

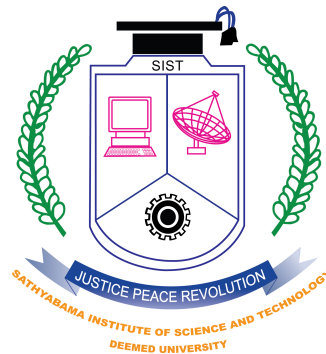
AN INTEGRATED BIM SYSTEM TO TRACK THE TIME AND COST IN CONSTRUCTION PROJECTS

A Thesis

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

by

VENKATESHWARAN S (40840019)



**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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This is to certify that this report is the bonafide work of **VENKATESHWARAN S (40840019)** who carried out the Thesis entitled "**AN INTEGRATED BIM SYSTEM TO TRACK THE TIME AND COST IN CONSTRUCTION PROJECTS**" under our supervision from January 2022 to May 2022.

Internal guide

(Ar. SURYA RAJKUMAR)

Internal Panel Member

(Ar. SUKIRTHA SURESH)

External guide

(Ar. S.KAVIN KUMAR)

DR. DEVYANI GANGOPADHYAY

Head of the Department

Submitted for Viva voce Examination held on 6th May 2022

Internal Examiner

External Examiner

DECLARATION

I **VENKATESHWARAN S** hereby declare that the Thesis Report entitled “**AN INTEGRATED BIM SYSTEM TO TRACK THE TIME AND COST IN CONSTRUCTION PROJECTS**” done by me under the guidance of **Ar. SURYA RAJKUMAR** (Internal) and **Mr. S.KAVIN KUMAR** (External) at Sathyabama Institute of Science and Technology is submitted in partial fulfillment of the requirements for the award of Master of Architecture degree in Building Management.



DATE: 06.05.2022

PLACE: CHENNAI

SIGNATURE OF THE CANDIDATE

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ABSTRACT

Building Information Modelling (BIM) is a product innovation used to effectively design, plan, develop and oversee structures and framework for Architecture, Engineering and Construction (AEC) experts. The level of accuracy and detailing given at every single phase of a development project is vital. To accomplish this, till today numerous data methods are utilised by development organizations viz. MIS, ERP and so forth. Presently there is a new innovation is becoming famous in development industry is BIM for example Building Information Modelling. The normal issues looked by development industry are time delays and cost invades. This issue basically in light of inaccurate and inadequate data sources and absence of data sharing. BIM will help to defeat these conditions in development industry. This study will focus on the use of 5D BIM to track cost and time control in projects. This instrument work with various expense related exercises like planning and checking of cost of an undertaking.

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CHAPTER 1

INTRODUCTION

1. INTRODUCTION

In, India many organizations which are involved in public sector or procurement area the designer and contractors needed an advance technology for fastest progress of work in construction area which is an essential tool for developing any country. India is an emerging country which has been suffering from economic issues regarding the construction projects to know this fact design or plan statements must be changed from 2D to 3D interface in construction industry. People who join with the firm do not have full information regarding the project which creates clashes between owner, designer, contractors or any other party joined with the work. To solve this problem BIM, implementation is the best option which provides

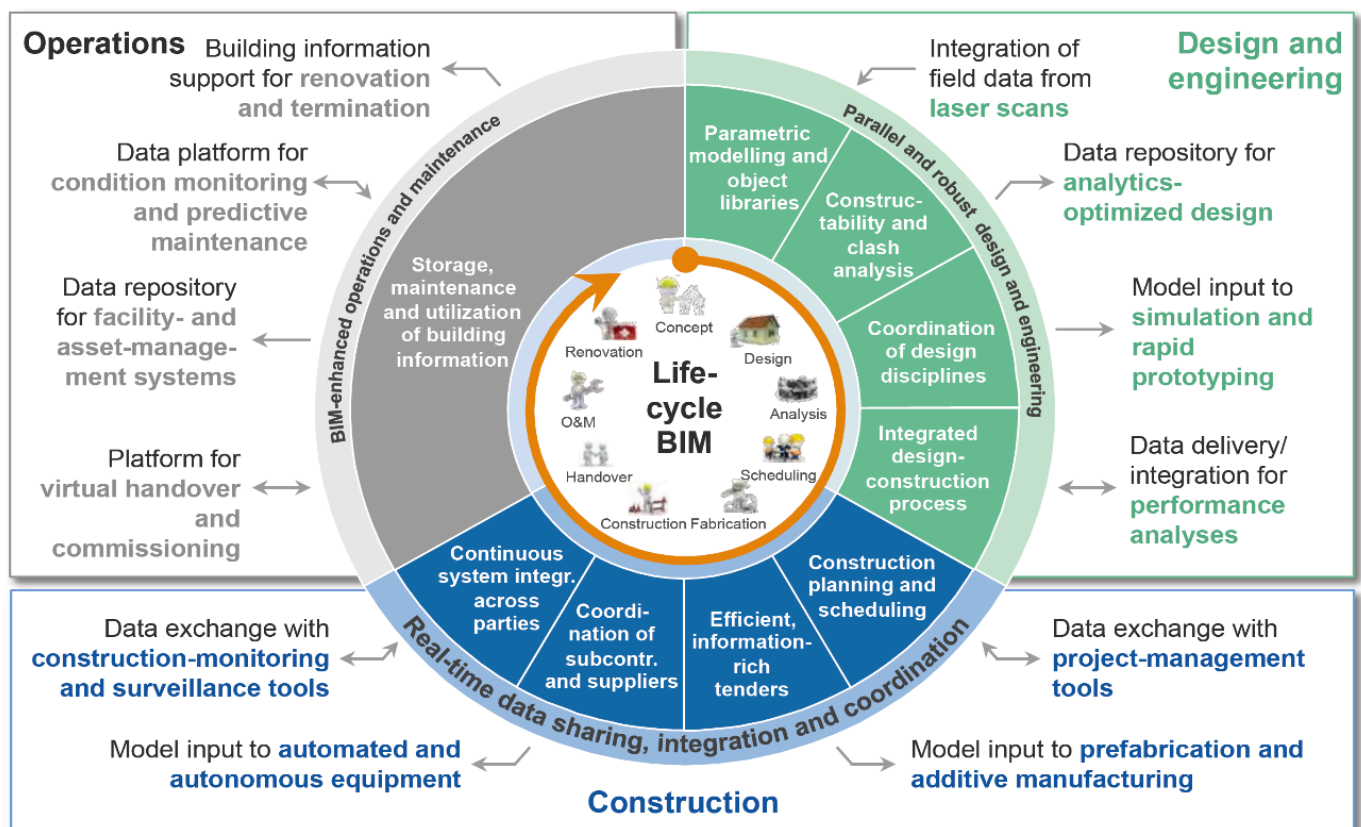


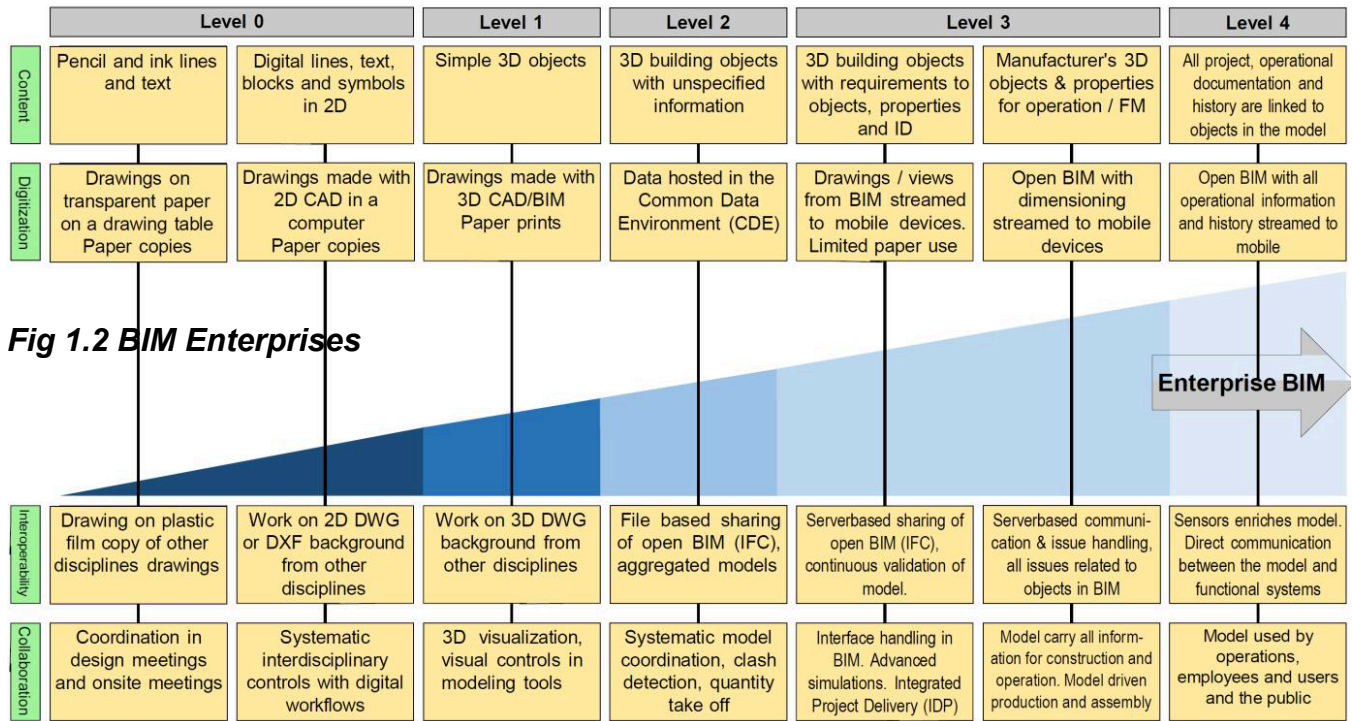
Fig 1.1 Applications of BIM along the engineering and construction value chain

productivity, quality of work by reducing lifecycle cost of whole project

Building Information Modelling (BIM) can be defined as a reliable, digital, three dimensional, virtual representation of the project to be built for use in design decision-making, construction scheduling and planning, cost estimates and maintenance of construction projects. The National Building Information Model Standard Project Committee defined the BIM as following:
“

A BIM is a digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its lifecycle from inception onward.”

The term BIM is a popular buzzword used by software developers to describe the capabilities that their products offer. As such, the definition of what constitutes BIM technology is subject to variation and confusion. To deal with this confusion, it is useful to describe modeling solutions that do not utilize BIM design technology. These include tools that create the following kinds of models: Models that contain 3D data only and no (or few) object attributes. These are models that can only be used for graphic visualizations and have no intelligence at the object level. They are fine for visualization but provide little or no support for data integration and design analysis. An example is Google's SketchUp application which is excellent for rapid development of building schematic designs, but limited use for any other type of analysis because it has no knowledge of the objects in the design other than their geometry and appearance for visualization. Models with no support of behavior. These are models that define objects but cannot adjust their positioning or proportions because they do not utilize parametric intelligence. This makes changes extremely labor intensive and provides no protection against creating inconsistent or inaccurate views of the model. Models that are composed of multiple 2D CAD reference files that must be combined to define the building. It is impossible to ensure that the resulting 3D model will be feasible, consistent, countable, and display intelligence with respect to the objects contained within it. Models that allow changes to dimensions in one view that are not automatically reflected in other



views. This allows for errors in the model that are very difficult to detect (similar to overriding a formula with a manual entry in a spreadsheet).

1.2. BIM MATURITY LEVEL

BIM levels of maturity can be divided into four levels according to the level of 'saturation' of the model with particular information. The BIM maturity levels, depending on their information content may be briefly described as follows[8]:

LEVEL 0 – currently the most commonly used level based on CAD programs. It consists mainly of 2D drawings, based on which paper documentation is generated. Cross-sections are prepared using projection planes or UCS (user coordinate system), and not from a 3D model. Consequently, the risk of potential errors is considerably higher. Partial automation at this level is possible by means of using Lisp programming languages.

LEVEL I – It uses only a small part of the possibilities offered by BIM technology. It is mainly used at the initial conceptual stage to communicate with the investor and for the preliminary construction analyses and. It also enables the designer to produce accurate 2D documentation without the need to verify all elements in 3D. It makes it possible to export CAD base renderings which are necessary for multi-discipline cooperation. Because of the insufficient

stage of development of the model, generating cross-sections of some elements is not possible, which may be a considerable drawback.

LEVEL 2 –At this level structural elements, installations and other interior fixtures are introduced into the model which allows for better 3D coordination and makes it possible to generate 2D documentation from a 3D model. Also detailed material quantity information is available at this stage which may be the basis for costing and preparation of the bill of quantities. Additionally, more developed model may considerably speed up the analyses of partial cross-sections during the process of overall multi-discipline coordination of the project. Level two allows for limited building management.

