

Review on Implementation of Earned Value Management (EVM) Systems

Rajani Bhavik Dineshkumar¹, R. Mahadev Swamy², Dr. Yashvant Patil³, Dr. M.S. Kuttimarks⁴, Pallavi B Padwal⁵

ME Student¹, Construction Engineering Management, Civil Engineering SSJCET, Asangaon, Thane, MH – 421601.

Associate Professor², Civil Engineering, SSJCET, Asangaon, Thane, MH – 421601.

Professor³, Civil Engineering SSJCET, Asangaon, Thane, MH – 421601.

Assistant Professor⁵, Civil Engineering, SSJCET, Asangaon, Thane, MH – 421601.

Abstract: *There are many studies and research were done for finding the causes for delay in time and overruns in the cost of the project. Earned value is a management technique which is developed for evaluating the performance of the project. We all know that the construction industry is most leading industry all over the world. The Construction industry includes major activities and their sub-activities. So projects are delayed due to overrunning of time, improper planning, and project resources. To avoid the problems many methods are implied to reduce the issue. Which helps to improve management control system of a construction project, to detect and control the problems in potential risk areas and to suggest the importance and purpose of monitoring the construction work. This analysis gives a graphical representation of the present status of the project. While in the market, there are so many software's available for project management scheduling earn vale for project and entire structure. The planned work and actual works on EVM analysis. Project management software, which define collecting, recording, monitoring, controlling and reporting function. This research explains elements of earned value key management system involved in the calculation of cost and time which are required for construction projects and analysis of commercial building. In this project, we study project controlling and monitoring can be done and cause of delay can be found out for commercial building.*

Keywords:- *Monitoring, Potential risk, Management technique, Earned Value Management, Project Scheduling, Project Monitoring.*

1.0 INTRODUCTION

1.1 General Background

The objective of Construction project management is to meet all project requisite within the budget estimated and the projected time frame. There has been a lot of competition in the construction industry in recent years as contractors try to complete their projects on time and within budget, but cost overruns

and construction delays are recurring problems that halt the completion of projects on time (Narvaez, et al., 2022). In a technologically advanced construction environment, numerous subcontractors, vendors and suppliers often have to be involved in project implementation simultaneously, which can make controlling costs and scheduling challenging (Araszkievicz & Bochenek, 2019). As a result, Project Management Control measures should be implemented to make sure that actual progress is measured and evaluated in order to finish projects on schedule and within budget by applying techniques such as Earned Value Management (EVM) (Willems & Vanhoucke, 2015). BIM (Building information Modeling), P6 (Primavera) and MSP (Microsoft Project) are some of the EVM tools and software available for implementing project control measures. A powerful construction management technique, BIM-EVM tool provides the user with an easy means of visualizing the cost and time performance of a construction project (Mushamalirwa, 2016). A Cost/Resource loaded schedule contain data to be analysed by Primavera (P6), thereby simplifying the EVM Technique and as a result, the project team can evaluate the project's health at any point in time through its lifecycle using (SPI) Schedule Performance Index and (CPI) Cost Performance Index (Costantino, 2019). By comparing the amount of work that was planned with what was actually accomplished, Microsoft Project (MSP) is able to measure project performance by using Earned Value Management and this technique evaluates the status of a project by measuring cost and schedule performance (Mehedintu, 2010). A detailed discussion of these tools and techniques will follow as the research progresses.

1.2 Earned Value Management (EVM)

“EVM (Earned Value Management) is a project management process that is structured for planning, collecting costs and tracking performance. It allows for the integration of objectives such as project scope, time, and costs as well as establishing a baseline for evaluating performance (Association for Project Management, 2006). Earned value management is a project management methodology that aims to evaluate project performance based on the integration of schedule, costs, and scope (PMI, 2008). A program, process, tool, and template used to manage EVM are called Earned Value Management Systems (EVMS). The objective of the EVM is to ensure that all tasks required to accomplish the contract are planned and resourced appropriately. Using EVM technique, helps project team understand where the project stands versus where it should have been, according to project plan. In this way, EVM provides project managers with actionable insights to assess if the initial plan is feasible and act accordingly. The following are some of the major benefits of using EVM. The current performance of a project can be used to predict the forecast with 10% deviation after 20% of a project is completed. This is the most influential way of forecasting the potential of EVM and makes it one of the best methods for managing project timeline and costs (Fleming & Koppelman, 2000).

1.3 EVM system in India

In the Indian construction industry, the EVM technique is not implemented using an integrated approach, which results in errors and a lack of transparency. Major construction firms in India use P6

(Primavera) or MSP (Microsoft Project) primarily for scheduling purposes and ERP (Enterprise Resource Planning) or SAP (System Applications and Products in Data Processing) for monitoring costs as shown in Figure 1 below.

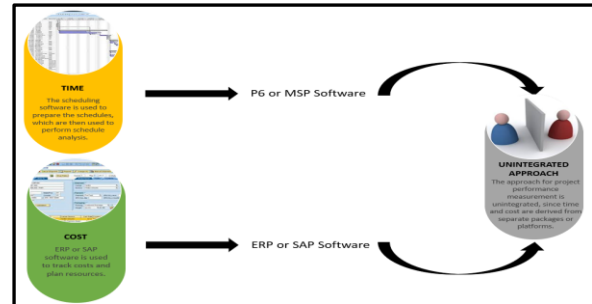


Figure 1. EVM technique used for Major projects in India.

A relatively small number of projects in India use the following 2D approach by loading the cost into P6 or MSP (as shown in Figure 2), but this approach is still far less efficient than visualizing 3D models. In India, construction projects face many challenges with the implementation of earned value management due to pressures for reporting only good news, imprecise evaluation, unavailability of management support, insufficient use of earned value management software, and ineffective communication (Vaibhava & Rao, 2019). Although, there are projects using the earned value management technique through Primavera to forecast the estimated work to be completed and provide early indications of project performance based on the schedule and cost analysis (Shukla, et al., 2016). Using real time construction projects primavera

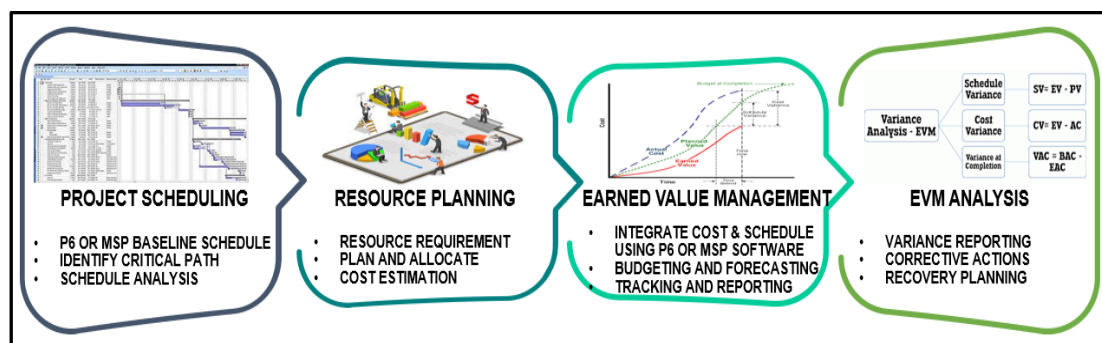


Figure 2. EVM technique used for few projects in India.

schedule, the Earned Value Analysis was applied to identify the success areas and limitations of Earned Value Management in construction projects in India. Using this data, the research validated the success areas and limitations of Earned Value Management in construction projects in India (Barikder & Paul, 2020).

