

## COMPARATIVE ANALYSIS OF BIM AND TRADITIONAL COST ESTIMATION METHODS IN CONSTRUCTION PROJECTS

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### Abstract

Cost estimation is an essential element of construction and the management of projects, including budgeting, allocation of resources, and overall project effectiveness. Traditional cost estimation depends on the manual calculations, expert judgment and historical data which can be challenging and prone to human errors. Building Information Modeling (BIM) has introduced more advanced digital techniques which give accuracy, efficiency and quick data integration. This dissertation offers an analysis of BIM-based and traditional cost estimation methods, comparing their efficacy, accuracy, cost efficiency, and impact on project performance. The study made a mixed-methods approach, integrating a literature review, questionnaires, and expert interviews to evaluate the benefits and drawbacks of each method. Important factors such data reliability, time efficiency, cost variations, and flexibility to project specifics are examined. The results indicate that BIM significantly reduces estimation mistakes, enhances collaboration among stakeholders, and facilitates dynamic cost modifications during the project lifecycle. However, obstacles including software expenses, training necessities, and reluctance towards technological use remain.

## 1 INTRODUCTION

### 1.1 Background

For the building construction projects successfully completed within the budget, cost estimation has always been an essential part. Traditional estimation methods such as unit rate estimation, comparative or analogous estimation, factor estimation and detail estimation that have been in use for a long time. All these methods are manual and at risk of human errors and time-consuming process.

Building Information Modeling (BIM) is a digital delivery system for a construction project with various aspects of project management and

planning. BIM allows the stockholders to visualize and element of the project with 3D model. BIM gives the more comprehensive and flexible method for cost estimations. As opposed to the traditional methods, using the BIM model for estimation provides the accurate and quality takeoff as well as immediate modification in case of any variation in the project.

Despite BIM technology advantages, there are some limitations and challenges such as initial expenditures, specialized training and software's learning to implementation of BIM system. Here the research purpose is to reach out the valuable approach into the practical implementation of

BIM and traditional estimation by analyzing their relative pros and cons.

### 1.2 Objectives

1. To analyze the accuracy of cost estimation in BIM as compared to traditional methods.
2. To compare the time and resources utilization in BIM and traditional methods.
3. To determine the difficulties and constraints associated with the implementation of BIM base cost estimation.

### 1.3 Scope

Every owner of a construction project has concerns with cost effectiveness in addition to safety and quality due to the rising rate of inflation. The construction industry enters a new era of technology by involvement of Building Information Modelling (BIM) in various construction sectors like project planning, estimation, designing, and management. Cost estimation is the critical activity of any construction project which affects the budget of the project and profitability. In the construction sector traditional methods of estimation are in common used for a long time, but if applied now in mega and modern complex projects they become the cause of errors which create the cost and time overrun. On the other hand, BIM improves project performance and increases the accuracy of the project budget and cost. Adopting the proper procedures and BIM standards could help in obtaining cost estimates that are precise and error-free. The challenge associated with the implementation of BIM for cost estimation in various construction projects is cost efficiency compared to conventional methods.

### 1.4 Expected Outcomes

- A deep understanding of both methods with their strengths and weakness.
- Recommendation with the analysis to implementation of BIM cost estimation.
- Illustrate how BIM estimation method improves construction project performance as compared to traditional methods.

### 1.5 Beneficiaries

Enhance the proficiency of forecasting of building construction cost through incorporate the real data and Building Information Modeling. Help

minimize the human errors and reduce the manual workload.

## 2 LITERATURE REVIEW

### 2.1 Introduction

In construction industry successful completion of project always depends on the accurate cost estimation which concerns the project resources allocation, budgeting and sustainability of project. This chapter reviews existing literature to examine the competitive aspects of traditional and BIM cost estimation methods in construction projects. Additionally, this chapter reviews the different studies on the benefits and drawbacks of each method and challenges of BIM implementation due to involvement of digitalization such as software proficiency and add in the BIM procedure in project.

### 2.2 Literature

#### 2.2.1 Traditional Methods of Cost Estimation

Cost estimation is an essential part of construction project management and development. The construction industry has several kinds of conventional cost estimation methods, each one having its own features, benefits and weakness. In construction and project management, cost assessment is an essential procedure that helps stakeholders in anticipating financial needs prior to project execution. Traditional cost estimating methods forecast project costs using analogous cost estimation, parametric and detailed estimation method main techniques for traditional cost estimating are listed below:

##### 2.2.1.1 Analogous Method of Cost Estimation

In analogous cost estimation method, previous projects data with similar size, scope, conditions use for the cost estimation of new project. That method is also known as historical method. By using such a method can get quick and effective cost for the preliminary stage of project (Oberlender & Oberlender, 1993). However, construction projects have different factors like location of project, resources availability and prices. If we consider these factors in mind then its accuracy is confined (Akintoye & Fitzgerald, 2000).

Analogy-based estimating is a common cost estimation method that utilizes historical costs of activities or products to forecast the costs of proposed new activities or items. The comparison of construction projects becomes complex due to the substantial quantity of modification and adjustability available to consumers in the industry. The problem happens frequently when historical activity yields to project the yield of new activities estimators utilize, as variations mostly result from the different conditions under which the individual activity is carried out (Riquelme & Serpell, 2013).

#### 2.2.1.2 Parametric Method of Cost Estimation

Using pre-established structure factors and attributes, such as volume, covered area, resource rates, or unit rates, statistical models and costs are created for parametric cost estimate. This method has better results than the analogous method (Kim et al., 2004).

The parametric cost estimate method is used for cost prediction by performing the estimation with the same parameters which is same nature of the object. The method is used for cost estimation in the early design phase of a construction project; it is advantageous in that it can support cost planning according to various design changes. That method is used in the early stage of construction project design phase, offering the efficient response of the in-cost planning in accordance with the various changes in the design. It is observed that parametric cost estimation methods have valuable approaches when the project has very limited information regarding its scope, specification and other data. However, it is challenging to forecast specific parameters like as material quantities, process intricacies, and estimated completion time (Yang et al., 2022).

#### 2.2.1.3 Detailed Estimation Method

Detailed cost estimation method in construction sector also called as bottom-up estimation method, it involves the cost estimation of each activity, component or task at the lowest level and then combining each cost of activity or component to figure out the total project cost. This technique is typically used for mega, complex and high budget

projects where more accuracy required (Anireddy, 2024).

Detailed cost estimation is a time-consuming task. It is prepared upon completing all building project documentation. Imagination and expertise are vital for formulating a construction cost estimate. Different contractors utilize varying techniques, methodologies, and technology throughout construction. Consequently, estimators require expertise, ingenuity, and experience to do the estimating duty effectively. Detailed cost estimation comprises two important phases: quantity estimation, referred to as quantity takeoff, and pricing. The project is divided into different work items by the estimator or quantity surveyor estimator and estimate the resources for the each items in detail cost estimation. This can be referred to as quantity takeoff. The labor, equipment, and materials required for performing a work item are subsequently identified based on the specifications and construction methodology (Samphaongen, 2010).