LEVEL 3 – encountered rather infrequently due to the aspect of limited time and finances, which has already been mentioned. It allows to build a facility management system based on smart building concept. In such detailed model various simulations of the construction process can be performed, also simulations of various situations regarding safety, maintenance and environment protection. The 3D rendering may be used not only during the construction stage but throughout the whole life cycle of the building. The data entered into the model optimize the management process of the facility to a minimum. Levels 1/2 being the reflection of contemporary reality in the construction industry Public tender requirements mentioned above are responsible for using BIM technology only in a limited scope. The choice of BIM model depends on designer's decision, system of work and procedures adopted by particular design office, and the selected level of detailed information in the documentation. Levels of maturity are often the reflection of the documents we have at our disposal. Lack of access to multi-discipline elements in 3D is a common situation and results from the lack of adequate software, inadequately qualified subcontractors, or prohibitive costs for exporting their models to IFC files. Based on the authors experience, on average, the cost is ca. 30% higher than the standard 2D design documentation in CAD. The budget allocated for public tender procedure hardly ever allows for additional costs, which results in resigning from multi-discipline BIM models altogether and necessitates gathering data from 2D drawings at the stage of preparing

detailed execution plan or during the construction process. Consequently, particular sections of documentation show different stages of the designing and building process and different levels of BIM technology

1.3. Technical Aspects of BIM

BIM has some specific features that can effectively be used in project management. These features, which are increasingly developed, can be summarised as follows

Clash Detection

One of the common problems of different disciplines' plans for a construction project is the geometrical design inconsistencies. This issue happens when there is an overlap between the plans of different disciplines. Using BIM, it would be possible to bring the plans together and detect the clashes. Modifying the aesthetic problems is another possibility of this visual checking.

Constructability

Using BIM, it would be possible for teammates in a project to review and handle constructability issues and (if needed) promote issues into RFIs. In addition, visual information can be provided from a vantage point to show the problems. This visual information accompanying markup allows further investigation for finding solutions and, thus, mitigates the risks.

Analysis

Helping the project managers, designers and engineers in doing more analyses and enabling better decision making is another aspect of BIM. By linking the building information models to appropriate tools, it would be possible to analyze the energy consumption of a construction project and then find better solutions such as changing materials and orientation, mass and space, etc.

Time & Cost Estimation (4D & 5D)

Time and cost estimation are other features of BIM which enable project managers to visualize the construction project at any point in time and have a clear understanding of project phases.

Time and cost estimation, which are generally called 4D and 5D, can be properly utilized in the first stages of a project and facilitate the decision making process with minimum cost and time needed. Furthermore, BIM has the capability to simulate the various alternatives for a construction project and hence helps project managers and executives to reliably predict the consequences of their decisions.

Integration

The project team can deal and interact with a unified model when a composite model is built from an amalgam of various disciplines' models. Having this capability, and through the different phases of a construction project, BIM can coordinate the design, analysis, and construction activities on a project and, therefore, results in integrity of projects.

Quantity Take-off

Quantity takeoffs in a BIM model can be very helpful for the project teams and managers to analyze their decision and have a clear and reliable insight to various alternatives in the design phase or even throughout the project lifecycle. Since there is a possibility of integration between the BIM model and a database containing cost estimation, an accurate estimation can be obtained faster. Moreover, these takeoff items can be used easily in procurement procedure.

1.4. Design-Build

The design-build (DB) process was developed to consolidate responsibility for design and construction into a single contracting entity and to simplify the administration of tasks for the owner (Beard et al. 2005) illustrates this process. In this model, the owner contracts directly with the design-build team (normally a contractor with a design capability or working with an architect) to develop a well-defined building program and a schematic design that meets the owner's needs. The DB contractor then estimates the total cost and time needed to design and construct the building. After all modifications requested by the owner are implemented, the

plan is approved and the final budget for the project is established. It is important to note that because the DB model allows for modifications to be made to the building's design earlier in the process, the amount of money and time needed to incorporate these changes is also reduced. The DB contractor establishes contractual relationships with specialty designers and subcontractors as needed. These are usually based on a fixed price, lowest bid basis. After this point, construction begins and any further changes to the design (within predefined limits) become the responsibility of the DB contractor. The same is true for errors and omissions. It is not necessary for detailed construction drawings to be complete for all parts of the building prior to the start of construction on the foundation and early building elements. As a result of these simplifications, the building is typically completed faster, with far fewer legal complications, and at a somewhat reduced total cost. On the other hand, there is little flexibility for the owner to make changes after the initial design is approved and a contract amount is established.

RESEARCH AIM AND OBJECTIVES

1.5 AIM

The main aim of this dissertation is to design 3D model using BIM software and integrating it with scheduling data and cost estimation data as fourth and fifth dimension of the model and to propose a methodology for the development of a system that will improve time and cost management of construction projects, within a virtual design and construction working environment

1.6 OBJECTIVES

The objective of this study is to

- To study BIM flow process
- To recognise the difference between BIM process and conventional method
- To state the advantages and limitation of BIM process

CHAPTER 2

RESEARCH PAPERS

2.1 Application of BIM for Scheduling and Costing in Construction - *Sarita Patil Int. Journal of Engineering Research and Applications, Dec 2017*

2.1.1 AIM - The purpose of this project is to study the BIM application for Project Scheduling and Costing of Construction projects including barriers in implementing BIM.

2.1.2 OBJECTIVE

The objective of this paper is

- i) To Study conventional method of preparing 2D/3D Drawing, Project Scheduling, Quantity Take Off and Cost Estimation.
- ii) To Study BIM (Building Information Modeling) for Project Scheduling and Quantity Take off by preparing 3D model in Revit Autodesk for practical problem.
- iii) To Study the Benefits of BIM Applications for Project Scheduling and Quantity Take off and additional requirements if any, to be put into the model to get more benefits in terms of Project Scheduling and Quantity Take Off.
- iv) To compare the conventional methods and BIM Applications of Quantity Take Off and Project Scheduling
- v) To Study the barriers of an effective implementation of BIM application for Project Scheduling and Quantity Take off.

2.1.3 METHODOLOGY

In order to achieve the objectives, the methodology adopted is follows.

Study of previous research on BIM Applications for Project Scheduling and Quantity Take Off / Costing.

- ii) Study of prevailing industry practices for preparing 2D/3D Drawing, Project Scheduling and Quantity Estimation / Cost Estimation.

- iii) Study of BIM Framework in relation with Modeling (3D), Project Scheduling (4D) and Quantity Take Off / Costing (5D)
- iv) By preparing of Sample model (3D) by using Autodesk Revit / Revit Architecture.
- v) Comparing process of Conventional Methods of Quantity Take Off and Project Scheduling with BIM Application for Quantity Take Off & Project Scheduling.
- vi) Study of Benefits / Advantages of Using BIM Applications for Quantity Take Off and Project Scheduling.
- vii) Bridge gapping measures and listing of additional inputs needed in the Software for additional benefits.

The following softwares are used for the sample preparation of Case Study for BIM integration 3D with 4D and 5D

- i) Autodesk Revit Architecture - For 5D
- ii) Astra Power Project – For 4D
- iii) Microsoft Project

A sample 2D drawing of Room is prepared in AutoCAD and thereafter 3D Model is prepared using AUTODESK Revit Architecture.

2.1.4 PROBLEM STATEMENT

1. **Lack of communication, rework, cost and time overrun** are the major problems faced by construction firms. Timely & accurate feedback of actual cost enables project managers to take appropriate corrective actions that would minimize cost overrun in a timely manner & is possible by using BIM.

2. As project progress, the process of construction **monitoring & control** gets more complex due to the **huge amount of information that need to be measured and analysed.**

BIM MODELLING - FROM 3D TO 4D & FROM 3D TO 5D

Building Information Modeling (BIM) is a process that involves creating, generating, managing and using a digital cum graphical representation of physical and functional characteristics of the Project e.g. quantitative and qualitative database.

- **BIM Modeling From 3D (Modeling) to 4D (Project Scheduling)**

The use of the term 4D is intended to refer to the fourth dimension; time, i.e. 4D is 3D+Schedule (time). The role of 4D BIM is to add a new dimension to 3D CAD Drawings or Solid modeling.

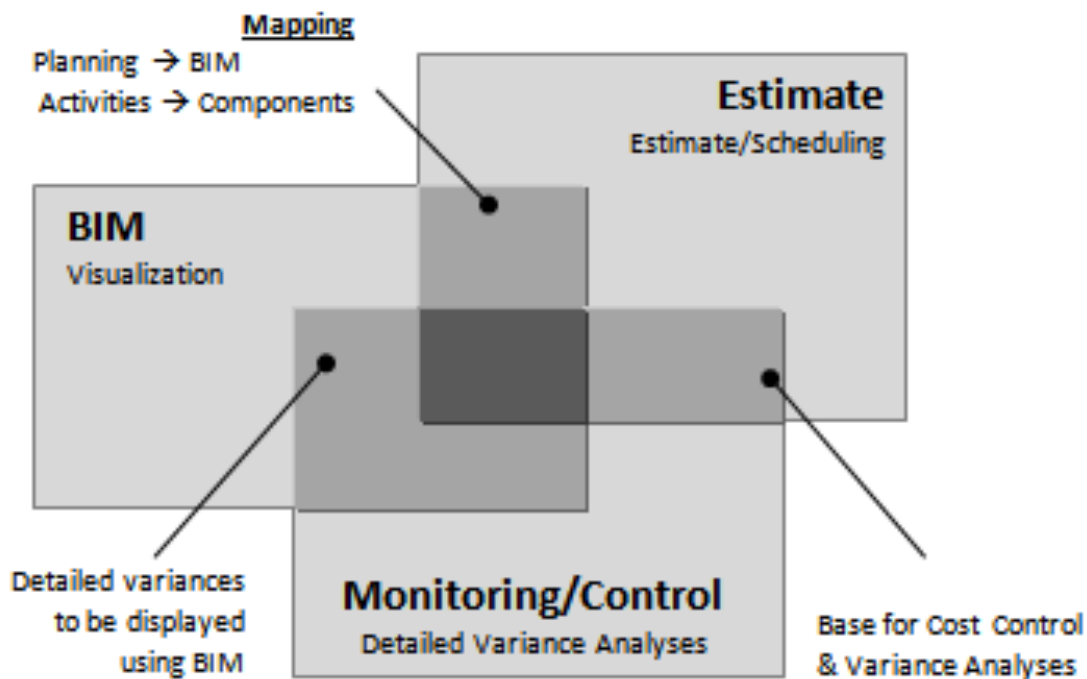


Fig 2.1 Conceptual Framework

- **BIM Modeling From 3D (Modeling) to 5D (Project Costing)**

The use of the term 5D is intended to refer to the fifth dimension; Cost, i.e. 5D is 3D+Cost (Quantity Take Off). The major benefit of this system is to workout different design options those can be compared and then act as a supporting base for decision-making. Furthermore, when connected to time aspects the model can facilitate cost control in real time, giving managers the opportunity to monitor cost developments during projects.

2.1.5 CONCLUSION

By using BIM for estimation there is **80% reduction in time as compare to estimation by conventional method**. It saves times. The implementation of BIM in AEC industry can make the industry more flexible, effective and innovative.

2.2 BIM-Based Cost Estimation/ Monitoring For Building Construction - Emad

Elbeltagi Int. Journal of Engineering Research and Applications, July 2014.

2.2.1 AIM - This paper aims to introduce a model that integrates cost estimate and monitoring processes with the advances in data visualization to provide decision makers with a tool for better monitoring and control of their construction projects.

2.2.2 CONCEPTUAL FRAMEWORK

The framework consists of three interacting modules; cost estimate and schedule module, cost monitoring and control module, and BIM module. The three modules interact together as illustrated in the figure through the intersected areas of these modules. The project Work breakdown Structure (WBS) is used to link the estimate/scheduling (i.e., planning) with the BIM where the project was broken down into a set of activities that are mapped to their corresponding building components. During construction the actual cost (ACWP) for each resource/activity is compared with its corresponding original budget (BCWS) and the Earned Value (EV). Then, cost variances in the different components are visualized through the BIM module.

The model has been introduced to several project management experts to provide the authors with an evaluation regarding the following points:

- The simplicity of the model and the sufficiency of its outputs;
- Its potential application in the area of cost monitoring and control
- Its benefits and advantages over current cost monitoring/control practices and

- Further suggestions for improvement.

2.2.3 QUANTITY CALCULATION

Quantities, based on the BIM model, are extracted and exported to a **MS Access** as an intermediate database which is linked to the cost estimate module/model in the proposed framework.

The model imports the **initial plan/schedule** from **MS Project** to realize project activities and imports also the matching quantities from BIM through MS Access then integrates the resources basic cost data to estimate activities' time and cost.

The **calculated time and cost** are exported back to **MS Project** to develop the schedule and determine the BCWS at the project level.

Actual resources data are collected from the **construction site** during the construction phase using structured acquisition forms. **Variance analysis** is exported back to the **BIM model** to allow the user visual the construction progress by viewing favorable/unfavorable cost variances in coloring schemes.