Indian construction is primarily based on 2D Computer-Assisted Design (CAD) drawings, and the data is exchanged via paper prints and/or electronic prints. In addition, implementation of EVM technique involves software such as Primavera or MS projects since only a few percent of construction firms in India

use BIM due to high costs and insufficient training (Jain, et al., 2020).

1.4 EVM system in the another country

In the United Kingdom (UK), the construction industry uses BIM technology in conjunction with Earned Value Management (EVM) techniques to monitor projects. Around 73% of construction professionals

accepted that they were aware of and were implementing BIM on their projects as of 2020, compared to 26% who were just aware of its existence, and 1% who were neither aware nor implementing BIM (Hazem, 2022). The research and literature review revealed the following BIM based integrated EVM technique is adopted in the UK, which is shown below in Figure 3 & Figure 5.

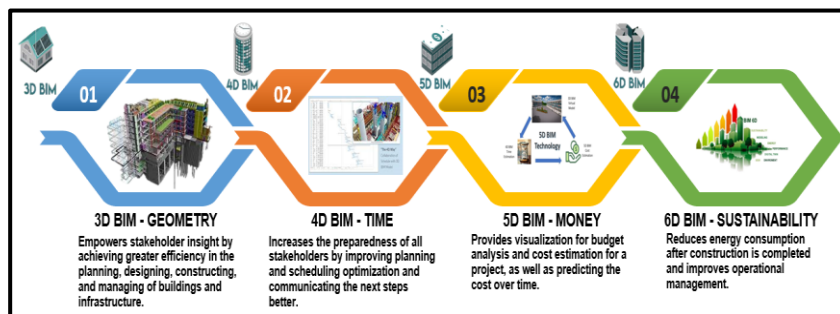


Figure 3. BIM based integrated EVM technique used for projects in the UK.

In 5D BIM model, a 3D BIM model is extended to have 4th and 5th dimensions. The 4th dimension is the time information on the 3D model, which can be derived from a 3D BIM model when the design information is associated with the anticipated and actual timelines of execution. By loading cost information into the 4DBIM model, the 5DBIM model

gets its 5th dimension. In the UK construction industry, 3D BIM models are integrated with EVM technique so that project team members can visualize virtual constructions and analyse projects using 5D BIM models for real time project performance and information, enabling management to make timely decisions.



Figure 4. BIM based integrated EVM technique used for projects in the UK (Maim Consulting, 2021).

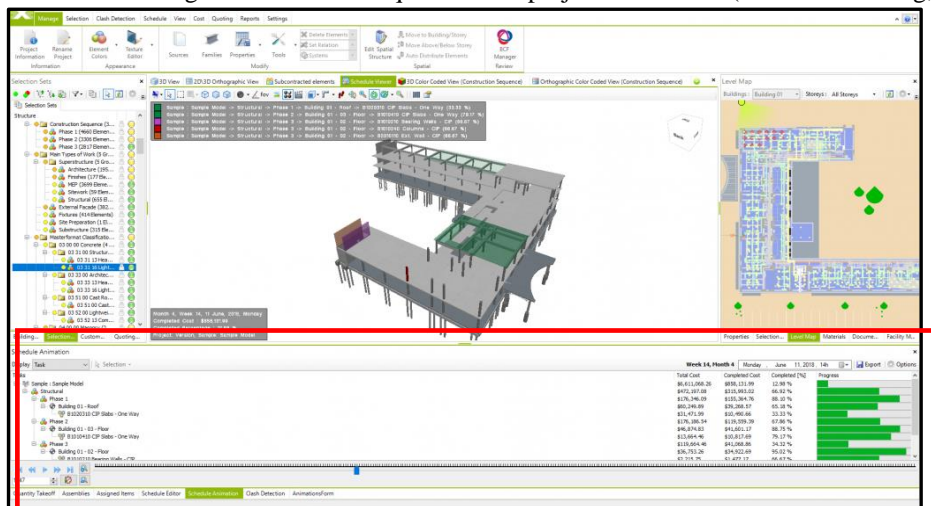


Figure 5. EVM coupled with BIM model (Tienda, 2020).

Study of time-cost integrated schedule for construction projects within BIM constraints led to the formulation of a visualized time-control model, for which adding a cost component enables the introduction of a fifth dimension (5D) (Feng, et al., 2010). For the purpose of having a progressive implementation of BIM, the government in the United Kingdom (UK) defined four levels of maturity (NBS, 2014) and directed all public projects must comply with the second level of maturity by 4th April 2016 (HM Government, 2015).

1.5 Justification for the Study

The Infrastructure and Project Monitoring Division (IPMD) reported that in November 2021, construction projects in India were delaying by an average of 39 months and 19.7% cost overrun (Offshore Technology, 2022). It is therefore necessary to implement Earned Value Management techniques and to optimize its efficiency, thus providing the Indian construction sector with a better sense of control and visibility of their projects, allowing them to meet the project deadlines and avoid extra costs. Despite the fact that the integrated performance measurements model is not adopted for implementation of EVM technique in Indian construction sector, the value-enhancing integrated technique discussed in this research has an important role to play in ensuring to maximise the efficiency of construction projects in India. The present study is therefore necessary to fill this gap. Research Aim: The study aims to examine the current methodologies involved in the implementation of EVM techniques in construction projects across the UK and India. Research Objectives: The present work paves the way for the implementation of the latest performance model applicable to the EVM, enabling construction projects in India to be as efficient as possible. This research is focused on the following objectives: Identify the key challenges of implementing EVM within the Indian construction industry. Examine the methodology used by construction companies in the UK and India to implement EVM. Evaluate whether and how technology can be used to optimising the efficiency of EVM in India by comparing the EVM implementation technique in the UK. Review the obstacles in the Indian construction industry to implementing the key enhancements identified following the comparison.

2.0 LITERATURE REVIEW

The Literature review is divided into four major parts. Its first part is about understanding the concept of

Earned Value Management. Second part is about analysing the key challenges of implementing EVM in the Indian construction industry. The third part examines the technique used by construction companies in the UK and India to implement EVM. The last section of this chapter compares both methods, identifies technology to maximize efficiency of EVM in India construction projects, and discusses barriers to implementing the key enhancements discovered. All key stakeholders associated with a project consider time and cost performance to be the most critical factors when working on it. It is every customer, contractor and client's goal to complete work in time and within budget but a good number of projects experience time and cost overruns. The recent survey conducted by M/s Cornerstone Projects has revealed that UK construction projects have experienced time and cost overruns. According to the survey, delays are usually less than 20% of the estimated delivery time, and delays can cost organisation up to 20% more than what they predicted (Constructional National, 2018). In a recent study, it was reported that UK construction projects overrun their budgets minimum by an average of 16% on average and experts often recommend adding a 20% contingency for cost overruns right from the beginning (Aero, 2020). As of December 1st 2021, the Ministry of Statistics and Programme Implementation's Infrastructure and Project Monitoring Division (IPMD) managed 1,679 construction projects in India. As a percentage of delayed projects in November 2021, 16.6% were delayed for one to twelve months, 20.9% for thirteen to twenty-four months, 39.2% for 25 to sixty months, and 23.3% for over sixty months (Offshore Technology, 2022). According to end-of-November 2021 figures, there is an overall 19.7% cost overrun compared to original estimates (Offshore Technology, 2022). Consequently, the project success can be effectively achieved through Earned Value Management, and the reason behind its implementation is to avoid schedule delays and overbudgeting (Eirgash & Baltaci, 2021).

