

ADOPTING BIM FOR EFFECTIVE COST MANAGEMENT

A Thesis

Submitted in partial fulfilment of the requirements for the award of
Master of Architecture degree in Building Management

by

G PRIYANKA (39840015)



**DEPARTMENT OF ARCHITECTURE
SCHOOL OF BUILDING AND ENVIRONMENT**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

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BONAFIDE CERTIFICATE

This is to certify that this Report is the bonafide work of **G PRIYANKA (39840015)** who carried out the Thesis entitled "**ADOPTING BIM FOR EFFECTIVE COST MANAGEMENT**" under our supervision from January 2021 to May 2021.

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ABSTRACT

Cost management is a critical component of construction performance. Effective cost management would aid in the company's cost goals being met. Despite this, many businesses in the sector do not have a cost-management mechanism in place. This study would look at how BIM can be used to manage costs and calculate cost overruns, lowering construction costs.

A systematic analysis of the literature and field work (questionnaire) was conducted to achieve the project's goal. With a BIM adoption rate of 22%, India lags behind European and North American countries where BIM adoption has reached maturity (>70%). Over a decade of acting as a catalyst, it has gained investor trust with business benefits such as positive return on investment, effect on reducing errors and omissions, enhanced cooperation with entire supply chain, time and cost savings, improved efficiency, clarity and accountability in decision making, and increased sustainability.

With 70% of our built environment assets still to be constructed, India needs a high rate of BIM adoption. The study started with a summary of the literature on cost management and its role in building, emphasizing its significance, outlining the advantages of using BIM for cost management, addressing the challenges of implementing the new method, and ultimately evaluated BIM's effectiveness.

Keywords: BIM, Cost management, MS Project, EVM, Navis work

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The success or failure of a project is determined by its cost; however, as technology advances, global competition between companies is intensifying, necessitating effective proactive systems. Any business in this industry would suffer from a lack of a good cost control system. As a result, the construction firm's cost control becomes of paramount importance. Future smart city and town developments would include the implementation of advanced technologies that can speed up the current development phase.

Building information modelling (BIM) is a method for creating and managing digital representations of a location's physical and functional characteristics. Planning and monitoring are two aspects of cost control. Project cost planning includes cost estimation, forecasting, and planning. The projection of potential costs is known as cost planning. Cost monitoring is retroactive: it accounts for what has already happened. Cost monitoring is the process of tracking the costs of different operations using an estimating and accounting cost control framework, which is achieved by cost coding activities and their related costs. Although and stage of the cost control system is important, cost monitoring is one of the most vital, since data collection vulnerabilities would have the most negative impact on the other stages. Bad risk management and preparation will result from inaccurate data.

Specific costs and associated tasks are included in the project analysis stage of forecasting and preparing, while the decision stage reviews and predicts the whole cost control framework and offers an opportunity to make necessary adjustments and implement best practices. The concept of BIM management revolves around cost management. Although forecasting and planning software can show how resources are allocated, an accounting system should be able to show when and why resources were allocated to a task or project.



Figure1.1 - Project Cost planning

1.2. NEED FOR THE STUDY

The construction industry uses a lot of resources including labour, materials, and machinery. Quick track projects have become common in the current market, implying that more money can be spent in a shorter period of time. Since cash is the lifeblood of a project, the contractor must ensure that they are paid on time by the employer and that the money is spent on equipment to keep the project on track. As a result, one of the most important factors determining the contractor's success is cost control. According to the McGraw-Hill Business Value Report 2013, India has a BIM adoption rate of just 22%. 27 percent are aware of BIM and are considering it.

43 percent are conscious, but are unsure how to put it into practice. Just 8% of people have no knowledge on this. INDIA is also experimenting with it. Famous among professionals, the majority of whom work in the real estate industry and only a few in infrastructure. As a result, the aim of our project is to create a BIM model that will serve as an example of how to effectively incorporate BIM at any stage of a project. With over 1.27 billion inhabitants, India is the world's second most populous nation, accounting for more than a sixth of the global population in 2014. India, which already has 17.5 percent of the world's population, is expected to overtake China as the world's most populated country by 2025, with a population of 1.6 billion by 2050.

The Indian population is rising at a rate of 1.2 percent per year. The housing market would be put under more strain as a result of such rapid population growth. This necessitates a change in contractibility, as well as new and updated methodology and adoption strategies. Our current demand is shifting toward an interconnected future with high-performance BIM models as a result of the BIM process series.

1.3. AIM

The aim of this research is to investigate the benefits and challenges of implementing BIM for effective cost management in Indian construction industry.

1.4. OBJECTIVES

- To review the importance of cost management in a construction project.
- To understand about the need of BIM in India
- To emphasise the benefits of adopting BIM in the cost management process.
- To examine in detail on the issues in adopting BIM
- To analyse the effectiveness of cost management by use of BIM and to recommend for better outcomes.

1.5. LIMITATION

The study covers only the Construction industry in India.

1.6. SCOPE

The construction industry is emerging swiftly and there are many competitors to take this forward. In construction, cost determines the project's success and failure, due to the advancement in technology the competition between companies are accelerated globally which demands effective proactive systems.

Lack of proper cost management system will have an aggressive effect on any company in this market. Therefore, an effective cost management becomes the supreme importance of the construction firm.

1.7. METHODOLOGY

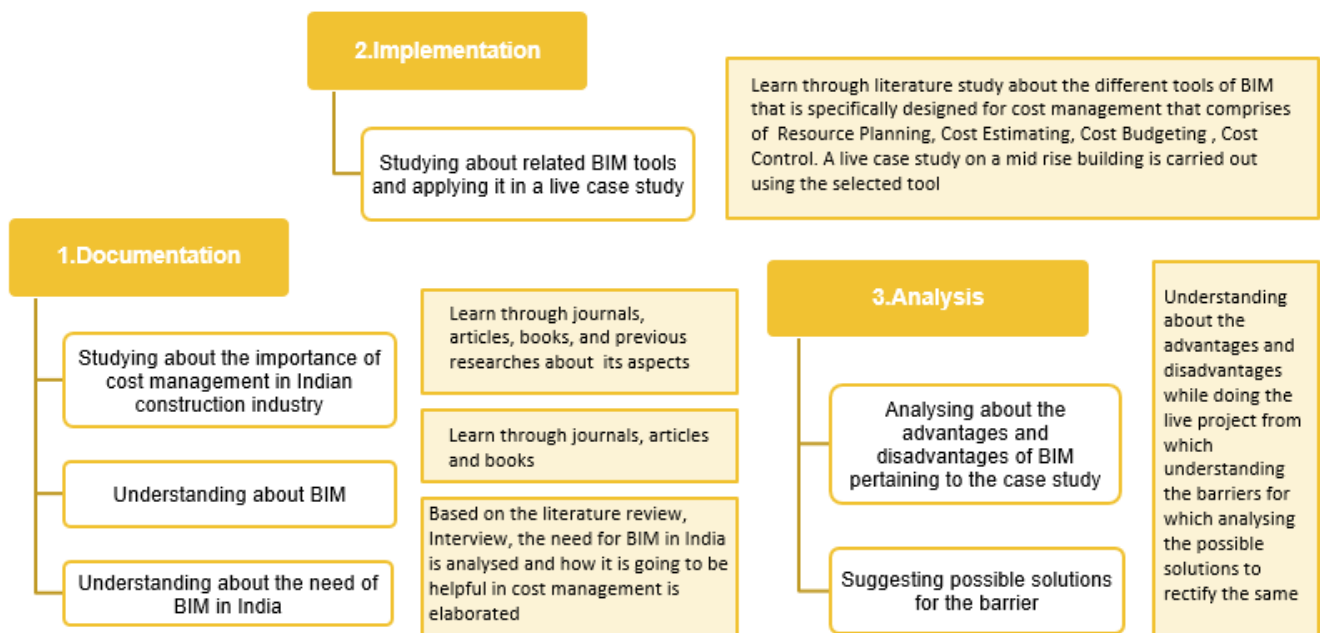


Figure1.2 – Research Methodology

CHAPTER 2

LITERATURE STUDY

2.1. MODERN METHODS OF COST CONTROL IN CONSTRUCTION INDUSTRY

2.1.1. INTRODUCTION

The modern methods for cost control in Indian construction industry is explored in detail. The word modern construction is commonly used to describe building information modelling (BIM). BIM despite having several advantages it has few disadvantages, because of this it cannot be easily implemented. The modern techniques stresses on the importance of adopting to applications which are available for cost control by evaluating its effectiveness is studied by means of literature review. The hindrance on adopting to these applications are also detailed.

2.1.2. MODERN COST CONTROL METHODS

The contractors in the construction are facing a tough condition for operations in the present market scenario. Due to the increase in competition every task from securing a job until concluding the project with a profit becomes challenging. The contractors are required to adapt and be advanced from the tendering until the completion.

This comprises implementing improved project controls. The crucial part of development in construction will be the development of software which will be the solution for cost reduction, improved efficiency, and better risk control. There are several products in the market which are followed by few firms in the industry. There is a high chance of human error during the handling of cost control process manually. To eliminate the human error an application is essential to any industry.

There are several applications in the market which can be used as a tool for effectively controlling the cost in construction. They are being developed by various companies, they perform similar task which is 'Cost Control'. These applications work on the principle of integrated cost management (ICM)

- Cost X by Exactal – BIM based software
- Navis work – BIM based software
- CCS (Build smart) – Cost management and enterprise accounts
- Ecosys – Enterprise planning and project cost control software
- Mpower – Project cost control software

This enables the effective management of all the costs in the project and eliminates the requirement of custom development for every site. Unified actual and accrued cost reporting for the comparison. This has the capacity to produce a detailed and timely report on the variance which directs to an effective cost control. Costing during operation – The manpower, material, plant, subcontractors, indirect costs are the costs during operation. The following describes how the ICM links the cost.

Manpower – The manpower is integrated with the attendance and human resource (HR)

Material – The material is integrated with the base line estimate, this is constantly updated by the valuation.

Plant – This is integrated with the plant division. Every detail such as internal hire, external hire, haulage, availability can be easily identified by this.

Sub contract – The cost of sub contract is linked with both project and finance control; therefore, every change can be easily identified. The ICM enables the organization to produce everyday cost information, includes accrued costs on all elements of cost combined with the project controls.

2.1.3. ELEMENTS OF MODERN COST CONTROL METHOD

Identifying the actual costs against the budget is an important element in the process of cost control. There must be a clear understanding between the direct and indirect costs. The costs include the following

- Fixed costs – The costs which does not change in response to the activity volume.
- Variable costs – The cost which changes in response to the activity volume.
- Mixed costs – Costs which contain both fixed and variable costs.
- Direct costs – The costs which can be linked to a specific activity.
- Indirect costs – The costs which cannot be linked with the specific activity.

The applications can integrate complex worksheets, the direct costs and indirect costs are broken down into manpower, material, plant and equipment, subcontractors, etc. Each cost will have a unique resource code by which it can be easily traced. This code is highly helpful in importing any data related to that in an accurate manner. Allocating the indirect cost is complex in many cases, these costs need to be managed within the specific resource codes. Cost planning is a

projection of future costs, cost tracking is looking back on the planned cost. The estimation, forecast and plan forms a part of cost planning. This method includes the collection of resource time and accumulation of expenses. By this type of data collection, the cost and activities of various scope of works are performed this will enable an accurate analysis and helps in decision making. Cost tracking is the most crucial stage because there are high chances that the data collection process is weak which will have negative impact on other stages of the project.

Therefore, the cost control by using an application is centralizing the cost of a project or an organization which can produce every single data for instance the resource part which shows when and why the resources were allocated also shows on the available resources. This phenomenally improvises the cost monitoring at the real time, which will result in effective cost control

2.1.4. EFFECTIVENESS OF MODERN COST CONTROL METHODS

The following discusses on the effectiveness of the modern cost control methods during the post contract stage. According to Manickam, G. (2016) the construction companies are facing difficulties hence an application must be implemented in the projects. Also, the contractors must adopt to the innovative approach during tender and execution of a project. The major factor to grow in the market is to develop an application which will reduce the cost during the execution and increases efficiency. The traditional method requires an extra effort and skills for the QS. Availability of the reports in traditional method depends on the concerned QS who have prepared the report no one has the report until the QS finalizes the report and issues to the concerned stakeholders. The integrated approach of the modern method links the estimation and the planning data's. Therefore, the data is carried from the tender stage. The applications can provide the rate and quantity at its highest level of accuracy which is the most important factor for an effective cost control. The cost is organized by the integrated system simultaneously by activity and cost type. This enables the one to one comparison of cost which can be utilized for effective cost control. The real-time comparison of actual cost and the estimated costs is possible which assists in taking effective corrective action on time. The actual costs can be returned to the estimation team which will help them improve the accuracy while preparing the future estimates which ensures proper pricing and increased project security.

This makes the application an effective tool which provides effective cost control which will produce more revenue and benefits to the organization in the competitive environment. Advancement of traditional systems with newly available applications enables the quantity surveyors to generate take-offs from any model swiftly and at time. This results in reduced time for quantity take-off and ensures that most of the scope of works are captured within the budget. The quantification becomes more accurate this will increase the confidence in quantity surveyor and reduce time rechecking the documents before submission.

The capability to evaluate cost vs. value in a real time will bring many opportunities for client and contractor. The opportunities include increased confidence in the cash position and profitability which will decrease issues related to productivity and claims. These opportunities will reduce the ongoing and future over spending also helps in pricing the works for future more accurately.

2.1.5. FACTORS HINDERING ADOPTION OF MODERN COST CONTROL

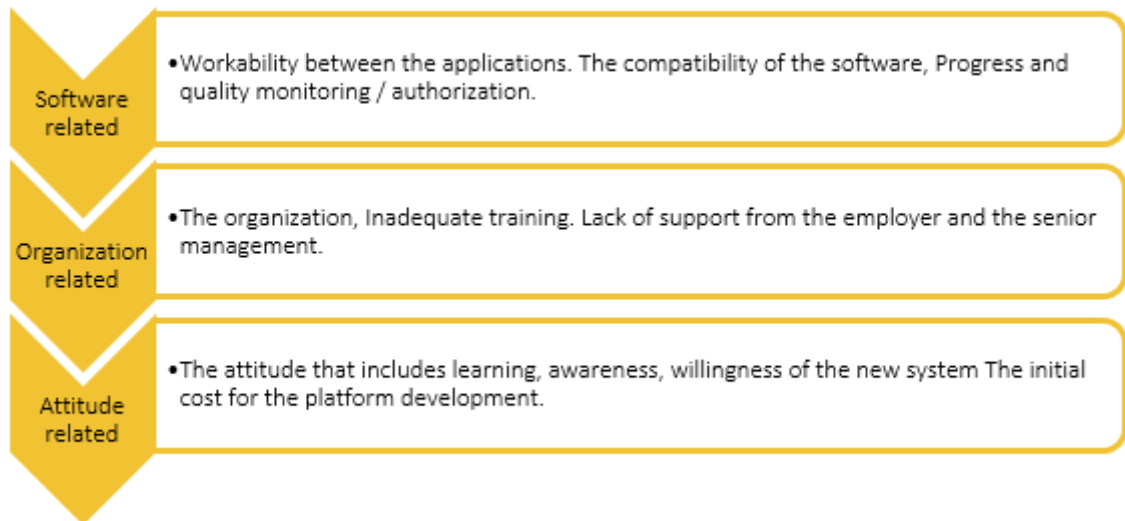


Figure 0.1 - Factors hindering adoption of modern cost control method

The benefits need to be developed from a business perspective. Acceptable baseline and benchmarks needs to be set. The need of qualified professionals remains as a resistance for the implementation in the new projects. More importantly the Employer must agree in some cases. The application should have their own metrics which would enable the team to measure success rate in relation to the technology and process.

2.1.6. CONCLUSION

The implementation of the modern technology in quantity surveying which will act as a radical tool for effective cost control in the future. The applications support in providing required outputs swiftly and accurately this would act as a facilitator of change. The major portion of the construction is hesitant to agree with the transformation which is one of the facts in Quantity Surveying why the field of innovation is not appreciated.

By the detailed exploration of literature and the case study it is very evident that the adoption of new technology will bring changes to the upcoming quantity surveyors which will turn the quantity surveying into smart bringing better outcomes. The companies which follows the traditional methods will be pressured to improve their systems with the new technology. Following new technology will reduce the time consumption, in accuracy, quantification of materials, etc. This will accelerate the commercial agreements and makes it Fast-Track.

In future, the companies will be challenged if they are prepared to adopt changes to manage the completion, to keep the margin high and for utilizing the resources to its best. Finally, for the implementation of the modern technology a company will be required to amend the organization where the employees will be provided with adequate training which will become a future investment.

2.2. COST ELEMENTS AND COST REDUCTION

The contractor's cost elements include all the elements involved for the execution of work. It can be majorly divided into Manpower, Material, plant, support chain (which are indirect costs such as preliminaries, management cost, etc.) and subcontracts.

Forecast cost can be achieved or cost reduction can be done on these cost elements i.e. manpower/ plant, material, support chain and sub-contractors if managed efficiently. The following illustrates how this cost elements are managed by traditional cost control technique.

2.2.1. MANPOWER AND PLANT

The construction is unique due to which the labour and plant utilization becomes inefficient and doesn't go as planned. Every activity is loaded with manpower and plant with certain combination. But in many cases, this always results in utilization of more manpower and plant during execution. According to Roy Pilcher, 1994 the cost control in construction is limited to the labour and plant cost. This emphasizes the importance of efficient use of labour and plant. In traditional method, the time keepers are responsible for updating the manpower and plant list which here the data's collected from the site is entered manually in the Excel sheet and the outputs are generated.

2.2.2. MATERIALS

Cost control can be done by evaluating the difference of delivered materials and the materials utilized by the site. This helps in identifying the wastage and check with the allowances if any surplus quantity of materials are identified it will be returned or utilized for other projects. This is simply a control of waste materials. The status of materials is checked often (usually monthly) in an effective material management system this acts as a notification to the operations team. In traditional method, the store keeper is in charge to carry out the excess materials inspection along with operations and commercial team. But this is not usually done frequently due to the cost and time involved to carry out the inspection.

2.2.3. SUPPORT CHAIN

An expenditure which is paid to monitor, provide assistance and support to the construction activities (i.e. indirect costs). This includes management cost, administration cost, costs of facilities at site, temporary work cost, etc. Every project and company is different the indirect cost will be directly in line with this. For example, the admin cost of Asian will be much less than the admin from the Europe. Better management, better administration, better temporary work design will help in reducing the cost.