#### 2.2.1.4 Expert Judgment

Expert judgment is a widely utilized method in cost estimating, this strategy relies on the expertise, experience, and intuition of professionals to generate accurate cost estimates. That method of cost estimation is also called the knowledge-based system, for the supporting and solving the problems by the expert judgments by knowledge base there is computer programming in the construction sector. This system operates by applying knowledge and analytical techniques that have been predetermined by specialists in their respective domains. That whole system and process which give the decisions and values by using the expert opinions and knowledge based information is called expert judgment method of cost estimation method (WP, 2018).

#### 2.2.2 Building Information Modeling

The new technology of Building Information Modeling has basic and main primary functions are presentation of construction projects in three-dimensional models. That model has a combination of intelligent elements of construction, each element having its own

parametric rules and features. BIM delivers dependable data for every perspective along with digital 3D model representation, connected views (Hergunsel, 2011). Building Information Modelling (BIM) includes several associated policies, technologies and processes that create a framework for handling the complex and critical mega construction design, it gives whole life cycle of project digital communication and coordination between the stakeholders. (Succar, 2009).

AEC sector the organizations recognize the advantages of BIM to enhancing productivity across the lifecycle. The International Alliance for Interoperability (IAI) makes the file formatting with the Industry Foundations Classes (IFC) file format, that format facilitate to exchange the information and data across the technological platforms. BIM technology comprises a wide range of features and attributes, including the 3d visualization, scheduling, reporting, generating drawings and cost estimating. The certain advantages of BIM to decryes the errors, enhance the productivity and increased the better communication between the stakeholders (Anireddy, 2024).

In Building Information Modeling it is possible to extract the rapid and accurate quantities of material directly from the BIM model. BIM programs have the capabilities to extract the quantities in shape of area, volume and counting in the shape of different schedules. It is necessity to define properly and accurately each component with its specification in the BIM model (Eastman, 2011). Accuracy in the initial stage of construction projects is generally accepted. Before, cost estimation was carried out with the traditional method of expert judgment. Cost estimation is important and crucial when making decisions because incorrect cost estimation becomes the cost overrun and delay of project. 5D BIM can help for the better project financing and better control on the cash flow (Lee et al., 2016).

Product life cycle costing can be aided by 5D BIM models, which are useful not only during project construction but also for facility management and asset ownership. BIM model and integrate with the project BOQ, cost plans and the life cycle

costing of the project to help the understand, update and find out the total from the feasibility stage to demolition stage (Kehily & Underwood, 2017). As compared to traditional cost estimation method, 5D modeling in building information modeling can facilitate finishing the project successfully on the time frame and allocated cost. Time, cost and quality performance are all improved and enhance by BIM. Communication of construction teams will be more efficient; visualization of the project is easier and scheduling for planning is quicker due to involvement of modeling. BIM facilitates discovering clash detection in the project before the construction phase and can help prevent the hard clashing between the elements of the structure (Rehman et al., 2021).

Significant obstacles occur during the design phase for the gathering of data and management in the creation and development of the complex project. Building information modeling (BIM) is the tool which facilitates the team enhance the collaboration and methodology aims in the architectural practices throughout the supply chain. The construction sector faces a change in direction to (i) enhance: project quality standards, productivity, efficiency in the works, infrastructure value, and sustainability, (ii) reduce: extra and over costs, time frame of the work, and repetition of the activity, with the help of effective collaboration and communication between project all involved stakeholders in construction projects. Building Information Modelling (BIM) having the target to make in streamline processes in the complete project duration. (Arayici et al., 2011).

### 2.2.3 Comparative Studies

A quantity surveyor is a person who is an expert at costing buildings in all stages. The whole project cycle costing, budgeting of project, tendering, contract managing and commercial matters plays the crucial role in the successful completion of the project (RICS, 2018). They are involved in complete construction economics and cost administration and can advise the construction team in the better way. From the feasibility stage preparation of estimate and monitor in construction/ execution phase they are

monitoring the whole cost cycle and end of the project involve in the depreciation cost, insurances, security bonds and tax, if essential for the adjustment or arbitration dispute. Here Building Information Modeling (BIM) gives the possibility of revolutionary technology with the access of the complete digital document throughout the complete duration of project from forcibility to facility management as compared to other cost estimation difficult to manage the data and collect the whole information of all activities cost breakdowns. Person will feel comfort with using the technology to acquire the data and visualization and quantification without any delay and error. However, technology provides advantages for the entire industry, there are risk factors and obstacles associated with it. BIM is having trouble being fully implemented (Nigam & Dixit, 2016).

Quantity take-offs are usually carried out using 2D documentation or CAD software. This conventional method entails hand measurements of numerous components, such as in floor plans, cross sections, and similar documents. Due to its need on human input, it is highly liable to mistakes, similar to 2D documentation. It is exceedingly challenging to explain complex situations, such as the connection of many structures, and the possibility of errors increases accordingly. Alternatively, specific BIM technologies provide direct quantity take-off from a model. This quantity take-off is dependent on the geometric properties of the model. It offers data regarding surface area, volume, and additional dimensions. BIM should be used as a tool for quantity take-off to enhance and refine cost estimation across all phases of development (Bečvarovská & Matějka, 2014). Cost estimation and quantity takeoff methods used to be done by hand. Due to their heavy reliance on human interaction, these methods are typically challenging to implement digitally. These approaches need to be updated considering BIM's first to fully enable the construction sector to use digital materials. Cost estimating is an essential component of many countries' which are either established or have already been developed (Matejka & Vitasek, 2018).

Manual work involves calculations that are prone to errors reason of the project's more complexity of some formulas, whereas Bim Software reduces the need for manual computation, allowing users to create models and input measurements to obtain material amounts. The variations in project prices determined by BIM software compared to manual methods arise from the absence of finishing components, such as plastering, flooring, and skirting, which cannot be accounted for in manual cost estimates (Haider et al., 2020).

Cost overrun in the construction project is a problem reason is the complexity of the project management. Following the standard cost estimation and controlling method follow in the organization for the project even within the companies there are different processes are followed for the cost estimation. However, in Building Information Modeling (BIM) there are standard tools and methods to evaluate the project with the better communication and cost effectiveness without ant cost overrun.(Pässe et al., 2022)

#### 2.2.4 Challenges and Opportunities

Building information modeling BIM is the latest technology to digital delivery of projects in the construction sector. There are significant barriers and issues arising when BIM systems apply in the field. It is important in the success of project to involve all stakeholders in implementation of process (Walasek & Barszcz, 2017). The terminology which we are talking about last fifteen year "Building Information Modeling" may be these methodologies and terminologies are dated back round before forty years or 1970s. before the 21<sup>st</sup> century the BIM implementation on the delivery of project did not exist because of lake of technology and unwillingness to emerging in the AEC industry. Furthermore, for the digital delivery of projects with BIM need to follow the standards and proficiency is required for all the stakeholders reach in the same level of the BIM (Tulenheimo, 2015).

##### 2.2.4.1 High Initial Investment Costs

BIM software such Bentley Systems, Cost X, Navisworks, Autodesk Revit, and ArchiCAD etc.

need costly licensing; yearly subscriptions can cost thousands of dollars. Moreover, to ensure accessibility across several design and construction disciplines, companies might need to invest in multiple software programs (Azhar, 2011). Working on the BIM software's with better performance and quality requires a high-performance computer system with better processing power, increased storage capacity, and advanced graphic capabilities. Companies are required to enhance the systems with the requirements standards frequently or need to purchase new systems, which increases the financial burden (Eastman, 2011).