2.1 Earned Value Management (EVM)

“EVM (Earned Value Management) is a project management process that is structured for planning, collecting costs and tracking performance. It allows for the integration of objectives such as project scope, time, and costs as well as establishing a baseline for evaluating performance (Association for Project Management, 2006).” As a starting point, Table 1 illustrates significant terms related to Earned Value

Management, and Figure 6 & Figure 7 provide a basic understanding of its concepts.

Term	Description	Interpretation
PV (BCWS)	Planned Value	It is the budgeted cost for the work scheduled to be completed on an activity or WBS component in a particular time. It is obtained from the cash flow diagram (The S-curve).
EV (BCWP)	Earned Value	It is the budgeted amount for the work accomplished on the schedule activity or work breakdown structure (WBS) component during a given time.
AC (ACWP)	Actual Cost	It is resolved from accounting records that keeps record of actual expenditure money, that means it is secret and actual money spent by the contractor.
BAC	Budget at Completion	The total approved budget when the scope of the project is completed.
EAC	Estimate at Completion	The expected total cost of the project when the defined scope of work is completed.
ETC	Estimate to Complete	The expected extra cost necessary to finish the project.
Cost Variance (CV)	EV - AC	Negative means over budget, Positive means under budget
Schedule Variance (SV)	EV - PV	Negative means behind schedule, Positive means ahead of schedule
Cost Performance Index (CPI)	EV / AC	More than 1 means Profit and less than 1 means loss.
Schedule Performance Index (SPI)	EV / PV	More than 1 means ahead of schedule and less than 1 means behind the schedule.

Table 1. Significant terms related to Earned Value Management (Eirgash & Baltaci, 2021).

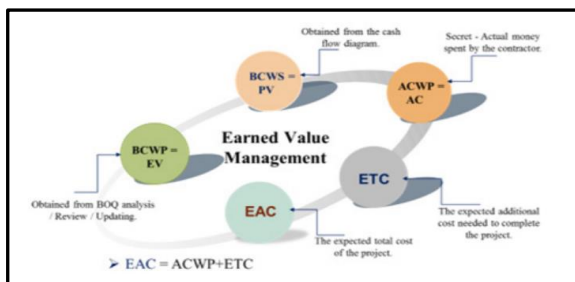


Figure 6. An overview of EVM concepts (Eirgash & Baltaci, 2021).

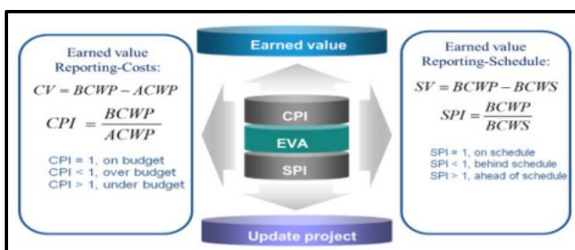


Figure 7. An overview of EVM concepts (Eirgash & Baltaci, 2021).

In addition to explaining basic concepts, the above well-figured illustration also emphasizes the importance of Earned Value Management as it pertains to construction projects. By comparing planned value (PV), earned value (EV), and actual cost (AC), earned value management provides an overview of a project's budget and schedule. As a result, instead of waiting until the end to find out about the cost overruns and delays, EVM technique allows teams to find out early on if a project is overbudget or delayed.

2.2 EVM implementation challenges in the Indian construction industry

Research has been conducted in the Indian construction industry in recent years that has explored the use of EVM technique in the field of construction and project management, although it is still fairly limited. The Indian construction industry remains underutilized of Earned Value Management (Padalkar & Gopinath, 2018). In the Indian construction industry, there are a number of challenges in applying earned value management to construction projects, including skills shortage, difficulty accepting new techniques, imprecise cost calculation, inadequate management support, inadequate documentation, delayed payments, and pressure to report only good news (Vaibhava & Rao, 2019). In addition to the above challenges, other issues were highlighted in the implementation of EVM, such as accurately assessing completion of work using a quantitative approach, availability of project progress data, and quantifying progress of procurement activities (Gaur, 2018). The Indian construction industry faces several other challenges in implementing EVM, including difficulty accessing project data, a lack of interdepartmental coordination, and lack of awareness about the benefits of EVM. The lack of a safety assessment in EVM technique is a barrier to its implementation, as the project team's safety manager and safety team are not in favour of implementing EVM. To address this, researcher developed the CSSI (Cost-Schedule-Safety Index), which includes earned costs, schedules, and safety management, in order to manage safety on

construction sites (Jha & Patel, 2012). Also, EVM does not provide any view of the client satisfaction or the quality assessment of the project, which can prove problematic in its implementation. Successful projects go beyond meeting schedules and budgets, and if clients are not satisfied or quality of project is poor, there is a huge problem no matter how well projects are executed (Ray, 2022). EVM implementation can be hampered by many other factors, such as the project manager’s approach, traditional organizational culture, unwillingness to adopt new technology, or lack of awareness and benefits. The use of EVM technique in the Indian construction sector remains underutilized due to the challenges and issues listed above. It was shown through a case study of Rashtriya Sanskrit Sansthan, Bhopal (Verma, et al., 2014), that EVM is crucial for the successful management of project teams but the EVMS is not widely used in many organizations in India due to its inadequate understanding (Verma, et al., 2014). Lack of understanding of EVMS in turn results in significant expenditures on education and training for their project teams, as well as information technologies assisting the management of project (Verma, et al., 2014). In a series of case studies for the 8 Indian construction projects as shown in below Figure 8, researchers describe how the limitations of EVM contributed to preventing the implementation of EVM in the construction industry in India, and also suggest recommendations to the construction project management team so that it can take advantage of the EVM technique (Barikder & Paul, 2020).

Case study	Typology	Project Duration	Project Cost (Rs)	Built-up area (sqm)
Case study 1	Residential	869 days	22.12 cr	7290
Case study 2	Office building	807 days	63.84 cr	20469
Case study 3	Hospital	1279 days	614.35 cr	137786
Case study 4	Residential	431 days	4.35 cr	800
Case study 5	Educational	697 days	66.41 cr	13570
Case study 6	Residential	326 days	13.66 cr	4510
Case study 7	Residential	1298 days	37.07 cr	16240
Case study 8	Hospital	1280 days	578.48 cr	92448

Figure 8. Series of Case studies (Barikder & Paul, 2020).

