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INVESTIGATION OF ROOT CAUSES OF DELAYS AND THE DATA USAGE TRENDS IN THE INDIAN CONSTRUCTION SECTOR

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Abstract: Construction projects often deviate from their planned schedule and have poor records about the updates on the project's progress. Access to project data is a crucial aspect that seeks attention to make data-driven decisions to reduce delays. Therefore, this research aims to investigate the causes of delays and the available data usage, specifically during the execution phase of a building construction project. The factors causing cost and time overruns and the less use of Electronic Data Management Systems (EDMS) were identified from the past literature. A questionnaire survey was conducted with 100 Indian professionals to assess the impact of the shortlisted factors and the data usage trends in the Indian context. Henry Garret's method was used to rank the factors. The experts were interviewed to investigate the root causes of the delays and identify the triggering events that cause the same. The survey findings indicated the change in scope of work, continuous revisions in the drawings, and delay in approval from higher authorities as the top three reasons. 88.8% of the respondents from the survey were affirmative that real-time monitoring of a project would help them to address the delay issues. This research presents a unique attempt to identify the delay causes specifically during the project's execution phase, along with outlining the data usage trends in the Indian context. The work can be extended to developing a real-time monitoring framework to optimally utilize the data of a project's execution phase.

Keywords: Data, Delay; Electric Document Management System (EDMS); Henry Garret's method

1 INTRODUCTION

The global construction industry is observing a huge surge in demand to deliver projects on time and within budget. The complexity of modern construction projects has increased manifold. (Ribeirinho et al. 2020). Construction projects handle a vast amount of data in hard copy documents throughout their lifecycles. The data volumes increase significantly during the design and execution phases (Guo et al. 2021). The information about the project data is a very critical and fundamental ingredient. It helps the top management to take further decisions or corrective measures to keep the project on track. Hence, there is a crucial need to firstly store the project data digitally and track it in a rational way to make data-driven decisions (Thomas and Bowman 2022).

Despite a share of 13% (accounts to $85 trillion) in global GDP, the construction industry has observed productivity growth of merely 1% annually over the past two decades. The issues of cost and time overruns have become like a norm (Ribeirinho et al. 2020). In the same context, when the national scenario is concerned, the Indian construction sector contributes around 9% in the national GDP and is the second-

largest employer, followed by the agricultural sector. India is foreseeing rapid growth in infrastructure development, with the government policies giving thrust to the construction sector. Also, the budgetary allocation for the sector has increased significantly. While this is seen as a welcome step, it becomes crucial to manage large-scale projects in respect of time and cost.

In India, there are two categories of construction projects based on cost allocation (Narayanan et al. 2019). Major Projects: these projects have costs in the range of USD 20 million to USD 133 million. Mega Projects: these projects have cost more than USD 133 million. Ministry of Statistics and Program Implementation (MoSPI 2022) monitors projects having a cost of USD 20 million and above on a monthly basis. As per the MoSPI flash report of January 2022, 1671, central sector infrastructure projects were monitored. The statistics of the same show that out of 1671 projects, only 8 were ahead of schedule, and 268 projects were running on schedule. 514 projects were running behind schedule, whereas 443 projects were having cost overrun. 206 projects have had both cost and time overruns being observed. The overall cost overrun reported was 19.76% of the original cost.

As discussed in the previous section, the statistics of cost and time overrun are alarming. Hence, this research presents a holistic view of cost and time overruns, specifically during the execution phase of a construction phase. Also, an attempt is made to get an overview about the awareness and the trends of data usage in the Indian construction sector. In this connection, the following objectives were set:

- To find out critical factors for cost and time overruns in the construction project
- To outline the trends in data usage and data management system in construction sector

2 LITERATURE REVIEW

Literature on the issues causing cost and time overruns in construction projects is studied. The use of Electronic Document Management System (EDMS) to store the data collected during the execution phase of a construction project is identified. Also, data management practices in the construction sector are explored.