2.2.4. SUBCONTRACTOR MANAGEMENT

The subcontractors are managed by the main contractor. The number of subcontractors used in the project are many due to the specialist requirement of various scope of works. The subcontractors should be managed efficiently failure to manage will result in disputes, delays, accidents, etc. which will lead into a project failure. The work done by the subcontractor has a direct effect on main contractor's reputation. Typically, there is no integrated system which is utilized in managing the subcontractors. In most of the cases these results in problems, which is mainly due to the poor management by the main contractor, lack of communication, scope changes. On the other side, the subcontractor will also be facing issues such as cash flow issues, incompetency.

2.3. Factors Causing Time and Cost Overrun throughout Life Cycle of Construction Project

Ismail, I., Abdul Rahman, I., & Memon, A. H. (2013). Study of factors causing time and cost overrun throughout life cycle of construction project.

Construction industry is a very important industry in a country's development and it can increase or generate economic development of the country. A study showed that since seventies, the economy in India has undergone rapid growth. It found that construction industry constitutes an important element of country's economy. However, majority of the construction are facing problem in achieving the completion of project within stipulated time and cost. Generally, cost overrun occurs when the expenses required to complete a project exceed the amount budgeted. Around the world, many studies showed the time and cost overrun issue is a common problem in construction project. A study conducted by was study on time and cost overrun in construction project. A total of 308 public sectors and 51 private sectors involves in this study.

The result shows percentage of time overruns is higher compared with percentage of cost overruns but both of them facing overrun more than 50%. For the public sector, only 20.5% of the projects completed within stipulated time and 46.8% of projects completed within the budget. Meanwhile for the private sector, only 33.35% and 37.2% of projects completed within time and cost estimation respectively. However, no researchers investigate this problem according to the phases of construction. Hence, this study is to classify the overrun factors into phases of project life cycle which include planning phase, design phase, construction phase and finishing phase.

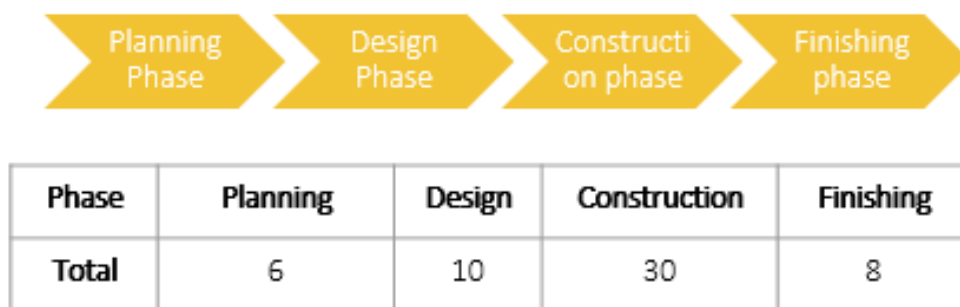


Figure 2.1 - Survey results

S.NO	FACTORS	REFERENCE
1	Incompetent subcontractors	•Causes of Project Delays in Nigerian Construction Industry, •Causes and Effects of Delays in Malaysian Construction Industry, •Ranking of Delay Factors in Construction Projects After Egyptian Revolution,
2	Schedule Delay	•Cost Escalation and Schedule Delays in Road Construction Projects in Zambia •Quantifying Schedule Risk in Construction Projects using Bayesian Belief Networks •Infrastructure Delays and Cost Escalation: Causes and Effects in Nigeria
3	Mistakes during construction	•Causes of Project Delays in Nigerian Construction Industry •Causes and Effects of Delays in Malaysian Construction Industry
4	Poor financial control on site	•Ranking of Delay Factors in Construction Projects After Egyptian Revolution
5	Delay in progress payment by owner	•Causes of Project Delays in Nigerian Construction Industry •Ranking of Delay Factors in Construction Projects After Egyptian Revolution •Evaluation of the Factors Influencing Time and Cost Overruns in Telecom Tower Construction in Ghana •Causes of Delay in Large Building Construction Projects •Causes of Delay in Building Construction Projects in Egypt
6	Delay payment to supplier /subcontractor	•Delays in Construction Projects: The Case of Jordan •Dealing With Cost and Time in the Portuguese Construction Industry •An Investigation into the Causes of Delay and Cost Overrun in Uganda's Public Sector Construction Projects
7	Lack of coordination between parties	•Quantification of Delay Factors by Using Relative Importance Index (RII) Method for Construction Projects in Turkey •Construction Delays in a Fast-growing Economy : Comparing Thailand with other Economies
8	Lack of communication between parties	• Causes of Project Delays in Nigerian Construction Industry • Causes and Effects of Delays in Malaysian Construction Industry • Quantification of Delay Factors by Using Relative Importance Index (RII) Method for Construction Projects in Turkey • Common Risks Affecting Time Overrun in Road Construction Projects in Palestine: Contractors' perspective
9	Labour productivity	Causes and Effects of Delays in Malaysian Construction Industry
10	Shortage of technical personnel	Delays in Building Construction Projects in Ghana

11	Equipment availability and failure	• Causes and Effects of Delays in Malaysian Construction Industry • Infrastructure Delays and Cost Escalation: Causes and Effects in Nigeria • Causes of Construction Delay : Traditional Contracts
12	Inadequate monitoring and control	• An Investigation into the Causes of Delay and Cost Overrun in Uganda's Public Sector Construction Projects
13	Mistakes and Errors in design	• Delay and Cost Overruns in Vietnam Large Construction Projects: A comparison with other Selected Countries <i>Table 2.2 – Causes for cost overrun</i> • Cost Performance for Building Construction Projects in Klang Valley
14	Contractual claims	Project Cost Overruns and Risk Management
15	High cost of labour	Significant Factors Causing Cost Overruns in Telecommunication Projects in Nigeria
16	Labour absenteeism	
17	Fluctuation of prices of materials	• Causes of Delay in MARA Management Procurement Construction Projects • Significant Factors Causing Cost Overruns in Telecommunication Projects in Nigeria • Cost Performance for Building Construction Projects in Klang Valley • Cost Overrun Factors In Construction Industry of Pakistan
18	Inaccurate quantity take-off	• Mathematical Expression for Explaining Project Delays in Southwestern Nigeria • Delays and Cost Overruns in the Construction Projects in the Gaza Strip
19	Poor site management and supervision	• Causes of f Project Delays in Nigerian Construction Industry • Causes of Delay in MARA Management Procurement Construction Projects • Cost Performance in Construction Industry of Pakistan

		• A Comparative Study of Causes of Time Overruns in Hong Kong Construction Projects
20	Inadequate planning and scheduling	• Causes of f Project Delays in Nigerian Construction Industry • Causes and Effects of Delays in Malaysian Construction Industry • Cost Overrun Factors In Construction Industry of Pakistan • Advancing and Integrating Construction Education, Research & Practice
21	Lack of experience	• Causes of Project Delays in Nigerian Construction Industry • Potential Effects on Large Mara Construction Projects Due To Construction Delay • Causes and Effects of Delays in Malaysian Construction Industry • Cost Performance for Building Construction Projects in Klang Valley
22	Frequent design changes	• Significant Factors Causing Cost Overruns in Telecommunication Projects in Nigeria • Identifying the Important Causes of Delays in Building Construction Projects • Delays and Cost Overruns in the Construction Projects in the Gaza Strip • Cost and Time Control of Construction Projects: Inhibiting Factors and Mitigating Measures in Practice
23	Cash flow and financial difficulties faced by contractors	• Potential Effects on Large Mara Construction Projects Due To Construction Delay • Causes of Delay in MARA Management Procurement Construction Projects • Cost and Time Control of Construction Projects: Inhibiting Factors and Mitigating Measures in Practice
24	Financial difficulties of owner	• The Significant Factors Causing Delay of Building Construction Projects in Malaysia • Stakeholders' Perception of the Causes and Effects of Construction Delays on Project Delivery

25	Slow information flow between parties	• Delay and Cost Overruns in Vietnam Large Construction Projects: A comparison with other Selected Countries • Delays and Cost Overruns in the Construction Projects in the Gaza Strip • Delays and Cost Increases in the Construction of Private Residential Projects in Kuwait • Reasons for Cost and Schedule Increase for Engineering Design Projects
26	Shortage of site workers	• Delays in Construction Projects: The Case of Jordan • Construction Delays in a Fast-growing Economy : Comparing Thailand with other Economies • Delays in Building Construction Projects in Ghana • Delay In Large Mara Construction Projects Based On Project
27	Shortages of materials	• Causes of Project Delays in Nigerian Construction Industry • Delay and Cost Overruns in Vietnam Large Construction Projects: A comparison with other Selected Countries • Causes and Effects of Delays in Malaysian Construction Industry • Infrastructure Delays and Cost Escalation: Causes and Effects in Nigeria
28	Late delivery of materials and equipment	• Identifying the Important Causes of Delays in Building Construction Projects • Preliminary Study on Causative Factors Leading to Construction Cost Overrun • Knowledge-based Material Cost Control for Building Construction Project using Expert System Approach
29	Poor project management	• Delay and Cost Overruns in Vietnam Large Construction Projects: A comparison with other Selected Countries • Cost Performance for Building Construction Projects in Klang Valley • Cost Overrun Factors In Construction Industry of Pakistan • Advancing and Integrating Construction Education, Research & Practice

30	Change in the scope of the project	• Cost Escalation and Schedule Delays in Road Construction Projects in Zambia • Evaluation of the Factors Influencing Time and Cost Overruns in Telecom Tower Construction in Ghana • An Investigation into the Causes of Delay and Cost Overrun in Uganda's Public Sector Construction Projects, • Cost Overrun Factors In Construction Industry of Pakistan • Advancing and Integrating Construction Education, Research & Practice
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Table 2.1 – Factors of cost overrun

Results showed a total of 30 factors were identified occur in the construction phase. This shows that the construction phase is the major contributor to the problem of time and cost overrun. By using the previous study, this study can identify the factors that occur in each phase of the project life cycle. In overall context, only two factors occurred in all phases. Among these factors is lack of communication between parties and change in the scope of the project. From these results, again, it is noted that construction phase is a major contributor on time and cost overrun in construction project. The findings could help the practitioners to gain better understanding about the factors influencing on time and cost along construction project.

2.4. Advantages and Challenges of Using BIM: a Cost Consultant's Perspective

Jununkar, S. M., Aswar, P. D. S., & Mittapalli, P. D. L. (2017). Application of Bim and Construction Process Simulation Using 5D Bim for Residential Building Project. *Int Res J Eng Technol.*, 4(07), 1063-7.

Building Information Modeling (BIM) represents the formation of digital models for use during the planning, design, construction and operation stages of a facility's life. Whilst BIM is currently receiving high volumes of attention around the world, it appears that general understanding of it is relatively low. Focus of this study is to identify the advantages, challenges and usability of BIM for cost consultants, and its likely impact during cost estimating. Research was carried out through an in-depth review of existing literature, which was refined through questionnaire surveys and expert interviews to assess the potential advantages and challenges for cost consultants using BIM in their working practices. This research also identifies potential areas for expansion of cost consultancy services, through BIM implementation and shows that BIM has the capacity to influence the operations throughout the construction industry.

This paper was inspired by the current level of uncertainty as to how BIM will affect the cost consulting profession; these being consultants employed to act as client

Quantity Surveyors, with primary roles of managing and controlling project costs. It is important for cost consultants to fully understand how they can work effectively with BIM, as the UK 'Government Construction Strategy 2011' outlines that it will be mandatory for all public projects of £5 million and over, to be working collaboratively with level 2 BIM by 2016.

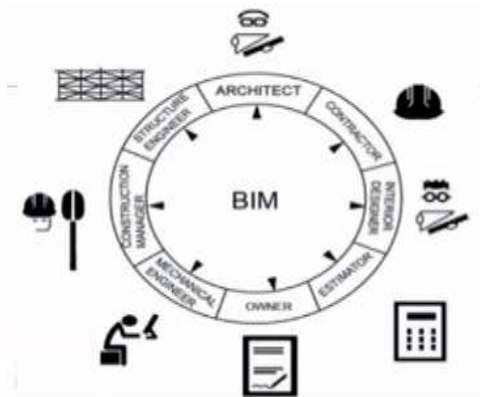


Figure 2.3 - Conventional method-Step by step

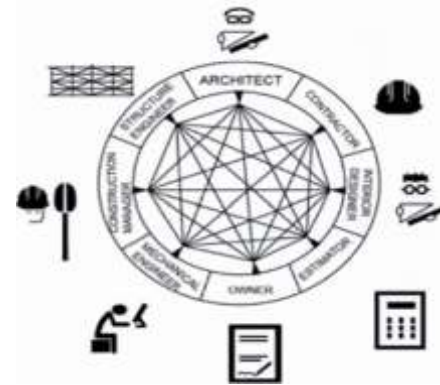


Figure 2.4 - BIM-Work together approach

The results showed a generally low level of BIM experience amongst the respondents, with approximately 20% of cost consultants and 40% of general construction professionals surveyed having previously used it. This was reflected within the RICS '2011 BIM Survey', which reported only 10% of Quantity Surveyors were regularly using BIM in working practices. Whilst there have been fears within the industry that BIM could threaten the viability of the quantity surveying profession through automatic quantification, a large international cost consultancy firm who are currently using BIM, promote a positive attitude and state that it has enhanced their service delivery, including the provision of up to-date cost planning.

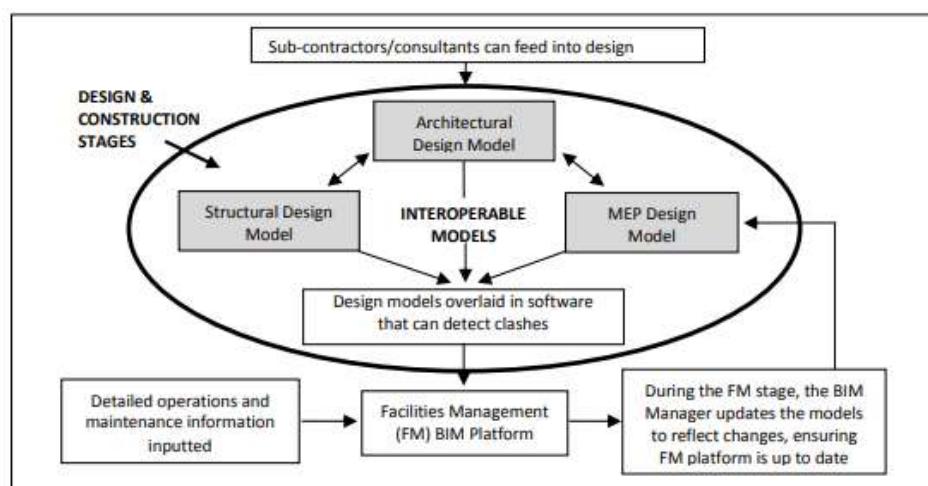


Figure 2.5 - Capabilities of BIM

A potential reason for the level of uncertainty towards BIM implementation may be due to a lack of personal knowledge and experience. When asked whether other members of their profession were keen to embrace BIM, both surveys showed a mixed opinion towards the usage of BIM in everyday practices. Similarly, the question of whether respondents felt that BIM would fundamentally change their current role received a varied response, with the majority neither agreeing nor disagreeing.

Again, this may be because of a lack of real understanding of BIM and how it can be integrated into the construction industry and within the various professional disciplines. An improved knowledge base may help individuals to form clearer attitudes towards BIM; however, this can be a complex process, as there is no single document instructing on its application and usage

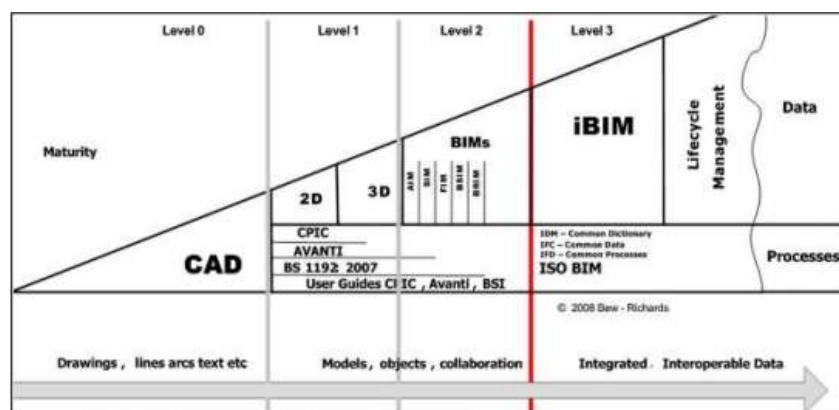


Figure 2.5 - Evaluation of BIM

Interviewee revealed that a key driver for his company investing in BIM was the commercial advantage they felt it would give them over competitors, hoping that clients would see the potential benefits BIM can offer as long term facility users. Interviewee B supported this viewpoint stating that as a client who has worked with BIM, in the future they would only look to appoint consultants who can use BIM. Whilst the research has shown a generally a slow uptake of BIM amongst Quantity Surveyors, the cost consultancy survey showed a 63% agreement that BIM will be used widely by the profession over the next five years, representing a higher level of agreement than the general construction professionals, at 47%. Therefore, as the findings show a general acceptance from cost consultants that BIM will be implemented across their profession, it would seem the most constructive attitude to take is to embrace the movement positively.

Integration and Interoperability	• A widely publicized advantage of BIM is the increased collaboration amongst the project team, achievable through use of a centralized model
Provision of Additional Information and Service Expansion	• As designs develop through BIM, it will be possible to link models with a National Building Standards (NBS) application. • This can be used to provide early and reliable specification data, which can be a useful cost management tool
Collaborative Working Approach and Change in Current Practice	• The detailed literature review shows that collaborative working is one of the most commonly reported advantages of using BIM on construction projects. • From the surveys undertaken, 70 % of the respondents agreed that BIM will improve project collaboration.

Table 2.2 – Benefits of BIM

The research has shown that widespread BIM implementation is anticipated to bring about a new way of working and thinking within the construction industry. Usage of BIM is increasing, therefore making it essential for cost consultants to adapt and embrace or risk the threat of losing ground to others. It is not only BIM's capability of performing automatic and accurate quantification that cost consultants need to be aware of, but also the opportunities that it can offer to the profession, through a understanding of BIM's potential advantages and challenges.

2.5. Scope of Building Information Modeling (BIM) in India

Kumar, J. V., & Mukherjee, M. (2009). Scope of building information modeling (BIM) in India. *Journal of Engineering Science and Technology Review*, 2(1), 165-169.