Researcher examined general data related to EVM in the Indian construction industry, such as challenges for schedule and cost control management so they could demonstrate the difference between the Indian

construction industry and western countries. The researchers examined the challenges for successful implementation of EVM in the Indian construction industry, including lack of top management support, lack of training, scope changes, as well as cost/schedule issues (Mahadik & Bhangale, 2013). In a broader sense, there were other challenges identified during the research that apply to the implementation of EVM techniques in the Indian construction industry.

2.3 Analysis of the EVM application in the UK and Indian construction industry

2.3.1 EVM Application in UK Construction Industry

In various studies, EVM combined with BIM has been proposed to structure compensation approaches in integrated project delivery, as well as using activity-based costing as an approach to optimize cost structures (Elghaish, et al., 2019). In addition, several studies describe a tool aimed at supporting project team, especially by using a 3D BIM model to present cost and time performance of construction work, as well as the Earned Value Management (EVM) technology (Bejarano, 2019). An information model made of BIM dimensions (3D, 4D, 5D, & 6D) refers to the type and presentation of information it contains. A model with these dimensions enhances understanding and clarity about construction projects by enhancing the data associated with it. Each of the BIM dimensions has its own purpose and helps determine the timeline, cost, sustainability of a project. A detailed illustration of BIM dimensions can be found.

When applied to construction projects, 4D BIM simplifies workflows, enhances on-site management, and allows construction feasibility analysis (Fischer, et al., 2008). As the UK construction industry has become more aware and informed about the benefits of 4D, barriers have been broken down and further adaptations have been made in order to keep up with technological advances (Swallow & Zulu, 2019; Gledson & Greenwood, 2017). Below (Figure 9) is an illustration of a 4D BIM model which incorporates the time dimension into the 3D model, thereby enabling visualization of the project in 3D alongside timeline.

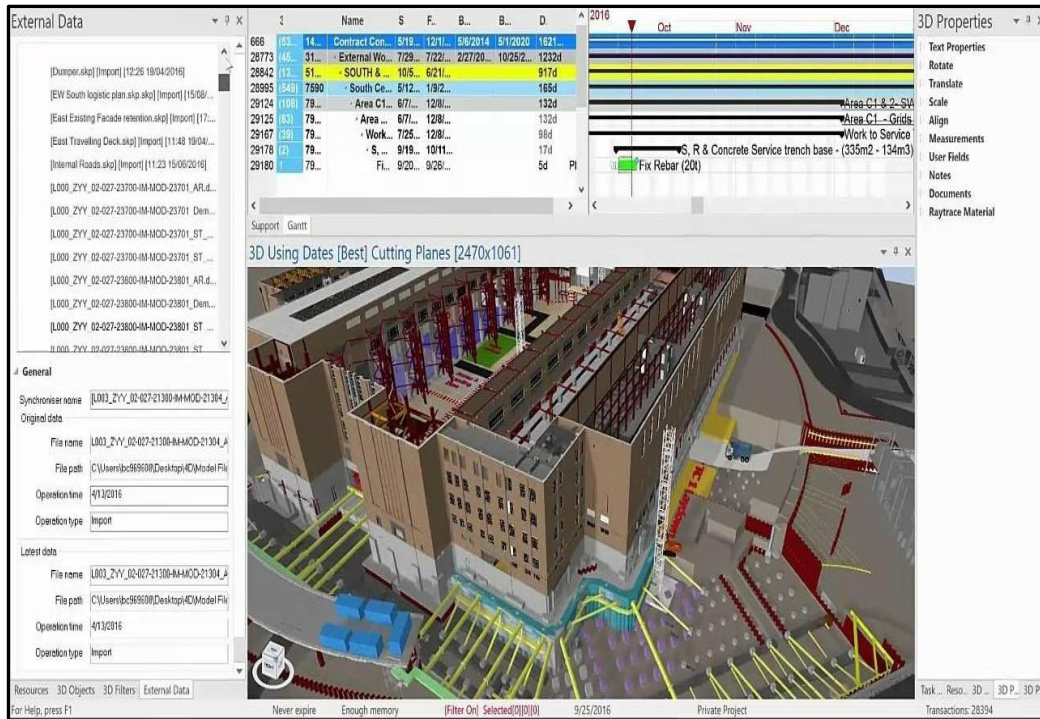


Figure 10. 4D BIM Illustration (Synchro Construction, 2017).

A BIM-EVM 5D model enhances productivity on construction projects in terms of cost management, and is therefore one of the most efficient AEC tools (Lee, et al., 2014). An alternative approach also allowed researcher to create a five-dimensional tool in accordance with EVM technique, which allowed them to calculate real-time costs and real-time schedules concurrently by administering both schedules and costs concurrently (Benghi, et al., 2010). The following (Figure 10) is a 5D BIM-EVM model that combines time and cost dimensions into the 3D model, providing a visual of the project in 3D alongside its schedule and budget. Government of the UK has launched a BIM implementation strategy specific to

the construction industry, requiring the implementation of BIM on public sector projects from 4th April 2016. The intention was to make the UK a global BIM leader within a relatively short period of time with one of the most progressive and leading centralized BIM implementation programs in the world (HM Government, 2015). By 2016, all centrally-procured projects were mandated to implement BIM Level 3 phased roll out as a part of the UK government's futuristic construction strategy (United BIM, 2022). As shown in the Figure 12, the BIM maturity levels can be divided into 4 levels, each representing a specific stage of maturity.



Figure 11. 5D BIM-EVM Illustration (Synchro Construction, 2017).

Government officials in the United Kingdom employed a "push-pull" approach by requiring that all government projects be delivered using BIM, the government "pulls" the industry toward BIM adoption, providing an alternative means of accessing information about the asset throughout its lifecycle. It is important to note that in addition to the above benefits of BIM 4D/5D models, there are a number of challenges associated with their implementation. Although BIM 4D/5D models have its challenges, researchers report that UK construction companies have achieved successful time and cost management using BIM-EVM techniques.

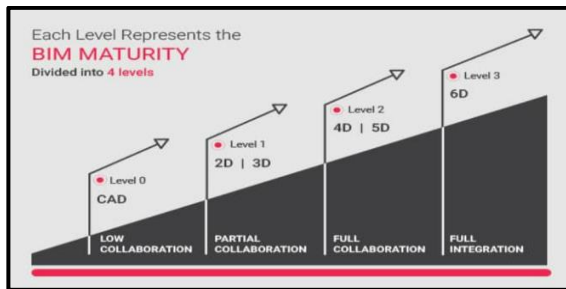


Figure 12. BIM Maturity Level (United BIM, 2022).

2.3.2 EVM Application in Indian Construction Industry

A large majority of construction projects in India do not apply the EVM methodology in a seamless and integrated manner, resulting in errors and a lack of transparency. The P6 (Primavera) or MSP (Microsoft Project) is primarily used by construction firms in India for scheduling (Varsani, et al., 2020; Shah, et al., 2017; Zerín & Joy, 2018; Bagade & Bhirud, 2018;

Narlawar, et al., 2019; Sharma, et al., 2016; Laddha, et al., 2017), and ERP (Enterprise Resource Planning) or SAP (System Applications and Products in Data Processing) is used to monitor costs (Patil & More, 2018; Anto, 2016; Prasad, et al., 2019; Kumar, et al., 2021). Consequently, the projects are unable to forecast and find appropriate corrective actions to ensure success. Below (Figure 13) is an illustration showing how most construction projects in India are managed in terms of time and cost.