However, the capital expenditure (CAPEX) and operational expenditure (OPEX) necessary for the involve the technology of Building Information Modeling (BIM) represent a substantial involvement, especially for small and medium-sized enterprises (SMEs). Since in the construction sector technology of building information modeling is a relatively new concept, The general lack of additional resources to support its adoption is a significant disadvantage. In the United Kingdom, 55% of both major and small enterprises say that rising costs (Georgiadou, 2019).

#### 2.2.4.2 Lack of Skilled Professionals

For a long time, there has been a critical barrier to promoting the technology of BIM and to taking advantage of its benefits in the insufficient training of the professionals, lack of experts and skilled personnel. The efficient implementation of BIM on the project needs the significant employs training, which gives the two direction expenditures direct cost for their training or certification and indirect costs productivity during training process (Shojaei et al., 2023). Companies try to provide personnel support and necessary tanning to enhance their competency and, in turn optimize to success of BIM implementation in entire sector. (Semaan et al., 2021) Training programs are required to enhance employees' proficiency in BIM software, including Autodesk Revit, Navisworks, AutoCAD Civil 3D and Cost X for the implementation of BIM environment. They have importance for maximizing the

advantages of BIM implementation and enhancing productivity over time.

Furthermore, a deficiency in internal proficiency in BIM modeling skills faces the expenses for the personals additional support tanning. That action makes impacts on both parties of sector individual practitioners and the company collectively, underscoring the necessity for awareness enhancement and skill development within the AEC sector. Several experts contend that the elevated expenses associated with applying BIM are often seen as a significant obstacle in the construction sector (Georgiadou, 2019).

The strategy structure to promote BIM adoption equally integrated personnel, techniques, and technology, resulting in capacity enhancement through advancements in processes, technological infrastructure, and the staff competencies uplifting to achieve enhanced productivity and competitive advantages (Arayici et al., 2011).

#### 2.2.4.3 Resistance to Change and Industry Culture

Building Information Modeling (BIM) has changed the construction industry by merging technology, increasing collaboration and improving project efficiency. However, the implementation the technology and system of the BIM in the construction industry culture has resistance.

Employees and stakeholders knowledgeable with traditional methods and construction designs think that BIM is a complex or stressful system for implementation in the construction project of costing or any other process (Succar, 2009). It's likely that many construction industry personnel, especially those from older generations, lack the digital abilities needed to use BIM technologies efficiently. Most organizations are working with the traditional system to change that system they required new hiring or need in-house training for the employers to implement the system so they avoid that in whole process will cost huge investment (MacLoughlin & Hayes, 2019).

Evidence indicates that the construction profession is facing pressure to adopt BIM. Despite BIM's history for over two decades, it is only in recent years that building owners have

recognized its potential to significantly enhance the efficiency and streamlining of design, construction, and operational processes. It is important to combat obstacles to change and facilitate awareness of the advantages and significance of BIM compared to 2D drawing, modifying current workflows to align with lean methodologies. While the adoption process may proceed more slowly than anticipated due to its comprehensive character and stakeholder engagement, the effects of BIM adoption on organizational practices are measurable (Arayici et al., 2011).

It is believed that large construction firms are required to lead BIM deployment, while Small & Medium Enterprises (SMEs) are considered as less likely to adopt BIM due to the reason of the clients' unfamiliarity with the system of BIM or the insufficient capability of their projects for BIM applications (Georgiadou, 2019).

The frequent implementation of new technologies and software has directly contributed to a decreasing level of technical understanding within the team, which is unable to adapt to the rapidly increasing pace of change. This can also be linked to the costs associated with modeling management, as the insufficient funding for digital transformation intensifies within the organization, limiting the purchasing of necessary software and hardware (Hall et al., 2023).

#### 2.2.4.4 Inconsistent BIM Standards and Regulations

Construction projects currently depend largely on Building Information Modelling (BIM), which improves project outcomes, collaboration, and cost effectiveness. However, a wide range of standards and regulations apply in different countries and organizations and industries create significant barriers to its support and implementation.

Simultaneously unique and technological advances the Building Information Technology (BIM) standards and regulations from people and groups to organizations and project teams to entire markets and industries. International projects face obstacles by these standards discrepancies, necessitating organizations to modify BIM

workflows to meet local needs (Succar & Kassem, 2015).

In the project BIM developers required a specific templet as per the Building Information Modeling (BIM) standards and standardized material library for fire resistance. It is necessary to provide the predefined library of material from the supplier to ensure reliable code compliance and decrease the errors. In the beginning of the construction design process, regulation compliance actions must be incorporated. If stakeholders of the project could look the entire designs for compliance at various stages during their project design phase, it's possible that their workflow might change. Additionally, this could change how stakeholders create (Shih, 2015).

To require a standardized approach to BIM workflows, the UK created BS EN ISO 19650, an international standard that extends upon the previous PAS 1192 series (Abanda et al., 2025). The National Institute of Building Sciences (NIBS) created its own standards the National BIM Standard-United States (NBIMS-US), which is used in the US but is not the same as the UK standard in respect to structure and implementation (East & Smith, 2016).

#### 2.2.4.5 Model Accuracy and Data Reliability

Building Information Modelling (BIM), in construction sector that provides a digital representation of a structure's physical and functional attributes, has revolutionized. However, the accuracy of models and the reliability of data used throughout the project lifecycle are essential for BIM's efficacy. Unreliable data and inaccurate BIM models can result in high-cost errors, hold-ups, and legal liabilities.

A few challenges avoiding the construction sector from applying BIM are the absence of understanding 5D standards, process disruption, unaware to technical knowledge about implementation of BIM system and lack of personal skills about the software's (Rehman et al., 2021).

The need for qualified personnel remains a bottleneck in BIM implementation. Modelling refers to the development of BIM objects that contain architectural elements, including both

geometric and non-geometric characteristics and connections. The quality of data in BIM, modelled on previously acquired building information, is influenced by the techniques of gathering data, processing, and recognition, as well as the employed technology and the specified Level of Detail (LoD). To evaluate various methodologies and their modelling capabilities, constructed models may be appraised in terms of modelling accuracy, limit of detection (LoD), or CMM6. However, no standardized BIM assessment methodology has been developed to evaluate model characteristics (Volk et al., 2014).

3 RESEARCH METHODOLOGY

3.1 Introduction

The aim of this study is to compare the effectiveness of both cost estimation methods traditional, and BIM based in a construction project. Here, methodology involves the evaluation of both techniques manual cost estimation preparation of a detail estimate and Bill of Quantities (BOQ) and then developing the 3D model in the Revit software of the same project for the cost estimation using the BIM Process. Using the MES Schedule of Rate 2021 (MES, 2021) to obtain the project rates' applicable costs. The final data result from both approaches will be analyzed according to its accuracy, time, efficiency, limitations, and benefits.