Building Information Modeling (BIM) may be a model-based design concept, during which buildings are going to be built virtually before they get built call at the sector, where data models organized for complete integration of all relevant factors within the building lifecycle which also manages the knowledge exchange between the AEC (Architects, Engineers, Contractors) professionals, to strengthen the interaction between the planning team.

BIM may be a shared knowledge about the knowledge for decisions making during its lifecycle. There are a lot of information to know about the opportunities and implications of this tool. This paper deals with the status check of BIM application in

India, to try to that a survey has been designed to see the acceptance of BIM till date.

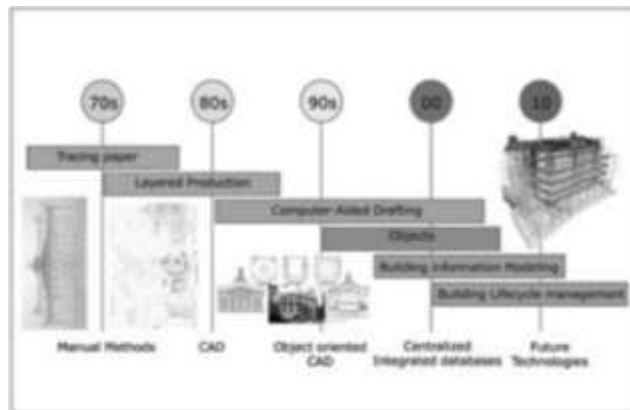


Figure 2.6 - Phases of development

BIM and CAD

The main differences between BIM and Computer Aided Design (CAD) are that CAD system is usually 2D document, which are created separately and have no intelligent connection between separately created documents.

Task	CAD (hours)	BIM (hours)	Hours saved	Time savings
Schematic	190	90	100	53%
Design development	436	220	216	50%
Construction documents	1,023	815	208	20%
Checking and coordination	175	16	159	91%
Totals:	1,824	1,141	683	

Source: (Rick Rundel (7), 2007)

Figure 2.7 - Time saving

2.5.1 Acceptance Level of BIM in India

BIM application has received different levels of acceptance in several countries. In US this is often not only accepted but also made compulsory to large extent. The General Service Administration (GSA) people has initiated a requirement in 2007 for the planners to supply a BIM model for spatial program validation as an open standard if they are applying funding for their projects. Even if BIM is a newly formed technique, it has shown strong acceptance potential here. A Questionnaire has been designed to check current status of BIM. Objectives: There are two main objectives

- The first objective is to spot the share usage of BIM among Indian AEC companies.

- The second is to record the benefits of BIM as comprehended by companies using this method. The barriers to adopt this technology have also been explored.

The survey questions listed variety of criteria to gauge BIM solutions. For each of these criteria, respondents indicated their preference by rating it on a 5 point scale, where 1 indicates “strongly agree” and 5 indicates “strongly disagree.”

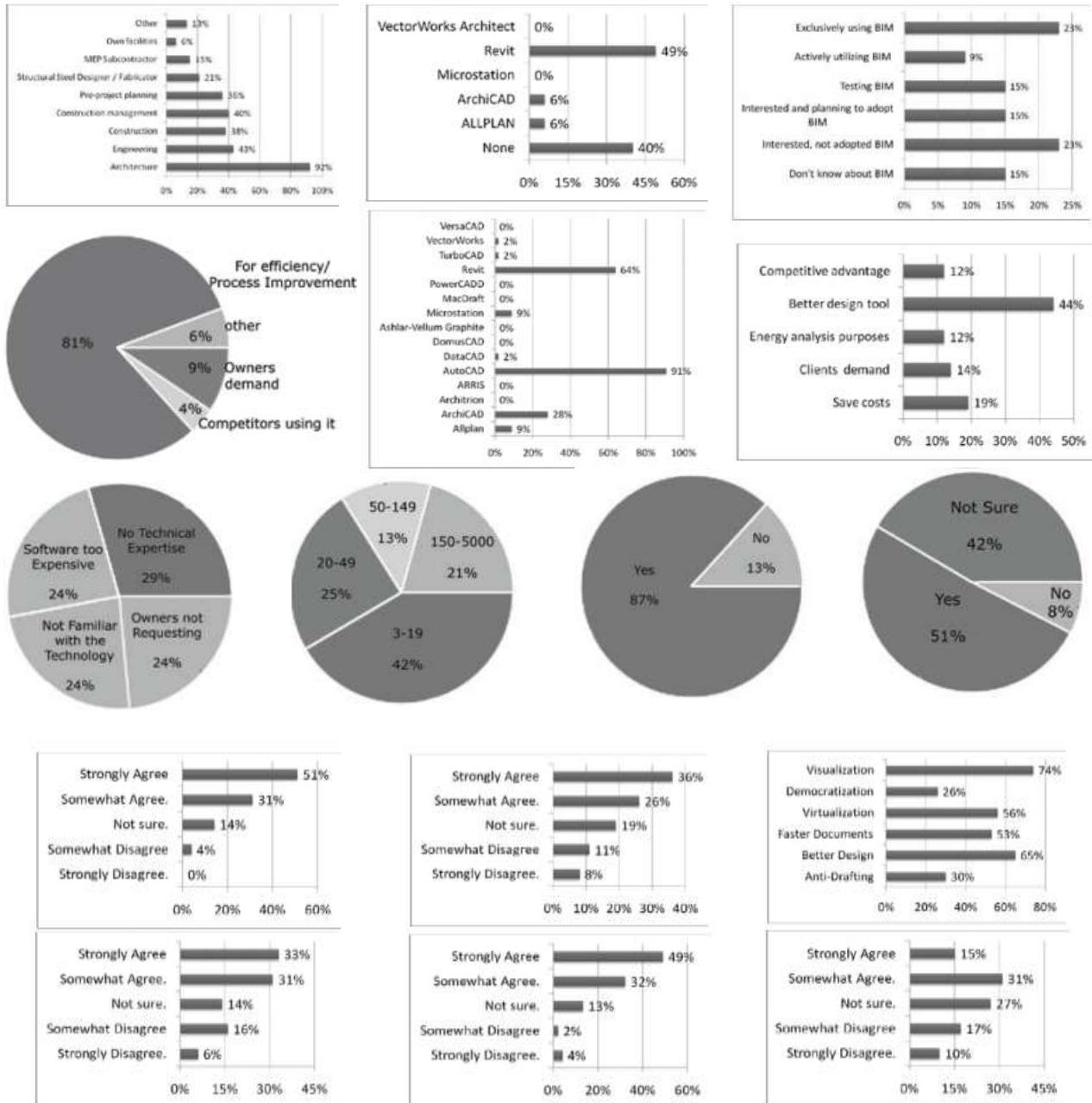


Figure 2.8 - Responses

The BIM is a new and promising approach in India which is gradually gaining acceptance by the owners, architects, engineers, and builders. The survey explores the BIM potentials when used in the field to better communicate and integrate construction information across different trades, allowing for efficient work processes and better decisions. More specifically, the study concentrated on the deployment of the model to support planning, scheduling and tracking of the job site operations in India. The survey has supported the authors' expectation that BIM has remarkable acceptance potential among the AEC firms in India.

2.6. Project Cost Management

Project Cost Management includes all the process that is needed to make sure that the project is completed within the allocated budget.

Resource Planning: determining what resources (people, equipment, materials) and what quantities required to perform project activities.

Cost Estimating: developing an approximation (estimate) of the prices of the resources needed to finish project activities.

Cost Budgeting: allocating the general cost estimate to individual work activities.

Cost Control: control the changes to the project budget.

Plan cost management

Plan Cost Management is the process of defining how the project costs will be estimated, budgeted, managed, monitored, and controlled. The key benefit of this process is that it provides guidance and direction on how the project costs will be managed throughout the project. This process is performed once or at predefined points in the project.

Estimate costs

Estimate Costs is the process of developing an approximation of the cost of resources needed to complete project work. The key benefit of this process is that it determines the monetary resources required for the project. This process is performed periodically throughout the project as needed.

Determine budget

Determine Budget is the process of aggregating the estimated costs of individual activities or work packages to establish an authorized cost baseline. The key benefit of this process is that it determines the cost baseline against which project performance can be monitored and controlled. This process is performed once or at predefined points in the project. A project budget includes all the funds authorized to execute the project.

Control costs

Control Costs is the process of monitoring the status of the project to update the project costs and managing changes to the cost baseline. The key benefit of this process is that the cost baseline is maintained throughout the project. This process is performed throughout the project.

2.7. Concept of BIM

Referring to the National Building Information Model Standard (NBIMS), BIM is defined as “a digital representation of physical and functional characteristics of a facility. It is a concept for a series of techniques that enable the process and practice of virtual design and construction through the project life cycle.

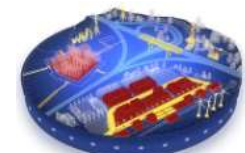
Plan

Inform project planning by combining reality capture and real-world data to generate context models of the existing built and natural environment



Design

During this phase, conceptual design, analysis, detailing and documentation are performed. The preconstruction process begins using BIM data to inform scheduling and logistics.



Build

During this phase, fabrication begins using BIM specifications. Project construction logistics are shared with trades and contractors to ensure optimum timing and efficiency.



Operate

BIM data carries over to operations and maintenance of finished assets. BIM data can be used down the road for cost-effective renovation or efficient deconstruction too.



2.7.1. Capabilities of BIM

BIM provides a collaborative single platform for AECO team which leads to

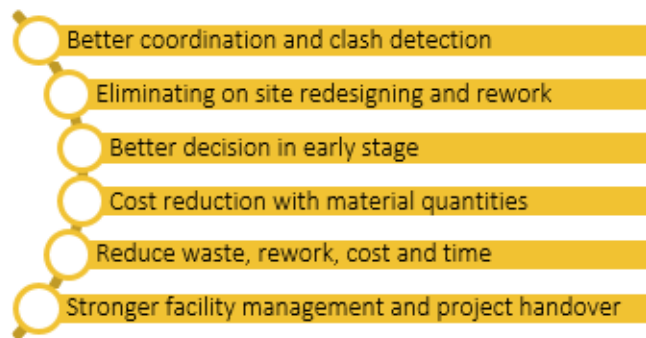


Figure 2.9 - Capabilities of BIM

2.7.2. Roles and Responsibilities of BIM Professionals

Building Information Modeling (BIM) BIM is one of the most recent developments, an emerging procedural and technological shift within the architecture, engineering, and construction sector. Researches have shown that BIM, a three-dimensional (3D) parametric modelling software has the capacity to address a number of technical challenges in construction projects.

For instance, BIM might reduce the costs of engineering and rework. It also promotes uninterrupted flow of information, improves engineering productivity, improves customer services, reduces lead times and design errors. BIM is more reliable in delivering projects within the shortest possible time and in streamlining the procurement of component parts or materials for production. BIM can reduce the time, mistakes and errors caused by modifications.

Reports on BIM indicate that the adoption of BIM can save between 3% and 5% in costs, can boost GDP by 0.2 and has a remarkable effect design, construction and the economy. The companies regularly seek to hire the most technically-skilled and creative design specialists available, especially with regard to BIM. Successful execution of construction projects and keeping them within the agreed schedule and estimated cost depend largely on the methodology which requires sound engineering judgment.

In order to minimize delays through the use of BIM, the understanding of the roles and responsibilities of the BIM specialist is vital. The understanding of the roles and responsibilities could be used to gauge BIM potentials with regard to delay mitigation.

S.No	BIM Specialist	Roles and Responsibilities
1	BIM Modeler	- The roles of the BIM Modeler are to develop, create and extract 2D documentations from BIM models. - May occupy the position of the Draftsperson
2	3D Modeler.	Develops the geometry in the BIM models, working in groups to create different parts of the model
3	- Cost Modeler - Detailing Modeler	- Embeds information about the processes and resources required. - Designing, drawing, sizing, specifying, detailing, verifying and documenting the design process.
4	- Sequencing Modeler - BIM Analyst	- Adds phases to the resources develops building phasing files used for planning by the general contractors. - Performs simulations and analyses based on BIM models, e.g., security analysis, building performance analysis, etc.
5	- Modelling Specialist - BIM Application Developer	- Contributes along with specialists in various areas of the industry, to the standards, from the software product's requirements to the final characteristics. - Creates and customizes the software to bolster integration and BIM processes, from plug-ins to servers, data repositories, and integrated project management tools.
6	BIM Facilitator	- Assists other specialists. Generally, he works with those that physically construct the building, helping the engineers to communicate with contractors or foremen. - Extracts information from the BIM model for space planning, asset management, and maintenance schedule.
7	BIM Consultant - Functional - Operational	- Guides designers, builders and developers in BIM project implementation. - Develops action plans according to strategies. - Executes the process of implementation.

	• Strategic	• Develops strategies, typically, from medium to long-term based on a vision of accomplishment.
8	BIM Researcher	• BIM experts in research institutions, universities and government organizations who coordinate, teach or train and develop research on BIM.
9	BIM Manager (General)	• Oversees people in the implementation as well as maintenance of BIM processes. • Coordinates the team, production, and implementation of the model. • Inspects and evaluates the objectives of the BIM process and afterward designs a plan to meet the desires and demands of clients. • Performs other functions including coordinating entity model's integration, setting design templates, etc. • Guides the decision-making of the team.
10	Project Model Manager	• Concentrates on the production model, interacts with other project actors and the system. • Coordinates information from various construction stakeholders, which guarantees non-dilution of the responsibilities between the contractor and the design team. • Plans the mechanisms of maintenance and exchange of data • Determines the necessary conventions for the management and reviewing of model versions. • Holds meetings or calls with the modelers and the client to determine the required models, owners of the models and the responsibilities. • Divides projects into teams of modelers. • Verifies interference and keep the models accurate and updated. • Ensures the alteration of models when there is a request for changes. • transfers, access rights control, and information compilation from smaller models of different members.

		• Avails model files to general contractors. • Identifies communication errors, improves communication and information technologies and facilitates communication protocols. • Manages and supports detailing teams for the implementation and establishment of BIM standards. • Specifies detailing budgets for cost estimations.
11	BIM Manager (Design Firm)	• Responsible for BIM implementation. • Coordinates project teams and establishes connections for correspondence between various offices. • Attends developmental plan meetings for BIM project implementation. • Arranges training for workers to keep them updated about the trends and versions of BIM software. • Attends and participates in industrial conferences. • Designs materials to educate clients of the company's BIM capabilities, evaluates new products and verifies technical problems and deficiencies in the software, hardware and the net. • Ensures teams' commitment by developing an effective procurement system so that every agent performs its responsibilities.
12	BIM Manager (Contractor)	• Assists in the estimation of time and cost for implementation • Uses BIM software. • Designs a plan for small teams that after training perform works with BIM. • Responsible for resources management (people, software, and hardware) involved in model development. • Select the right individuals for every project activity. • Promotes credibility and confidence in the project team including clients, subcontractors and internal team members.

Table 2.3 – Roles and responsibilities of a BIM Professional

2.8. Roles and Responsibilities of a Quantity surveyor

On this challenging environment, it is important that every team member in the construction project is responsible for cost control. For instance,

- The Project Manager will be aware of the effective utilization of materials, manpower and equipment as he has the complete knowledge of what is happening at site.
- The Design Manager will be effective in reducing cost by changing the design which will provide the same function at the same time by reducing cost.
- The Site Engineer can effectively reduce the cost by properly monitoring and reporting the site activities to their boss.

Having discussed on the role of every member in the team, the project manager or the design manager will not be able to focus on cost control every time as it is not the main role of their job.

It is the role of quantity surveyors as they are employed full time to work on the cost part. It is important for the quantity surveyors to monitor the cost and to update the operations and design team if any elements cost exceeds the budget. The role of modern quantity surveyor is increasing to undertake more responsibilities. Initially a quantity surveyor's role was limited to measurement of drawings and materials. It gradually developed and now the role of quantity surveyors includes

- project finance planning,
- commercial management,
- Cost control during a period of scratch to finish.

The role of quantity surveyor will vary if he works for an employer, consultant, contractor, etc. As mentioned in the objective, the discussion is limited to the cost control during the post contract stage of the project therefore the roles and responsibilities discussed are limited to this context.

As per Chung (2002) the duties of quantity surveyor is to

- provide initial cost estimate,
- value management,
- sub-contractor selection,
- valuation,

- Cost control.

RICS (2008) states that the quantity surveyor services changes during different project stages, during the contract stage the quantity surveyor should

- provide advice on the contractual documents to employer,
- recommendation for the interim valuations and payments,
- variations, cost control,
- Final account, etc.

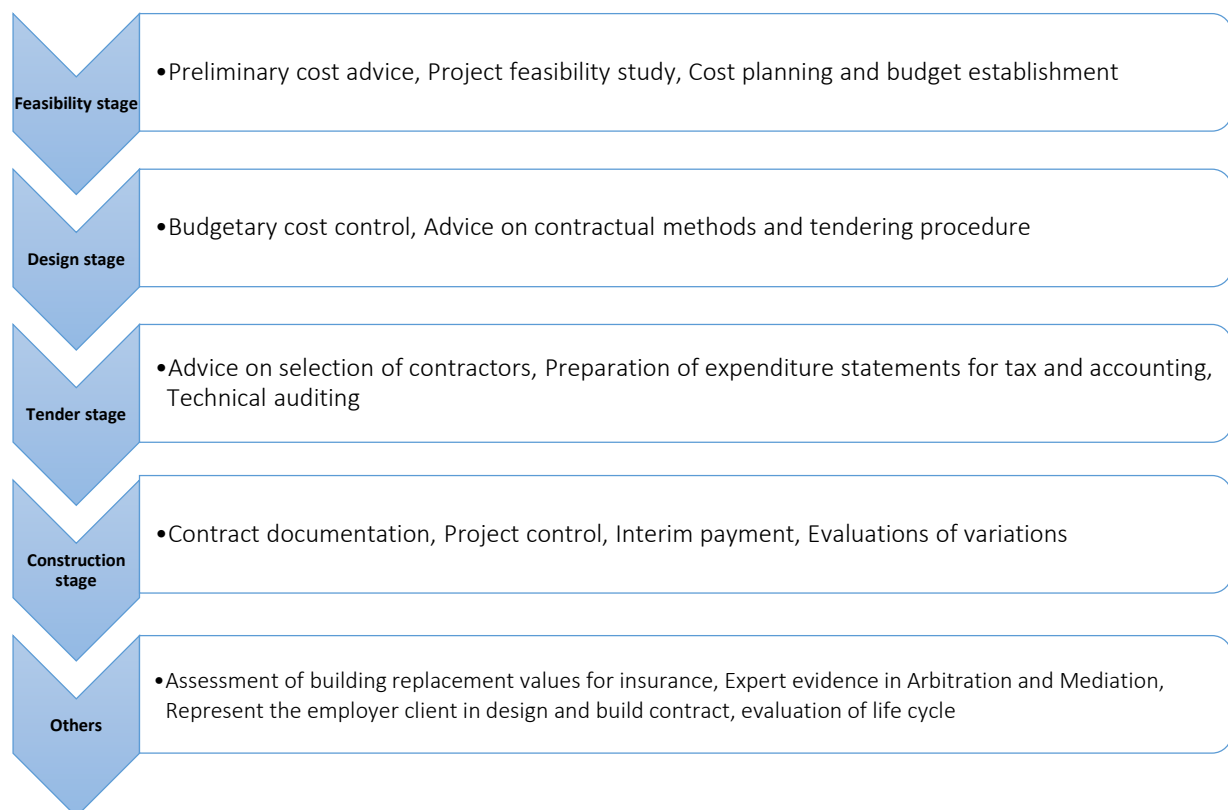


Figure 2.9 – Rules and Responsibilities of a Quantity Surveyor

RIBA (Ribaplanofwork.com, 2017) plan of work list the role of quantity surveyor during the projection execution as

- managing contract documents,
- project cost control,
- interim evaluation,
- payments,
- valuation of variations, etc.