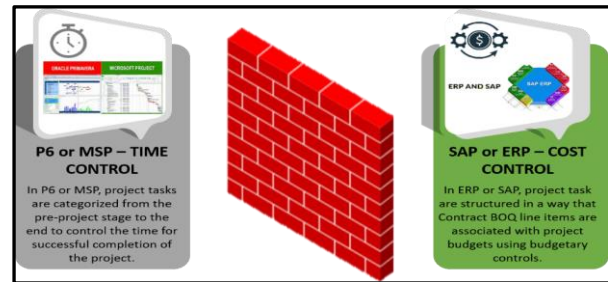


Figure 13. Unintegrated approach used for Major projects in India.

Meanwhile, fewer projects in India are using P6 or MSP to implement EVM techniques, which is still significantly less efficient than BIM 4D and 5D models. A number of researchers discuss the implementation of the EVM in the Indian construction industry using P6 and MSP (Badgujar & Konnur, 2016; Belsur, et al., 2017; Nalawade, et al., 2018; Chiranjeevi, et al., 2017; Ali, et al., 2018; Salikuma, 2016). The following Figure 14 illustrates the EVM layout in the P6 software.

Activity ID	Activity Name	BL Project Duration	AT	BL Project Start	BL Project Finish	Actual Start	Actual Finish	Start	Finish	BL Project Total Cost	Estimate At Completion	Actual Total Cost	Earned Value	Performance Index	Cost Performance Index	Schedule Performance Index
SP	Sample Project	1000	1153	25-Apr-19	13-Sep-22	25-Apr-19	25-Apr-19	25-Apr-19	15-Dec-22	99,450.00	1,067,480.97	1,106.99	17,703.12	0.03	0.01	
SP.1	KEY DATES	1	0	25-Apr-19	25-Apr-19	25-Apr-19	25-Apr-19	25-Apr-19	25-Apr-19	Ru0.00	Ru0.00	Ru0.00	Ru0.00	0.00	0.00	
A1000	Issue of LOD	1	0	25-Apr-19	25-Apr-19	25-Apr-19	25-Apr-19	25-Apr-19	25-Apr-19	Ru0.00	Ru0.00	Ru0.00	Ru0.00	0.00	0.00	
SP.11	INITIAL MOBILIZATION	21	19	25-Apr-19	20-May-19	25-Apr-19	18-May-19	25-Apr-19	18-May-19	Ru0.00	Ru0.00	Ru0.00	Ru0.00	0.00	0.00	
A1010	Introductory meeting with Client/FMC to start	0	4	25-Apr-19	05-May-19	25-Apr-19	03-May-19	26-Apr-19	03-May-19	Ru0.00	Ru0.00	Ru0.00	Ru0.00	0.00	0.00	
A1020	Establishment of labor colony (initially for 50 labours)	6	5	14-May-19	20-May-19	13-May-19	13-May-19	13-May-19	18-May-19	Ru0.00	Ru0.00	Ru0.00	Ru0.00	0.00	0.00	
A1060	Establishment of site quality lab/soil office	6	5	14-May-19	20-May-19	13-May-19	13-May-19	13-May-19	18-May-19	Ru0.00	Ru0.00	Ru0.00	Ru0.00	0.00	0.00	
A1050	Establishment of site store/yard	6	5	14-May-19	20-May-19	13-May-19	13-May-19	13-May-19	18-May-19	Ru0.00	Ru0.00	Ru0.00	Ru0.00	0.00	0.00	
A1040	Establishment of site office	6	5	09-May-19	15-May-19	07-May-19	13-May-19	07-May-19	13-May-19	Ru0.00	Ru0.00	Ru0.00	Ru0.00	0.00	0.00	
A1080	Technical manpower mobilization (for 50 labours)	6	5	25-Apr-19	03-May-19	25-Apr-19	03-May-19	25-Apr-19	03-May-19	Ru0.00	Ru0.00	Ru0.00	Ru0.00	0.00	0.00	
A1090	Machinery manpower mobilization	6	5	25-Apr-19	03-May-19	25-Apr-19	03-May-19	25-Apr-19	03-May-19	Ru0.00	Ru0.00	Ru0.00	Ru0.00	0.00	0.00	
A1030	Incorporation and approval of site logistics plan	2	1	07-May-19	09-May-19	05-May-19	07-May-19	05-May-19	07-May-19	Ru0.00	Ru0.00	Ru0.00	Ru0.00	0.00	0.00	
A1020	Review and comment by client on site logistics plan	2	2	06-May-19	07-May-19	03-May-19	05-May-19	03-May-19	05-May-19	Ru0.00	Ru0.00	Ru0.00	Ru0.00	0.00	0.00	

Figure 14. Sample EVM layout in P6 software.

According to the study, P6 is an excellent tool for tracking the progress of projects, as well as their corresponding costs, and it was also found that P6

eliminates lots of paperwork, unlike traditional methods of planning and scheduling (Abuzar, et al., 2016). Even though the Indian construction industry

primarily implements EVM using P6 or MSP software, having a visual support can have a more effective impact on success. For instance, red zones on a BIM model do not only display if something is crucial or unusual, but also show where the problem is located.

2.3.3 Comparative Analysis

In summary, the following Table 4 summarizes the approach used by the UK and Indian construction industries to implement Earned Value Management in their construction projects based on the literature review mentioned above.

Parameter Description	UK Construction Industry	Indian Construction Industry
Model or Framework	EVM is implemented in the UK construction industry using 5D models that assist in visualizing the project, thereby facilitating effective project management (Jrade & Lessard, 2015).	Figure 1 and Figure 2 illustrate how EVM is implemented in construction projects in India using a 2D approach (Varsani, et al., 2020; Laddha, et al., 2017). However, this approach is still far less efficient than 5D ones.
Approach	EVM is implemented using an integrated approach, as shown in Figure 7, in which cost and time progress are evaluated in the same system (Marzouk & Hisham, 2014).	EVM is mostly implemented in un-integrated way as shown in Figure 1, where time and cost progress are evaluated independently (Bagade & Bhirud, 2018; Kumar, et al., 2021).
Conflict	UK's current EVM practice promotes alliance as all stakeholders utilize one platform to seek information and input their data, thereby avoiding conflicts (Fischer, et al., 2008).	EVM practice in India currently does not facilitate alliance as P6 or MSP is used to assess time progress (Shah, et al., 2017); and ERP or SAP is used to assess cost progress (Patil & More, 2018), leading to disputes and discrepancies.
Control	With the help of EVM practices in the UK, better controls can be implemented on projects since progress can be visualized on 5D model, which provides a better basis for planning, evaluating and controlling them (Benghi, et al., 2010).	India's EVM practices provided less control on project progress since a 3D model is not available to visualize progress, making controls over projects difficult (Kenley & Harfield, 2015).
Collaboration	The current UK EVM practice promotes collaboration since planners, estimators, site managers, procurement teams, commercial teams, safety teams and all other key stakeholders have access to the same interface which helps in the successful completion of projects (Elghaish, et al., 2019).	In India, EVM implementation does not facilitate collaboration as all key stakeholders are not provided with the same interface to access project information, thereby making successful project completion difficult (Badgujar & Konnur, 2016; Prasad, et al., 2019).
Decision Making	As a result of the BIM-EVM integrated model, teams have access to it and can provide feedback during the decision-making process, while project stakeholders can enforce timely solutions to problems that may be visible as a result of digital modeling (Bejarano, 2019).	As a consequence of the different interfaces, teams do not have access to complete information about the project and thus cannot provide feedback during the decision-making process, which may hamper the visibility of early problem detection (Soundarya & Uma, 2016).
Policies and Support	UK government policies require all public projects to comply with the second level of BIM maturity, thus creating an environment conducive to building industry-wide adoption of BIM-EVM (HM Government, 2015).	In India, the government encourages the use of BIM (Gleeds India I&A, 2021), but there are no policies enabling a supportive environment for the adoption of the BIM-EVM model in the construction industry, which hinders its implementation.