Initially a scheduling module for the project is developed using Ms Project software. The project is an eight-storey building (Ground floor, 6 typical floors and a roof) of a foot print area of 1000 m² and a built up area of 8200 m². Visual Basic for Applications (VBA) macro programming language of Excel is used to retrieve the project schedule to the Excel spreadsheets. It acquires the initial plan for the project from Ms Project. By developing an initial schedule and integrate it with the cost estimating module, the total cost of the project is calculated as well as the detailed cost for all activities and resources. Actual cost data in addition to resources data, which represent actual progress information, can be plugged into the cost control module in Excel environment by using friendly forms.

There are three key indicators that are used in performance measurement: (1) budgeted cost of work scheduled (BCWS), (2) budgeted cost of work performed (BCWP), (3) and actual cost of work performed (ACWP). The performance measurement computes variances from

Fig 2.2 Research Framework analyses the effect of BIM

No	Position	People	Time (month)	People time	Unit price (in million IDR)	Cost (in million IDR)
(1)	(2)	(3)	(4)	(3)x(4)	(5)	(6)
A	Expert worker					
1	Team leader	1	12	12	24.250	291.000
2	Geotechnical engineering	1	2	2	16.750	33.500
3	Surveyor	1	2	2	13.750	27.500
4	Architect	1	8	8	16.750	134.000
5	Cost estimator	1	1	1	13.750	13.750
6	Structure	1	4	4	16.750	67.000
7	MEP	1	4	4	16.750	67.000
B	Assistant expert workers					
1	Assistant surveyor	1	2	2	2.523	5.046
2	Architect expert assistant	2	8	16	2.523	40.368
3	MEP expert assistant	2	4	8	2.523	20.184
C	Supporting workers					
1	Administration	1	12	12	1.500	18.000
2	Drafter	2	11	22	1.500	33.000
Total cost						750.348

baseline. Cost variance for the activity/project is quantified from its three main resources: material, crew (labor and equipment), and subcontractor.

2.2.4 CONCLUSION

Based on the previous analysis, the proposed project monitoring system provides useful information for **effective control of construction projects**. The proposed model can be effectively used in controlling small to medium projects. The main advantage of the system is that it enables **nD visualization of the construction progress along with the geographical conditions**. The system provides **project participants with a framework to effortlessly view and evaluate construction progress**. This paper emphasizes the importance of **integration between project cost estimate, cost monitoring/control techniques and BIM**

Table 1.1 Cost of conventional method workers

No	Position	People	Time (month)	People time	Unit price (in million IDR)	Cost (in million IDR)
(1)	(2)	(3)	(4)	(3)x(4)	(5)	(6)
A	Expert worker					
1	BIM experts	1	6	6	24.250	145.500
2	Geotechnical engineering	1	2	2	16.750	33.500
3	Surveyor	1	2	2	13.750	27.500
4	Cost estimator	1	1	1	13.750	13.750
5	Structure	1	3	3	16.750	50.250
6	MEP	1	3	3	16.750	50.250
B	Assistant expert workers					
1	Assistant surveyor	1	2	2	2.523	5.046
2	Architect expert assistant	1	3	3	2.523	7.569
3	MEP expert assistant	1	3	3	2.523	7.569
C	Supporting workers					
1	Administration	1	6	6	1.500	9.000
2	Drafter	1	5	5	1.500	7.500
Total cost						357.434

platforms. The integration will add other dimensions to construction progress visualization. The developed framework can be considered as an effective tool for monitoring construction projects and providing decision makers with a visualization aid to enable them to take cost and progress related decisions in a timely manner.

2.3. Effect of Building Information Modeling (BIM) on reduced construction time-costs: a case study - Moh Nur Sholeh^{1*}, ICENIS 2020

2.3.1 AIM - The purpose of this study is to analyze the correlation between BIM expectations and the time-cost of construction projects. Delays are analyzed from the project life cycle caused by unskilled workers, incorrect design, material delays, incorrect work, and miscommunication.

This study identifies differences in the use of the conventional BIM method which is currently still used by Indonesian construction stakeholders. This study compares BIM with conventional

methods using three methods: questionnaire, interview, and case study. Questionnaire method to find out the comparison between BIM and conventional methods in the company. Respondents were asked whether the BIM method provided benefits to the company. Besides, the question in-depth to find out the advantages and disadvantages of BIM. Interviews with respondents were used to find out the direct application of the BIM method in the field and a comparison of case studies used to determine the difference in the effect of construction costs.

2.3.2 Comparison of the cost of conventional and BIM methods in case studies

In a life cycle project, the use of conventional methods takes longer than BIM. This is because the conventional method between design, structure, and mechanical, electrical, plumbing (MEP) cannot be done simultaneously. Whereas the BIM between design, structure, and MEP can be done together to speed up planning because there is no need to wait for either party to finish first.

The time required for planning using BIM is 50% faster than planning using conventional methods. The most significant time reductions occur in architectural, structural, and MEP design activities. This is due to the use of BIM technology capable of accelerating these activities. BIM if done by skilled workers will succeed in ensuring accurate design and calculation. Insignificant or equal duration changes in preparation, surveying, scheduling and budgeting activities, and preparing tender documents.

2.3.3 ANALYSIS

The difference in cost between the use of conventional applications with BIM in project planning, where the use of BIM applications compared to the use of conventional applications in planning can **reduce costs by 52.36%**. This figure is obtained from a comparison between the difference between the amount of BIM and conventional costs and the total cost when using conventional methods. The big difference in cost between BIM and conventional applications is because of several experts and time. The number of experts required in the use

of BIM is less than the conventional application user expertise. **The time required between planning using BIM is only 6 months, while planning using conventional applications takes 12 months**, so the costs incurred by conventional application users are greater because it requires more planning time. As a note, the cost calculation in this study does not include investment in BIM software. This is because there will be differences in variables between the two methods. BIM software investment in construction projects is a large capital but will also have a major impact on the effectiveness and efficiency of project performance.

2.3.4 CONCLUSION

The challenge to reduce the time and cost of construction projects will always occur throughout the project. Integrated management is needed in answering these challenges. Utilization of Building Information Modeling (BIM) is expected to be a solutive answer.

The results of research with a case study in a construction project stated that **the use of BIM can reduce work time by up to 50%. While costs can be reduced by 52.36%**. A good result when compared with conventional methods. The main factor of the large time-cost reduction caused by the use of BIM technology is accelerating the design process and structure calculation.

Besides, the number of workers' needs is also less because skilled workers can work more optimally with BIM software.

This study also analyzed the **advantages and disadvantages of BIM which can be used as literature for construction projects especially in Indonesia**. This research is still limited to time in general in the project life cycle so that it can be developed into detailed design work or structural calculations for example.

Besides, more case studies can also be developed to find out the characteristics of the type of construction work, because this research is still focused on buildings.

CHAPTER 3

CASE STUDY

VIKRAM COLLEGE OF NURSING

3.1 DESCRIPTION

Project Name : Vikram College of Nursing

- Start Date : 10.07.2018
- Area : 740.7 sq.m(per floor)
- Building Type : Institutional
- No. Of Floors : Stilt + 4 floors
- Foundation : Matt Foundation
- Structural : Alif Consultants
- Actual Cost : 9.7 Crore



Fig 3.1 Vikram College of Nursing - Site photos

- 1) Creating 3D model in Revit 2022 and extracting quantities from the model each item of work
- 2)) Defining specification for each item of work in the project, and assigning cost per unit
- 3) Preparing work breakdown structure in Microsoft Project (MSP), and giving time to each task.
- 4) Assigning resources and cost to each task in MSP, and assigning quantity of each task and arriving at duration and cost of the project.
- 5) Further exporting MSP schedule and 3D model to the Navisworks Manage 2020 and creating visual results for planned schedule and actual schedule.

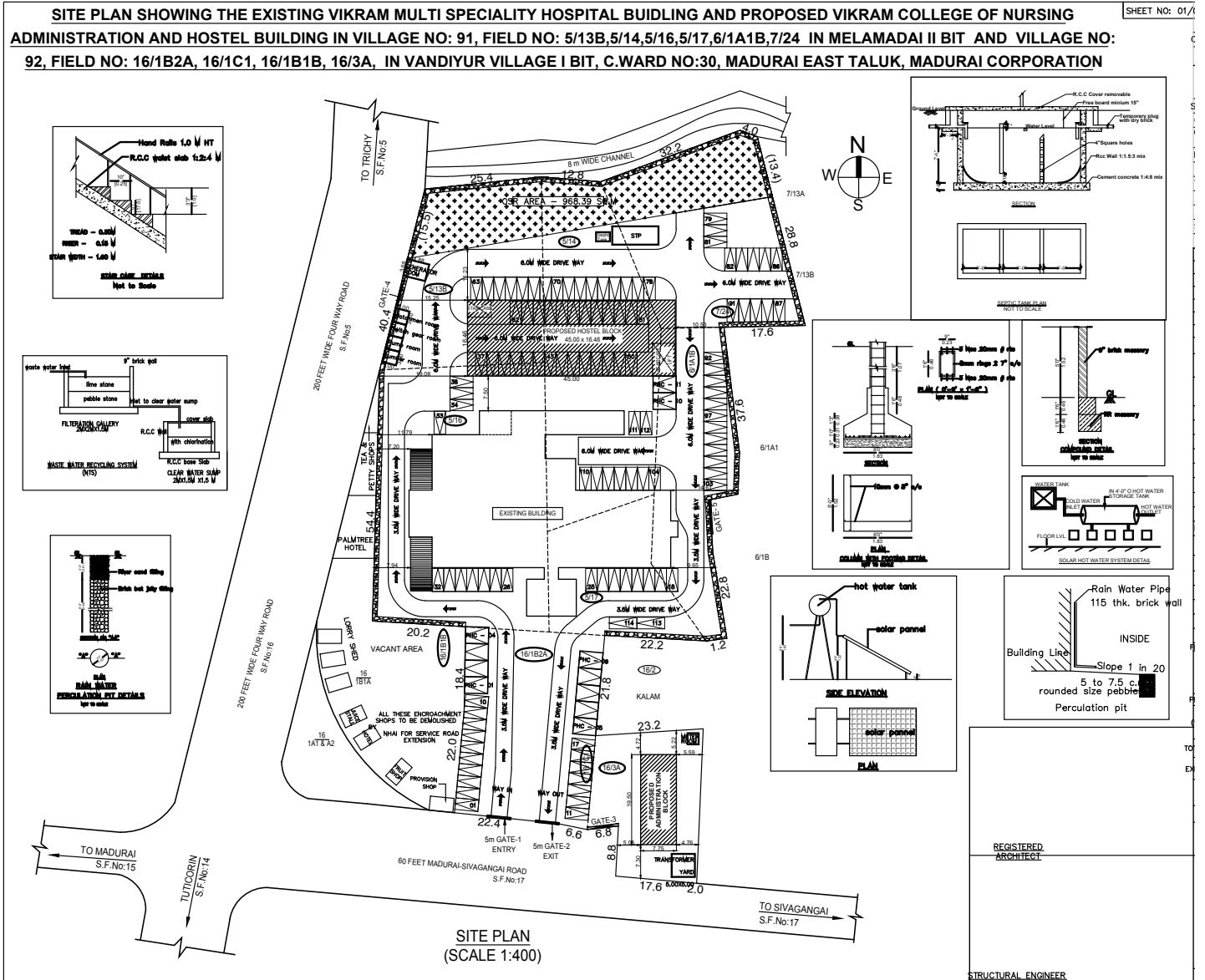


Fig 3.2 CAD Drawings

To get more acquainted with concept of BIM, an ongoing work of G+4 educational building projects based in Madurai is selected. Project size 39,864 sq.ft.. This project is owned by Dr.Veera Rajkumar. The name of selected project for BIM study is Vikram College of Nursing. By formulating the BIM the study of cost and time parameter is done. Also the cost effectiveness of BIM is studied by physically going to the site at regular intervals, to monitor the building activities and casing the difference between the planned work progress and actual work progress.

