to adopt such advanced tools and keep sticking to the labor-intensive and ineffective techniques. This research study aimed at exploring and understanding the prevailing CPM techniques and providing a holistic overview of the current methods to understand the motivation of the industry behind continued usage of such techniques. This research study summarizes current CPM process from the viewpoint of contractual obligations, provided an overview of current CPM practices, i.e. from planning to progress data collection from the worksite and from analyzing the progress data to reporting the useful information to all the stakeholders and explored the motivation of continued usage of such techniques by the industry and possible point of departure from traditional methods to ACPM techniques. The results of this research efforts confirmed that the prevailing CPM methods are heavily mandated by the construction contracts and a widely accepted way of progress reporting throughout the construction industry. Also, the prevailing CPM method relies heavily on document-centric and labor-intensive techniques to collect, analyze and report progress information, which makes it slow, erroneous and ineffective. Lastly, the industry practitioners acknowledged their realization of the shortcomings of current methods and opinionated several suggestions towards improving the existing methods, integrating technology into traditional methods and replacing prevailing methods with technologically advanced tools and techniques. This research discussed and concluded that there is a need for research which holistically addresses the automation of the CPM process from every angle, i.e. business case, management practices, contractual allowance, stakeholders' awareness and willingness, resources required, etc., not just the technology.

However, this research study did not explore the comprehensive needs and requirements of construction contracts and expectations of construction industry practitioners from the automated systems. Future research endeavors are directed toward exploring such requirements and laying down guidelines for the integration of advanced tools and techniques for resolving progress monitoring and reporting related problems throughout the CPM process, i.e. planning, execution and closing-out phases of a construction project. Since this research study explored the existing construction progress monitoring practices by conducting semi-structured interviews with a relatively small number of industry practitioners, future research study can gather shortcomings, barriers and potential of ACPM, as identified in this research study, to confirm these findings from a larger demographic. Further research efforts will focus on in-depth exploration of the contractual and procedural requirements of the CPM process and assess the available technologically advanced tools and techniques for their effectiveness and potential of replacing the traditional process.

References

Ali, U. and Kidd, C. (2014), "Barriers to effective configuration management application in a project context: an empirical investigation", *International Journal of Project Management, Pergamon*, Vol. 32 No. 3, pp. 508-518, doi: 10.1016/J.IJPROMAN.2013.06.005.

Alizadehsalehi, S. and Yitmen, I. (2019), "A concept for automated construction progress monitoring: technologies adoption for benchmarking project performance control", *Arabian Journal for Science and Engineering*, Vol. 44 No. 5, pp. 4993-5008, Springer Verlag, doi: 10.1007/S13369-018-3669-1/METRICS.

Arthur, W. (1994), "Inductive reasoning and bounded rationality", *The American Economic Review*, Vol. 84 No. 2, pp. 406-411, doi: 10.2307/2117868.

Boyce, C. and Neale, P. (2006), *Conducting In-Depth Interviews: A Guide for Designing and Conducting In-Depth Interviews for Evaluation Input*, Vol. 2, Pathfinder International, Watertown, MA, available at: https://cnxus.org/wp-content/uploads/2022/04/Boyce_In20Depth20Interviews.pdf

Braun, V. and Clarke, V. (2006), "Using thematic analysis in psychology", *Qualitative Research in Psychology*, Vol. 3 No. 2, pp. 77-101, doi: 10.1191/1478088706QP063OA.

Changali, S., Mohammad, A. and Van Nieuwland, M. (2015), "The construction productivity imperative", *McKinsey Quarterly* June, pp. 1-10.

Davidson, I.N. and Skibniewski, M.J. (1995), "Simulation of automated data collection in buildings", *Journal of Computing in Civil Engineering*, Vol. 9 No. 1, pp. 9-20, doi: 10.1061/(asce)0887-3801(1995)9:1(9).

Doloi, H., Sawhney, A., Iyer, K.C. and Rentala, S. (2012), "Analysing factors affecting delays in Indian construction projects", *International Journal of Project Management*, Vol. 30 No. 4, pp. 479-489, Pergamon, doi: 10.1016/J.IJPROMAN.2011.10.004.

Ekanayake, B., Wong, J.K.W., Fini, A.A.F. and Smith, P. (2021), "Computer vision-based interior construction progress monitoring: a literature review and future research directions", *Automation in Construction*, Vol. 127 January, 103705, Elsevier B.V, doi: 10.1016/j.autcon.2021.103705.

Fusch, P. and Ness, L. (2015), "Are we there yet? Data saturation in qualitative research", *Walden Faculty and Staff Publications*, Vol. 20 No. 9, pp. 1408-1416, available at: https://scholarworks.waldenu.edu/facpubs/455/

Hegazy, T. (2013), "Computer-based construction project management", *Pearson Higher Education*, available at: https://www.pearson.ch/HigherEducation/Pearson/EAN/9781292027128/Computer-Based-Construction-Project-Management-Pearson-New-International-Edition (accessed 14 October 2021).