Table 4. Comparative analysis of EVM approach in India and the UK.

2.4 Optimising the efficiency of EVM in the Indian construction industry and the barriers to its application

2.4.1 Optimising EVM efficiency

Among the 1,682 Indian construction projects analysed by the Ministry of statistics and programme implementation, the cost of the projects increased by INR 4 trillion (42.32 billion GBP: Gleeds India I&A, 2021) during their lives and the Government plans to use BIM technology to speed up construction (Gleeds India I&A, 2021). Additionally, a think tank within the Indian Government - Niti Aayog, has also encouraged BIM and believes that the use of BIM technology can

save upto 20% in costs. It is important to retain an understanding of the construction process under the expanding world of construction. This understanding cannot be accomplished with just proficient experts alone, and thus there is a great need for BIM in the field of construction so that the project can be managed by lower-level management staffs as well (Soundarya & Uma, 2016). By generating a budget and schedule, along with EVM indicators and performance curves for any kind of project, the researcher demonstrated the BIM-EVM system that handles planning, executing, tracking, and controlling a construction project, centered in the building project's 3D model (Cardenas, et al., 2018). An illustration of BIM EVM methodology is shown below Figure 15.

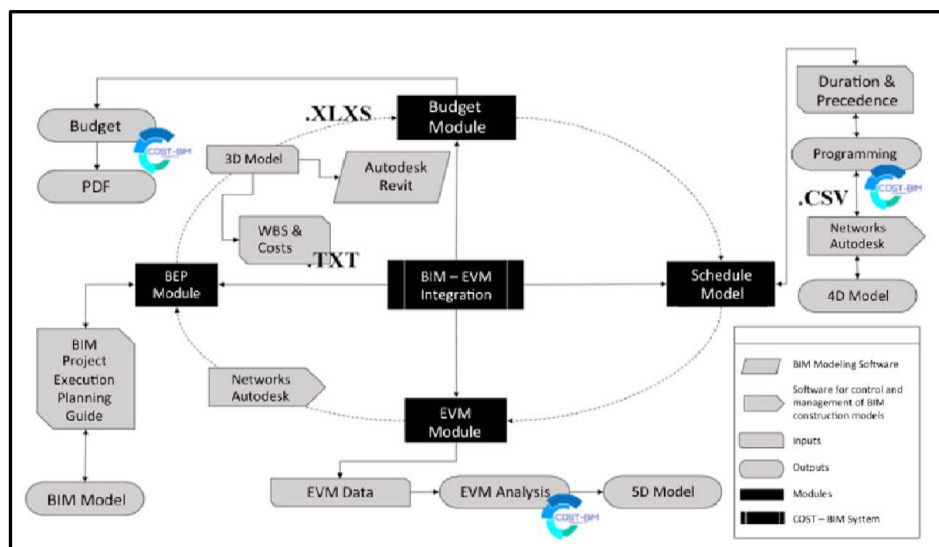


Figure 15. System of BIM-EVM methodology (Cardenas, et al., 2018).

To improve Earned Value Management, the researcher has developed a BIM system that can work in conjunction with BIM software such as Revit to better control cost and time. Also, it provides a glimpse of how BIM can be further enhanced in the future in project management, which would aid in convincing upper management, decision makers, and company officials to adopt and utilize it (Kamyab, 2018). Implementing BIM-EVM systems can result in improved productivity, superior quality, cost control, effective schedule control, and an integrative approach to successful project delivery.

3. LITERATURE OVERVIEW

Research relevant to barriers to implementing Earned Value Management in the Indian construction industry includes the following, Vaibhava & Rao (2019), Gaur (2018), Bajpai & Misra (2021), Jha & Patel (2012), Ray (2022) and following is a literature review of the

analysis of EVM applications in the UK and Indian construction industries, Biancardo, et al. (2020), Elghaish, et al. (2019), Bejarano (2019), Fischer, et al. (2008), Swallow & Zulu (2019), Gledson & Greenwood (2017), Badgujar & Konnur (2016), Belsur, et al. (2017), Nalawade, et al. (2018), Chiranjeevi, et al. (2017), Ali, et al. (2018), Salikuma (2016). Further, this study suggested a need for an empirical investigation to compare the two methods, identify the technologies that maximize construction efficiency in India, and analyse the obstacles to implementing these key improvements. The following study shed some light on how to improve the efficiency of EVM in the Indian construction industry along with the barriers to implementing it, Soundarya & Uma (2016), Uddin & Khanzode (2014), Kenley & Harfield (2015), Haas, et al. (2012), Cardenas, et al. (2018), Sawhney (2014), Sreelakshmi, et al. (2017), Meganathan & Nandhini (2018), Peterson, et al.

(2011), Akhtar (2020). Additionally, as stated in the literature review, interviews with industrial experts in the construction industry who have experience and knowledge of EVM have confirmed challenges to adopting it, maximizing its efficiency, and the barriers to its application in the Indian construction industry.