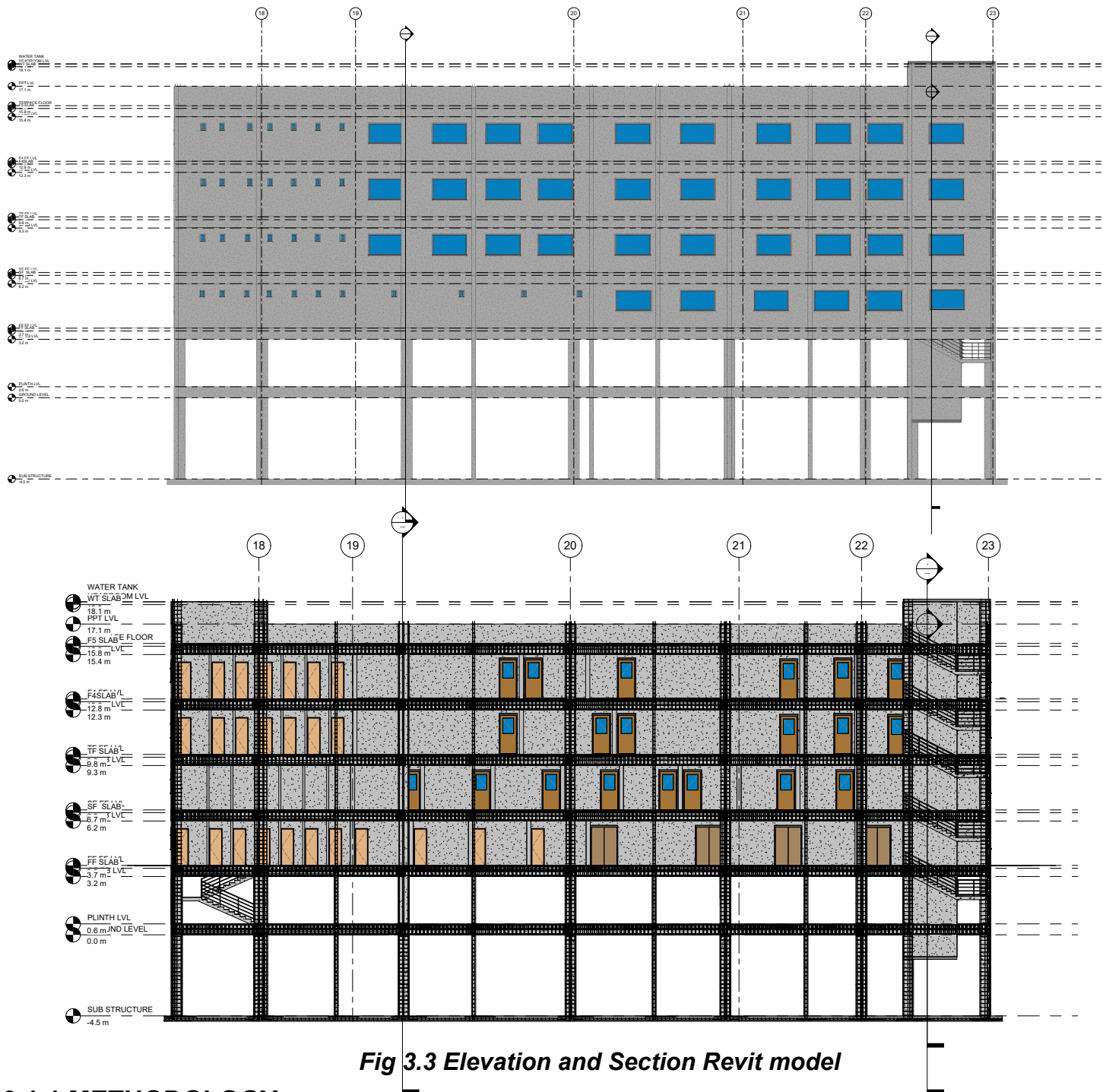


Fig 3.3 Elevation and Section Revit model

3.1.1 METHODOLOGY

- 1) Creating 3D model in Revit 2022 and extracting quantities from the model each item of work
- 2)) Defining specification for each item of work in the project, and assigning cost per unit
- 3) Preparing work breakdown structure in Microsoft Project (MSP), and giving time to each task.
- 4) Assigning resources and cost to each task in MSP, and assigning quantity of each task and arriving at duration and cost of the project.
- 5) Further exporting MSP schedule and 3D model to the Navisworks Manage 2020 and creating visual results for planned schedule and actual

3.2 QUANTITY TAKEOFF

3.2.1 CEMENT, SAND AND AGGREGATE QUANTITY TAKEOFF

Table 3.1 Cement, Sand And Aggregate Quantity Takeoff

MATERIAL QUANTITY TAKE-OFF (M 25 GRADE)					
Material: Name	Category	Material: Volume	Required Cement (No. of Bags)	Required Sand (in cft)	Required Aggregate (in cft)
Concrete, Cast-in-Place gray	Stairs	32.07 m³	224.48	577.24	1,154.48
Concrete, Cast-in-Place gray	Structural Columns	0.47 m³	3.28	8.44	16.88
Concrete, Cast-in-Place gray	Structural Foundations	483.09 m³	3,381.60	8,695.54	17,391.08
00 FOUNDATION		515.62 m³	3,609.36	9,281.22	18,562.43
Concrete, Cast-in-Place gray	Structural Foundations	252.65 m³	1,768.55	4,547.70	9,095.39
03 SLAB		252.65 m³	1,768.55	4,547.70	9,095.39
Concrete, Cast-in-Place gray	Structural Foundations	161.29 m³	1,129.03	2,903.22	5,806.44
COLUMN_F4_01		161.29 m³	1,129.03	2,903.22	5,806.44
Concrete, Cast-in-Place gray	Structural Columns	8.02 m³	56.12	144.31	288.61
COLUMN_F4_02		8.02 m³	56.12	144.31	288.61
Concrete, Cast-in-Place gray	Structural Columns	23.12 m³	161.81	416.08	832.16
COLUMN_GF_01		23.12 m³	161.81	416.08	832.16
Concrete, Cast-in-Place gray	Structural Columns	13.66 m³	95.62	245.88	491.76
COLUMN_SF_01		13.66 m³	95.62	245.88	491.76
Concrete, Cast-in-Place gray	Structural Columns	14.07 m³	98.52	253.33	506.66
COLUMN_SF_02		14.07 m³	98.52	253.33	506.66
Concrete, Cast-in-Place gray	Structural Columns	11.01 m³	77.05	198.13	396.26
COLUMN_TF_01		11.01 m³	77.05	198.13	396.26
Concrete, Cast-in-Place gray	Structural Columns	13.66 m³	95.62	245.88	491.76
COLUMN_TF_02		13.66 m³	95.62	245.88	491.76
Concrete, Cast-in-Place gray	Structural Columns	11.01 m³	77.05	198.13	396.26
COLUMN_GF_02		11.01 m³	77.05	198.13	396.26
Concrete, Cast-in-Place gray	Structural Columns	11.01 m³	77.05	198.13	396.26
F4 COLUMN_01		11.01 m³	77.05	198.13	396.26
Concrete, Cast-in-Place gray	Structural Columns	18.89 m³	132.22	339.99	679.99
SLAB_SF		18.89 m³	132.22	339.99	679.99
Concrete, Cast-in-Place gray	Structural Foundations	161.29 m³	1,129.03	2,903.22	5,806.44
SLAB_TF		161.29 m³	1,129.03	2,903.22	5,806.44
Concrete, Cast-in-Place gray	Structural Foundations	161.29 m³	1,129.03	2,903.22	5,806.44
STAIRCASE TERRACE		161.29 m³	1,129.03	2,903.22	5,806.44
Concrete, Cast-in-Place gray	Stairs	4.19 m³	29.34	75.45	150.89
STAIRS_GF_01		4.19 m³	29.34	75.45	150.89
Concrete, Cast-in-Place gray	Stairs	4.19 m³	29.34	75.45	150.89
STAIRS_GF_02		4.19 m³	29.34	75.45	150.89
Concrete, Cast-in-Place gray	Stairs	5.10 m³	35.71	91.82	183.64
SUB_COLUMN_1		5.10 m³	35.71	91.82	183.64
Concrete, Cast-in-Place gray	Structural Columns	19.52 m³	136.67	351.45	702.90
SUB_COLUMN_01		19.52 m³	136.67	351.45	702.90
Concrete, Cast-in-Place gray	Structural Columns	0.70 m³	4.88	12.55	25.10
SUB_COLUMN_02		0.70 m³	4.88	12.55	25.10
Concrete, Cast-in-Place gray	Structural Columns	16.03 m³	112.22	288.56	577.11
TERRACE_COLUMN_01		16.03 m³	112.22	288.56	577.11
Concrete, Cast-in-Place gray	Structural Columns	6.11 m³	42.80	110.07	220.13
TERRACE_COLUMN_02		6.11 m³	42.80	110.07	220.13
Concrete, Cast-in-Place gray	Structural Columns	4.82 m³	33.74	86.75	173.50
Grand total		1437.25 m³	10,060.76	25,870.53	51,741.05

No. of Cement bags required - 10,061

No. of Sand required - 25,871 (cft)

No. of Aggregates bags required - 51,742 (cft)

Table 4.1 Reinforcement Steel_Foundation Quantity Takeoff

[illegible]

Weight of Reinforcement steel - Column - 2889

3.2.3 REINFORCEMENT STEEL BEAM AND SLAB QUANTITY TAKEOFF

Table 4.1 Reinforcement Steel_Foundation Quantity Takeoff

[illegible]

Weight of Reinforcement steel - 16M - 1850

Weight of Reinforcement steel - 19M - 16087

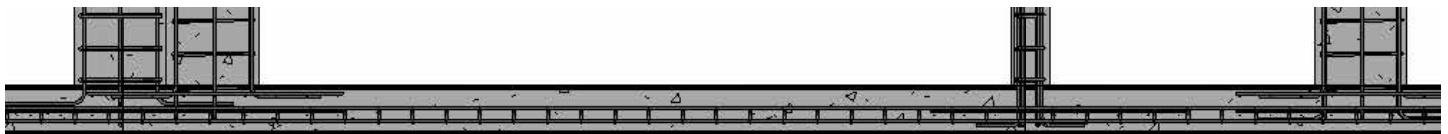


Fig 3.4 Renforcement Footing Section

Visualization of a construction project provide better understanding to all the participants involved. But most importantly it becomes simple to communicate information with the investors. It provides reliable features to architects, engineers, contractors and all the other participants. It creates a single centralized model which is accessible to all the entities and defines each and every element of a building. Therefore any update in the model will be noticed by all. 5D BIM helps avoid costly error during construction. Predetermining the clashes between other elements helps save time, cost and many other discrepancies. Computerized automated model support decision making by evaluating the model with different construction methods, materials and techniques without even actually performing the construction, and select the most optimum process which can save time and money. The 3D model is designed on Autodesk Revit by creating elements such as walls, floors, foundation, doors, windows and so on. These element can also be viewed in cross-section. The quantity of all the elements used during modelling can be imported in excel sheet from Revit software. There are many barriers that are faced by organizations, such as failure of implementation, high initial investment, time consumed during software training, inefficient hardware. But the most common reason for implementing BIM is lack of knowledge about strict BIM implementation standards.

BIM is applicable in every aspects of the AEC industry. The scope of this thesis is limited to 5D BIM modeling, which is only applicable for constructing the building, but the level of detailing (LOD) can be increase by integrating Mechanical- Electrical- Plumbing(MEP) works, sustainability(6th Dimension), operation & maintenance(7th Dimension) and so on to make the model more rich in information. In recent study, safety is also considered to be an important aspect and is considered as 8th dimension in modeling. This thesis only considered the time and cost aspect during decision making, whereas there are many other factors that can influence the decision, such as environmental aspect, safety aspect and so on. It would not only help the construction industry but also the environment by using LEED tools for energy efficient designs and to human energy by reducing the use of materials and skilled labour.

3.3 QUANTITY TAKEOFF COMPARISON BETWEEN BIM AND TRADITIONAL METHOD

TYPE	BIM	MANUAL ESTIMATED	ACTUAL	DIFFERENCE (E - A)	DIFFERENCE (B - A)	COST (in Rs.) (E - A)	COST (in Rs.) (B - A)
Cement (No. of bags)	10061	10185	10045	140	16	₹ 53,200.00	₹ 6080.00
Aggregates (Cft)	24171	24350	24050	300	121	₹ 12600.00	₹ 5082.00
Sand (Cft)	48120	48250	48035	215	85	₹ 14620.00	₹ 5780.00
Reinforcement_Foundation (Kgs)	17737	17950	17700	250	37	₹ 18000.00	₹ 2664.00
Reinforcement_Column (Kgs)	2839	2925	2790	135	49	₹ 9720.00	₹ 3528.00
Reinforcement_Beam (Kgs)	4754	4820	4740	80	14	₹ 5760.00	₹ 1008.00
Reinforcement_Slab (Kgs)	5980	6040	5930	110	50	₹ 7920.00	₹ 3600.00
Blockwork (Nos)	8098	8200	8050	150	48	₹ 16500.00	₹ 5280.00
				TOTAL in Rs.		₹ 1,38,320.00	₹ 33022.00
				TOTAL COST SAVING USING BIM in Rs.			₹ 105298.00

3.4 ISSUES IDENTIFIED

Table 7.1 Issues Identified

ISSUES IDENTIFIED		
ERROR	CATEGORY	BENEFITS IF FIXED
DIMENSIONING ERRORS	DIMENSION CHANGE	OBVIATE REWORK
DIMENSION CHANGES IN ARCHITECTURAL ELEMENTS	DIMENSION CHANGE	OBVIATE REWORK
LACK OF APPROVAL	POOR COMMUNICATION	PREVENTION IN DELAY
CHANGE IN COLUMN LAYOUT	DRAWING CHANGES	OBVIATE REWORK
CLASH BETWEEN STRUCTURAL AND BUILDING COMPONENTS	INTERFERENCE SIMULATION	OBVIATE REWORK
STAIR LEVEL MISMATCH	DIMENSION CHANGE	OBVIATE REWORK
ABRUPT CHANGES IN SECTION OF WALL	DRAWING CHANGES	PREVENTION IN DELAY
INACCURATE ESTIMATES	MISCALCULATION	PREVENTION IN DELAY
LACK OF STOCK IN INVENTORY	MISCALCULATION	PREVENTION IN DELAY
WRONG EXECUTION OF WORK	DRAWING CHANGES	PREVENTION IN DELAY