It has been observed that conventional planning methods are easy to be comprehended by various stakeholders (AlNasseri and Aulin 2015). Many stakeholders in the construction sector do not have the knowledge of modern planning and scheduling techniques which needs to be imparted. Construction organizations' culture has a very critical link with delays (Arditi et al. 2017). There are many factors that cause delays, out of which competency of top management was found as the most critical success factor, followed by proper management of the organization (Tripathi and Jha 2019). To address these issues, Key Performance Indicators (KPIs) have to be well defined. It has been observed that the Indian construction sector lacks a proper framework for Management Information Systems (MIS) (Munvar et al. 2020). MIS system can help to track three vital KPIs viz. finance, quality, and progress of a project. Automated project tracking systems using technologies viz. BIM, MS Project and Primavera can help identify delays; thereby mitigation measures can be planned well in advance to track the KPIs on a real-time basis (Omar and Nehdi 2016).

In developing countries, the issues of delays are extensively observed. In many arbitration and tribunal cases, reasons for disputes were delay in handling over the site and Extension of Time (EoT) (Munvar et al. 2020). In a study by Narayanan et al. (2019), Prasad et al. (2019), and Wanjari and Dobariya (2016), escalation in prices of raw materials, irregularities in planning project activities, and communication gap and conflict among various stakeholders of the project, lack of knowledge, financial failures, delayed decision were found as main causes, leading to cost overrun. The aforementioned delays are dependent on each other and are cumulative in nature. Hence, emphasis should be given to identifying triggering events that lead to these delays (Hsu et al. 2017).

The data volumes increase significantly during the design and execution phases (Guo et al. 2021). Electronic Document Management System (EDMS) is a platform which can store all necessary data in digital format. It includes storing of AutoCAD files (.dwg), Plot files (.plt), MS word files (.doc), Adobe PDFs,

MS Excel files (.xls) etc. Past studies have shown that the EDMS system is not used up to the expected level of system structure. Only a small proportion of construction professionals use it in extensive manner (KPMG 2019; Kähkönen and Rannisto 2015). The consequence of low use of EDMS would result in low performance at organizational levels. Effective use of EDMS can help to improve the workflow and MIS in any organization (Omar and Nehdi 2016). Figure1 show the status of digitization in the construction sector. It can be inferred from Figure 1 that 96% of the data in the Engineering and Construction (E&C) industry remains unused. Hence, it is not used up to its potential. Also, 13% of the total working hours are spent in segregating data to extract useful insights. When the format of data is viewed, 90% it is unstructured. 30% of the modern construction firms use applications which do not integrate with each other, hindering the data transfer mechanism. Presently, at the global level, only 8% of the E&C firm have a real-time Project Management Information System (PMIS). This data statistics enlightens the need to develop a data-driven system for project monitoring and seek the attention of construction professionals to justify the importance of the same. This can help take more objective decisions and reduce the chances of delay (Snyder et al. 2018).

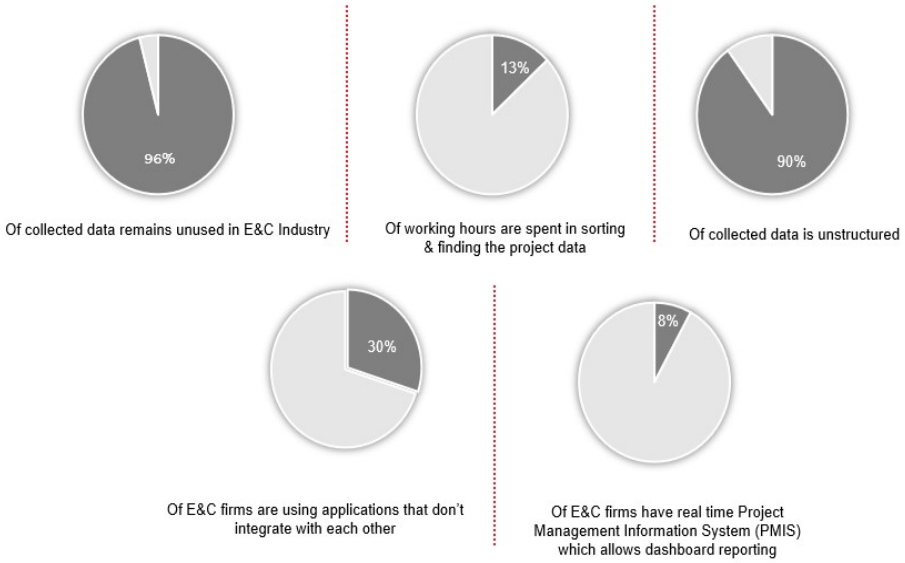

Figure 1: Status of digitization in the construction sector (Snyder et al. 2018)