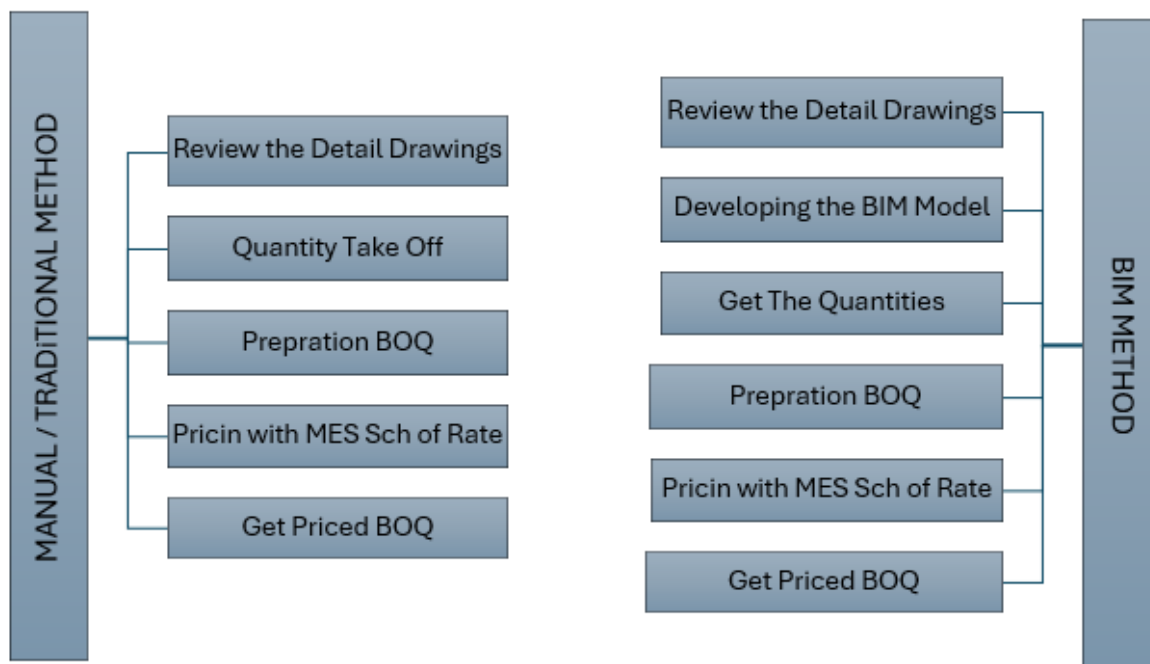


Figure 3 1 Traditional & BIM Based Process

3.2 Selection of Project

The initial phase is to choose a construction project using the following criteria to compare both methods.

3.2.1 Project Type

For that research study, a mid-scale residential building project has been selected, containing the

frame structure members with a ground floor plus four floors. Considering its complex structural and architectural elements, the building is the ideal choice for an in-depth assessment.

### 3.2.2 Project Availability

The project has sufficient details, including architectural and structural drawings, which are available for the detail estimation process.

### 3.2.3 Selection of Project Elements

Here the structural component of the project will be considered for the assessment of the research. In structural part of the project including footing, column, beams, RCC walls, slabs and other concrete elements.

## 3.3 Analysis and Comparing

After executing both BIM-based cost estimation and Manual cost estimation methods, an in-depth analysis comparing the two methodologies will be conducted in the following areas:

### 3.3.1 Comparison of Time

Time will measure for both methods which are spent during the preparation of bill of quantities including the quantities take off from 3D model and manual from drawings.

### 3.3.2 Accuracy in Cost

The bill of quantities prepared using the manual method will be compared with the BIM based method BOQ to assess the accuracy.

### 3.3.3 Accessibility

The accessibility of both methods will be individually compared, considering factors such as the usage of software and manual effort involved.

### 3.3.4 Initial Cost

The initial Cost of both BIM (Building Information Modeling) and manual methods will compare in term of software expenses and expert's involvements. This comparison includes the cost of the Revit software licenses and BIM modular expert services.

## 3.4 Reporting and Conclusion

After completion of both processes the last step is to gather the results of study and format the conclusion. A comprehensive report will be written, focusing on:

- A detailed analysis of time needed in both methods.
- Analysis of the cost accuracy, including the errors and other discrepancies.
- Recommendation to determine the best method based on the complexity of the project, size of project and available resources.

## 4 DATA COLLECTION

### 4.1 Data Collection

To ensure accuracy of the research, detailed and comprehensive documents of project need to be gathered. These details can be used for both traditional and BIM-based cost estimation methods.

- Architectural Drawings (Floor Plans, Section, Elevations)
- Structural Drawings (Footing Detail, Column Details, Beams Details)

• Specification of materials and finish  
Above mentioned drawing resources will be used to collect relevant information for further analysis. Below listed types of data will gather for research.

#### 4.1.1 Data for the BIM Based Method

- Software data (Price, Training Charges and System Requirements).
- Quantity takeoff data from the BIM model (Concrete Structure Components).
- Unit cost of each component (Foundation, Column, Beam & Slab etc.)
- Detailed cost of complete structure in BOQ.
- Time consumption to create the BIM model.

#### 4.1.2 Data for the Manual Estimation Method

- Manual measurements for the quantities of materials based on project drawings.
- The unit cost of each component (Foundation, Column, Beam & Slab etc.)
- Detailed cost of complete structure in BOQ.
- Time Spent on Manual Estimation.
- Any time spent revising or adjusting the estimate as changes occur.

#### 4.2 Manual Estimation Data Collection

In manual cost estimation method, work activities break down through reviewing the drawing and preparing the detailed takeoff sheet of each element on excel and extracting the quantities of these structural elements (Footing, Column, Beams & Slab) in volume of concrete. These extracted quantities transferred into the bill of quantity (BOQ), accompanied by detailed descriptions with specification from the MES schedule of rates 2021, including the unit of measurement and associated rate. The cumulative duration of this process will be documented in comparison with BIM estimation techniques.

#### 4.3 BIM Based Estimation Data Collection

In the BIM base estimation method after reviewing the structural and architectural drawings, develop the detailed 3d Structural model in Revit software (Wikipedia, 2025). 3D model will develop with all components including footings, columns, beams and slabs. Through the Revit material schedules quantity of concrete in volume extract directly from 3D model. Generate the Bill of Quantities with the extracted quantities from 3D model and apply same rate which applied in manual method from MES schedule of rates 2021. Created 3D model not only for the cost

estimating process it can be used for the time estimation for 4D processes in the project. Time recorded during whole BIM based process. Model can help to determine quantity variation in case there is any change in the design or size of the member.

#### 4.4 Rates and Structural Members

In the adoption of rates for the building structure, the specific rates from the MES Schedule of Rate 2021 have been carefully selected to ensure accuracy and consistency in cost estimation for each element of the structure. That schedule of rates covers a wide range of components such as foundations, columns, beams, slabs, walls, and roofing, provided rates are included with both materials and labor for each type of work. Structure member of the building, whether it's a foundation, structural supports (columns and beams), or load-bearing walls, has been detailed in terms of the type of material used. This allows for precise and transparent budgeting, ensuring that the building's structural integrity is met without compromising on cost-efficiency. Below the table shows the details of each member, units of measurements, item of the schedule, schedule of

Table 1 : Selected Schedule Items Rate List

Sch Item	Description	Unit	Rate
3-2	Providing and laying lean concrete using crushed or broken stone graded; 1:4:8, all as specified.	cum	7,075.00
3-7	Providing and laying of RCC with 3000 psi compressive cylindrical strength in different structural elements ( <b>foundation</b> etc.) including form work all as specified. Reinforcement measured and paid separately.	cum	10,095.00
3-9	Providing and laying of RCC with 3000 psi compressive cylindrical strength in structural elements in <b>plinth beams</b> and bands etc. all as specified including form work (reinforcement measured and paid separately).	cum	13,547.00
3-9	Providing and laying of RCC with 3000 psi compressive cylindrical strength in structural elements in <b>walls</b> etc. all as specified including form work (reinforcement measured and paid separately).	cum	13,547.00