PLAUSIBLE COST OF RECONSTRUCTION			
ISSUES IDENTIFIED	SOLUTION	ESTIMATE	
Abrupting changes in section of wall	Reconstruction	Estimate = (Volume) × (Unit rate)	
Stairs Level Mismatch	Reconstruction		
Clash between structural and Building components	Reconstruction		
	LABOUR COST ESTIMATE DUE TO RE CONSTRUCTION		
CONSTRUCTION	UNIT FEE	VOLUME (CU.M)	ESTIMATE
DEMOLITION OF WALLS	₹ 600	11.84	₹ 7,104
RECASTING OF WALLS	₹ 800	11.84	₹ 9,472
DEMOLITION OF STAIRS	₹ 4500	4.74	₹ 21,330
RECASTING OF STAIRS	₹ 3500	4.74	₹ 16,590
DEMOLITION OF STRUCTURAL ELEMENTS	₹ 4500	5.69	₹ 25,605
RECASTING OF STRUCTURAL ELEMENTS	₹ 3500	5.69	₹ 19,915
	Subtotal		₹ 1,00,016
	MATERIAL COST ESTIMATE DUE TO RECONSTRUCTION		
CONSTRUCTION	UNIT FEE	VOLUME (CU.M)	ESTIMATE
RECASTING OF WALLS	₹ 3500	11.84	₹ 41,440
RECASTING OF STAIRS	₹ 13,042	4.74	₹ 61,819.08
RECASTING OF STRUCTURAL ELEMENTS	₹ 13,042	5.69	₹ 74,208.98
	Subtotal		₹ 1,77,468.06
	Total reconstruction charge because of rework		₹ 2,77,484.06

Due to the rework in designing, there were orders of the reconstruction as well. To calculate the cost for the reconstruction of certain works, the cost has been split into two parts. In the first part, labour cost was computed for the unit volume of reconstruction; in the second part, materials required for the reconstruction and rate of the materials for the unit volume of the same work. The cost of the material was taken from the schedule of rates (SOR) of the Tamilnadu Public Work Department. For the rate of the labour, SOR was taken as reference only as in the SOR labour rates vary with different specifications of work. This table illustrates the cost determined for reconstruction.

The fees of the labours incurred due to the rework were found to be **₹ 1,00,016**. The total amount of the materials was found to be **₹ 1,77,468.06**. The total of both costs was **₹ 2,77,484.06** which could have been saved and the amount could have been spent in other productive activities if BIM was employed.

3.5 BIM WORKERS ESTIMATES

Table 8.1 BIM Worker cost Estimates

BIM WORKER COST ESTIMATES				
Cost = (No. of worker) × (Man-hour/8 h) × (Daily Wages)				
POSITION	MAN-HOUR	NO.OF WORKERS	DAILY WAGES	COST
BIM MANAGER	36	1	₹ 7,500.00	₹ 33,750
BIM COORDINATOR	64	1	₹ 6,000.00	₹ 48,000
BIM MODELER	52	2	₹ 5,000.00	₹ 65,000
			TOTAL	₹ 1,46,750
		amount with 10% allowance		₹ 1,61,425

Table 9.1 Traditional Workers Estimates

POSITION	PEOPLE	TIME (hrs)	DAILY WAGES	COST
EXPERT WORKER				
TEAM LEADER	1	104	₹ 1,200	₹ 65,000
ARCHITECT	1	192	₹ 3,500	₹ 84,000
CAD DRAFTSMAN	1	148	₹ 1,200	₹ 22,200
PROJECT COORDINATOR	1	156	₹ 4,000	₹ 78,000
COST ESTIMATOR	1	172	₹ 2,000	₹ 43,000
STRUCTURAL CONSULTANT	2	128	₹ 2,500	₹ 80,000
MEP CONSULTANT	2	96	₹ 2,500	₹ 60,000
ASSISTANT EXPERT WORKER				
ASSISTANT ARCHITECT	1	174	₹ 1,500	₹ 32,625
3D MODELER	1	178	₹ 1,500	₹ 33,375
MEP ASSISTANT	1	124	₹ 1,500	₹ 23,250
SUPPORTING WORKER				
ADMINISTRATION	1	120	₹ 1,200	₹ 18,000
DRAFTER	1	160	₹ 1,200	₹ 24,000
		Total		₹ 5,63,450

Table 10.1 BIM Workers Estimates

POSITION	PEOPLE	TIME (hrs)	DAILY WAGES	COST
EXPERT WORKER				
BIM MANAGER	1	36	₹ 7,500	₹ 33,750
ARCHITECT	1	192	₹ 3,500	₹ 84,000
BIM COORDINATOR	1	64	₹ 6,000	₹ 48,000
STRUCTURAL CONSULTANT	2	128	₹ 2,500	₹ 80,000
MEP CONSULTANT	2	96	₹ 2,500	₹ 60,000
ASSISTANT EXPERT WORKER				
ASSISTANT ARCHITECT	1	174	₹ 1,500	₹ 32,625
BIM MODELER	2	52	₹ 5,000	₹ 65,500
MEP ASSISTANT	1	124	₹ 1,500	₹ 23,250
SUPPORTING WORKER				
ADMINISTRATION	1	120	₹ 1,200	₹ 18,000
DRAFTER	1	160	₹ 1,200	₹ 24,000
		Total		₹ 4,69,125
COST DIFFERENCE BETWEEN TRADITIONAL VS BIM WORKERS				₹ 94,325

3.5.1 COST ESTIMATION OF BIM MODEL

Firstly, to estimate the cost, it was worked out to anticipate the requirements of the workers needed to make the BIM model, for collection of the data, and to apply the BIM model at the worksite. BIM implementation requires two processes: BIM work and site investigation for BIM implementation. For the BIM work, professionals are needed where they are generally termed as BIM modellers, BIM coordinators, and BIM managers. Where BIM managers are experienced compared to the BIM modellers who usually creates the BIM model. For supervision of the construction, professional engineers are required where the level of professional engineers at the site are: project manager, senior engineer, junior engineer, and supervisor. This table below demonstrates the cost of the BIM modellers and professional engineers required to implement the BIM for the research. It can be seen, the cost of the creation of a BIM model was ₹ 1,61,425. As the data collected was based on the assumption that they are accurate and the rate does not change under different areas to finish the work; So, an extra 10% was added to the cost as contingency charges.

3.6 RESOURCES CHART

Table 11.1 Resources Chart

Name	Resource Names	Baseline Work	Actual Work	Work Variance
SITE CLEARANCE	FEMALE HELPER[400%],MALE HELPER[600%],SURVEYOR	176 hrs	352 hrs	176 hrs
COLUMN MARKING	HEAD MASON,MALE HELPER,MASON,SURVEYOR	32 hrs	32 hrs	0 hrs
EXCAVATION	EXCAVATOR_3 TON LOADER[4],EXCAVATOR_OPERATOR[1,200%],EXCAVATOR_SIGNAL MAN[1,200%],MALE HELPER[300%],SURVEYOR	672 hrs	1,344 hrs	672 hrs
LAYING PCC	CEMENT_2018[147],AGGREGATES_2018[1,456],CONCRETE MIXER[200%],FEMALE HELPER[800%],HEAD MASON[1,200%],MALE HELPER[1,800%]	160 hrs	160 hrs	0 hrs
SHUTTERING WORK	CENTERING MATERIALS[1],HEAD MASON[800%],MALE HELPER[1,200%],MASON[1,500%]	240 hrs	304 hrs	64 hrs
FOOTING REINFORCEMENT	REINFORCEMENT STEEL_2018[8.55],BAR BENDER[1,200%],MALE HELPER[1,800%],MASON[1,600%]	464 hrs	464 hrs	0 hrs
COLUMN GRID	REINFORCEMENT STEEL_2018[1.42],BAR BENDER[1,200%],MALE HELPER[2,400%]	312 hrs	408 hrs	96 hrs
COLUMN REINFORCEMENT	REINFORCEMENT STEEL_2018[3.17],BAR BENDER[3,000%],MALE HELPER[3,200%],MASON[2,400%]	832 hrs	1,216 hrs	384 hrs
CONCRETING	AGGREGATES_2018[4,534.5],CEMENT_2018[1,390],SAND_2018[2,274],CONCRETE MIXER[200%],FEMALE HELPER[1,200%],HEAD MASON[800%],MALE HELPER[600%],MASON[1,200%]	96 hrs	96 hrs	0 hrs
CURING	MALE HELPER	8 hrs	8 hrs	0 hrs
SHUTTERING WORK	CENTERING MATERIALS[1],HEAD MASON[800%],MALE HELPER[1,200%],MASON[1,500%]	240 hrs	240 hrs	0 hrs
FOOTING REINFORCEMENT	REINFORCEMENT STEEL_2018[8.55],BAR BENDER[3,200%],MALE HELPER[3,000%],MASON[2,400%]	1,040 hrs	1,040 hrs	0 hrs
COLUMN GRID	REINFORCEMENT STEEL_2018[0.42],BAR BENDER[1,200%],MALE HELPER[2,400%]	312 hrs	408 hrs	96 hrs
COLUMN REINFORCEMENT	REINFORCEMENT STEEL_2018[3.17],BAR BENDER[3,000%],MALE HELPER[3,200%],MASON[2,400%]	832 hrs	1,024 hrs	192 hrs
CONCRETING	CEMENT_2018[1,390],SAND_2018[2,274],AGGREGATES_2018[4,534.5],CONCRETE MIXER[200%],FEMALE HELPER[1,200%],HEAD MASON[800%],MALE HELPER[600%],MASON[1,200%]	96 hrs	96 hrs	0 hrs
CURING	MALE HELPER	8 hrs	8 hrs	0 hrs
SAND FILLING	SAND_2018[6,400],EXCAVATOR_3 TON LOADER[3],EXCAVATOR_OPERATOR,EXCAVATOR_SIGNAL MAN,FEMALE HELPER[600%]	72 hrs	88 hrs	16 hrs
SURFACE HARDENING	AGGREGATES_2018[360],CEMENT_2018[1],SAND_2018[1],MALE HELPER[1,200%]	384 hrs	384 hrs	0 hrs
LAYING PCC	AGGREGATES_2018[977],CEMENT_2018[57],SAND_2019[1,118],CONCRETE MIXER[150%],FEMALE HELPER[400%],HEAD MASON[600%],MALE HELPER[1,200%],MASON[1,000%]	120 hrs	156 hrs	36 hrs
BEAM REINFORCEMENT	REINFORCEMENT STEEL_2018[5.98],BAR BENDER[2,400%],MALE HELPER[3,600%],MASON[1,200%]	336 hrs	336 hrs	0 hrs
BEAM SHUTTERING	CENTERING MATERIALS[1],HEAD MASON[2,400%],MALE HELPER[1,200%],MASON[1,800%]	224 hrs	224 hrs	0 hrs
CONCRETING	AGGREGATES_2018[4,573],CEMENT_2018[612],SAND_2018[1,765],CONCRETE MIXER[200%],FEMALE HELPER[1,200%],HEAD MASON[800%],MALE HELPER[600%],MASON[1,200%]	96 hrs	96 hrs	0 hrs
CURING	MALE HELPER	8 hrs	8 hrs	0 hrs
SANDFILLING	SAND_2018[658],MALE HELPER[800%]	128 hrs	128 hrs	0 hrs
SURFACE HARDENING	AGGREGATES_2018[350],CEMENT_2018[226],SAND_2018[768],HEAD MASON[600%],MALE HELPER[1,200%]	112 hrs	160 hrs	48 hrs
CURING	MALE HELPER	32 hrs	32 hrs	0 hrs
COLUMN REINFORCEMENT	REINFORCEMENT STEEL_2018[3.89],BAR BENDER[1,800%],HEAD MASON[2,400%],MALE HELPER[3,000%]	480 hrs	624 hrs	144 hrs
SHUTTERING	CENTERING MATERIALS[2],HEAD MASON[600%],MALE HELPER[1,000%],MASON[800%]	128 hrs	224 hrs	96 hrs
CONCRETING	CEMENT_2018[207],SAND_2018[680],AGGREGATES_2018[340],HEAD MASON[1,000%],MALE HELPER[800%],MASON[600%],CONCRETE MIXER[200%]	232 hrs	232 hrs	0 hrs
BEAM REINFORCEMENT	REINFORCEMENT STEEL_2018[3.5],BAR BENDER[3,600%],HEAD MASON[1,800%],MALE HELPER[3,000%]	736 hrs	1,024 hrs	288 hrs
SLAB REINFORCEMENT	REINFORCEMENT STEEL_2018[4.83],BAR BENDER[4,000%],HEAD MASON[1,200%],MALE HELPER[3,600%]	432 hrs	624 hrs	192 hrs
CONCRETING	HEAD MASON[600%],MALE HELPER[1,000%],CEMENT_2018[1,078],SAND_2018[2,903],AGGREGATES_2018[5,806]	112 hrs	112 hrs	0 hrs
CURING	MALE HELPER	56 hrs	56 hrs	0 hrs
COLUMN REINFORCEMENT	BAR BENDER[1,800%],HEAD MASON[2,400%],MALE HELPER[3,000%],REINFORCEMENT STEEL_2018[2.89]	480 hrs	480 hrs	0 hrs
SHUTTERING	CENTERING MATERIALS[1],HEAD MASON[600%],MALE HELPER[1,000%],MASON[800%]	128 hrs	224 hrs	96 hrs
CONCRETING	AGGREGATES_2018[340],CEMENT_2018[207],CONCRETE MIXER[200%],HEAD MASON[1,000%],MALE HELPER[800%],MASON[600%],SAND_2018[680]	80 hrs	80 hrs	0 hrs
BEAM REINFORCEMENT	REINFORCEMENT STEEL_2018[2.89],BAR BENDER[3,600%],HEAD MASON[2,400%],MALE HELPER[3,000%]	624 hrs	1,200 hrs	576 hrs
SLAB REINFORCEMENT	BAR BENDER[4,000%],HEAD MASON[600%],MALE HELPER[3,600%],REINFORCEMENT STEEL_2018[4.83]	256 hrs	352 hrs	96 hrs
CONCRETING	CEMENT_2018[1,078],HEAD MASON[600%],MALE HELPER[1,000%],SAND_2018[2,903],AGGREGATES_2018[5,806]	112 hrs	112 hrs	0 hrs
CURING	MALE HELPER	56 hrs	56 hrs	0 hrs
COLUMN REINFORCEMENT	BAR BENDER[1,800%],HEAD MASON[2,400%],MALE HELPER[3,000%],REINFORCEMENT STEEL_2018[2.89]	480 hrs	480 hrs	0 hrs
SHUTTERING	CENTERING MATERIALS[1],HEAD MASON[600%],MALE HELPER[1,000%],MASON[800%]	128 hrs	224 hrs	96 hrs
CONCRETING	AGGREGATES_2018[340],CEMENT_2018[207],CONCRETE MIXER[200%],HEAD MASON[1,000%],MALE HELPER[800%],MASON[600%],SAND_2018[680]	80 hrs	80 hrs	0 hrs