The above various sources emphasis the role of quantity surveyors in cost control.

In construction, the cost control starts from the beginning and concludes during final account. There are several methods followed by the quantity surveyors who work for a contracting company for cost control during the pre-and post-contract stage. The need of cost control aims to deliver the employer with a “value for money” project, to achieve the balance in expenses for different elements of a building, to limit the expenditure from employer within the agreed amount. The quantity surveyors engage strict cost control during various stages of construction. This will ensure the cost is managed within the initial estimated amount. There are various methods followed by QS for cost control. Rough Estimation, Cost advice, Cost plan, Cost monitoring, Periodical finance statements. These methods enable the employer to know the anticipated final cost and to control the finance commitments.

2.9. LITERATURE CASE STUDY

2.9.1. 500 bedded hostel building of Osmania University, Hyderabad

Aziz, A., & Kumar, S. (2019, March). Financial and work management analysis for residential construction: A case study. In *International Conference on Advances in Civil Engineering (ICACE-2019)* (Vol. 21, p. 23).

The traditional construction process has never been into the scheduling the time and cost management. As a result, there are lost of time, materials, cost and poor quality of construction. In recent years, software’s play vital role in resolving such problems in construction industry, which benefit financial and work management. Primavera is one such software which helps in planning the work to its maximum extent and help in improving the quality and productivity of work. It also helps in efficiently manipulating the project cost. The present study analyses the comparison of financial and work management of a traditionally constructed building (G+4 building, Osmania University, Hyderabad) and implementing the scheduled work and financial management using primavera to the same building and compares the results. The study discusses the pros and cons of the analysis of the above results. This study relieved that the primavera helps in optimization the construction project in scheduling and improves the productivity. The results will project the earned value

graph which show the cost performance index and scheduled performance index of resources.



Figure 2.10 – Osmania University, Hyderabad

Description of Site

The study area is located in OU Hyderabad, TS. It is a G+4 building consisting of 250rooms which accommodates 500 people. The project started in dec2017. The present status of the project: external and internal brick work competed. Terrace parapet wall construction in process. Inside and outside plastering work, plumbing work, tile work, paint work, electrical work, carpentry work, and flooring are pending

Description of work

The methodology adopted/ involved in this research work is comparison of the two processes of sequential steps, as per objectives set for his study, and that runs parallel throughout the research until the analysis and comparison of the project outcomes of both the processes are done to conclude on the research

S.No	Title	Details
1	Project cost	21Crores
2	Total area of the project	10942.30 Sq.mt
3	Ground floor area	2506.82 Sq.mts
4	First floor area	1903.84Sq.mts
5	Second floor area	2256.00 Sq.mts
6	Third floor area	2256.00 Sq.mts
7	Fourth floor area	2019.64 Sq.mts
8	Ground floor	43rooms – 86persons
9	First floor	49rooms – 98persons
10	Second floor	52rooms – 104persons
11	Third floor	52rooms – 104persons
12	Fourth floor	54rooms – 108persons

Table 2.4 – Project details

A 500 bedded hostel building of Osmania university of Hyderabad is selected and this project consists of G+4 floors.

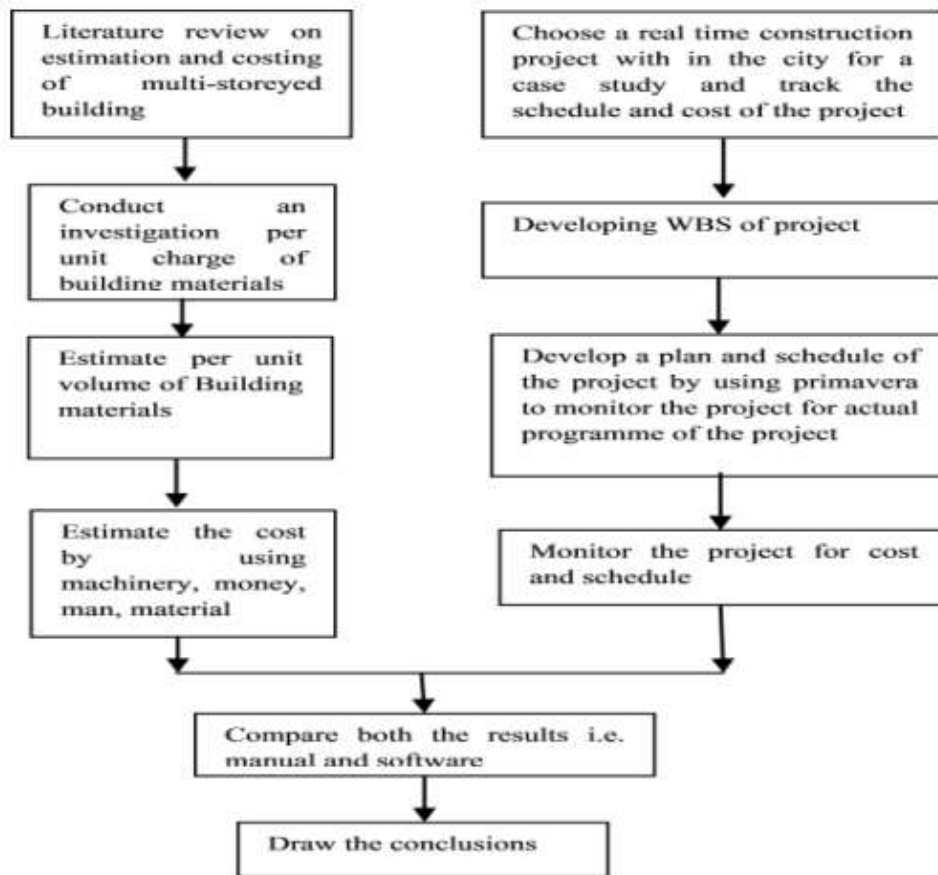


Figure 2.11 – Methodology

Primavera description

Project management using primavera (p6) software to plan, monitor, schedule, and update the progress of the project can be done effectively in terms of cost and time. Steps involved in implementing the project in primavera

Enterprise project structure (EPS): EPS is a hierarchical arrangement of projects in an organization. The EPS is available to all existing and future projects in the Enterprise

Organizational breakdown structure (OBS): After Creating EPS the main step involved in the software is to create OBS which shows that the persons responsible for the project in the enterprise.

Interlinking: link both enterprise project structure (EPS) and organizational breakdown structure (OBS).

Create a project: After linking the EPS and the OBS the project has been created. A project is a collection of both activities and tasks that all together result in the creation of the structure or product.

Creating a Calendar: The project calendars form a very important part in the project schedule and mainly calendar is created to calculate the start and finish dates of the project. Figure II shows the calendar in primavera



Figure 2.11 – Calendar Creation

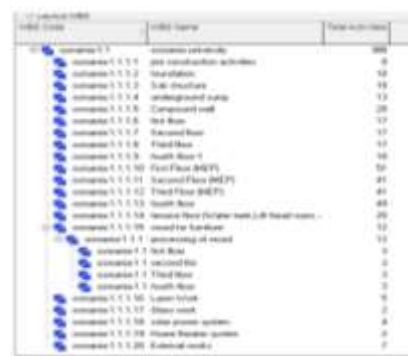


Figure 2.12 –Creating WBS

Creating a work breakdown structure: It is one of the following steps in the project management and it break down the project into major deliverables i.e. project components and it is called work break down structure (WBS). Focusing on the deliverables it is small enough to work activities can be clearly defined and assigned to that element. The work breakdown structure of our project comprises of 18 stages, namely 1) Pre-Construction Activities 2) Foundation 3) Sub Structure 4) Underground Water Sump 5) Compound Walls 6) First Floor 7)Second Floor 8) Third Floor 9) Fourth Floor 10) First Floor MEP 11) Second Floor MEP 12) Third Floor MEP 13) Fourth Floor MEP 14) Lawn Work 15) Glass Work 16) Solar Power System 17) Home Theatre System 18) External Works

Listing of project activities: after creating the work break down structure, we have to define the activities i.e. to break down the components into sub components. It is known that each activity has its own duration, start and finish dates and logical relationship which helps in scheduling the project. And all the stages of activities consist of 485 activities



Figure 2.13 – Assigning activities

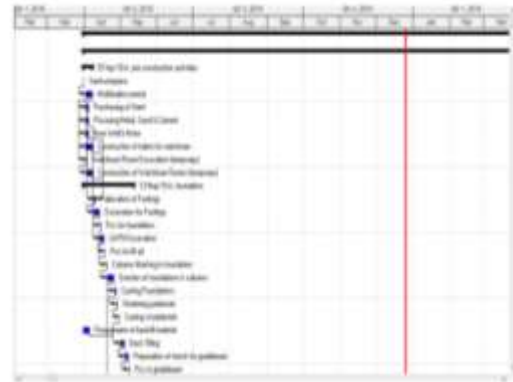


Figure 2.14 – Gantt chart

Assigning relationships among activities After entering all the task, the next step is to assign the relationships. Assigning logical links is nothing but assigning interdependency of each activity. **Predecessor**: The preceding activity for a specific activity is called Predecessor. **Successor**: The succeeding activity for a specific activity is called Successor. There are four types of relationships available. They are as follows:

1. Finish to start (FS): It is a default relationship followed in primavera; here the activity starts the completion of the previous activity.
2. Start to start (SS): It indicates that the current activity and its predecessor will start on the same date.
3. Finish to finish (FF): It indicates that the current activity and its predecessor will finish on the same date.
4. Start to finish (SF): It indicates that the current activity and its predecessor activity start date will be same.

Project scheduling: It is the main step to analyses the project is to schedule the overall project. If any changes are made in project during the execution, primavera software enables us to reschedule the project for cost and other parameters and project scheduling is used to know the total duration and cost of the project from the assigned baseline.

Gantt chart: It is used in project management and it helps in how the project will run and also it provides a project illustration of schedule which has start and finish dates of the project and it helps to manage the relationships between the tasks. It provides undeniable graphical presentation of schedule activities and their relationships over time. In this we can view clearly see the duration of activities and their sequential placement on the calendar.

Network diagram: It clearly defines the relationship between the tasks when compared to Gantt chart. The network diagram depicts the cycle of activities by showing activities as terminal elements and their relationships as connecting arrows. In this way the network diagram highlights the relationships between activities.

Assigning the resources: Resources like men, machinery, money and materials are to be assigned to the activities as needed by them. Project success will mainly depend upon the proper utilization of resources which in turn will be resulting to the cost optimization of the project.

Fixing the Base Line & Updating the project: After completing the above steps it is necessary to make a base line of the project and it refers to the copy of the original schedule, while updating the project it allows you to display where the project is diverting from the original schedule.

Tracking the project progress: It is the important step in the primavera. It helps to track the project against the original schedule by EVA (Earned Value Analysis). It is one of the most popular and standard method of measuring the project progress at any given time and also used to analyses variances of the actual cost of the project from the baseline cost during the progress of the project. EVA requires three parameters namely

1. **Planned value (PV):** It is referred to the budgeted cost for the work schedule for the project.
2. **Earned value (EV):** It is referred to the budgeted cost for the work schedule for the evaluation of the progress of the project in terms of schedule and cost.
3. **Actual cost (AC):** It is referred to the actual amount spent on the work performed.

Budget at completion (BAC) is referred to the budget scheduled to complete the project. Schedule performance index (SPI) is the ratio of earned value to the planned value. Cost performance index (CPI) is the ratio of earned value to actual cost.

Results

As on tracking cost performing 88% (CPI 0.88) as budgeted cost, it shows the project cost is overrunning. 67.19% of the project is completed up to December 26 2018. Blue line in the graph shows that the project has been updated in the December month. As, mentioned in the objectives the comparison of manmade estimate and the primavera 21,50,39,633 and 21,64,18,103.50. The difference between manmade estimate and the primavera is 13,78,470.5. It seems that the primavera software is estimating high cost than the manmade estimate it results that software includes all the taxes and accurate and perfect result. Primavera software reduces the time of the estimate. While manmade estimate is the time-consuming process. So now days all companies prefer primavera software and its demand is very high in the market.

Inference

Financial and work management of any project decided its successfulness. The present study aimed to know difference between the manmade and primavera software, in estimation of scheduling of financial and work management of a project with the aid e.g. literature references and the unique methodology in monitoring and control with the help of primavera software. The planning of various activities throughout the project run would be optimum, then financial and work management can be done properly. The primavera software is a perfect and efficient tool for the purpose of monitoring and controlling of the various construction projects

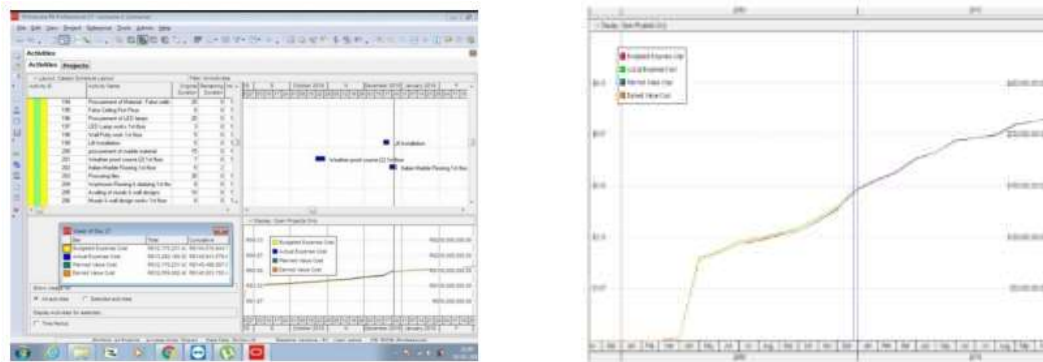


Figure 2.15 – Result

2.9.2. Sai Shriya Samruddhi, Wagholi, Pune

Kulkarni, S. B., & Mhetar, G. (2017). Cost control technique using Building Information Modeling (BIM) for a residential building. *International Journal of Engineering Research and Technology*, 10(1), 324-330

Introduction

This project is located in Wagholi, Pune. It is a 12 storied residential building with total construction area is about 15,000 m². This has alternate floor designing same. Framing is RCC and wall structure is in light weight concrete bricks. Designing is done in 2D Auto-CAD drawings, Scheduling is in Microsoft's project software.

Levels of maturity of BIM

Level 0

Usage of BIM software At level 0, 3D is utilized in the design phase. But there is no coordinated connection to the models of other disciplines or requirements regarding documentation of information exchange. Many of the 3D softwares which are employed in the day-to-day work have functions that could be classified as BIM. However, these functions are not utilized at the present time and there is unexploited potential which could be benefited from.

Level 1 - DEFINED

3D coordination

Stage 1 in the BIM maturity levels implies a well-functioning coordination between different disciplines. As the building information models of different disciplines are interconnected, clash controls can be performed. An example of an additional service that can be provided at this level is identification and organization of information flows within the project, which is a prerequisite for creating a common understanding regarding goals in the project.

Level 2 - MANAGED

Analyzes, time and cost estimation

At level 2 in BIM maturity, level 1 and one or several additional BIM services which require input from more than one discipline are provided. Examples of services which can be provided at level 2 are energy analyzes and more elementary variants of time and cost estimation.

Level 3 - INTEGRATED

Integrated model

In order to operate at level 3, more advance models are required. Services from both level 1 and 2 are provided with a highly integrated model between the different disciplines. Examples of services which can be provided at level 3 are more advanced time and cost estimation, programmed with a parametric design, as well as maintenance models which is fully integrated with the client's management and maintenance systems.

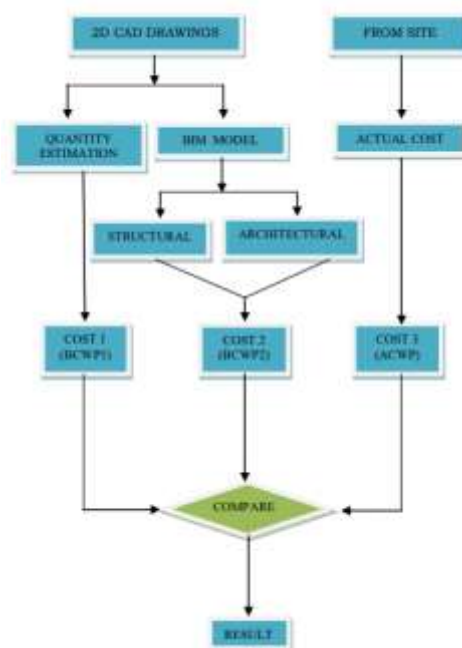


Figure 2.15 – Work flow

- Preparation of 3-D BIM model using Autodesk's Revit Architecture software for given building plan with details.
- Quantity Estimation and cost for different items from 3D model using Autodesk's Revit Architecture software.
- Put these details in a Microsoft Excel sheet (.xml format) for further use.
- Preparation of MSP schedule for construction activities using Microsoft Project.
- Using Autodesk's Navis Work Software, integrate both the MSP Schedule and Cost data for each item from excel sheet.
- Obtain simulated view of project in terms of time and cost as 4D & 5D model.
- Feed the Actual data of construction site using Microsoft Excel sheet to Navis Work to obtain the variance of time and cost to observe the critical area for cost variance by simulation.
- Collecting the details of quantities and cost items with traditional method from office to verify the difference with respect to BIM model.
- Calculate the difference of traditional method over BIM model and compare.
- Observe which method is meeting to actual expenditures.