To justify the success of research work, critical attributes for the study should be identified (Doloi et al. 2012). Past literature has done well-versed work on attributes leading to cost and time overruns in the construction project. However, research on specific phase (example, the execution phase in the present study) of a construction project is still unexplored. Moreover, the usage of data in the construction sector is another vibrant area that needs to be explored. In this regard, this research presents a holistic view to investigate the causes of delays and the usage of the available data, specifically during the execution phase of a building construction project.

3 RESEARCH METHODOLOGY

The factors causing cost and time overruns in construction projects were explored in detail in the literature review section. Also, the usage of data and EDMS were explored to get an insight into current practices and issues in the same. Figure 2 shows the flow chart of the research methodology adopted for the present study.

For the study, twenty key factors causing cost and time overruns during the construction execution phase were identified (Annamalaisami and Kuppuswamy 2019; Hsu et al. 2017; Lindhard and Wandahl 2014; Doloi et al. 2012). Before formulating the questionnaire, these factors were discussed with the industry experts to include their perspectives and suggestions. Because some of the factors were dependent or

were the consequences of the parent factors, they were consolidated to ten prime factors, shown in Table 1. These identified ten factors were examined based upon a five-point Likert scale as follows: 1= Strongly Disagree, 2= Disagree, 3= Neutral, 4= Agree, 5= Strongly Agree (Table 1).

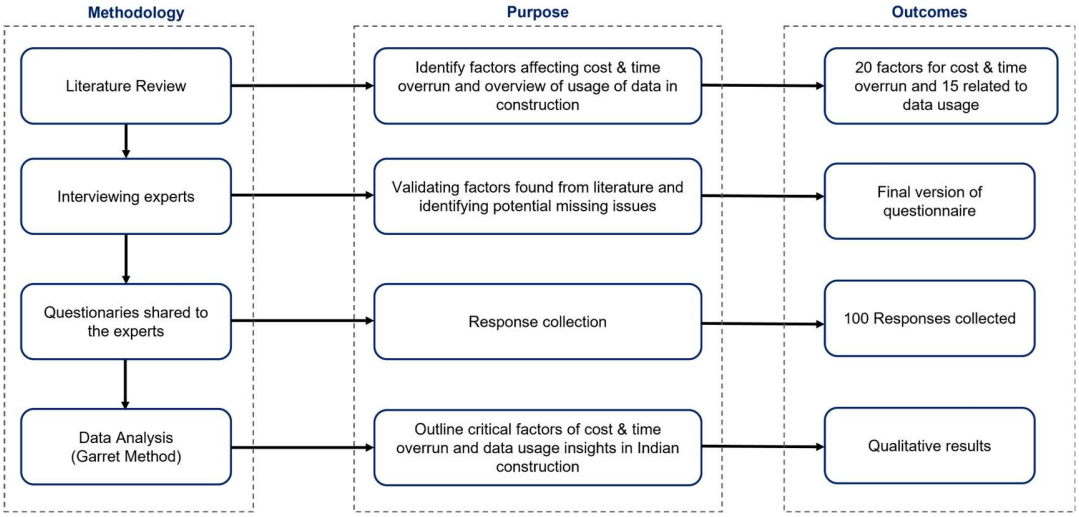

Figure 2: Research methodology framework

Table 1: Finalized factors causing cost and time overruns

No.	Factor
1.	Change in scope of work
2.	Continuous revisions in the drawings
3.	Delay in material delivery by vendor
4.	Rework due to poor quality of work during execution
5.	Site accidents due to poor safety of measures
6.	In accurate scheduling of activities and poor resource planning
7.	Communication gap between internal/external stakeholders
8.	Cost and time overrun due to traditional methods of construction
9.	Delay in approval from higher authorities
10.	Lack of proper project progress monitoring framework

Similarly, current data usage trends and use of Electronic Document Management System (EDMS) were studied. The issues for low usage of EDMS were identified (Guo et al. 2021; Ghanem et al. 2015; Arnold and Javernick-Will 2013; Hjelt and Björk 2007). Major reasons were found as the lack of skilled users, resistance to adopting new technologies, security protocols, substantial initial investment, and the user interface.