Ika, L.A. and Saint-Macary, J. (2012), "The project planning myth in international development", *International Journal of Managing Projects in Business*, Vol. 5 No. 3, pp. 420-439, Emerald Group Publishing, doi: 10.1108/17538371211235308/FULL/PDF.

Keyvanfar, A., Shafaghat, A. and Awanghamat, M.A. (2021), "Optimization and trajectory analysis of drone's flying and environmental variables for 3D modelling the construction progress monitoring", *International Journal of Civil Engineering 2021 20:4*, Vol. 20 No. 4, pp. 363-388, Springer, doi: 10.1007/S40999-021-00665-1.

Kopsida, M., Brilakis, I. and Vela, P. (2015), "A review of automated construction progress and inspection methods", *Proceedings of the 32nd CIB W78 Conference on Construction IT*, January, pp. 421-431.

Kulatunga, K., Amaratunga, D. and Haigh, R. (2007), "Researching construction client and innovation: methodological perspective", *7th International Postgraduate Research Conference in the Built and Human Environment*, 27th - 28th March, pp. 479-488.

Mantel, S. and Meredith, J. (2009), *Project Management: A Managerial Approach*, John Wíley and Sons, New Jersey, NJ.

Mason, J. (2017), "Intelligent contracts and the construction industry", *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, American Society of Civil Engineers*, Vol. 9 No. 3, 04517012, doi: 10.1061/(ASCE)LA.1943-4170.0000233.

Matthews, J., Love, P.E.D., Heinemann, S., Chandler, R., Rumsey, C. and Olatunj, O. (2015), "Real time progress management: Re-engineering processes for cloud-based BIM in construction", *Automation in Construction*, Vol. 58, pp. 38-47, Elsevier, doi: 10.1016/J.AUTCON.2015.07.004.

Mostafa, K. and Hegazy, T. (2021), "Review of image-based analysis and applications in construction", *Automation in Construction*, Vol. 122 October 2020, 103516, Elsevier B.V, doi: 10.1016/j.autcon.2020.103516.

Navon, R. (2003), "Automated project performance control of construction projects", *Proceedings of the 20th ISARC*, Eindhoven, Holland, pp. 78-81.

Navon, R. (2005), "Automated project performance control of construction projects", *Automation in Construction*, Vol. 14 No. 4, pp. 467-476, Elsevier, doi: 10.1016/J.AUTCON.2004.09.006.

Navon, R. and Sacks, R. (2007), "Assessing research issues in automated project performance control (APPC)", *Automation in Construction*, Vol. 16 No. 4, pp. 474-484, doi: 10.1016/j.autcon.2006.08.001.

Omar, T. and Nehdi, M.L. (2016), "Data acquisition technologies for construction progress tracking", *Automation in Construction*, Vol. 70, pp. 143-155, Elsevier B.V, doi: 10.1016/j.autcon.2016.06.016.

Sami Ur Rehman, M. and Shafiq, M.T. (2022), "Automated construction progress monitoring – industry perspective", *The Twelth International Conference on Construction in the 21st Century (CITC-12)*, Amman.

Sami Ur Rehman, M. and Tariq Shafiq, M. (2021), "Identifying the process for automated vision-based construction progress monitoring", *8th Zero Energy Mass Custom Home (ZEMCH 2021) International Conference*, Dubai.

Sami Ur Rehman, M., Shafiq, M.T. and Ullah, F. (2022a), "Automated computer vision-based construction progress monitoring: a systematic review", *Buildings*, Vol. 12 No. 7, pp. 1-32, doi: 10.3390/buildings12071037.

Sami Ur Rehman, M., Thaheem, M.J., Nasir, A.R. and Khan, K.I.A. (2022b), "Project schedule risk management through building information modelling", *International Journal of Construction Management*, Vol. 22 No. 8, pp. 1489-1499, Taylor & Francis, doi: 10.1080/15623599.2020.1728606.

Saunders, M., Lewis, P. and Thornhill, A. (2009), *Research Methods for Business Students*, 5th ed., Prentice Hall, pp. 128-130.

Tracy, S. (2019), *Qualitative Research Methods: Collecting Evidence, Crafting Analysis, Communicating Impact*, John Wiley and Sons, New Jersey, NJ.

Vanhoucke, M. (2012), "Measuring the efficiency of project control using fictitious and empirical project data", *International Journal of Project Management*, Vol. 30 No. 2, pp. 252-263, Pergamon, doi: 10.1016/J.IJPROMAN.2011.05.006.

Corresponding author
Muhammad Tariq Shafiq can be contacted at: muhammad.tariq@uaeu.ac.ae