Structural building information model

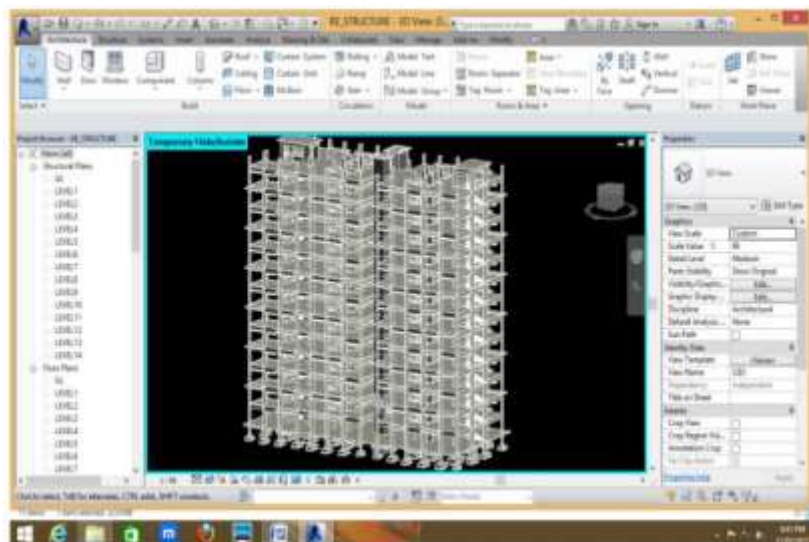


Figure 0.16 - Structural building information model

For construction of Structural Building Information Model detailed structural drawings are referred. With the assistance of Revit Architecture 2014 software, and other available details like, material used and cost of respective materials etc.

Architectural building information model

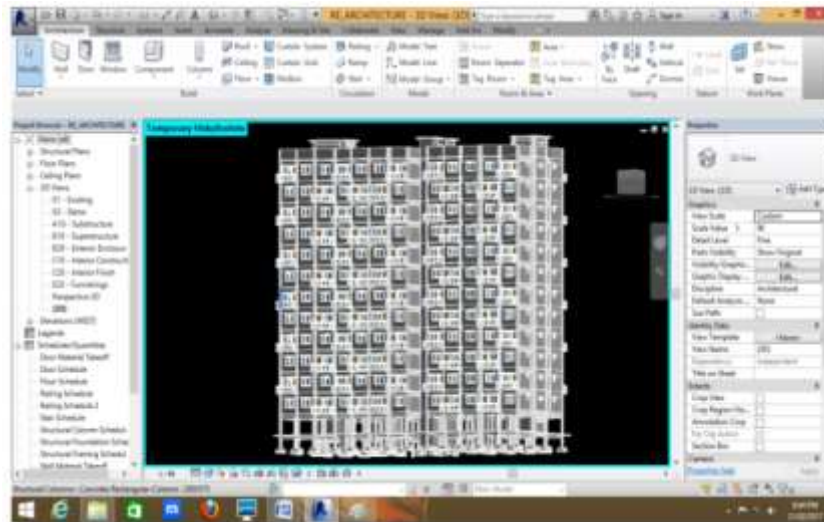


Figure 0.17 - Architectural building information model

For construction of Architectural BIM detailed AutoCAD drawings are referred. With the assistance of Revit Architecture 2014 software, and other available details like, material used and cost of respective materials etc. the model is completed.

Quantities and cost from Revit architecture 2014

Family and Type	Level	Structural Material	Count	Width	Length	Volume	Cost
R_Footing-Rectangular P1	T.O. Footing	8025	1	1000	1000	0.90 m³	4320
R_Footing-Rectangular P1	T.O. Footing	8025	1	1000	1000	0.90 m³	4320
R_Footing-Rectangular P1	T.O. Footing	8025	1	1000	1000	0.90 m³	4320
R_Footing-Rectangular P1	T.O. Footing	8025	1	1000	1000	0.90 m³	4320
R_Footing-Rectangular P1	T.O. Footing	8025	1	1000	1000	0.90 m³	4320
R_Footing-Rectangular P2	T.O. Footing	8025	1	1000	1100	0.99 m³	4410
R_Footing-Rectangular P2	T.O. Footing	8025	1	1000	1100	0.99 m³	4410
R_Footing-Rectangular P2	T.O. Footing	8025	1	1000	1100	0.99 m³	4410

Figure 0.18 - Quantities and cost from Revit architecture 2014

Msp schedule for project

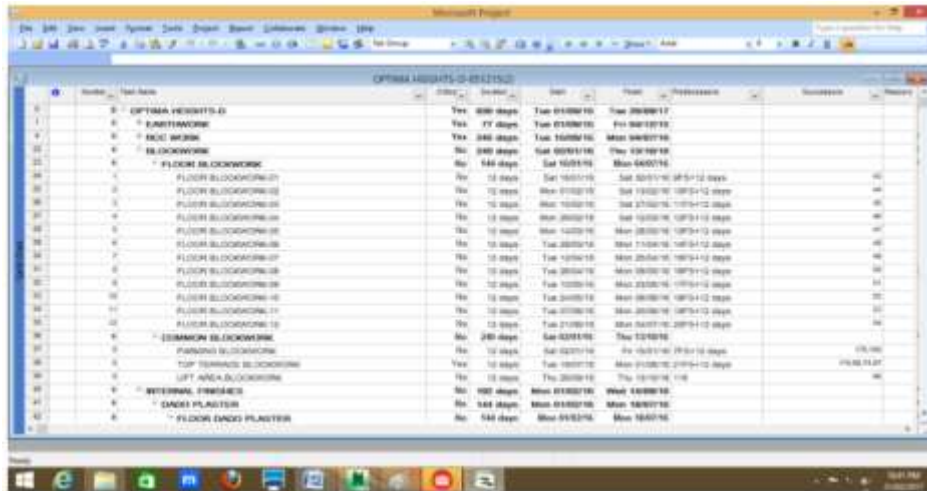


Figure 0.19 - Msp schedule for project

All the project item details are transferred to Excel sheets. Few building items are taken in consideration for the research study from BIM model and those items are compared to actual cost. The costs with BIM model are named as COST 2.

Costs of all the items which are traditionally figured out i.e. with help of 2D drawing only also are taken for the comparison and this costs are named as COST 1.

Actual costs of all the items required are collected from construction site. These are named as COST 3.

Now as per EVA (Earned Value Analysis) method the variances are calculated.

Variance1 = COST 1 - COST 3

Variance 2 = COST 2 - COST 3

Further this values are to be compared for result of the research work.

5d BIM modelling in Autodesk's Navisworks

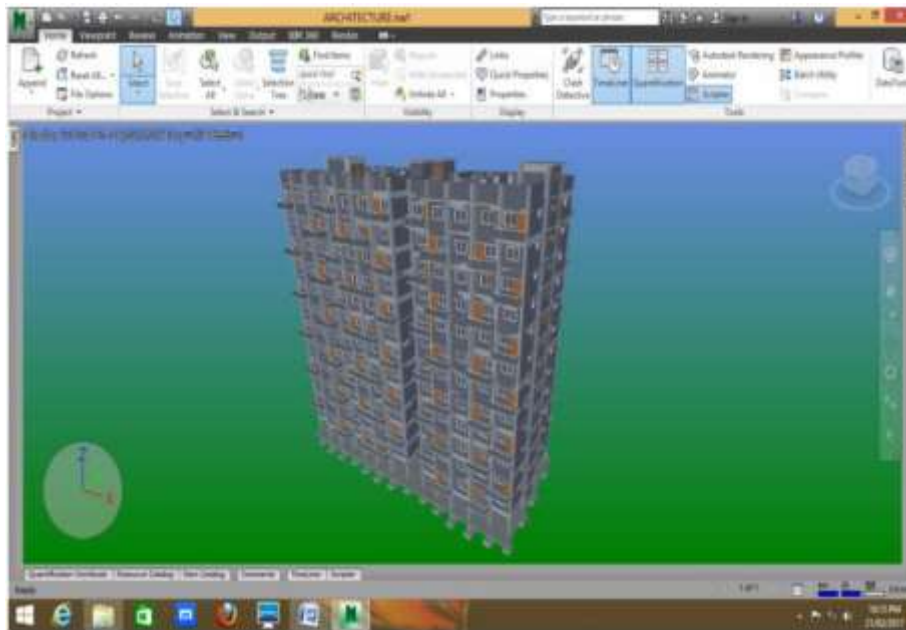


Figure 0.20 - 5d BIM modelling in Autodesk's Navisworks

Cost data from Revit models and time schedule from MSP software is imported to Navisworks for simulation and better visualization purpose. Then a three colour simulation is obtained as,

- Green - before time and within cost
- Grey - behind time and within cost,
- Grey - before time and over cost,
- Red - behind schedule and over cost.

INFERENCE

Although developing 5D - BIM model with minor details is time expensive, on the other hand cost control process is extremely beneficial with BIM than a conventional method throughout the project cycle. Simulation proves to be a strong tool to seek out critical areas of project with reference to time and price, so it helps in deciding in cost control.

2.9.3. G+5 residential building

Jununkar, S. M., Aswar, P. D. S., & Mittapalli, P. D. L. (2017). Application of Bim and Construction Process Simulation Using 5D Bim for Residential Building Project. *Int Res J Eng Technol.*, 4(07), 1063-7.

A proposed G+5 residential building (Parag Construction) situated at Off PaudPhata Road, Near Dr. KalmadiShamarao High School, Pune has been selected for project study. Designing is done in 2D AutoCAD drawings, 3D model in Revit Autodesk and scheduling and cost estimation is in MSP

Adopted software for project

Autodesk Revit

Microsoft Project

Autodesk Navisworks

Autodesk Revit

After introducing the most popular Building Information Modeling software and Autodesk as company that develops Revit, the spotlight will move now to Revit itself. In 1997 ReonidRaiz and Irwin Jungreis founded the company Charles River Software, which started building Revit.



Figure 0.21 – G+5 Residential building

Their main goal was to include parametric modelling to existing idea of CAD, and to allow the user to determine the parametric components graphically, instead of having to use a programming language. This idea of bidirectional associativity is the concept that distinguished Revit from other Building Information Modeling software platforms for a certain period of time, until the competition caught up. Bidirectional associativity means that when u change a certain component of your model (for example wall) all components in relation with the modified one will automatically adjust themselves to applied changes. This concept of bi-directional associativity makes the software

more intuitive and therefore easier to work with for the user. It also saves enormous amount of time when applying changes to an existing model.

Microsoft project

Using this software we can get the actual cash flow, planned cash flow and achieved cash flow. Microsoft Project is a project management software program, developed and sold by Microsoft, which is designed to assist a project manager in developing a plan, assigning resources to tasks, tracking progress, managing the budget, and analyzing workloads. Project creates budgets based on assignment work and resource rates. As resources are assigned to tasks and assignment work estimated, the program calculates the cost, equal to the work times the rate, which rolls up to the task level and then to any summary tasks and finally to the project level. Resource includes people, equipment and materials can be shared between projects using a shared resource pool. Each resource can have its own calendar, which defines what days and shifts a resource is available. Resource rates are used to calculate resource assignment costs which are rolled up and summarized at the resource level. Each resource can be assigned to multiple tasks in multiple plans and each task can be assigned multiple resources, and the application schedules task work based on the resource availability as defined in the resource calendars.

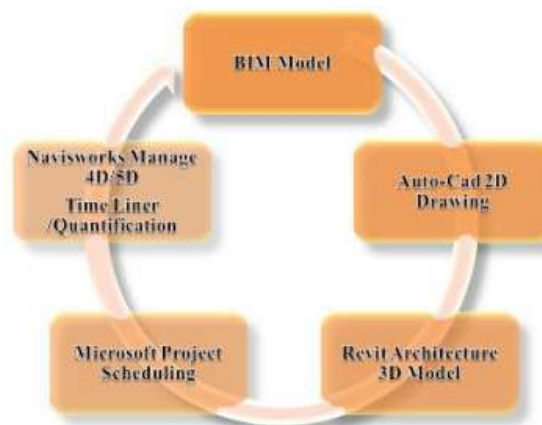


Figure 0.22 – Work process

Autodesk Navisworks

Autodesk Navisworks Manage is a software application providing a comprehensive project review solution which supports coordination, analysis, and communication of design intent and constructability. It allows integration of multidisciplinary design data created in different BIM design applications to a single project model. It also provides the interference management and clash detection functions to anticipate and avoid potential problems in the project which can eventually minimize delays and reworks. In addition, it supports 4D and 5D simulation and analysis by combining parametric models with the project schedule and costs (Autodesk, 2012).

Process of 5d simulations

There are many kinds of BIM software, such as BIM technology, ArchiCAD, Bentley Architecture, Digital Project, BIM software, PKPM, BIM 5D software, Luban and so on, which are widely used in BIM modelling software products that achieve part of the function of BIM. The Revit + Navisworks combination is popular in civil buildings among them. Revit has the functions of modeling, modeling and testing for buildings, hydropower, HVAC and structures while Navisworks supports 3D model integration, simulation, data collaboration and calibration. Commonly used deep engineering design software are Architecture, Navisworks and so on. The simulation software of construction collision detection and construction process includes Navisworks, Bentley and so on.

3D Model

3D model of the case study building created by Revit Autodesk For construction of Architectural Building Information Model detailed AutoCAD drawings are referred. With the help of Revit Architecture 2014 software, and other available details such as, material used and cost of respective materials etc. the model is completed

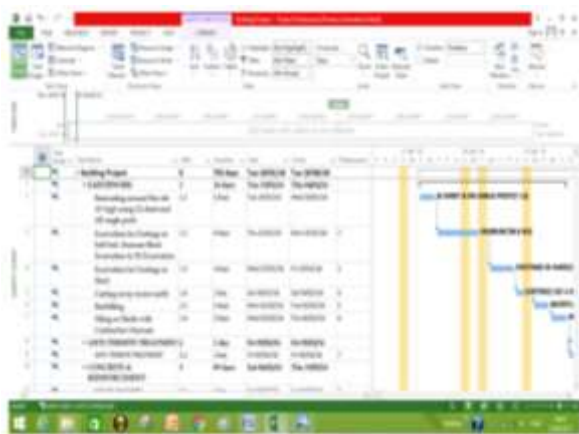


Figure 0.23 – Activities,duration,linking shown in MSP

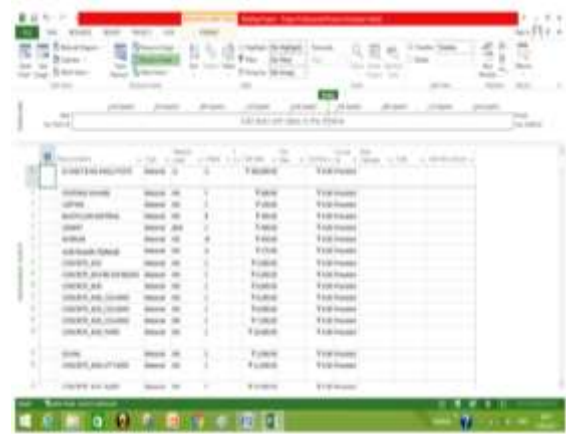


Figure 0.24 – Resources sheet in MSP shown below

5D BIM Model in Autodesk Naviswork

3D model from Autodesk Revit and time schedule and cost from Microsoft Project software is imported to Navisworks for simulation and better visualization purpose



Figure 0.25 – Navisworks result

Inference

The 5D Model is integrated with all useful information including 3D model, schedule and cost which is prepare in Microsoft project, it is very easy and convenient to obtained information from the single integrated model by using Navisworks manage without referring to other information By inputting the schedule and duration of tasks into the model, the 5D BIM software able to the users to easily define the forecast interval and can generate cash flow forecast monthly, weekly, daily or even hourly in the simulation, which is very difficult to achieve in the traditional approach.

CHAPTER 3

LIVE CASE STUDY

3.1. VIT hostel – R Block, Vellore

Name	VIT hostel – R Block
Client	Vellore Institute of technology
EPC Contractor	B&B builders
Design firm	Murty and manyam architects
No. of floors	G+10
Total Built-up area	20,786 sq.m
Total project cost	57 crores
Total project duration	464 days
Project status	On - going

Table 3.1– Project details

VIT, Vellore campus hosts 24 hostels, with 18 blocks for boys and 6 blocks for girls. Men's hostel accommodates around 17000 students and Women's hostel caters to 4700 students. The new hostel block accommodates 1000 beds. It consists of G+18 floors with the total built up area of 20,786 sq.m. The total estimation of the project is 56 crores and project duration is 16 months



Figure 3.1 – VIT Hostel block

3.2. Software tools used

Autodesk Revit Architecture: Architects and designers can use this BIM-enabled design tool. It can capture a design concept and render a virtual representation of the building design.

Autodesk Quantity Takeoff: Software for cost estimators who work in the construction industry. It can count building components and measure areas automatically, convert to Microsoft Excel, and publish to DWF format.

Microsoft Project: Microsoft Project is a software programme for managing projects. It's intended to help a project manager create a timetable, assign resources to tasks, track progress, manage budgets, and analyse workloads.

Autodesk Navisworks: A project review programme that includes scheduling, visualisation, and communication features, as well as powerful clash detection features, to enable intelligent 3D model-based designs.

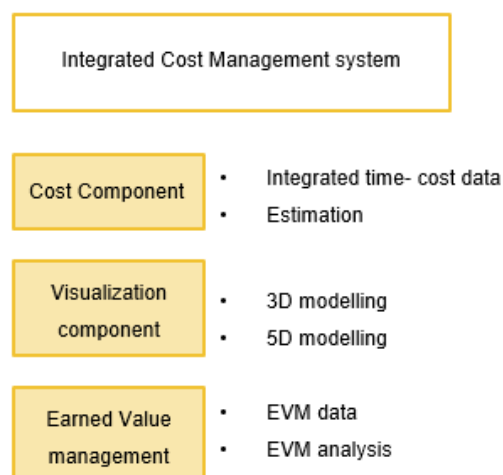


Figure 3.2 – Integrated cost management system



Figure 3.3 – Site photos

3.2.Methodology

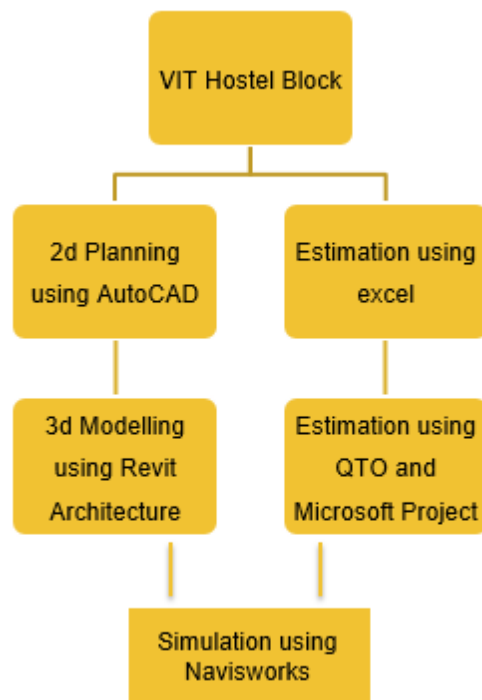


Figure 3.4 – Methodology

- Helps the operations lead to measure project performance
- The work completed is compared with the planned work.
- This method is useful for preparing forecasts. The data from EVM is quantitative.
- The baseline of the project is a reference point and forms as an essential part of EVM.