The factors for EDMS from the literature were purely subjective and qualitative in nature. These cannot directly depict the data usage trends in the construction sector. Therefore, industry experts suggested a simpler format of the questionnaire related to data usage. A total of eight questions were asked with varying options (likert-point scale, yes/no, percentage-wise categorization). The questions were related to personal opinions of the usage of the various system to store data, the efficiency of the system, data analysis in construction, and whether real-time tracking will help reduce cost and time overrun issues.

3.1 Data Collection

From the questionnaire survey floated among 210 industry professionals, 100 responses were received. Their average experience was recorded as 12.54 years. Figure 3 shows the respondents' profile, wherein 67% of the respondents were from the Planning department, 26% were from the Execution department, and the remaining 7% were from various departments, viz. Billing, Contract Administration, Quality etc.

Before using any research technique for data analysis, the credibility of the responses has to be checked (Ingle and Mahesh 2020). For this study, the reliability of the responses was checked using Cronbach's alpha method. Cronbach (1951) first introduced Cronbach alpha method to assess the internal consistency by comparing the amount of shared variance, or covariance, among the responses to the amount of overall variance. The value for of Cronbach alpha range lies in between 0.0 to 1.0, where 0.70 is considered as the minimal acceptance value. Thus, for the present study it was found to be 0.89, indicating that it was well above the cut-off limit of 0.70. Therefore, further analysis of the responses can be done.

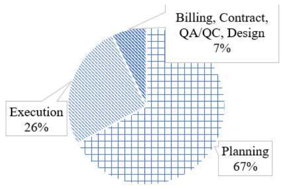

Figure 3: Respondent's Profile

3.2 DATA ANALYSIS USING HENRY GARRET METHOD

The Henry Garret technique is used to analyze the responses and rank factors causing cost and time overruns by using eq. (1).

$$\text{Percent Position} = \text{Ru} \times (\text{Rij} - 0.5) \div \text{N} \qquad \text{……(1)}$$

Where, Ru = total number of responses received (Here, Ru = 100), Rij = Rank allotted to alternatives as per its importance (Rij = 1,2,3,4,5), N = Total number of ranks (N=5, Strongly Agree to Strongly Disagree). The Garret value score was calculated using Garret Score as shown in the Table 2.

Table 2: Ranking of factors using Garret method

	Garret Score					Total Score	Average Score (%)	Rank
Factor's Rank	1st	2nd	3rd	4th	5th			
Change in scope of work	4050	1800	350	240	72	6512	65.12	1
Continuous revisions in the drawings	3300	2340	350	320	48	6358	63.58	2
Delay in approval from higher authorities	2700	2700	550	240	48	6238	62.38	3
Communication gap between internal/external stakeholders	2625	2700	450	320	72	6167	61.67	4
In accurate scheduling of activities and poor resource planning	3375	1800	450	320	192	6137	61.37	5
Delay in material delivery by vendor	2325	2760	650	280	72	6087	60.87	6
Lack of proper project progress monitoring framework	1800	2760	600	400	192	5752	57.52	7
Rework due to poor quality of work during execution	1875	2340	950	320	216	5701	57.01	8
Site accidents due to poor safety of measures	1425	1920	1550	400	192	5487	54.87	9
Cost and time overrun due to traditional methods of construction	825	2160	1700	560	120	5365	53.65	10