The building to be constructed when presented in the form of 3D model it is easy to understand and even non-technical person can imagine what is going to construct.

For this case study BIM concept is formulated with the help of Revit, M.S. Project and Naviswork Manage.

By creating a model in Revit various views(plans, section and elevation) are automatically created and changes in any view ,other views get updated according to it .It has reduced manual editing work and errors which saves the time. Revit model provides quantity take off in customize way and in systematic format. Revit is plug –in that directly allows the model to be exported to Naviswork. Revit 3D model can be used for analysis purpose like structural analysis, energy analysis, space planning etc. Rendering and walkthrough of building through Revit can be used for the presentation of the project.

Use of MSP provides scheduling and costing of the project. MSP helps in interconnecting of the project activities, assigning resources and cost of resources to each activity and finding out cost of each activity and the whole project cost. MSP helps to monitor the project progress by time to time updating the schedule. Reports generated from MSP helped in interpreting the statistics of the building. It works very well when the MS Project file is linked to the model since this can be modified anytime and linked again to the Navisworks file. Improved resource management will lead to a reduction in spending time and will also lead to more environmental friendly practices.

In Navisworks Manage 3D model of Revit and schedule prepared in MSP are imported. This allows linking the schedule to the actual building element. This makes easier to understand the time schedule as visual simulation can be created in the Navisworks Manage. Naviswork provides visual results of the actual and planned schedule of the project. The Navisworks model makes it easy the (3Dimensional interface) to discuss or solve problems. Advanced and improved planning analysis through BIM clash detection and 4D Planning will lead to lesser uncertainty during the construction execution stage. There is switch back facility in naviswork with the help of the clash occurs we can correct that model by this facility and resolve the clash.

Overall the tools like Revit, MSP and Navisworks Manage helped in better understanding of the building design ,construction sequence, effective resource management and timely completion of the project activities as per requires standards. Results in are useful efficient and timely delivery of the project.

3.7 SCHEDULING ACTUAL VS PLANNED

Table 12.1 Scheduling Actual vs Planned

ID	Task Name	Baseline Duration	Actual Duration	Duration Variance	Act. Start	Act. Finish	Baseline Start	Baseline Finish	Baseline Cost	Act. Cost	Cost Variance	Work Variance	July 2018					
1	VIKRAM COLLEGE OF NURSING	187 days	279 days	92 days	Tue 10-07-18	Fri 02-08-19	Tue 10-07-18	Wed 27-03-19	₹ 15,485,988.79	₹ 16,536,829.71	₹ 1,050,840.92	6,460 hrs	27	02	07	12	17	22
2	SITE CLEARANCE	2 days	4 days	2 days	Tue 10-07-18	Fri 13-07-18	Tue 10-07-18	Wed 11-07-18	₹ 14,720.00	₹ 29,440.00	₹ 14,720.00	176 hrs						
3	COLUMN MARKING	1 day	1 day	0 days	Thu 12-07-18	Thu 12-07-18	Thu 12-07-18	Thu 12-07-18	₹ 3,520.00	₹ 3,520.00	₹ 0.00	0 hrs						
4	SUB STRUCTURE	67 days	67 days	0 days	Fri 13-07-18	Mon 15-10-18	Fri 13-07-18	Mon 15-10-18	₹ 5,717,367.98	₹ 6,081,028.90	₹ 363,660.92	1,604 hrs						
5	EXCAVATION	3 days	6 days	3 days	Fri 13-07-18	Fri 20-07-18	Fri 13-07-18	Tue 17-07-18	₹ 97,200.00	₹ 170,400.00	₹ 73,200.00	672 hrs						
6	LAYING PCC	4 days	4 days	0 days	Wed 18-07-18	Mon 23-07-18	Wed 18-07-18	Mon 23-07-18	₹ 180,849.12	₹ 180,849.12	₹ 0.00	0 hrs						
7	MATT FOUNDATION - GRID_01	17 days	17 days	0 days	Tue 24-07-18	Wed 15-08-18	Tue 24-07-18	Wed 15-08-18	₹ 1,817,967.39	₹ 1,994,407.39	₹ 176,440.00	544 hrs						
8	SHUTTERING WORK	3 days	4 days	1 day	Tue 24-07-18	Fri 27-07-18	Tue 24-07-18	Thu 26-07-18	₹ 83,840.00	₹ 91,520.00	₹ 7,680.00	64 hrs						
9	FOOTING REINFORCEMENT	4 days	4 days	0 days	Fri 27-07-18	Wed 01-08-18	Fri 27-07-18	Wed 01-08-18	₹ 545,705.00	₹ 545,705.00	₹ 0.00	0 hrs						
10	COLUMN GRID	3 days	4 days	1 day	Thu 02-08-18	Tue 07-08-18	Thu 02-08-18	Mon 06-08-18	₹ 60,870.00	₹ 129,890.00	₹ 69,020.00	96 hrs						
11	COLUMN REINFORCEMENT	4 days	6 days	2 days	Tue 07-08-18	Tue 14-08-18	Tue 07-08-18	Fri 10-08-18	₹ 215,975.00	₹ 315,715.00	₹ 99,740.00	384 hrs						
12	CONCRETING	2 days	2 days	0 days	Mon 13-08-18	Tue 14-08-18	Mon 13-08-18	Tue 14-08-18	₹ 910,857.39	₹ 910,857.39	₹ 0.00	0 hrs						
13	CURING	1 day	1 day	0 days	Wed 15-08-18	Wed 15-08-18	Wed 15-08-18	Wed 15-08-18	₹ 720.00	₹ 720.00	₹ 0.00	0 hrs						
14	MATT FOUNDATION - GRID_02	25 days	25 days	0 days	Thu 16-08-18	Wed 19-09-18	Thu 16-08-18	Wed 19-09-18	₹ 2,229,474.14	₹ 2,321,054.14	₹ 91,580.00	304 hrs						
15	SHUTTERING WORK	3 days	3 days	0 days	Mon 20-08-18	Mon 20-08-18	Mon 20-08-18	Mon 20-08-18	₹ 83,840.00	₹ 83,840.00	₹ 0.00	0 hrs						
16	FOOTING REINFORCEMENT	5 days	5 days	0 days	Tue 21-08-18	Mon 27-08-18	Tue 21-08-18	Mon 27-08-18	₹ 605,625.00	₹ 605,625.00	₹ 0.00	0 hrs						
17	COLUMN GRID	3 days	4 days	1 day	Tue 28-08-18	Fri 31-08-18	Tue 28-08-18	Thu 30-08-18	₹ 60,870.00	₹ 72,390.00	₹ 11,520.00	96 hrs						
18	COLUMN REINFORCEMENT	4 days	5 days	1 day	Fri 31-08-18	Thu 06-09-18	Fri 31-08-18	Wed 05-09-18	₹ 215,975.00	₹ 294,595.00	₹ 78,620.00	192 hrs						
19	CONCRETING	2 days	2 days	0 days	Thu 06-09-18	Fri 07-09-18	Thu 06-09-18	Fri 07-09-18	₹ 910,857.39	₹ 910,857.39	₹ 0.00	0 hrs						
20	CURING	1 day	1 day	0 days	Mon 10-09-18	Mon 10-09-18	Mon 10-09-18	Mon 10-09-18	₹ 720.00	₹ 720.00	₹ 0.00	0 hrs						
21	SAND FILLING	3 days	4 days	1 day	Tue 11-09-18	Fri 14-09-18	Tue 11-09-18	Thu 13-09-18	₹ 295,000.00	₹ 296,440.00	₹ 1,440.00	16 hrs						
22	SURFACE HARDENING	4 days	4 days	0 days	Fri 14-09-18	Wed 19-09-18	Fri 14-09-18	Wed 19-09-18	₹ 56,586.75	₹ 56,586.75	₹ 0.00	0 hrs						
23	PLINTH BEAM	18 days	18 days	0 days	Thu 20-09-18	Mon 15-10-18	Thu 20-09-18	Mon 15-10-18	₹ 1,391,877.33	₹ 1,414,318.25	₹ 22,440.92	84 hrs						
24	LAYING PCC	2 days	5 days	3 days	Thu 20-09-18	Wed 26-09-18	Thu 20-09-18	Fri 21-09-18	₹ 145,584.82	₹ 162,265.74	₹ 16,680.92	36 hrs						
25	BEAM REINFORCEMENT	3 days	3 days	0 days	Mon 24-09-18	Wed 26-09-18	Mon 24-09-18	Wed 26-09-18	₹ 380,570.00	₹ 380,570.00	₹ 0.00	0 hrs						
26	BEAM SHUTTERING	2 days	2 days	0 days	Mon 24-09-18	Fri 28-09-18	Mon 24-09-18	Fri 28-09-18	₹ 76,960.00	₹ 76,960.00	₹ 0.00	0 hrs						
27	CONCRETING	2 days	2 days	0 days	Mon 01-10-18	Tue 02-10-18	Mon 01-10-18	Tue 02-10-18	₹ 597,397.21	₹ 597,397.21	₹ 0.00	0 hrs						
28	CURING	1 day	1 day	0 days	Wed 03-10-18	Wed 03-10-18	Wed 03-10-18	Wed 03-10-18	₹ 720.00	₹ 720.00	₹ 0.00	0 hrs						
29	SANDFILLING	2 days	2 days	0 days	Thu 04-10-18	Fri 05-10-18	Thu 04-10-18	Fri 05-10-18	₹ 37,543.90	₹ 37,543.90	₹ 0.00	0 hrs						
30	SURFACE HARDENING	2 days	3 days	1 day	Mon 08-10-18	Wed 10-10-18	Mon 08-10-18	Tue 09-10-18	₹ 150,221.40	₹ 155,981.40	₹ 5,760.00	48 hrs						
31	CURING	4 days	4 days	0 days	Wed 10-10-18	Mon 15-10-18	Wed 10-10-18	Mon 15-10-18	₹ 2,880.00	₹ 2,880.00	₹ 0.00	0 hrs						
32	SUPER STRUCTURE	117 days	123 days	6 days	Wed 13-02-19	Fri 02-08-19	Tue 16-10-18	Wed 27-03-19	₹ 9,750,380.81	₹ 10,422,840.81	₹ 672,460.00	4,680 hrs						
33	GROUND FLOOR	23 days	25 days	2 days	Wed 13-02-19	Tue 19-03-19	Tue 16-10-18	Thu 15-11-18	₹ 1,958,120.57	₹ 2,158,020.57	₹ 199,900.00	720 hrs						
34	COLUMN REINFORCEMENT	3 days	4 days	1 day	Wed 13-02-19	Mon 18-02-19	Tue 16-10-18	Thu 18-10-18	₹ 223,055.00	₹ 297,835.00	₹ 74,780.00	144 hrs						
35	SHUTTERING	2 days	4 days	2 days	Mon 18-02-19	Thu 21-02-19	Fri 19-10-18	Mon 22-10-18	₹ 70,720.00	₹ 138,240.00	₹ 67,520.00	96 hrs						
36	CONCRETING	2 days	2 days	0 days	Wed 20-02-19	Thu 21-02-19	Tue 23-10-18	Wed 24-10-18	₹ 163,640.80	₹ 163,640.80	₹ 0.00	0 hrs						
37	SHUTTERING	7 days	9 days	2 days	Fri 22-02-19	Wed 06-03-19	Tue 25-10-18	Fri 02-11-18	₹ 609,775.00	₹ 667,375.00	₹ 57,600.00	480 hrs						
38	BEAM REINFORCEMENT	3 days	5 days	2 days	Fri 22-02-19	Thu 28-02-19	Thu 25-10-18	Mon 29-10-18	₹ 280,930.00	₹ 315,490.00	₹ 34,560.00	288 hrs						
39	SLAB REINFORCEMENT	4 days	6 days	2 days	Wed 27-02-19	Wed 06-03-19	Tue 30-10-18	Fri 02-11-18	₹ 328,845.00	₹ 351,885.00	₹ 23,040.00	192 hrs						
40	CONCRETING	2 days	2 days	0 days	Thu 07-03-19	Fri 08-03-19	Mon 05-11-18	Tue 06-11-18	₹ 885,889.77	₹ 885,889.77	₹ 0.00	0 hrs						
41	CURING	7 days	7 days	0 days	Mon 11-03-19	Tue 19-03-19	Wed 07-11-18	Thu 15-11-18	₹ 5,040.00	₹ 5,040.00	₹ 0.00	0 hrs						
ID	Task Name	Baseline Duration	Actual Duration	Duration Variance	Act. Start	Act. Finish	Baseline Start	Baseline Finish	Baseline Cost	Act. Cost	Cost Variance	Work Variance	July 2018					
42	FIRST FLOOR	22 days	22 days	0 days	Wed 20-03-19	Thu 18-04-19	Mon 17-12-18	Mon 17-12-18	₹ 1,878,005.57	₹ 1,970,165.57	₹ 92,160.00	768 hrs						
43	COLUMN REINFORCEMENT	3 days	3 days	0 days	Wed 20-03-19	Fri 22-03-19	Fri 16-11-18	Tue 20-11-18	₹ 223,055.00	₹ 223,055.00	₹ 0.00	0 hrs						
44	SHUTTERING	2 days	4 days	2 days	Mon 25-03-19	Thu 28-03-19	Wed 21-11-18	Thu 22-11-18	₹ 70,720.00	₹ 82,240.00	₹ 11,520.00	96 hrs						
45	CONCRETING	2 days	2 days	0 days	Wed 27-03-19	Thu 28-03-19	Fri 23-11-18	Mon 26-11-18	₹ 145,480.80	₹ 145,480.80	₹ 0.00	0 hrs						
46	SHUTTERING	6 days	8 days	2 days	Fri 29-03-19	Tue 09-04-19	Tue 27-11-18	Tue 04-12-18	₹ 547,820.00	₹ 628,460.00	₹ 80,640.00	672 hrs						
47	BEAM REINFORCEMENT	2 days	4 days	2 days	Fri 29-03-19	Wed 03-04-19	Tue 27-11-18	Wed 28-11-18	₹ 240,335.00	₹ 309,455.00	₹ 69,120.00	576 hrs						
48	SLAB REINFORCEMENT	4 days	6 days	2 days	Tue 02-04-19	Tue 09-04-19	Thu 29-11-18	Tue 04-12-18	₹ 307,485.00	₹ 319,005.00	₹ 11,520.00	96 hrs						
49	CONCRETING	2 days	2 days	0 days	Mon 08-04-19	Tue 09-04-19	Wed 05-12-18	Thu 06-12-18	₹ 885,889.77	₹ 885,889.77	₹ 0.00	0 hrs						
50	CURING	7 days	7 days	0 days	Wed 10-04-19	Thu 18-04-19	Fri 07-12-18	Mon 17-12-18	₹ 5,040.00	₹ 5,040.00	₹ 0.00	0 hrs						
51	SECOND FLOOR	23 days	23 days	0 days	Fri 19-04-19	Tue 21-05-19	Tue 18-12-18	Thu 17-01-19	₹ 1,902,005.57	₹ 1,982,645.57	₹ 80,640.00	672 hrs						
52	COLUMN REINFORCEMENT	3 days	3 days	0 days	Fri 19-04-19	Tue 23-04-19	Tue 18-12-18	Thu 20-12-18	₹ 223,055.00	₹ 223,055.00	₹ 0.00	0 hrs						
53	SHUTTERING	2 days	4 days	2 days	Wed 24-04-19	Mon 29-04-19	Fri 21-12-18	Mon 24-12-18	₹ 70,720.00	₹ 82,240.00	₹ 11,520.00	96 hrs						
54	CONCRETING	2 days	2 days	0 days	Fri 26-04-19	Mon 29-04-19	Tue 25-12-18	Wed 26-12-18	₹ 145,480.80	₹ 145,480.80	₹ 0.00	0 hrs						
55	SHUTTERING	7 days	10 days	3 days	Tue 30-04-19	Mon 13-05-19	Thu 27-12-18	Fri 04-01-19	₹ 570,860.00	₹ 639,980.00	₹ 69,120.00	576 hrs						
56	BEAM REINFORCEMENT	3 days	6 days	3 days	Tue 30-04-19	Mon 07-05-19	Thu 27-12-18	Mon 31-12-18	₹ 240,335.00	₹ 309,455.00	₹ 69,120.00	576 hrs						
57	SLAB REINFORCEMENT	4 days	4 days	0 days	Fri 03-05-19	Mon 13-05-19	Tue 01-01-19	Fri 04-01-19	₹ 330,525.00	₹ 330,525.00	₹ 0.00	0 hrs						
58	CONCRETING	2 days	2 days	0 days	Thu 09-05-19	Fri 10-05-19	Mon 07-01-19	Tue 08-01-19	₹ 886,849.77	₹ 886,849.77	₹ 0.00	0 hrs						
59	CURING	7 days	7 days	0 days	Mon 13-05-19	Tue 21-05-19	Wed 09-01-19	Thu 17-01-19	₹ 5,040.00	₹ 5,040.00	₹ 0.00	0 hrs						
60	THIRD FLOOR	23 days	25 days	2 days	Wed 22-05-19	Tue 25-06-19	Fri 18-01-19	Tue 19-02-19	₹ 1,911,605.57	₹ 2,026,805.57	₹ 115,200.00	960 hrs						
61	COLUMN REINFORCEMENT	3 days	5 days	2 days	Wed 22-05-19	Tue 28-05-19	Fri 18-01-19	Tue 22-01-19	₹ 223,055.00	₹ 257,615.00	₹ 34,560.00	288 hrs						
62	SHUTTERING	2 days	4 days	2 days	Mon 27-05-19	Thu 30-05-19	Wed 23-01-19	Thu 24-01-19	₹ 70,720.00	₹ 82,240.00	₹ 11,520.00	96 hrs						
63	CONCRETING	2 days	2 days	0 days	Fri 31-05-19	Mon 03-06-19	Fri 25-01-19	Mon 28-01-19	₹ 145,480.80	₹ 145,480.80	₹ 0.00	0 hrs						
64	SHUTTERING	7 days	9 days	2 days	Tue 04-06-19	Fri 14-06-19	Tue 29-01-19	Wed 06-02-19	₹ 570,860.00	₹ 639,980.00	₹ 69,120.00	576 hrs						
65	BEAM REINFORCEMENT	3 days	5 days	2 days														