Tracking methods

Cost variance:

It is used to measure the cost performance of the project. It's the difference between Earned Value and Actual cost. i.e., it is the difference between what you planned to spend and what you actually spent.

$$CV = EV - AC$$

If +ve then the project is under budget

If -ve then the project is over budget

If 0 then the project is on budget

Cost performance index:

It signifies the efficiency of the project in terms of cost. It's the ratio between Earned Value and Actual Cost.

$$CPI = EV/AC$$

If $CPI \geq 1$ Project is under and on budget

If $CPI < 1$ Project is over budget

Forecasting methods

Estimate at completion (EAC):

To obtain the estimated total cost for a given work break down structure item or to estimate the cost at completion multiply the total budgeted cost to the ratio of actual cost by earned value.

It shows the current spending pattern which might continue till the completion.

$$EAC = (AC/EV) * \text{total budget}$$

Estimate to completion (ETC):

It estimates the total cost which is required at the end of the completion of the project if the current pattern is maintained.

It also helps to give a clear picture of budget needed to complete the project.

The difference between Estimation at Completion and Actual Cost Gives Estimation to completion.

$$ETC = EAC - AC$$

3.3. Process

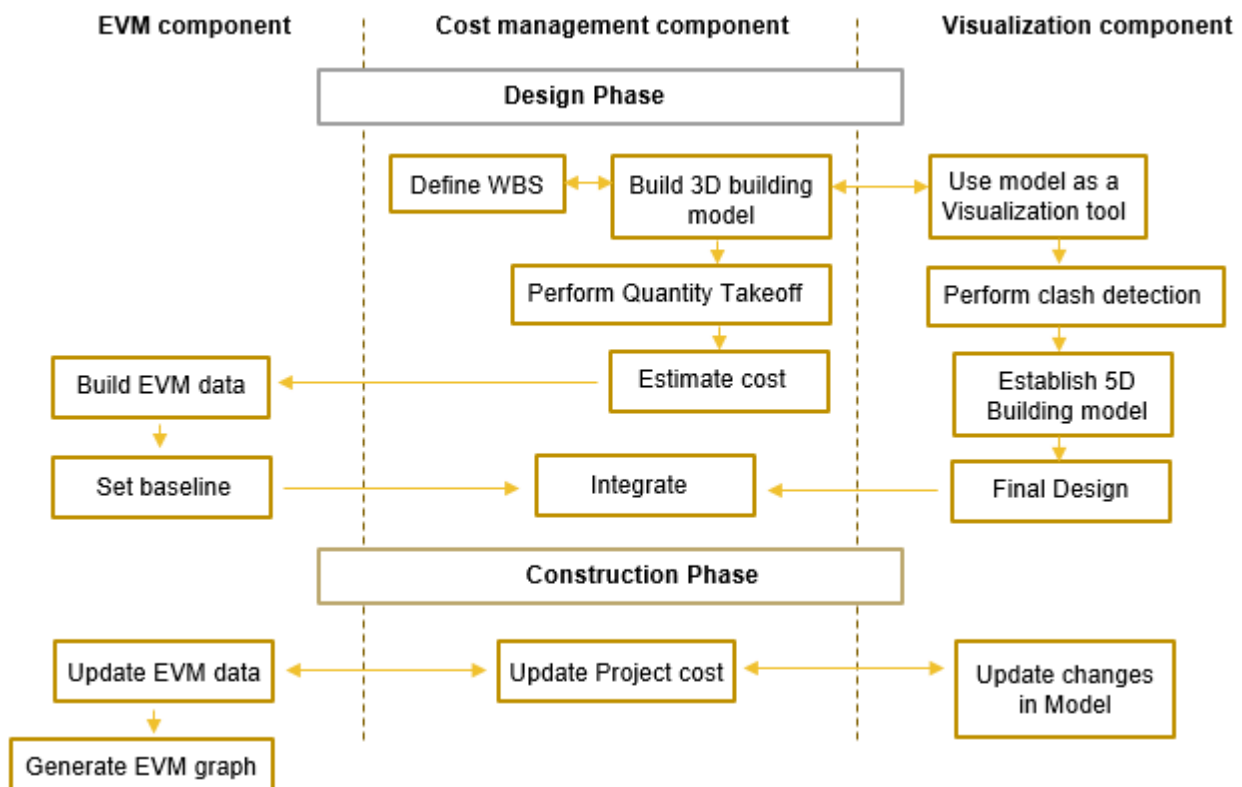


Figure 3.5 – Work flow

1. Conversion of 2D plans into 3D model using Revit Architecture

Autodesk Revit is the BIM technology used to produce the building model because it permits the integration of architectural, structural, mechanical, electrical, and other models into a single 3D model, which simplifies design team cooperation and eases the transition to planning and construction. After the 3D model is complete, it is exported into Autodesk Quantity Takeoff for cost estimations.

2. Quantity Take off Using Autodesk QTO

In Autodesk QTO, the building model is transferred from Autodesk Revit Architecture to Autodesk QTO, and the building components are automatically categorised and coloured. Autodesk QTO, for example, automatically categorises and colours the curtains walls in yellow. The entire building's QTO, as well as each of the created building components, will be colour coded.

The building components are separated into several categories in the list of grouped building components, such as doors and windows, walls, ceilings, curtain panels, and so on. Each building component is assigned the same colour in the QTO list as it is in the 3D view. The curtain wall is yellow and belongs to the Curtain Panel category. The curtain wall has a total area of 23,768.516 square feet, according to the QTO list.

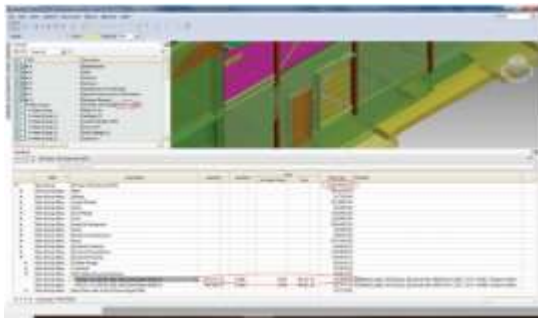


Figure 3.6 – Autodesk QTO

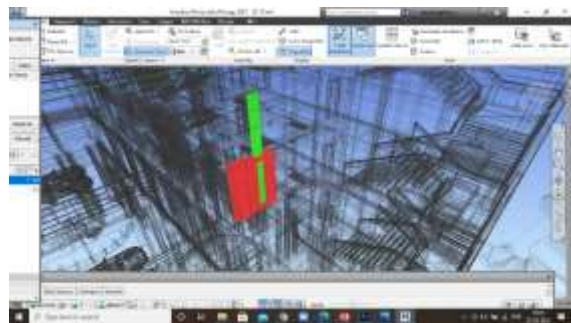


Figure 3.7 – Clash detection



Figure 3.9 –MSP work flow

The cumulative Planned value are calculated in accordance with BAC and cumulative Earned Value are calculated with work performed in accordance with BAC.

This enables us to monitor the cost and schedule of the project in the monthly basis which provides the clear-cut idea of the project.

The Estimate amount to complete the project is Rs 57, 00,00,000 (57 crores). This is called as Budgeted at Completion (BAC).

Type of work	Allotted amount (in rupees)
Earthwork and excavation	1,22,65,368.00
Anti termite treatment	1,48,719.00
PCC and RCC and formwork	28,47,78,579.00
Masonry work (Brick/Stone/AAC block)	4,20,41,025.00
Finishing	8,26,85,012.00
Flooring	5,18,74,649.00
Steel work	4,38,68,304.00
Joinery	4,81,27,116.00
Waterproofing	42,11,228.00
Total	57,00,00,000.00

Table 3.2– Project cost details

The initial duration of the project with the scheduled cost allotted for the project. It is a typical S curve which show the flow of the project in the monthly manner.

Month	Cumulative Planned value	Cumulative Actual cost	Cumulative Earned value
Sept 2020	5,40,000	5,56,890	4,80,000
Oct 2020	11,40,000	11,72,650	10,20,000
Nov 2020	23,40,000	23,95,750	21,00,000
Dec 2020	34,80,000	35,67,830	31,80,000
Jan 2021	49,20,000	51,57,820	48,00,000
Feb 2021	61,20,000	62,30,750	61,80,000

Table 3.3 – PV, AC, EV

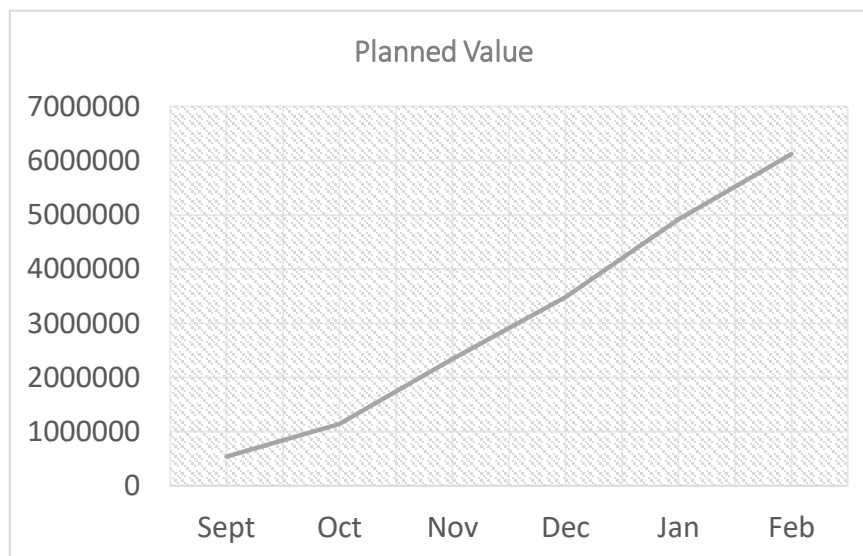


Figure 3.10 – PV curve

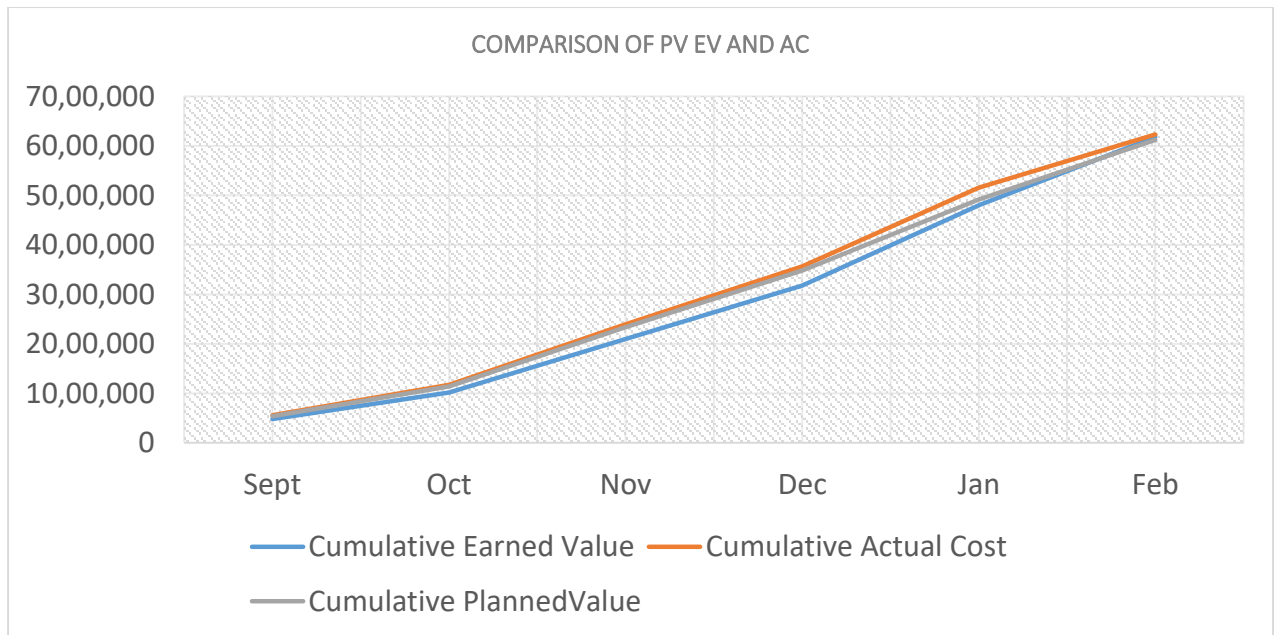


Figure 3.11 – Comparison of PV EV and AC

To calculate	Formula	Value	Project management questions	Interpretation
1. How are we doing cost-wise? Cost analysis and forecasting				
Cost variance (CV)	CV = EV-AC	-76890	Are we under or over our budget?	CV < 1 - The project is overly budgeted
		-152650		
		-295750		
		-387830		
		-357820		
		-50750		
Cost performance index (CPI)	CPI = EV/AC	0.862	How efficiently are we using resources?	CPI < 1 – Over budget i.e., Earning less than amount spent.
		0.870		
		0.877		
		0.891		
		0.931		
		0.991		
Estimate at completion (EAC)	EAC = BAC/C PI	2,78,44,500	What is the project likely to cost?	Assumption: Current performance trends continue
		3,46,50,500		
		2,73,80,000		
		2,69,27,080		
		2,57,89,100		
		2,41,97,090		
Variance at completion (VAC)	VAC = BAC-E AC	-1,97,090	Are we under or over budget?	Over budget

Table 3.4 – Findings

Inference

- The project's Actual cost tends to rise dramatically over the course of the month, affecting both the Planned and Earned values.
- CV has a negative value for the entire month.
- My study project is over budget during the beginning stages of the project, which every project faces, based on the CPI values.
- The project's Estimated At Completion (EAC) is virtually identical to the Budgeted At Completion (BAC) in February (excess of 2 lakhs will be spent)

4. Simulation using Navisworks

Finally, Navisworks is updated with the amended schedule. A simulation has been created. The expense of the various phases may also be seen in the simulation along with the stage-by-stage 3D development. Red denotes material costs, Blue denotes labour costs, Green denotes equipment costs, Black denotes subcontractor costs, and Grey denotes total costs.

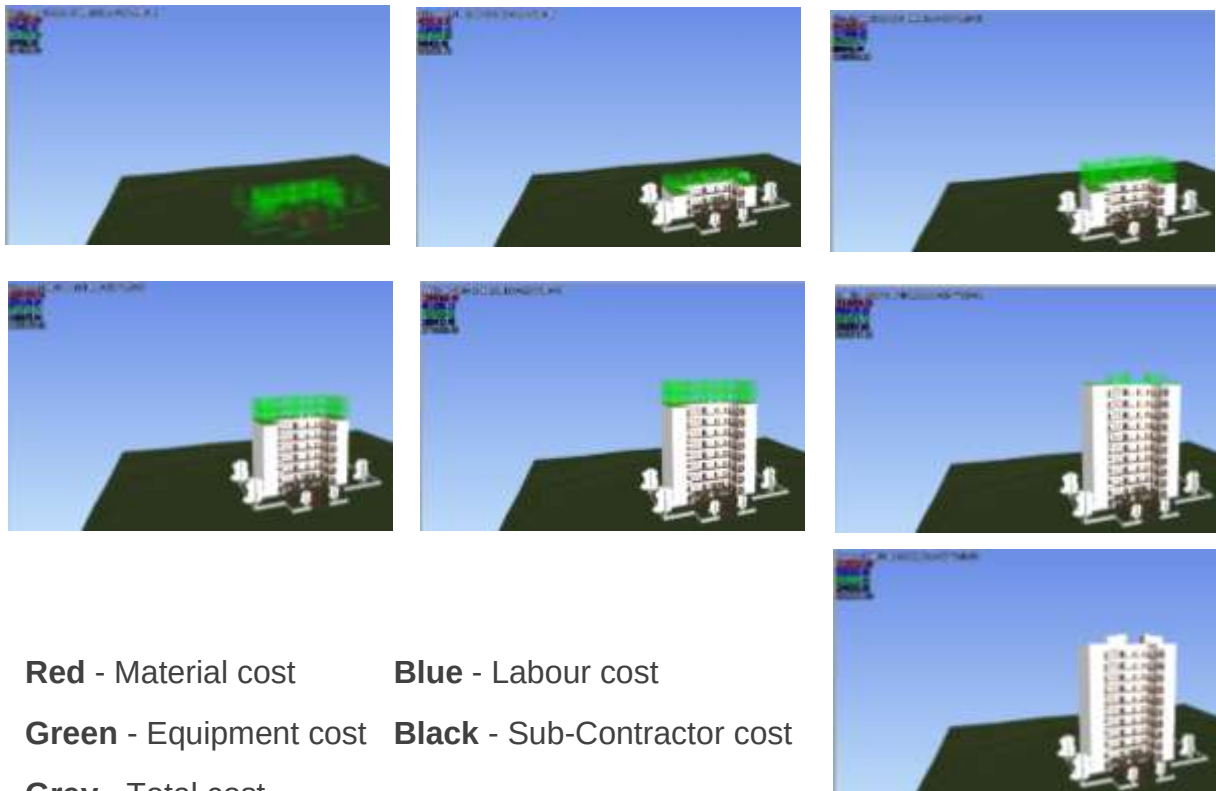


Figure 3.12 – Result

3.4.Scenario 1

The actual planned cost for the block work completion of 5th -8th floor is 97,941.64 (L+M+P) and the number of days planned was 72 of cost 97,941.64. Assume that there is an early completion of the block work from 5th to 8th floor. The project that is scheduled for 72 days gets over by 36 days causing a hike in resource cost of 1,95,883.28. That would be reflected in the simulation video as,



Figure 3.13 – Planned cost Scheduled on 27/6/21



Figure 3.14 – Change assumed on 27/6/21

3.5.Scenario 2

Assume we are facing a project delay. According to planned schedule at 14/03/2021 the RCC work is completed and Block Work at 1st floor should be completed and frame work at 2nd floor level should be in process but actually frame work of 1st and 2nd floor is on process.