4 RESULTS OF DATA USAGE TRENDS IN THE INDIAN CONTEXT

In this section, the results of subjective questions asked to experts regarding the data usage trends in the Indian context are discussed. Figure 4(a) shows that 40.4% of respondents strongly agreed, and 44.4% agreed that real-time monitoring of projects would help reduce the cost & time overrun issues. Figure 4(b) shows that 68.7% of the respondents were monitoring projects using various systems/software viz. Microsoft Excel spreadsheets, scheduling software (Microsoft Project, Primavera, Tilos), Customized Enterprise Resource Planning (ERP) systems, customized software etc. Figure 4(c) presents that 63.2% of the respondents reverted that around 24% of cost and time overrun issues can be controlled using the real-time monitoring system. The awareness about the data analysis among processionals was found to be of a moderate level (58.6%) as shown in Figure 4(d). Figure 4(e) shows that 63.6% of the respondents said their organisation used previous data to forecast risks in the upcoming planned activities. Figure 4(f) display that 58.6% of respondents were tracking Key Performance Indicators (KPIs) (Cost, Time, Quality) on a real-time basis. However, most of them referred to data from spreadsheets to track the cost usage. Lastly, Figure 4(g) 86.9% of the respondents were affirmative that if the constraints and requirements are tracked on a real-time basis, it can help the top management take more objective decisions, thereby reducing the issues of cost and time overrun.

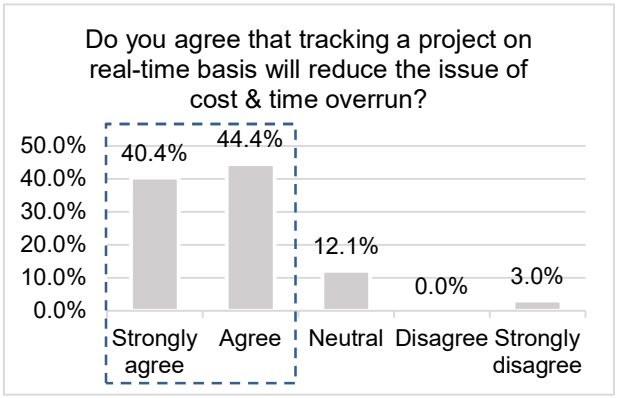

Figure 4(a): Responses on real-time monitoring system

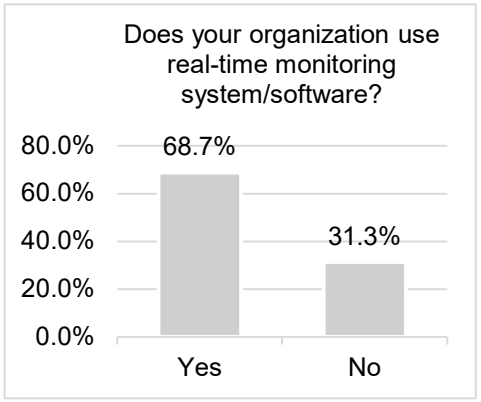

Figure 4(b): Current use of project monitoring systems/software

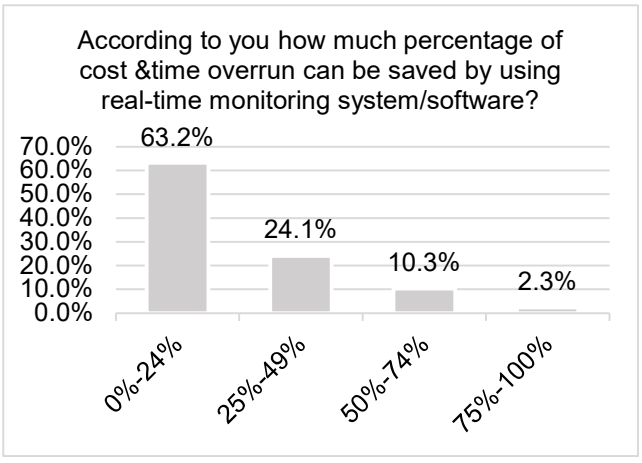

Figure 4(c): Percentage wise reduction in cost & time overrun issues due to use of real-time monitoring systems/software