3.8 DELAY ANALYSIS

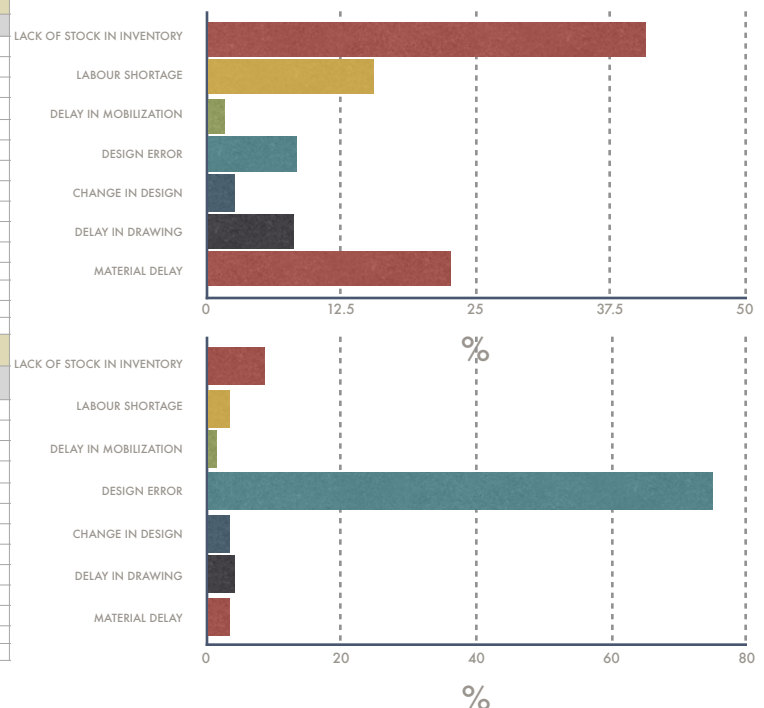
Table 13.1 Delay Analysis

DELAY ANALYSIS								
ACTIVITY	PLANNED (days)	ACTUAL (days)	DELAY (days)	PROBLEM CAUSING DELAY	PLANNED COST	ACTUAL COST	COST VARIANCE	CONTROLLABLE/UNCONTROLLABLE
Site Clearance	2	4	2	Delay in Mobilisation	₹ 14,720.00	₹ 29,440.00	₹ 14,720.00	CONTROLLABLE
Excavation	3	6	3	Geographical Conditions	₹ 97,200.00	₹ 1,70,400.00	₹ 73,200.00	UNCONTROLLABLE
MATT FOUNDATION_01 - Shuttering work	3	4	1	Material Delay	₹ 83,840.00	₹ 1,21,680.00	₹ 37,840.00	CONTROLLABLE
MATT FOUNDATION_01 - Column Grid	3	4	1	Lack of Stock in Inventory	₹ 60,870.00	₹ 1,29,890.00	₹ 69,020.00	CONTROLLABLE
MATT FOUNDATION_01 - Column Reinforcement	4	6	2	Labour Shortage	₹ 2,15,975.00	₹ 3,15,715.00	₹ 99,740.00	CONTROLLABLE
MATT FOUNDATION_02 - Top Reinforcement	4	5	1	Lack of Stock in Inventory	₹ 2,15,975.00	₹ 2,94,595.00	₹ 78,620.00	CONTROLLABLE
MATT FOUNDATION_02 - Column Grid	3	4	1	Weather/Climatic Conditions	₹ 60,870.00	₹ 72,390.00	₹ 11,520.00	UNCONTROLLABLE
Sand Filling	3	4	1	Lack of Stock in Inventory	₹ 2,95,000.00	₹ 3,13,440.00	₹ 18,440.00	CONTROLLABLE
PLINTH BEAM - Laying PCC	2	5	3	Weather/Climatic Conditions	₹ 1,45,584.82	₹ 1,62,265.74	₹ 16,680.92	UNCONTROLLABLE
Surface Hardening	2	3	1	Lack of Stock in Inventory	₹ 1,50,221.40	₹ 1,75,981.40	₹ 25,760.00	CONTROLLABLE
GF - Column Reinforcement	3	90	90	Design Error	₹ 2,23,055.00	₹ 2,94,125.20	₹ 71,070.20	CONTROLLABLE
GF - Column Shuttering	2	4	2	Change in Design	₹ 70,720.00	₹ 82,240.00	₹ 11,520.00	CONTROLLABLE
GF - Beam Reinforcement	3	5	2	Delay in Drawing	₹ 2,80,930.00	₹ 3,15,490.00	₹ 34,560.00	CONTROLLABLE
GF - Slab Reinforcement	4	6	2	Delay in Drawing	₹ 3,28,845.00	₹ 3,51,885.00	₹ 23,040.00	CONTROLLABLE
FF_SLAB - Column Shuttering	2	3	1	Delay in Drawing	₹ 70,720.00	₹ 82,240.00	₹ 11,520.00	CONTROLLABLE
FF_SLAB - Beam Reinforcement	2	4	2	Weather/Climatic Conditions	₹ 2,40,335.00	₹ 3,09,455.00	₹ 69,120.00	UNCONTROLLABLE
FF_SLAB - Slab Reinforcement	4	6	2	Labour Shortage	₹ 3,07,485.00	₹ 3,41,505.00	₹ 34,020.00	CONTROLLABLE
SF_Column Shuttering	2	4	2	Change in Design	₹ 70,720.00	₹ 82,260.60	₹ 11,540.60	CONTROLLABLE
SF_Beam Reinforcement	3	6	3	Lack of Stock in Inventory	₹ 2,40,335.00	₹ 3,09,455.00	₹ 69,120.00	CONTROLLABLE
TF_Column Reinforcement	3	5	2	Lack of Stock in Inventory	₹ 2,23,055.00	₹ 2,57,615.00	₹ 34,560.00	CONTROLLABLE
TF_Column Concreting	2	3	1	Weather/Climatic Conditions	₹ 1,45,480.80	₹ 1,92,230.00	₹ 46,749.20	UNCONTROLLABLE
F4_Shuttering	2	3	1	Material Delay	₹ 70,720.00	₹ 1,26,480.00	₹ 55,760.00	CONTROLLABLE
F4_Beam Reinforcement	3	5	2	Material Delay	₹ 2,40,335.00	₹ 3,42,045.00	₹ 69,120.00	CONTROLLABLE
F5_SLAB - Concreting	2	3	1	Lack of Stock in Inventory	₹ 8,96,449.00	₹ 9,51,649.00	₹ 55,200.00	CONTROLLABLE
TF_Column Reinforcement	1	2	1	Local Strike	₹ 80,900.00	₹ 86,660.00	₹ 5,760.00	UNCONTROLLABLE
TF_Column Shuttering	1	2	1	Local Strike	₹ 59,360.00	₹ 62,000.00	₹ 2,640.00	UNCONTROLLABLE
	68	196	131		₹ 48,89,701.02	₹ 59,73,131.94	₹ 10,50,840.92	