3-10	Providing and laying of RCC with 3000 psi compressive cylindrical strength in structural elements in <b>columns</b> including form work, all as specified. Reinforcement measured and paid separately.	cum	13,921.00
3-10	Providing and laying RCC with 3000 psi compressive cylindrical strength in structural elements in <b>beams</b> including form work, all as specified. Reinforcement measured and paid separately.	cum	13,921.00
3-10	Providing and laying of RCC with 3000 psi compressive cylindrical strength in structural elements in <b>stairs</b> including form work, all as specified. Reinforcement measured and paid separately.	cum	13,921.00
3-9	Providing and laying of RCC with 3000 psi structural elements in <b>roof slabs, landings</b> etc. all as specified including form work (reinforcement measured and paid separately).	cum	13,547.00

## 5 DATA ANALYSIS

### 5.1 Accuracy in Cost Estimation Comparative Analysis BIM vs. Manual Method

Analyzing the Bill of Quantities (BOQ) created for the structural work of a Ground+4 story residential structure, this study examines the accuracy and efficacy of cost estimation using Building Information Modeling (BIM) compared with traditional approaches. Both methods involved calculating the quantities and total costs for identical construction components, including lean concrete, reinforced concrete in various

structural elements such as foundations, beams, columns, slabs, and stairs.

The total estimated cost derived from the BIM-based BOQ amounted to Rs.14,752,548.71, while the manual estimation produced a slightly lower total of Rs.14,724,245.13. This results in a cost differential of 28,303.58, with the BIM method showing a 0.19% increase in total cost estimation compared to the manual method.

In annexure C' attached the detailed taking of sheets of all items and priced bill of quantities (BOQ) for both methods. Below showing in figure 5.1 the result after comparing both methods.

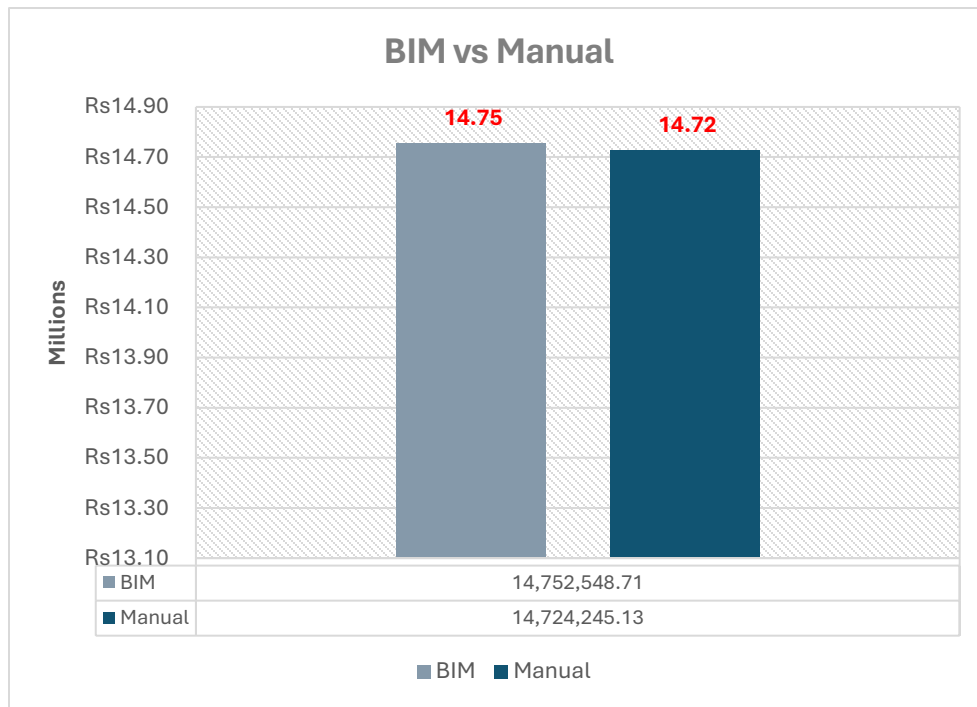


Figure 5 1: BIM vs Manual

This variation is primarily due to differences in quantity take-offs for individual structural components of the building. BIM reported slightly lower quantities for lean concrete, plinth beams, stairs, and roof slabs, likely due to its precise 3D modeling capabilities that eliminate over estimation common in manual rounding. Conversely, it yielded higher quantities in walls and beams, where complex geometries and

detailed component modeling captured elements typically simplified in manual calculations. These itemized variations highlight BIM's superior accuracy and comprehensiveness, which result from its ability to model every structural element with precision, automatically update changes, and minimize human error. The quantities and amount-wise differences are displayed in the figures below.