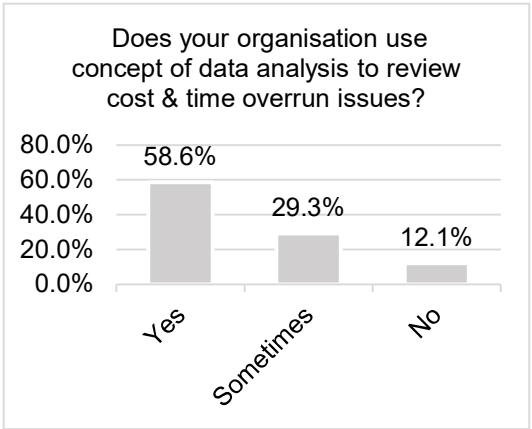

Figure 4(d): Responses on awareness about data analysis

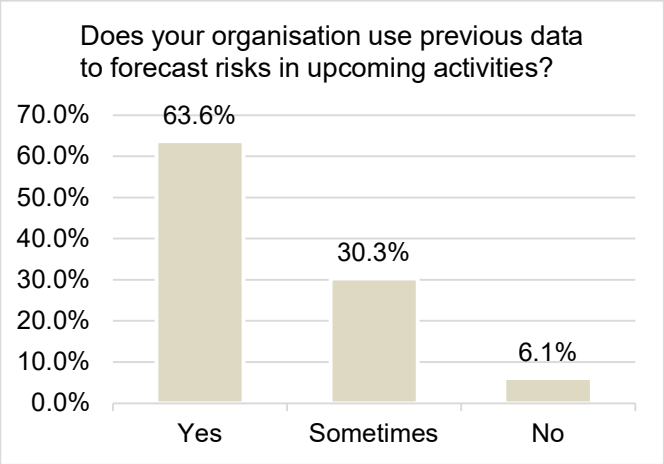

Figure 4(e): Responses on risk forecasting using available data

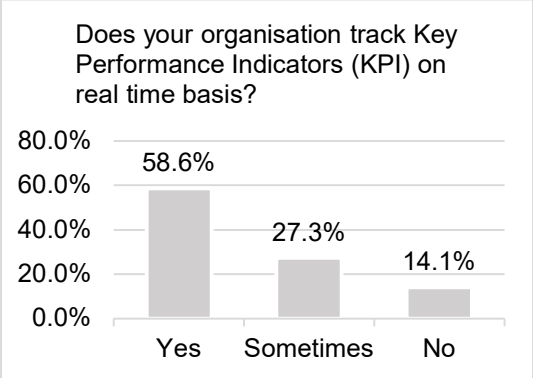

Figure 4(f): Awareness on use of KPIs to track the project

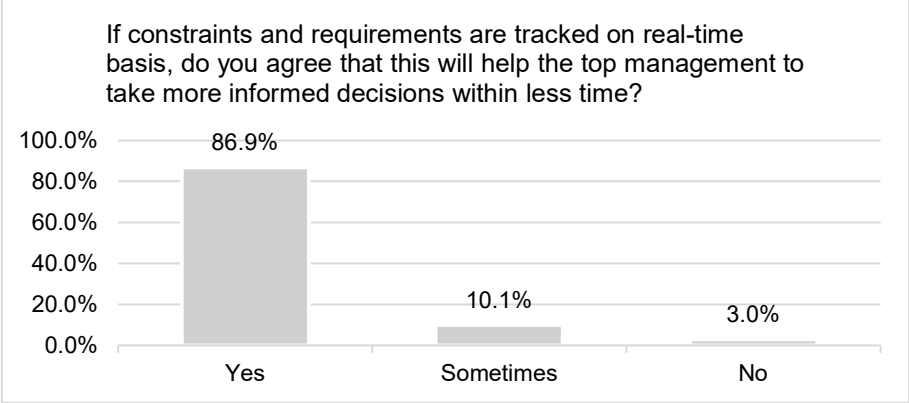

Figure 4(g): Responses on project constraints and requirements analysis

5 DISCUSSIONS

The response analysis using the Henry Garret method showed Change in the scope of work as the key reason for cost and time overrun issues, followed by continuous revisions in the drawings, delay in approval from higher authorities and communication gap between various stakeholders. The discussions with the experts revealed that around 80% of the changes in scope of works occur during the execution phase only. It may be due to design changes, change in the functionality of the structure (Residential to commercial or changing the number of storeys to be constructed and so on). The client's clarity and vision for the project is very much essential. The client's indecisiveness creates hindrances which need to be addressed. In any project, the flow of drawings among various stakeholders is as per Figure 5.