4. CONCLUSION

This dissertation aims to examine the current methodologies involved in the implementation of EVM techniques in construction projects across the UK and India. Comparing both methods, identify the technology to optimising the efficiency of EVM in the India construction industry and analyse the hindrances to implementing the key enhancements discovered. In order to achieve the objectives, the following steps were taken – As a first objective in exploring the cross-currents in the Earned Value Management literature, the study found that the Indian construction industry is underutilizing Earned Value Management. Consequently, it was essential to discover the major obstacles to the effective implementation of Earned Value Management in the Indian construction sector. A detailed literature review, qualitative interviews, as well as quantitative interviews were conducted to achieve this objective. Nvivo and Decision Explorer were used for qualitative interview analysis, and SPSS statistical software was used for quantitative interview analysis. The subsequent objective was to examine the literature on EVM implementation methods in the UK and India, followed by a detailed comparative analysis which helps to determine the differences in approaches between the two countries. As a final objective, upon conclusion of the comparative analysis, it was determined that BIM-EVM technology could be used to optimize the efficiency of EVM in the Indian construction industry along with identifying the key barriers to its adoption. In order to achieve this objective, a comprehensive literature review, as well as qualitative and quantitative interviews were conducted. Analysis of qualitative interviews were conducted using Nvivo and Decision Explorer, while analysis of quantitative interviews was carried out using SPSS statistical software. Finally, chapter 6 shows the critical analysis and discussion of all the useful information. According to the outcome and assertion of the dissertation, Indian construction faces a considerable number of challenges when implementing EVM as discussed and summarized in section 6.2. Additionally, the literature review and qualitative analysis revealed that the traditional approach used by the Indian construction industry to

implement EVM lacks integration and collaboration. As part of its traditional approach, the Indian construction industry uses Primavera (P6) or Microsoft Project (MSP) to track schedule, while ERP (Enterprise Resource Planning) or SAP (System Applications and Products in Data Processing) to track costs. A relatively small number of projects in India use the following 2D approach by loading the cost into P6 or MSP (as shown in Figure 2), but this approach is still far less efficient than visualizing 3D models. On the other hand, construction firms in the UK implement Earned Value Management in conjunction with BIM in a collaborative and integrated approach. The section 2.4.3 presents a comprehensive and detailed comparative analysis. As a result of integrating BIM with EVM, the EVM technique becomes more effective since graphical representations and model information are visualized, and a collaborative environment is created to eliminate communication gaps and miscommunications during the project lifecycle through the creation and sharing of information. The 5D BIM approach conformed well to Earned Value Management techniques and provided the best results for controlling models and projects in the construction projects, since it enabled effective collaboration, visualization, and cost estimation for each component of each model. A key conclusion of the dissertation is that adoption of BIM-EVM technology will allow the Indian construction industry to address two major issues associated with Indian construction: cost overruns and schedule overruns, and will also improve project performance. As discussed in section 6.4, BIM-EVM technology has a number of benefits when implemented. It was therefore necessary to conduct a study in order to identify the key barriers to adoption of BIM-EVM in the Indian construction industry which is briefly discussed and summarised in the section 6.5. Construction projects in India will benefit greatly from BIM-EVM technology because it facilitates collaboration and coordination between the design team, the engineering team, contractors, and other key players. Besides improving project management, BIM-EVM enhances efficiency in workflow models, as well as maintain and modernize past projects, and helps to understand the life cycle of a building. As a result of BIM-EVM technology in the Indian construction industry, Earned Value Management efficiency will improve, indicating it will revolutionize the construction sector, and so BIM-EVM will become the future of construction management.

REFERENCES

- [1] Abuzar, S., Jayaraj, G. & Raju, R., 2016. Time and Cost Analysis using Project Planner Software. *International Journal of Recent Advances in Engineering & Technology*, 4(4), pp. 2347-2812.
- [2] Aero, P., 2020. 10 Construction Project Cost Overrun Statistics You Need to Hear. [Online] Available at: <https://www.propelleraero.com/blog/10-construction-project-cost-overrun-statistics-you-need-to-hear/> [Accessed 16 08 2022].
- [3] Amarnath, C., 2019. *India Building Information Modelling Association*, Bangalore: The National Society for Digital Transformation.
- [4] Anto, J., 2016. An empirical study of Enterprise Resource Planning systems in construction industry. *International Research Journal of Engineering and Technology*, 3(4), pp. 1310-1313.
- [5] Araszkiwicz, K. & Bochenek, M., 2019. Control of construction projects using the Earned Value Method - case study. *Open Engineering*, 9(1), pp. 186-195.
- [6] Association for Project Management, 2006. *APM Knowledge*. 5 ed. Buckinghamshire: APM.
- [7] Badgular, K. & Konnur, B., 2016. EVM Analysis with Primavera. *International Research Journal of Engineering and Technology*, 03(06), pp. 510-513.
- [8] Bagade, P. & Bhirud, A., 2018. Review on construction project management software primavera p6. *IJESRT*, 7(1), pp. 110-114.
- [9] Bajpai, A. & Misra, S., 2021. Barriers to implementing digitalization in the Indian construction industry. *International Journal of Quality & Reliability Management*, n.v.(n.i.), pp. 1-12.
- [10] Barikder, H. & Paul, V., 2020. Application of Earned Value Management in Indian Construction Projects. *International Journal of Creative Research Thoughts*, 8(6), pp. 3081-3089.
- [11] Bejarano, E., 2019. Integration of Earn Value Management into BIM Projects. *Journal of Architectural Engineering Technology*, 7(2), pp. 1-6.
- [12] Cardenas, C., Zapata, P. & Lozano, N., 2018. Building Information Modeling 5D and Earned Value Management methodologies integration through a computational tool. *Construction Engineering Magazine*, 33(3), pp. 263-278.
- [13] Chance, R., 2006. *Earned value management systems (EVMS)*. Washington, PMI.
- [14] Constructional National, 2018. How much are delays costing the UK construction industry?. [Online] Available at: <https://www.constructionnational.co.uk/news-menu/3431-how-much-are-delays-costing-the-uk-construction-industry-in-2017> [Accessed 17 08 2022].
- [15] Costantino, E., 2019. *Earned Value Management in Primavera P6*. Mission Viejo, DRMcNatty.
- [16] Dhawale, A. & Tuljapurkar, V., 2015. Cost control and tracking of a building by earned value method. *International Journal of Technical Research and Applications*, 3(2), pp. 15-22.
- [17] Eirgash, M. & Baltaci, Y., 2021. Project Monitoring and Early Warning of Time-Cost Overruns in Earned Value Management. *Current Trends in Civil & Structural Engineering*, 7(5), pp. 1-7.
- [18] Feng, C., Chen, Y. & Huang, J., 2010. Using the MD CAD model to develop the time-cost integrated schedule for construction projects. *Automation in Construction*, 19(3), pp. 347-356.
- [19] Fischer, M., Hartmann, T. & Gao, J., 2008. Areas of Application for 3D and 4D Models on Construction Projects. *Journal of Construction Engineering and Management*, 134(10), pp. 776-785.
- [20] Gaur, A., 2018. Earned Value Management Challenges. [Online] Available at: <https://milestonetask.com/earned-value-management-challenges/#.YqHidajMI2w> [Accessed 09 06 2022].
- [21] Georgiadou, M., 2019. An overview of benefits and challenges of Building Information Modelling (BIM) adoption in UK residential projects. *Construction Innovation*, 19(3), pp. 298-320.
- [22] Gledson, B. & Greenwood, D., 2017. The adoption of 4D BIM in the UK construction industry: An Innovation Diffusion approach. *Engineering, Construction and Architectural Management*, 24(3), pp. 1-44.
- [23] Haas, C., Turkan, Y., Bosche, F. & Haas, R., 2012. *Toward Automated Earned Value*