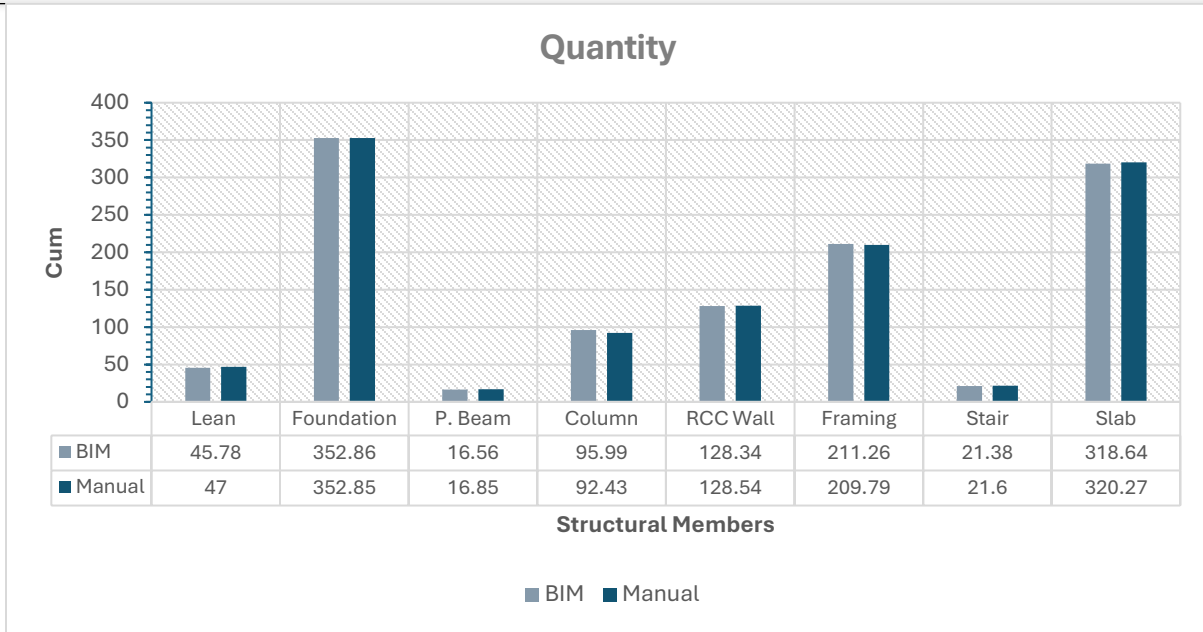


Figure 5 2: Difference in Quantity

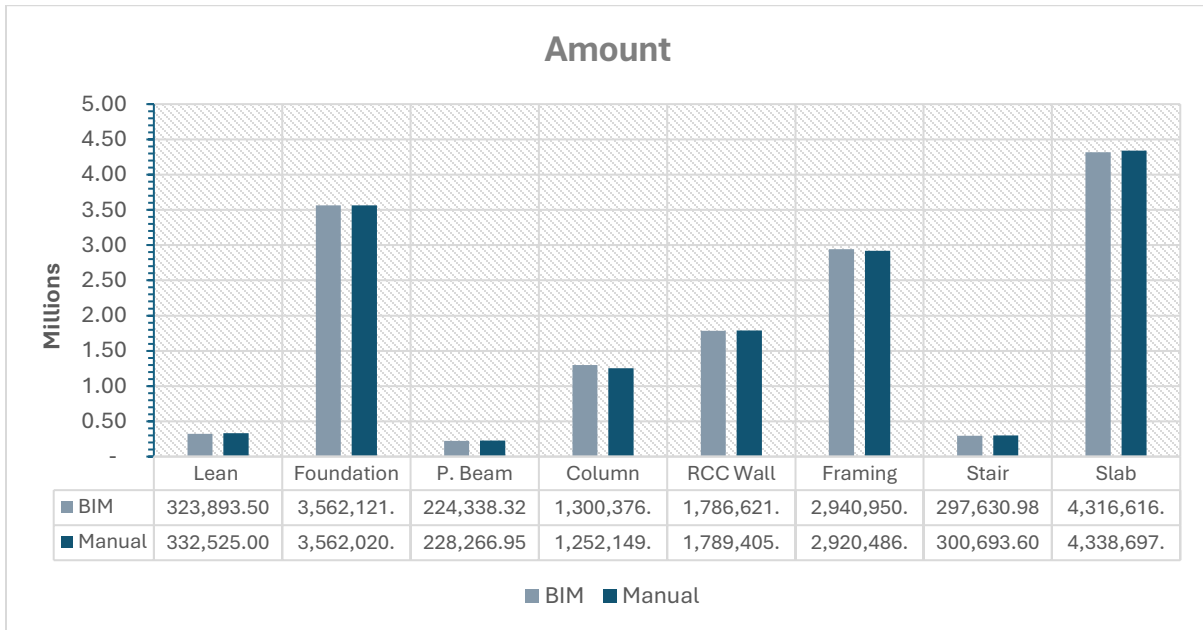


Figure 5 3: Difference in Amount

Table 2: Difference in Quantities:

Sr.	Structural Member	Qty	
		BIM	Manual
1	Lean Concrete	45.78	47
2	Foundation Concrete	352.86	352.85
3	P. Beam Concrete	16.56	16.85
4	Column Concrete	95.99	92.43
5	RCC Wall Concrete	128.34	128.54
6	Framing Concrete	211.26	209.79
7	Stair Concrete	21.38	21.6
8	Slab Concrete	318.64	320.27

Table 3: Difference in Amount

Sr.	Structural Member	Amount	
		BIM	Manual
1	Lean Concrete	323,893.5	332,525.00
2	Foundation Concrete	3,562,121.7	3562020.75
3	P. Beam Concrete	224,338.32	228,266.95
4	Column Concrete	1,300,376.53	1,252,149.21
5	RCC Wall Concrete	1,786,621.14	1789405.34
6	Framing Concrete	2,940,950.46	2,920,486.59
7	Stair Concrete	297,630.98	300,693.6
8	Slab Concrete	4,316,616.08	4,338,697.69
<b>Total Amount</b>		<b>14752548.71</b>	<b>14724245.13</b>

### 5.1.1 Explanation of Differences

The following factors contribute to the slight cost difference:

#### 5.1.1.1 Accuracy in Quantity Take-Off

BIM facilitates the automated quantity take off directly from the 3D model. Consequently, elements such as slab areas, beam volumes, and column dimensions are calculated with enhanced precision, reducing the likelihood of human errors prevalent in manual techniques.

#### 5.1.1.2 Detailed Component Breakdown

BIM considers all the geometric and spatial data in all components of building, including minor elements of components often overlooked or rounded in manual estimation. That act makes the slightly higher quantities for some components.

#### 5.1.1.3 Accuracy in Data Administration

The BIM model gives consistency in complete project lifecycle. Any variation or changes in

design are reflected instantly across all drawings and quantities schedules, reducing discrepancies that might occur in traditional workflows where revisions may not be uniformly applied.

### 5.1.2 Evaluating the Reliability of the Estimation Methods

To evaluate the reliability of BIM and Manual cost estimation methods, a second set of estimations was carried out. Another BIM structural model was developed by a different individual within the same scope and the design to get the cost. Using the same drawings, a BOQ was produced by another individual.

After analysis the manual estimation method there are substantial differences between the two professionals. The differences resulted from two different sets of estimates due to the manual method of quantity takeoff, drawing interpretation and human error.

Conversely, the building Information Modeling (BIM) indicated remarkable uniformity with

minor variation due to the software default setting or modeling option.