Figure 3.15 – Planned Schedule on 14/3/21



Figure 3.16 – Assumed delayed schedule on 14/3/21

3.6. Conclusions

The case study demonstrates how BIM technology can help with cost management by bringing numerous advanced construction management skills to the table. The QTO procedure in this case study is automatic and dependable, and it takes only 15 minutes to complete. This will save time for contractors when estimating costs. On the other hand, a modification in the building model's design can be updated and reflected in the QTO list in minutes, giving the owner a faster cost feedback on adjustments. The present EVM is efficiently constructed utilizing MSP, which is a cost-effective method of cost control. The simulation of progress can also assist contractors in adjusting project costs in response to changes in building model.

CHAPTER 4

RESEARCH ANALYSIS

4.1. INTRODUCTION

This chapter captures the results attained from the questionnaire survey. This includes data analysis and the presentation.

4.2. QUESTIONNAIRE SURVEY ANALYSIS

The questionnaire link was distributed by email to commercial professionals in the construction industry. Around 70 professionals took part in the survey. The survey was carried out in a period of two weeks. The questionnaire results were presented on the following topics.

- General
- Cost management
- Role of QS in cost Management
- BIM

To emphasise the results of survey in a simple and accurate method, every question was presented with table, figure and comments.

4.2.1. GENERAL

QUESTION 1: Which of the following best identifies you?

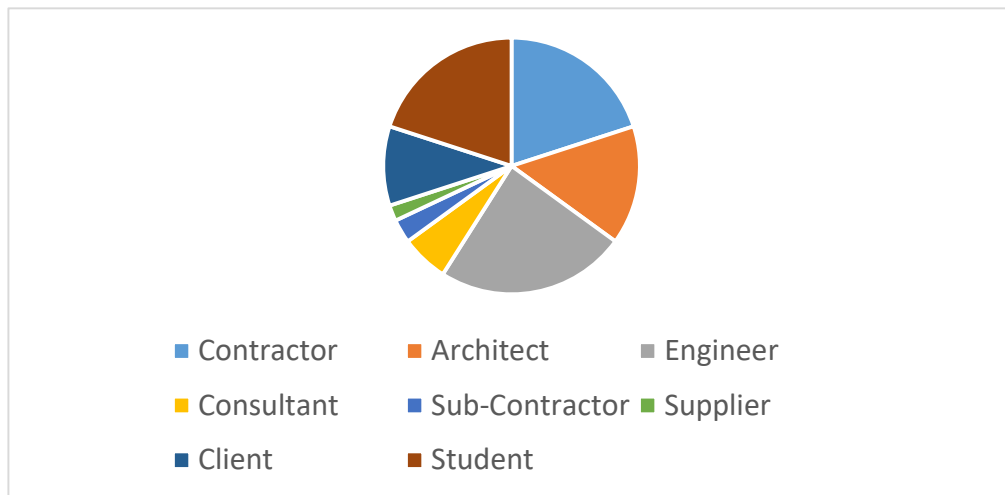


Figure 0.1 - Response to question 1

QUESTION 2: What is your total years of experience in Indian Construction Industry?

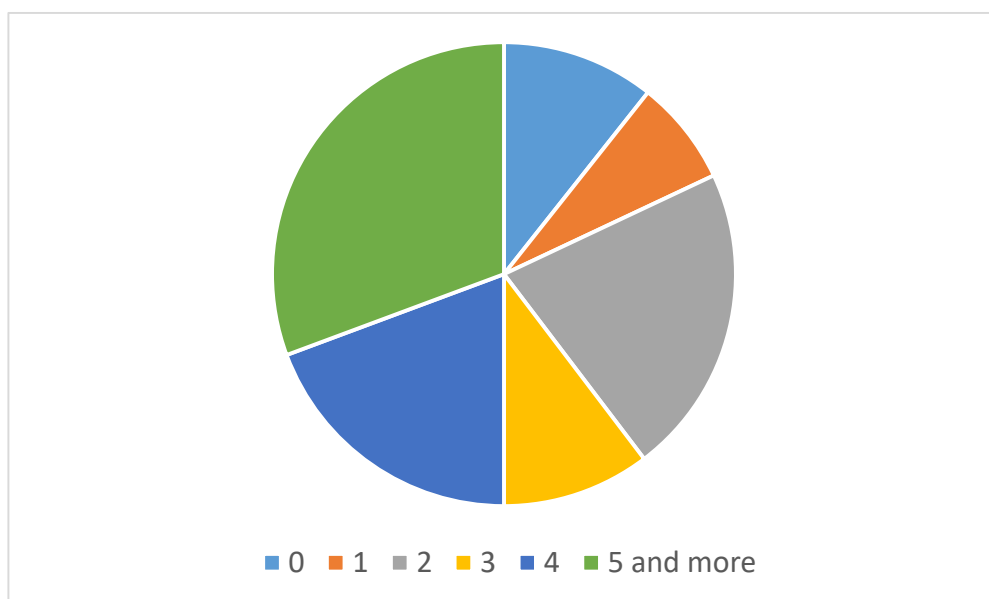


Figure 0.2 - Response to question 2

QUESTION 3: Please specify the type of work undertaken by your company

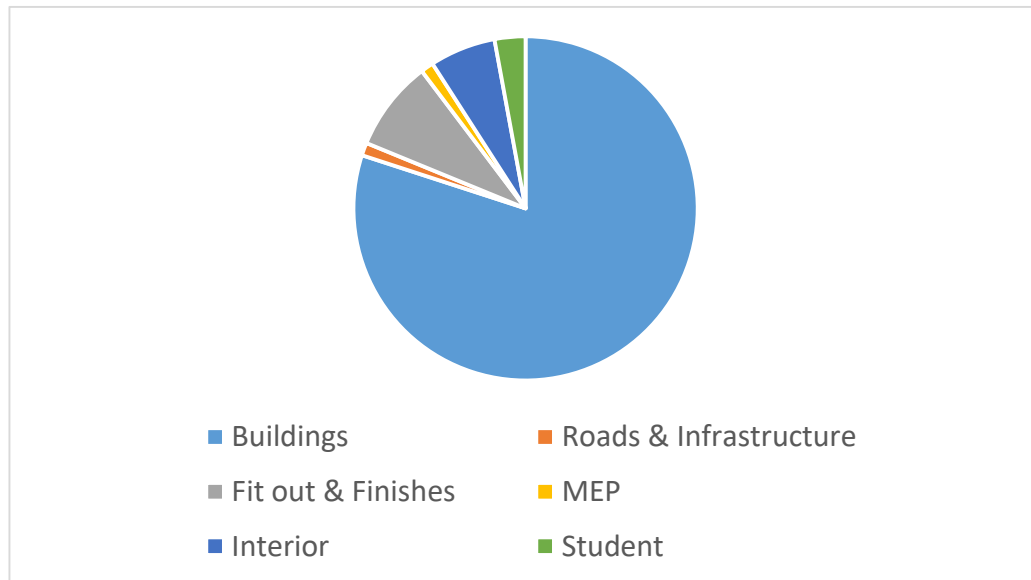


Figure 0.3 - Response to question 3

4.2.2. COST MANAGEMENT

QUESTION 4: According to you how important is cost management in a construction

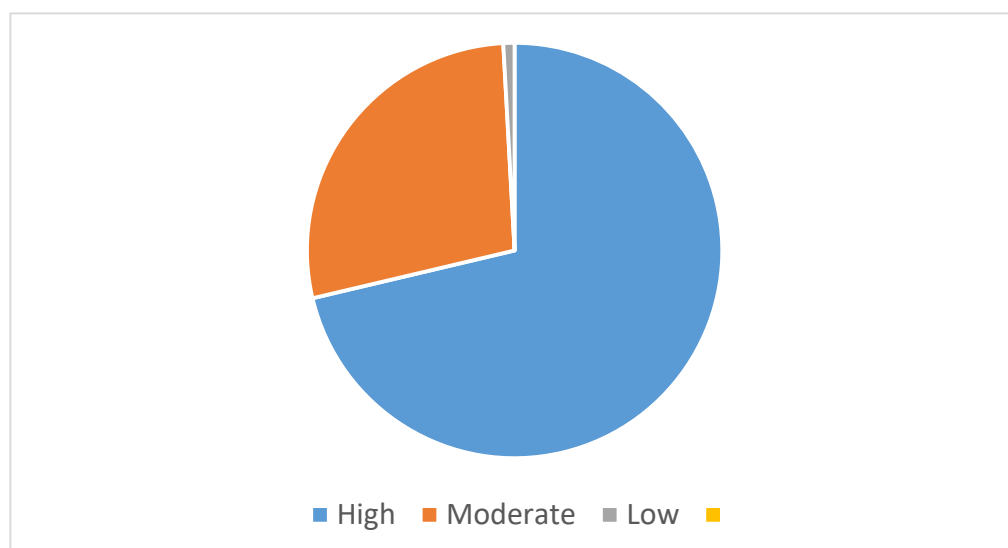


Figure 0.4 - Response to question 4

QUESTION 5: Please mention the frequency of cost overrun during your experience

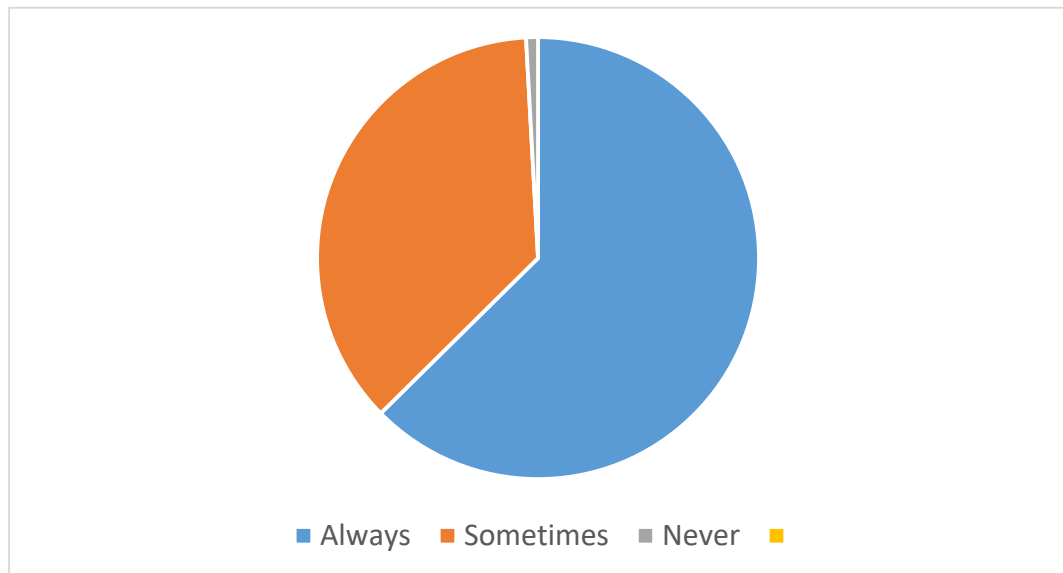


Figure 0.5 - Response to question 5

QUESTION 6: Is there a project budget before commencement of work?



Figure 0.6 - Response to question 6

QUESTION 7: From the following, what do you think is the major cause of cost over run?

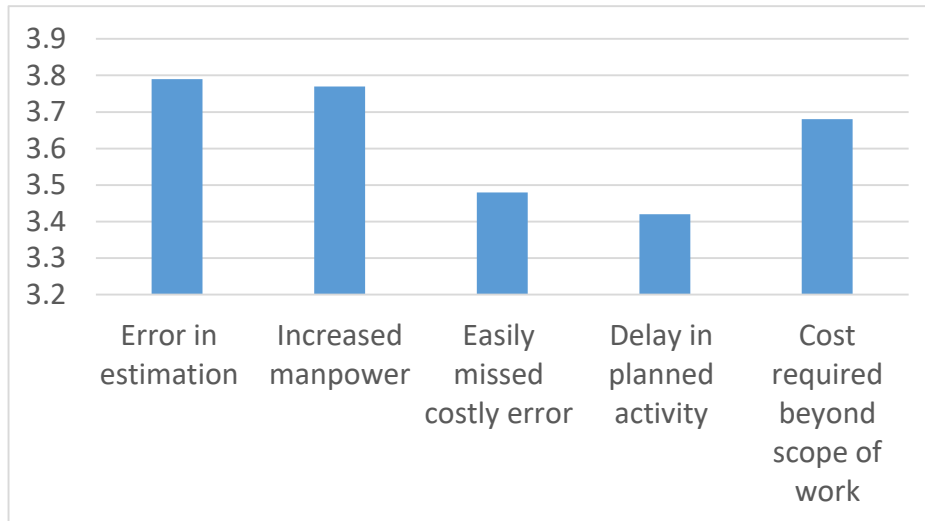


Figure 0.7 - Response to question 7

QUESTION 8: Which of the following team members should be responsible for producing and taking ownership of the project cost report?

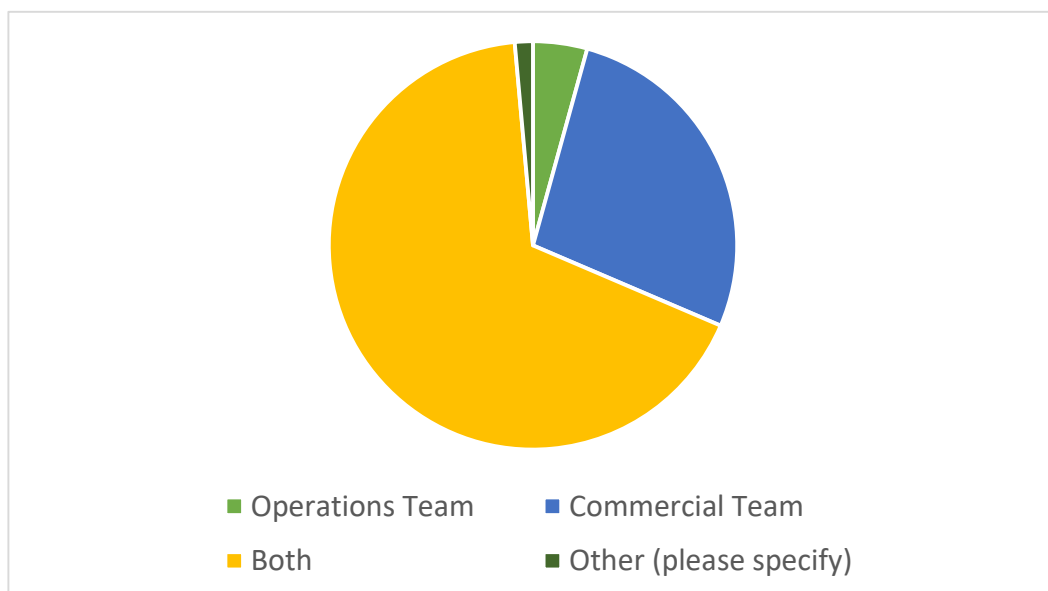


Figure 0.8 - Response to question 8

QUESTION 9: How often do your organization prepare the cost report?

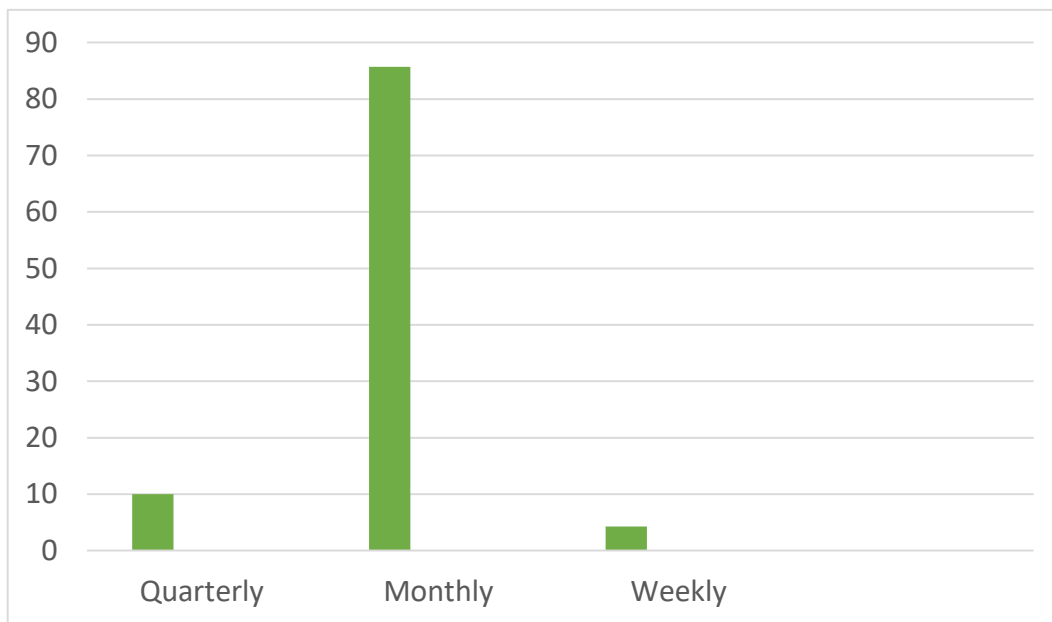


Figure 0.9 - Response to question 9

QUESTION 10: What are the challenges faced by contractors during cost Management?

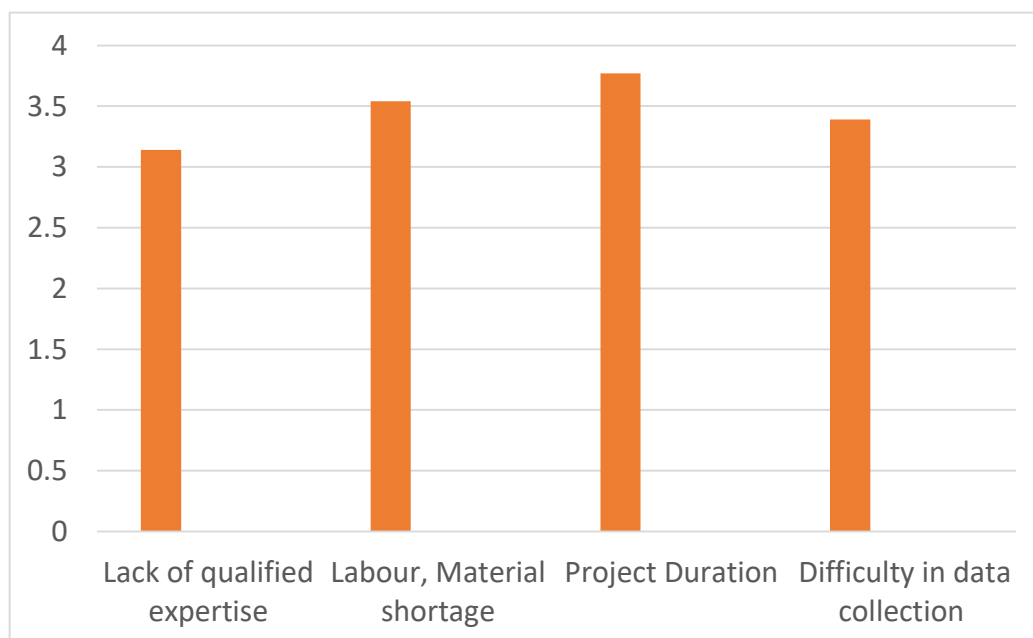


Figure 0.10 - Response to question 10

4.2.3. BIM

QUESTION 11: What level of knowledge you have in BIM for cost control?