- Tracking Using 3D Imaging Tools. *Journal of Construction Engineering and Management*, 139(4), pp. 423-433.
- [24] Hakanen, L., 2017. Classification of Cost data and its use in 5D Building Information Modelling. [Online] Available at: <https://www.semanticscholar.org/paper/Classification-of-Cost-data-and-its-use-in-5D-Hakanen/567da129e2fcc6d8638026977593e3cdc53651e5> [Accessed 11 06 2022].
- [25] Hamid, M. & Abdelhaleem, M., 2021. Project cost control using five dimensions building information modelling. *International Journal of Construction Management*, n.v.(n.i.), pp. 1-6.
- [26] Hazem, Z., 2022. BIM adoption in the UK – history and impact. [Online] Available at: <https://www.planradar.com/gb/bim-in-uk-construction-technology-market/> [Accessed 20 08 2022].
- [27] Jain, M. et al., 2020. Factors influencing BIM adoption in emerging markets – the case of India. *International Journal of Construction Management*, 20(1), pp. 65-76.
- [28] Jha, N. & Patel, D., 2012. Evaluation of Construction Projects in Terms of Cost, Schedule and Safety Performances. Singapore, CIB W099 International Conference.
- [29] Kaewunruen, S., Sresakoolchai, J. & Zhou, Z., 2020. Sustainability-Based Lifecycle Management for Bridge Infrastructure Using 6D BIM. *Sustainability*, 12(6), pp. 2436-2452.
- [30] Kamyab, N., 2018. BIM and Project Management in AEC Industry, Pennsylvania: Harrisburg University of Science and Technology.
- [31] Laddha, S., Chanda, P. & Khedekar, S., 2017. Planning and scheduling of a project using Microsoft Project (msp). *International Journal of Advanced Research*, 5(6), pp. 161-168.
- [32] Lee, S., Kim, K. & HoYu, J., 2014. BIM and ontology-based approach for building cost estimation. *Automation in Construction*, 41(1), pp. 96-105.
- [33] Mahadik, G. & Bhangale, P., 2013. Study & Analysis of Construction Project Management with Earn Value Management System. *International Journal of Innovative Technology and Exploring Engineering*, 3(4), pp. 40-43.
- [34] Maim Consulting, 2021. Case Study : 5D BIM Digital Construction Project Management. [Online] Available at: <https://maimconsulting.com/blog/f/case-study-5d-bim-digital-construction-project-management> [Accessed 20 08 2022].
- [35] Marzouk, M. & Hisham, M., 2014. Implementing Earned Value Management using Bridge Information Modeling. *KSCE Journal of Civil Engineering*, 18(1), pp. 123-130.
- [36] Meganathan, S. & Nandhini, N., 2018. A review on challenges involved in implementing building information modeling in construction industry. *International Research Journal of Engineering and Technology*, 5(1), pp. 1329-1332.
- [37] Moses, T., 2018. The development of 5D BIM framework to facilitate costing in contractor-led projects. [Online] Available at: file:///C:/Users/jains/Downloads/Tochukwu_PhD%20Thesis.pdf [Accessed 20 08 2022].
- [38] Mushamalirwa, A., 2016. Technico Lisboa. [Online] Available at: [file:///C:/Users/jains/Downloads/Extended%20abstract%20\(2\).pdf](file:///C:/Users/jains/Downloads/Extended%20abstract%20(2).pdf) [Accessed 20 08 2022].
- [39] Nalawade, S., Ghode, O. & Vaidya, P., 2018. Earn value analysis of construction project using primavera p6. *IJEDR*, 6(4), pp. 276-278.
- [40] Narlawar, G., Chaphalkar, N. & Sandbhor, S., 2019. Application Of Primavera Software In Management Of Construction Project: A Review. *International Journal of Scientific & Technology Research*, 8(8), pp. 912-914.
- [41] Offshore Technology, 2022. India's major project pipeline still subject to delays and cost overruns. [Online] Available at: <https://www.offshore-technology.com/comment/india-project-pipeline-delays/> [Accessed 16 08 2022].
- [42] Othman, I. et al., 2021. Barriers of value management implementation for building projects in Egyptian construction industry. *Ain Shams Engineering Journal*, 12(1), pp. 21-30.
- [43] Otuyemi, F., 2017. The Use of Earned Value Management As a Trend Analysis Tool in UK Construction Sector. [Online] Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2943331 [Accessed 27 05 2022].
- [44] Padalkar, M. & Gopinath, S., 2018. Earned value analysis in project management: Survey and research potential. Kerala, POMS.
- [45] Patil, S. & More, K., 2018. Construction management approach by using ERP system.

- International Journal of Scientific Development and Research, 3(6), pp. 1-3.
- [46] Qureshi, T. & Hasani, M., 2020. Status of building information modelling (BIM) in construction practice-UK context. Bristol, IOP.
- [47] Ray, S., 2022. Using Earned Value Management to Measure Project Performance. [Online] Available at: <https://www.projectmanager.com/blog/using-earned-value-management-to-measure-project-performance> [Accessed 19 06 2022].
- [48] Salikuma, S., 2016. Application of Earned Value Analysis in Analysing Project Performance. International Journal of Engineering Research & Technology, 5(9), pp. 459-461.
- [49] Sawhney, A., 2014. State of BIM Adoption and Outlook in India, Gurgaon: RICS.
- [50] Sharun, M. & Sundara, P., 2018. Study and analysis on earned value management system in construction industry. International Journal of Civil Engineering and Technology, 9(3), pp. 332-338.
- [51] Shukla, M., Magar, R. & Razak, A., 2016. Use of Earn Value Management in Indian Construction Industry : State of Art. International Journal of Engineering Research, 5(1), pp. 262-264.
- [52] Soundarya, R. & Uma, R., 2016. Building Information Modeling in Construction Industry - A Review. International Research Journal of Engineering and Technology, 3(11), pp. 1324-1327.
- [53] Sreelakshmi, S., Sagar, B. & Roshan, M., 2017. A study on the barriers to the implementation of building information modeling. International Journal of Civil Engineering and Technology, 8(5), pp. 42-50.
- [54] Subramani, T., Jabasingh, S., Jayalakshmi & J., 2014. Analysis of Cost Controlling In Construction Industries by Earned Value Method Using Primavera. International Journal of Engineering Research and Applications, 4(6), pp. 145-153.
- [55] Tienda, J., 2020. Visual project control by EVM and BIM in building structure, Barcelona: Plexos.
- [56] Uddin, M. & Khanzode, A., 2014. Examples of How Building Information Modeling Can Enhance Career Paths in Construction. Practice Periodical on Structural Design and Construction, 19(1), pp. 95-102.
- [57] Vaibhava, S. & Rao, P., 2019. Challenges of Earned Value Management Application in Indian Construction Industry. International Journal of Recent Technology and Engineering, 8(2), pp. 733-735.
- [58] Varsani, P., Bhavsar, A. & Pitroda, J., 2020. Effective scheduling and control of construction project using primavera p6: a review. UGC Care, 10(50), pp. 5050-5062.
- [59] Wells, W., Kim, E. & Duffey, M., 2003. A model for effective implementation of Earned Value Management methodology. International Journal of Project Management, 21(5), pp. 375-382.
- [60] Willems, L. & Vanhoucke, M., 2015. Classification of articles and journals on project control and earned value management. International Journal of Project Management, 33(1), pp. 1610-1634.