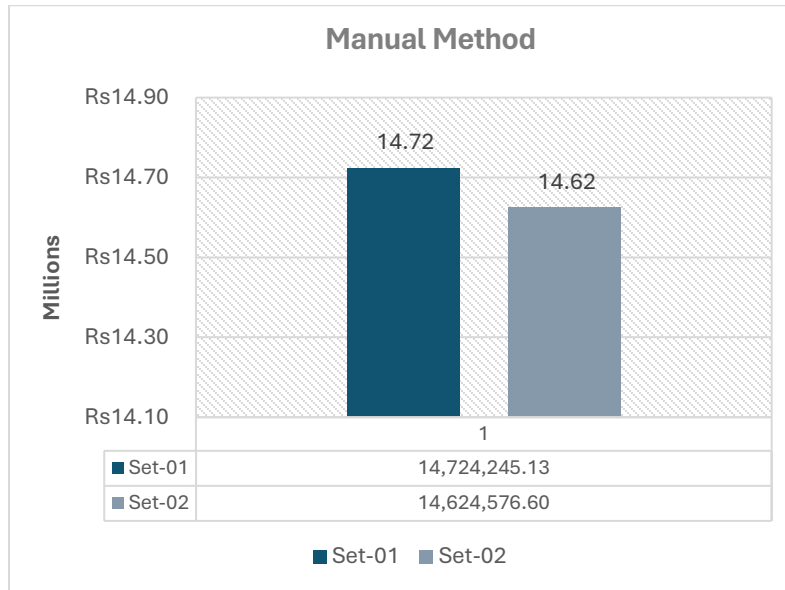


Figure 5 5 Manual Method two Set of Calculations

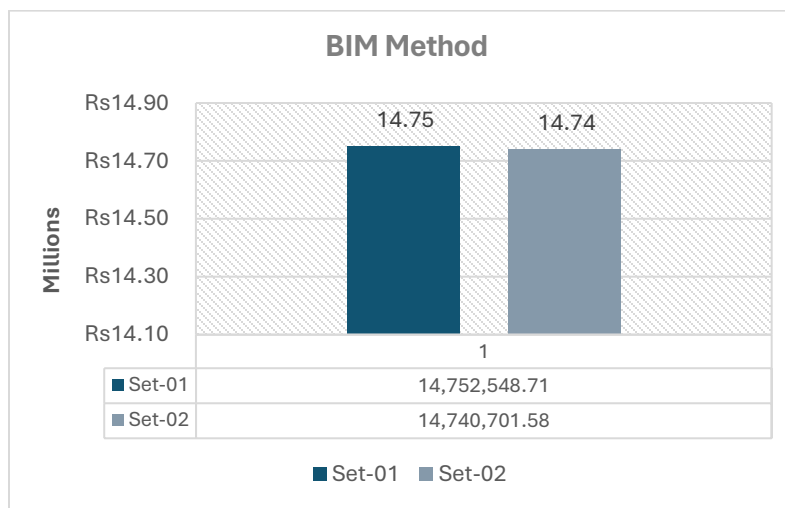


Figure 5 4 BIM Method two set of Calculations

### 5.1.3 Results

These results suggest that cost estimation becomes more accurate and reliable through Building Information Modeling (BIM), despite the slight increase in total cost compared to manual methods. The differences highlight BIM's ability to take detailed quantities take off more precisely, offering more accurate budgeting for construction projects.

### 5.2 Comparative Analysis of Time and Resources Utilization in Bim Vs Traditional Methods

The aim of the analysis to determine the time and resources efficiency of the both methods BIM and manual estimation method. Building Information Modeling (BIM) is the advancement of the construction industry that makes work easy and reduces resources and time consumption as compared to the manual methods where time and resources are required more than the BIM

methods. Manual cost estimation method rely on the manual calculations and in any change and variation need to do the complete job other hand BIM give the integrated and collaborative work environment.

**5.2.1 Time Management**

Both methods are performed on a residential project to get the objective results both method time consumption were noted to compare each other. Below figure 5.4 shows the time difference between both methods. Time was noted on each structural calculation of the structure in both methods to determine the time consumption.

**5.2.1.1 Building Information Modeling (BIM) Method**

The process of the quantity take-off in the BIM process is usually faster because the model has already created for the project other kind of project management practices, the software can extract the quantities fast and automatically. It gives the quick response in any change of the

drawing design in any structural member. BIM system has the relation and collaboration between all steps of the construction stages. The model was created in Revit software and for the quantity take off it took only five minutes for each member to make the schedule of the detailed calculations with full details. In schedule I got detailed descriptions, area of member, volume, numbers etc.

**5.2.1.2 Manual Method**

Manual method was done by the quantities take off through the 2d drawings and manual calculations in the excel sheet. Each member was calculated with the help of different drawings and plans; each calculation of structure member time was noted to analysis the difference between the BIM method. The manual method for the take-off was time taking it involves all manual calculations and if any change is required in the drawing and design it may need recalculation and become the cause of delay.

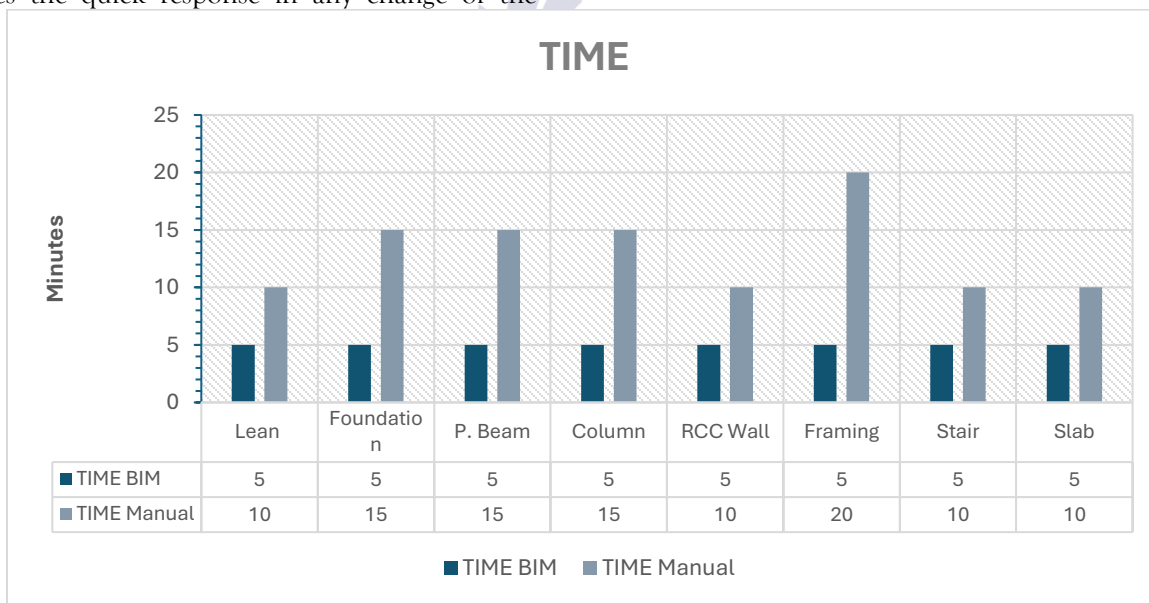


Figure 5 6: Difference in TIME

Table 4: TIME for Both Methods

Sr.	Structural Member	TIME	
		BIM	Manual
1	Lean	5	10
2	Foundation	5	15
3	P. Beam	5	15
4	Column	5	15
5	RCC Wall	5	10
6	Framing	5	20
7	Stair	5	10
8	Slab	5	10
<b>Total Time</b>		<b>40</b>	<b>105</b>

5.2.2 Resource Management

To perform the analysis for the resources in both methods BIM and Manual for cost estimation,

each method resources are noted with their working skills to determine the difference between both methods.

5.2.2.1 Building Information Modeling (BIM) Method

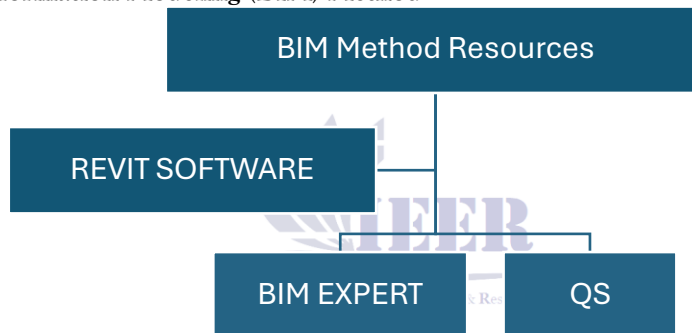


Figure 5 7: BIM Method Resources

In Building Information Modeling (BIM) cost estimation is integrated into the digital model. Cost estimation through BIM, resources are required to get the quantities form the model and prepare the BOQ. In complete process in the project, we assessed that we required the BIM Expert or the BIM software expert to get the quantities schedules form the model and all kinds

of information which required for preparation of Bill of Quantities (BOQ). In the project Revit software was used to make the model and get the quantities schedules. After getting the quantities take off from the software Quantity Surveyor required to arrange the items with the specification in BOQ and apply the rates to get the whole project cost.