Architect transfer drawing to the structural consultant from where, MEP consultant approves the same and lastly Goods for Construction (GFC) drawing is prepared. Any revision in the GFC drawing is passed back to the architect, and the cycle repeats. Poor coordination among these stakeholders leads to clashes and is the root cause for continuous revisions in the drawings. Since the consultants do not send the drawings on time, the top management takes a longer time to approve them. This was found as key root cause for the delay in approval from higher authorities.

The discussions with the experts also revealed that the revenue (cash flow) should be generated from work being completed. Otherwise, the contractor himself has to add the capital, which can trigger the cost

overrun. The concept of Customer Relationship Management (CRM) can help to regulate the cash flow cycles.

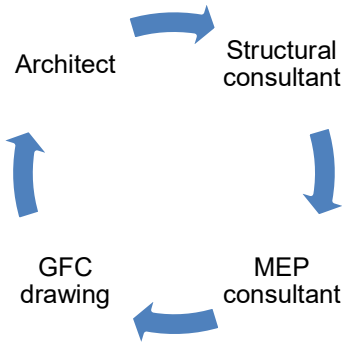

Figure 5: Transfer of drawings among various project stakeholders

The usage of capital on various activities should be tracked precisely. Often, funds allocated for an activity are used to complete other activities, due to which set milestones are not achieved, and it delays the payment from the client. It has to be noted that money in terms of stock is harmful. It should generally be in liquid form only. Discussion with the experts outlined two terminologies viz. cost of money and cost of time, which are explained using the following example. Consider that for a building construction project having an area of 2.5 Lakh sq ft, the interest/day/sq ft is USD 0.00664; hence, the interest/day is around USD 1660/day. Now, if the project is delayed by 1 day, it will cost the contractor a loss of around USD 1660/day. This example justifies the cost of time that even delaying a project by just 1 day; it is significantly causing a cost overrun. This micro-level analysis is found to be absent among the contractors, which leads to the burning of their profit.

As per Figure 4(a) 88.8% of the respondents (40.4% strongly agree and 44.4% agree) affirmatively said that real-time tracking could reduce the cost and time overrun issues. The most common responses for the current software/system used to track the project were MS-Excel spreadsheets, MS-Project, Primavera P6 by Oracle, Customized ERP (Enterprise Resource Planning) systems and Power-Bi. The advantage of real-time monitoring is explained below:

A project has a total duration of six months. Assuming that it takes one week for the planning engineer to send a progress report to the top management to take further decisions. By sending of the report, the work completed in that one-week duration is not incorporated in the report. Hence, the decision taken by the authority will be outdated and not the actual one. This justifies the need to monitor the progress on a real-time basis to make more informed and data-driven decisions. In most of the discussions with the experts, a common issue for delays was observed that the Project Manager did not have enough access to the data based on which he could make any decisions. Hence, the site Project Manager should be involved from the start of the project kick-off meeting.

6 CONCLUSIONS

The present study outlined the key factors leading to cost and time overruns in the execution phase, along with the data usage trends in the Indian construction sector. The change in scope of work, followed by continuous revisions in the drawings, delay in approval from the higher authorities and communication gap between various stakeholders were key reasons for the delays. The client's indecisiveness was one of the key issues as per the expert discussions, which triggered these delays. 88.8% of the respondents affirmatively said that real-time tracking could reduce the cost and time overrun issues. The usage of data storage in construction has increased manifold. However, the top management is still facing difficulties in

making informed decisions. Had there been a system which could give updates on the project's progress to the top management on a real-time basis, any discrepancies could have been identified well in advance. Thereby mitigation steps can be taken at the right time to prevent the delays. The present research signifies the importance of the notion of real-time monitoring, which is to firstly have enough access to the data on which logical decisions can be taken at the right time. The limitation of the present research is to explore the relationships between the delay factors and the data usage trends in detail. Also, the issues of delays change on a regional basis. Hence, the factors may change as per the local scenario. The outcomes of the present research put a way forward to develop a real-time monitoring framework that would record and monitor the data of a project's execution phase on a real-time basis. The modern construction sector seeks an ecosystem of people driven to the process driven work culture. This attempt can be a step toward standardization of the construction sector to prevent delays.

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