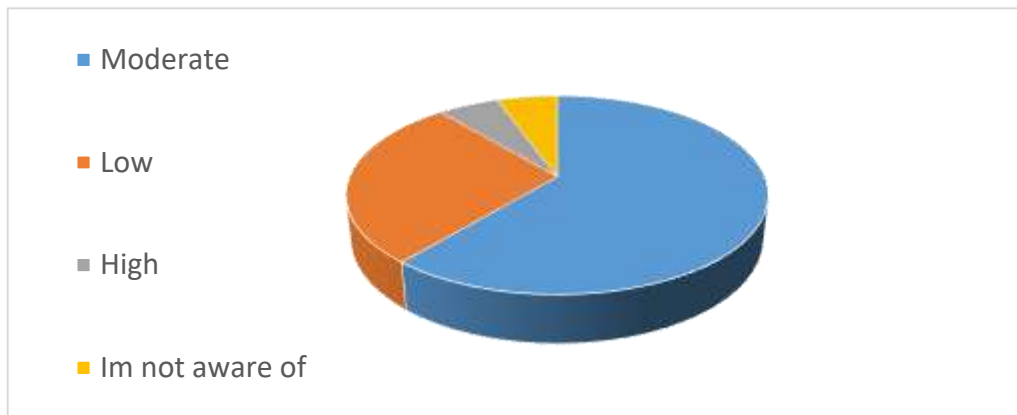


Figure 0.11- Response to question 11

QUESTION 12: Which of the below application are you aware of?

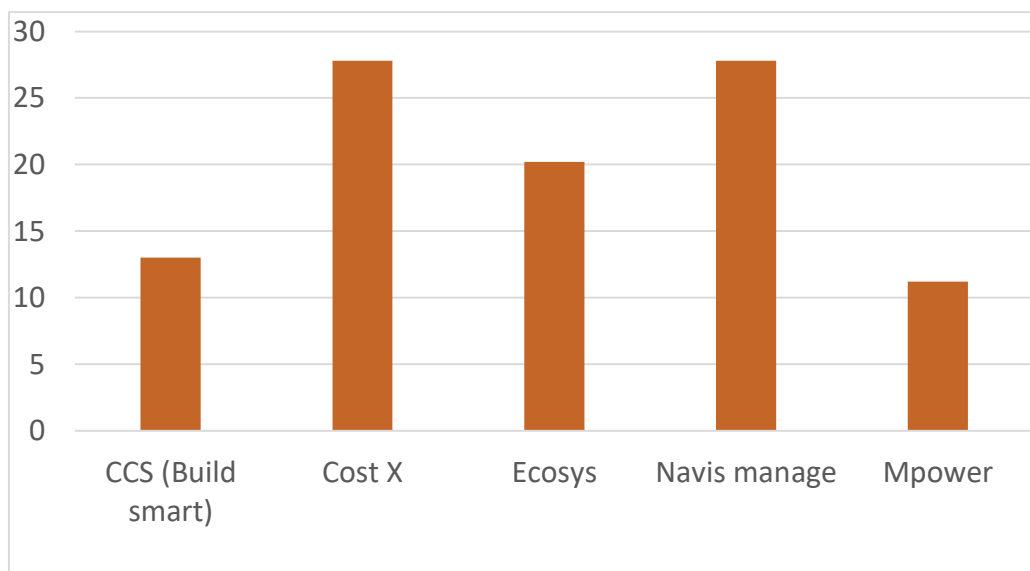


Figure 0.12- Response to question 12

QUESTION 13: What holds the implementation of BIM?

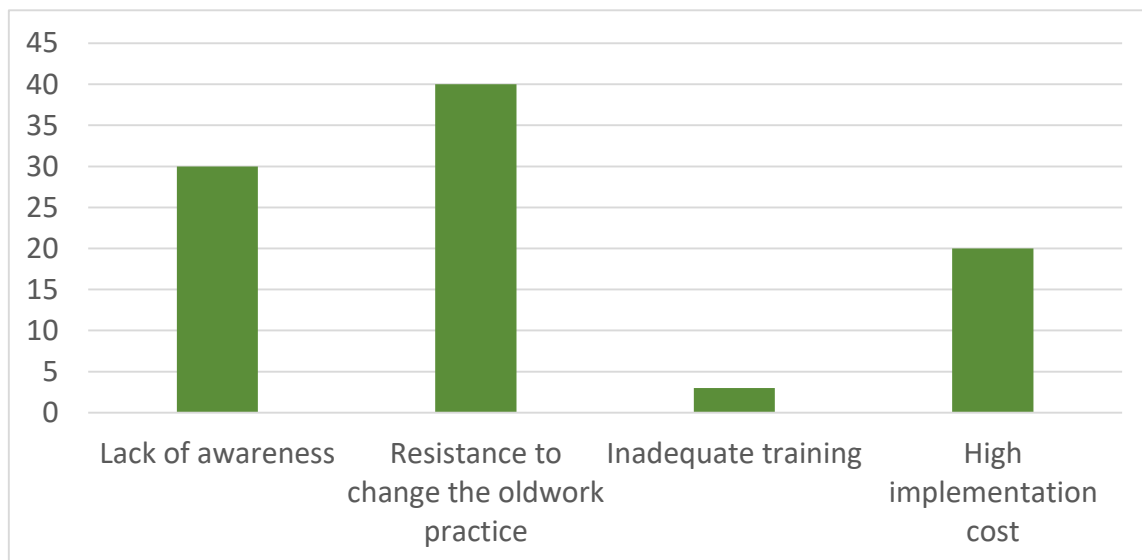


Figure 0.13 - Response to question 13

QUESTION 14: According to you, who must motivate and lead the implementation of modern cost management in Indian construction industry?

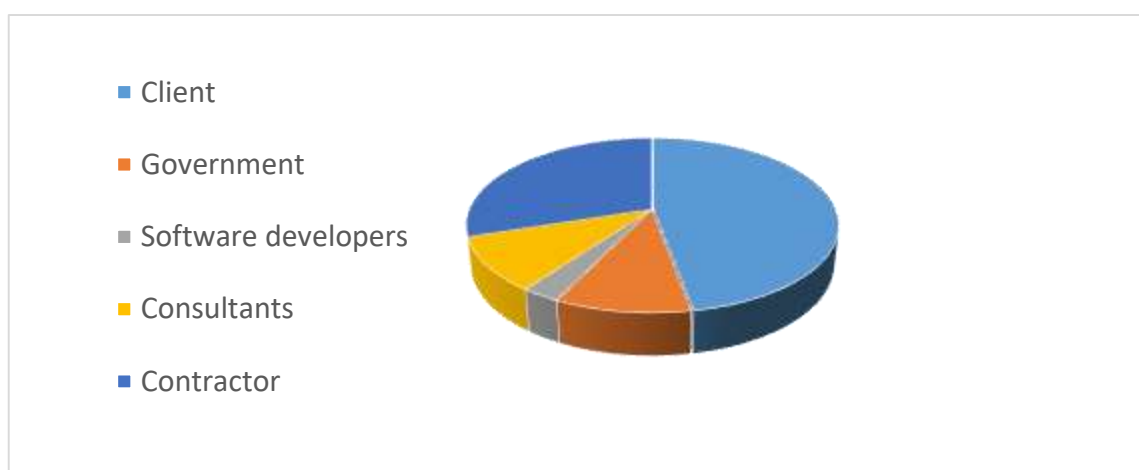


Figure 0.14 - Response to question 14

QUESTION 15: What is important to facilitate and accelerate the implementation of BIM in Indian construction?



Figure 0.15 - Response to question 15

QUESTION 16: According to you in how many years would this application's used for cost management, will be commonly practiced?

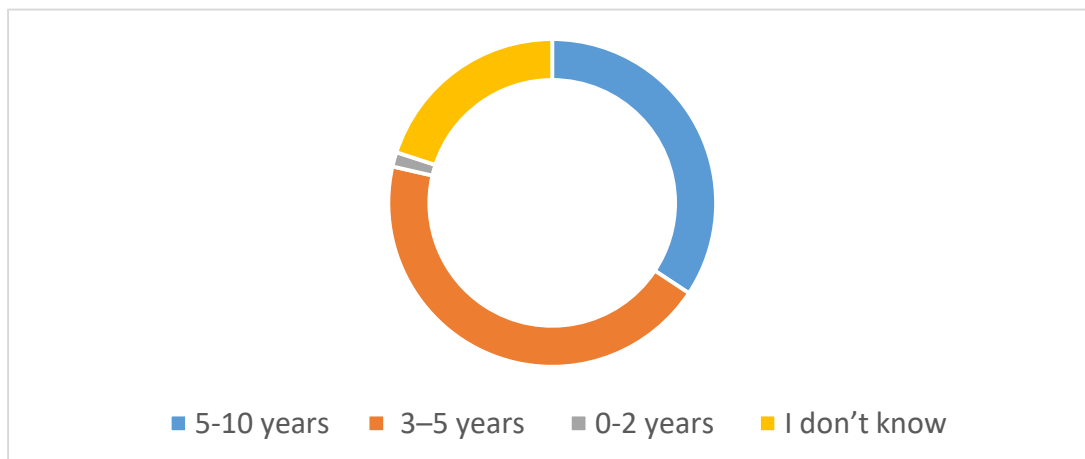


Figure 0.16 - Response to question 16

4.3. DISCUSSION OF RESULTS

In this section, the responses from the survey are discussed with respect to the literature review. A co-relation is made between the desk and field work data collection. Many respondents have indicated their strong influence and knowledge on the topic. Many of the respondent's organization utilises some form of cost control technique. Around 92% of the respondents agree with the high importance of the post contract cost control. Although it is shocking to see a result of 65% of the respondent's experience cost over runs always or very often in their experience.

The company must be following an application with the ICM. From the literature review, it is understood that the lack of ICM in the project where cost, target cost will be integrated and monitored. Which would bring the effectiveness in cost control around 62% of the respondents strongly agree to this. Having been acknowledged by the benefits the modern techniques are not fully used in the industry where 40% of the respondents believe that an awareness must be created. The literature review highlighted that the willingness to change from the old practices are the major factor for the resistance to the new techniques similarly, the willingness with the existing people to adopt to the change was the main factor which the respondents pointed out in survey. Every team member must adopt to the change with their own interest which will ultimately makes a phenomenal change in the industry making it 'smart' leading to an effective cost control.

CHAPTER 5

CONCLUSION

5.1. OBJECTIVES

Objective 1 – To review the importance of cost control in a construction project.

From the literature review it is noted that the cost control is essential for every project in the construction industry. The fundamental issues are mainly related to the nature of the industry itself. Starting from the estimates which are prepared quickly and likely to have errors, any error in the estimation adds more pressure on the cost control during the post contract stage. Therefore, it is important for the construction industry to compare and learn from other industries on their field to improve the standard of working. More importantly a collaborative approach is required within the team to make things work, 67% of the respondents have agreed to the requirement of collaborative approach in the project. It is mandatory for the organizations in the Indian construction industry to improve the standards of commercial activities which will help them in taking corrective actions at the right time and achieve better cost control.

Objective 2 – To understand about the need of BIM in India

As India embarked on massive infrastructure development to meet the growing number of people striving for a better way of life, there was a need to implement BIM processes for efficient and faster project execution along the lines of several developed countries. India is expected to outnumber China by 2025, with a population of 1.4 billion. This will necessitate more housing and public transportation. Apart from constructing new infrastructure, the existing ones must be renovated. At a time when many advanced countries, such as Italy and Singapore, have already begun to use such technology, India should do the same to reap the benefits of reduced cost, time, and increased efficiency in the construction of infrastructure projects. As more people move to cities, we need to deliver things faster. Seven billion people will live in cities alone by 2030, doubling the size of existing cities. As a result, we require better tools and a more efficient automation process. In India today, every project has a cost overrun of 20% on average, including time overrun. It is critical to alert the operations team in order to effectively manage the project and avoid the cost risk. The use of an application will make the project easier to manage and will improve project control.

The field work by questionnaire where 62% of the respondents believes that implementation of BIM will be highly effective to the organization and believes that the change is required for effective cost management

Objective 3 – To emphasise the benefits of adopting BIM in the cost management process.

The basic principles of BIM; 3D modeling, interoperability, parametric objects and advance information management features, hold a lot of potential for improving the state of cost management practice by resolving problems identified in the traditional practice

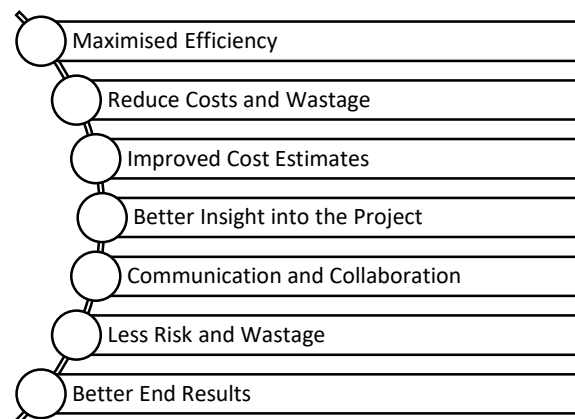


Figure 5.1 – Benefits of BIM

Objective 4 – To examine in detail on the issues in adopting BIM

From the literature review three factors were identified as an issue for adopting to the modern technology.

- Workability between the applications / software compatibility
- Organization, training, support from client and senior management
- Awareness, learning attitude, willingness to change.

The questionnaire survey results shows that the major weightage was given to the willingness to change from the old practices, where the professionals stressed on the importance of willingness to change from the old practices. Inadequate training and the lack of awareness are the major issues which are holding the adoption of modern techniques. It is important that the people in managerial level adopt to the changes. The organization must invest money on implementation of the system and provide training to their employees to adopt to the new system. Apart from this issue, all the parties in the construction project must be aware of legal issues while using the technology. The information exchange, security, copyrights have a possibility of misuse. The data base of cost must be user friendly and must be accepted by all

Objective 5 – To analyze the effectiveness of cost control by use of BIM and to recommend for better outcomes.

From the literature review and case study effectiveness of the BIM was discussed. The main advantage being the less intervention for the data input by human on the reports which will eliminate/reduce the error in all stages. BIM can generate the reports always by the ICM which gives the real-time data which eliminates the requirement of a commercial team member to dedicate the time for the preparation of reports. This will enable the commercial team to effectively monitor the cost and to alert other teams in case of over runs at the right time.

The questionnaire survey showed a strong positive feedback on the effectiveness of BIM . Most of the respondents with 53% having moderate knowledge in the applications used for cost control this symbolizes that the awareness of applications is growing in the industry, however the attitude of people must change for a successful implementation. And it is strongly believed that in India there won't just be modern buildings the methods utilized by the construction for cost estimation will also become modern.

5.2. RESULTS

The visualisation of a building project aids all participants in gaining a better knowledge of the project. Most significantly, it becomes more easier to share information with investors. It gives architects, engineers, contractors, and all other players with dependable features. It establishes a single, centralised model that is available to all entities and defines each and every component of a structure. As a result, any changes to the model will be observed by everyone. Using a 5D BIM model during construction can help you prevent costly mistakes. Predicting collisions between other elements saves time, money, and a variety of other inconsistencies. Computerized automated models aid decision-making by comparing the model to various construction methods, materials, and procedures without actually completing the work, and selecting the most efficient procedure that saves time and money.

The case study demonstrates how technological advancements have brought the building business into the computer age. It has shown to be a promising strategy that has resulted in more positive developments in the building sector as a whole. From the planning stage through the implementation stage to the operational stage, BIM

can be used at any point in the lifecycle. BIM allows for the optimization of complicated projects.

While BIM technique has numerous advantages, it also has certain drawbacks. Initially, software training takes a long time, and the computer machines required to handle the load of these softwares must be upgraded, resulting in a high installation cost. Second, it was noted throughout the literature review study that the government has a significant role in the acceptability and success of these strategies. For example, the UK government made it mandatory to use BIM in all government-funded projects, which resulted in BIM being accepted by all construction businesses; the same is true in Italy and Australia. In these countries, the BIM methodology was a success. There are numerous new softwares on the market, but they aren't being used successfully because of constraints such as current contractual arrangements and traditional businesses that prioritise their own interests over finding better project delivery solutions.

5.3. CONCLUSION

From the literature review, it is understood that the lack of ICM in the project where cost, target cost will be integrated and monitored. Which would bring the effectiveness in cost control, around 62% of the respondents strongly agree to this and believe that utilization of modern techniques will be effective for the project in effective cost control. Having been acknowledged by the benefits the modern techniques are not fully used in the industry where, 40% of the respondents believe that an awareness must be created.

The literature review highlights that

- The willingness to change from the old practices are the major factor for the resistance to the new techniques
- The utilization of any system requires the willingness to do it to the fullest (effective utilization).
- The importance of carrying out a pilot project in a company before applying to the entire system.

Therefore, from the responses it is obvious that the advancements are happening gradually in the industry, but it is not being utilized to its fullest. Every team member must adopt to the change with their own interest which will ultimately makes a phenomenal change in the industry making it 'smart' leading to an effective cost control.

5.4. FUTURE SCOPE

BIM can be used in all parts of the construction sector. The scope of this thesis is limited to 5D BIM modelling, which is only relevant for building construction. However, the level of detailing (LOD) can be increased by incorporating Mechanical-Electrical-Plumbing (MEP) works, sustainability (6thDimension), operation & maintenance (7thDimension), and so on to make the model more information-rich. In a recent study, safety was also identified as a significant factor, and it was classified as the eighth dimension in modelling. This thesis just looked at the cost element while making a decision, but there are many other elements that might influence a decision, such as time, the environment, safety, and so on. It would benefit not only the construction business, but also the environment and human energy by decreasing the consumption of materials and skilled labour by employing LEED tools for energy efficient designs.

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