## 5.2.2.2 Manual Method

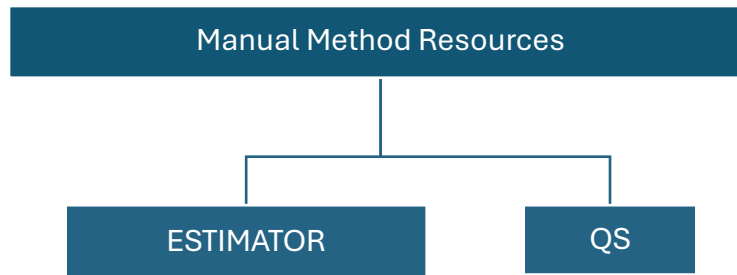


Figure 5 8: Manual Method Resources

Manual method of cost estimation is the first step to calculate the quantities from the 2D drawings to perform the activity an estimator required to take off all quantities with are required. The estimator works closely with the QS to estimate the items' details form the drawings. Quantity Surveyor responsible for arranging the all take-off quantities in the Bill of Quantity to get the project cost. QS is also responsible for getting the update in any change in the design and drawing or scope of work and updating the project cost accordingly.

## 5.2.3 Results

Building Information Modeling (BIM) processes significantly reduce the time consumption to get the quantities take off to prepare the BOQ, other side manual / traditional method required the more time to get the take-off form the drawing because here manual calculation are involved. In any change or variation manual method need recalculation but BIM needs only update the model as per new design and get accurate quantities in same schedules through the software. In terms of the resource's utilization, BIM requires software to generate the model and extract schedules, based on QS generating the BOQ for cost of project. In manual method an estimator

extracts the quantities manually and QS makes the BOQ accordingly. In both methods resources are almost equally required in terms of human requirements but in BIM method software is the additional requirement but its calculations are more accurate than the manual calculations.

## 5.3 Difficulties and Constraints Associated with Implementation of BIM

In this research, we determine the different difficulties and constraints for the cost estimation. Various factors that affect the Building Information Modeling (BIM) process effectiveness in this context.

## 5.3.1 BIM Implementation

It makes difficult and unfavorable for a project if we apply the BIM process only for the cost estimation. BIM process needs to apply throughout the entire life cycle of the project, beyond only for the cost estimation. BIM systems can be used in various tasks, such as design phase, project scheduling, facility management etc. The whole system makes the calibration between the stakeholders and gives the more accurate and comprehensive model for each task.

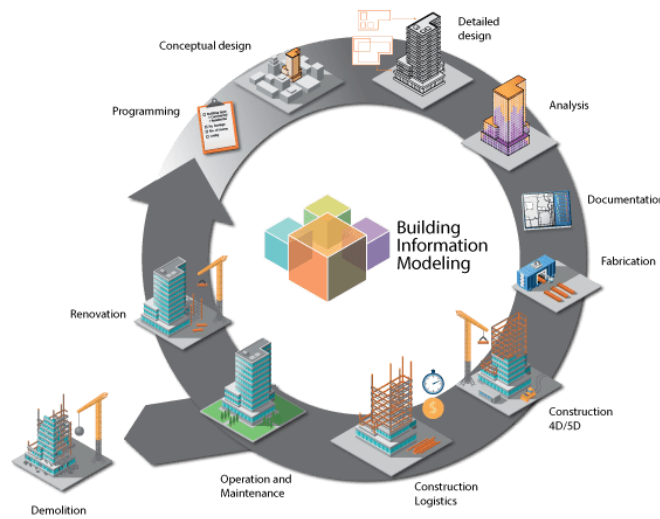


Figure 5 9: BIM Process in Project Life Cycle (Fig-01, n.d.)

5.3.2 Level of Details (LOD)

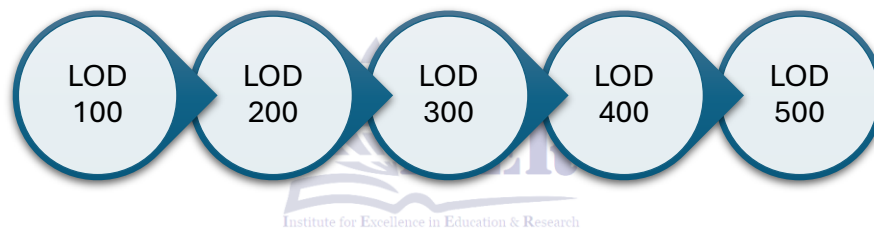


Figure 5 10: BIM Level of Details

For the accurate cost estimation need a fully detailed and specified model. The quality and level of detail are most important in the BIM model. A low LOD BIM model may not give accurate and complete details for cost estimation. LOD 400 models have complete details and specifications of the component. It is most important to get high LOD models for cost estimation.

5.3.3 Initial Cost

Implementing the BIM process in the project for the porose of cost estimation, it often requires substantial initial cost in the shape of software, hardware and expert persons or training of available people. It looks like a Hauge amount if we apply that process only for one purpose if it applies whole project other fields then it will be effective.

5.3.4 Results

The implementation of Building Information Modeling (BIM) for the cost estimation offers significant benefits and reliability, but due to some difficulties which are explained above that system become ineffective for the small and low budget projects because it requires more investment, resources and coordination.

6 RECOMMENDATIONS

Building Information Modeling (BIM) is highly recommended due to time efficiency and accuracy in large-scale projects, complex and high budget projects. BIM technology provides precise cost estimations in the construction industry, adjustments during the construction phase and reduce the errors. However, for the low budget and small-scale projects where the return of

investment is low, traditional methods might be more feasible due to the high initial amount spent on BIM implementation.

Building Information Modeling (BIM) to be fully effective, it should be used for the whole life cycle of the project and involves other management roles not just for the cost estimation. IF BIM incorporates in the scheduling, designing and facility management it can maximize the efficiency of the project and keep the project in control. That integration can reduce the rework, quick decision and effective coordination.

It is recommended to focus on the accuracy and detailed BIM model. It needs to ensure that all components of the building structures are correctly detailed and align with the specifications it can increase the accuracy of the project cost. By using the high detailed model such as (LOD-400 or LOD500) also containing the more detailed help to get the precise estimate.

If the construction companies apply the BIM process in the small-scale project and understand become familiar with the BIM protocols, standards and build the skills before applying on the large-scale projects.

Building Information Modeling (BIM) can make a strong communication and collaboration among the stakeholders including construction team, designers, engineers and clients. Therefore, it is recommended that we use BIM for the collaboration to mitigate the overrun project timeline and budget.

## 7 CONCLUSION

That study of comparative examination of the Building Information Modeling (BIM) and traditional cost estimation method in the construction projects demonstrates benefits of the BIM especially accuracy in the take-off and cost, time management and resource management. BIM requires high initial cost and demands professional personnel; however, it significantly enhances the precision of cost and project management with the capability of a 3D model and real time update.

Alternatively, traditional methods are familiar and initially economical but become the cause of human errors particularly in complex and large-

scale projects. Here spent need more investment in human resources to do the job and in case of the change of design modification. The manual method becomes expensive and challenging in accordance with design modification.

In conclusion, BIM has a bright future in digital era. It is a powerful tool for cost estimation and project management, to make a successful project in terms of budget, time and quality. The success of the construction companies depends on the development of advanced methodologies, aligning innovations in the construction industry. This will ensure that BIM is the latest technology with the advanced methodologies of project, enhance project efficiency, cost controlling, minimizing errors and conflicts between stakeholders.

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