3.9 TIME AND COST OVERRUNS

Table 14.1 Time and Cost Overruns

REASON FOR DELAY	COST OVERRUN				
UNCONTROLLABLE		PLANNED COST	ACTUAL COST	COST VARIANCE	%
Weather/Climatic Conditions		₹ 7,36,340.74	₹ 5,92,270.62	₹ 1,44,070.12	
Geographical Conditions		₹ 1,70,400.00	₹ 97,200.00	₹ 73,200.00	
Local Strike		₹ 1,48,660.00	₹ 1,40,260.00	₹ 8,400.00	
CONTROLLABLE				₹ 2,25,670.12	
Lack of Stock in Inventory		₹ 24,32,625.40	₹ 20,81,905.40	₹ 3,50,720.00	40.9
Labour Shortage		₹ 6,57,220.00	₹ 5,23,460.00	₹ 1,33,760.00	15.6
Delay in Mobilisation		₹ 29,440.00	₹ 14,720.00	₹ 14,720.00	1.7
Design Error		₹ 2,94,125.20	₹ 2,23,055.00	₹ 71,070.20	8.3
Change in Design		₹ 1,64,500.60	₹ 1,41,440.00	₹ 23,060.60	2.7
Delay in Drawing		₹ 7,49,615.00	₹ 6,80,495.00	₹ 69,120.00	8.1
Material Delay		₹ 5,90,205.00	₹ 3,94,895.00	₹ 1,95,310.00	22.8
		₹ 59,73,131.94	₹ 48,89,701.02	₹ 8,57,760.80	
REASON FOR DELAY	TIME OVERRUN				
UNCONTROLLABLE		PLANNED DURATION	ACTUAL DURATION	DURATION VARIANCE	%
Weather/Climatic Conditions		16	9	7	
Geographical Conditions		6	3	3	
Local Strike		4	2	2	
CONTROLLABLE				12	
Lack of Stock in Inventory		30	20	10	8.6
Labour Shortage		12	8	4	3.4
Delay in Mobilisation		4	2	2	1.7
Design Error		90	3	87	75.0
Change in Design		8	4	4	3.4
Delay in Drawing		14	9	5	4.3
Material Delay		12	8	4	3.4
		196	68	116	



3.10 ANALYSIS

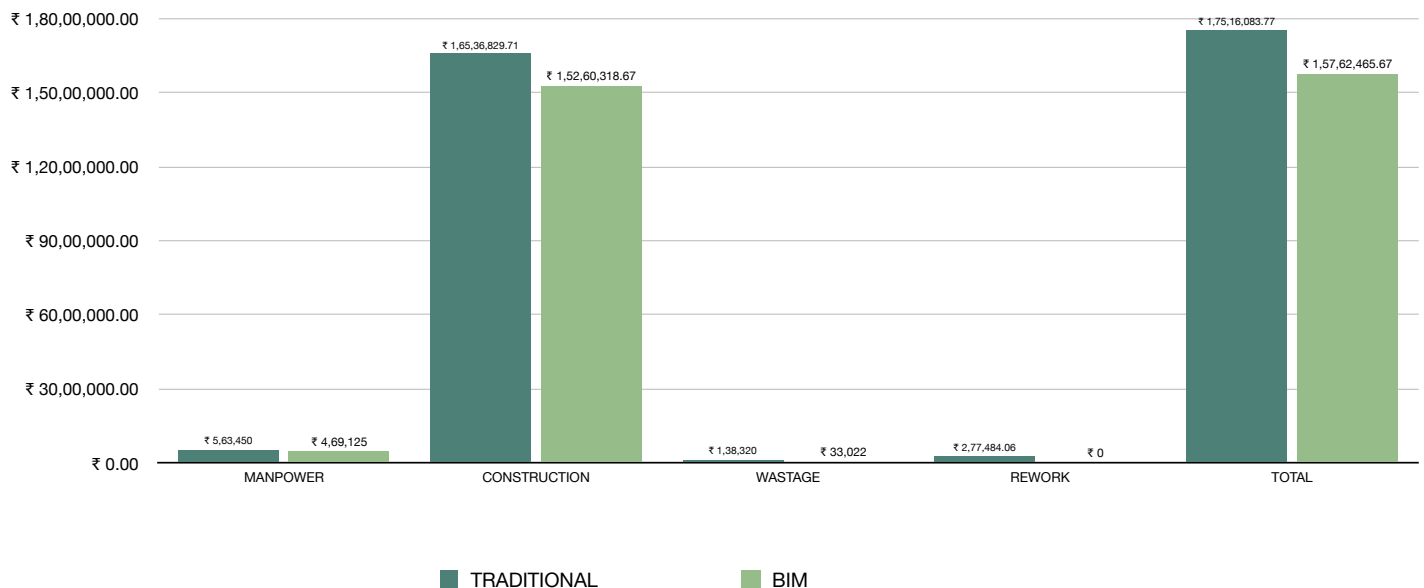
Table 15.1 Analysis

Workflow	Benefits	Definition	Quantifiable with	Constraints	Savings(	Cost Savings	Additional Information
3D MODELLING							
Earthworks Modelling	Visualization of risks and opportunities	The degree to which the visualization of Permanent Works within a 3D model aids in visualizing either risks and/or opportunities.	Reduction of Waste	Geographical Conditions	3	₹ 73,200	
Conflict Resolution	Clash Detection and Design Changes	Clashes among the Architectural, Structural and MEP works can be deteted. Once they are detected, changes in design can be made and the 3D model is updated automatically. This leads to prevention of future mistakes.	Saving of time/ Added value	Rework	21	₹ 2,77,484.06	Avoid risk of delay due to clash detected between Architectural elements and structure, rework for structural works
Easier Handover	As-Built Drawings	During project execution the 3D model is constantly updated according to the changes. At the end of the project, the as-built model conditions are defined and as-built drawings can be extracted easily.	Saving of time	Delay in Drawing	5	₹ 69,120	
Clash Detection	Increased Documentation/ Claims	Information is managed and used properly. In this way, the understanding of the client is increased and there is high chance of speeding-up the construction process.	Added Value	Clash between Architectural elements and Structure	90	₹ 71,070.20	
3D BASED SURVEYING							
	Complexity of Projects	The complexity of some projects makes the surveying hard and time-consuming.	Saving of time				
	Efficiency of processes	If the 3D model is directly installed on the total station, the on-site coordination is achieved faster.		Lack of stock in Inventory	10		Procurement Planning
4D MODEL FOR PLANNING							
Planning/Phasing	Interface Cordination	Especially in large and complex projects which involve numerous activities, the coordination of the interfaces is essential in order to avoid confusion on-site and time delays.	Saving of time	Lack of Resources	4	₹ 1,33,760.00	Resource Management
	Sequence of Activities	The sequence of activities in managed in a way that relationships among them are maintained while resources and equipment are used efficiently.		Material Delay	4	₹ 1,95,310.00	Procurement Planning
Meetings to view 3D meeting and discuss Constructability	Visualization for the client	Visual representation of the schedule combined with additional information visualised (4D CAD) helps the client understand the progress. This increases the possibility for proposals to be accepted by the client	Saving of time				Reduction in time required to explain programme to the client and site personnel will lead to reduced costs.
4D PROGRESS MONITORING							
	Project Monitoring	4D planning allows visualisation and tracking of the progress of the activities. In this way, problems can be detected and resolved on time. This contributes in efficient control of the project and facilitates the supervision of the project team.	Added Value				
5D _COST ESTIMATION							
	Cost Estimation	5D model contributes inaccurate cost estimation before the initiation of the project in comparison to the traditional methods	Reduction of Waste	Inaccurate Estimates		₹ 1,05,298.00	
	Accuracy of Cost Estimation	5D model ensures higher accuracy in the cost estimation.	Reduction of Waste				
BIM MODELLING							
Manpower		Implementation of proper deputation of manpower is crucial for any AEC project to go smoothly. Without such implementations and use of manpower, an AEC project will never be able to meet up to its goals.	Saving of time		90	₹ 94,325.00	

3.11 COMPARISON BETWEEN BIM AND TRADITIONAL METHOD

Table 16.1 Comparison between BIM and Traditional Method

ACTIVITY	TOTAL COST	OPTIMIZED COST (USING BIM)	COST SAVING	COST SAVING %	TOTAL DURATION (DAYS)	OPTIMIZED DURATION (USING BIM)	TIME SAVING (DAYS)	TIME SAVING %
MANPOWER <i>Professional</i>	₹ 5,63,450	₹ 4,69,125	₹ 94,325	16.74	219	144	75	34.25
CONSTRUCTION	₹ 1,65,36,829.71	₹ 1,52,60,318.67	₹ 12,76,511.04	7.72	279	175	104	37.28
WASTAGE	₹ 1,38,320	₹ 33,022	₹ 1,05,298	76.13	0	0	0	0.00
REWORK	₹ 2,77,484.06	₹ 0.00	₹ 2,77,484.06	100.00	18	0	18	100.00
TOTAL	₹ 1,75,16,083.77	₹ 1,57,62,465.67	₹ 17,53,618.1	10.01	516	319	197	38.18



The challenge to reduce the time and cost of construction projects will always occur throughout the project. Utilization of Building Information Modeling (BIM) is expected to be a solutive answer. The results of research with a case study in a construction project stated that the use of BIM can reduce work time by up to 38.18%. While costs can be reduced by 10.01%. A good result when compared with conventional methods. The main factor of the large time-cost reduction caused by the use of BIM technology is accelerating the design process and structure calculation. Besides, the number of workers' needs is also less because skilled workers can work more optimally with BIM software. This study also analyzed the advantages of BIM which can be used as literature for construction projects.

Benefits of BIM to reduce time and make time overrun zero:

- The 3D aspect of the BIM makes it a very effective method of communicating between the architect, MEP consultant, contractors and the other project participants. It benefits to communicate problem, its better understanding & resolving the problem. it saves time and effort spend in traditional way of communication.
- BIM model is effective in Material management. A proper resource management benefit in timely procurement of material .It reduces wastage of time (Quality and Quantity control of material) as we can extract the quantities as per our requirement.
- The 4D model visualization of the construction schedule- helps to understand the sequence of the construction. It is a very effective means of communicating the construction sequencing process which helps identifying critical activities, identification of unforeseen conditions and the resultant cost to all the stakeholders.
- BIM strengthens the capability and output of each phase and stakeholder of the project. It helps project in conceptual design, visualization, cost estimation, clash detection, time management, scheduling, environmental analysis, spatial analysis, fabrication, quality assessment, facility management and maintenance.
- For faster and better execution of project accurate and comprehensive information is required. Using BIM softwares, it is possible to extract accurate and reliable data as and when required and could be updated and modified as project progresses which results in better control and efficiency of the project.

Benefits of BIM to reduce cost and make cost overrun zero:

- Effective communication results in to completion of project in stipulated time.Also we could demand for increasing cost of material such as steel, cement, sand etc.so no increased material rate is charged.
- Effective material management reduces excessive procurement and wastage of material also reduces excessive Transportation cost.
- Through 3D coordination model the concept of execution of project is clear to all stakeholders, and GFC (Good For Construction) drawing for execution reduces the rework and it results in reduce the over work of cost.

3.12 INTEGRATED TIME-COST MANAGEMENT SYSTEM WORKFLOW

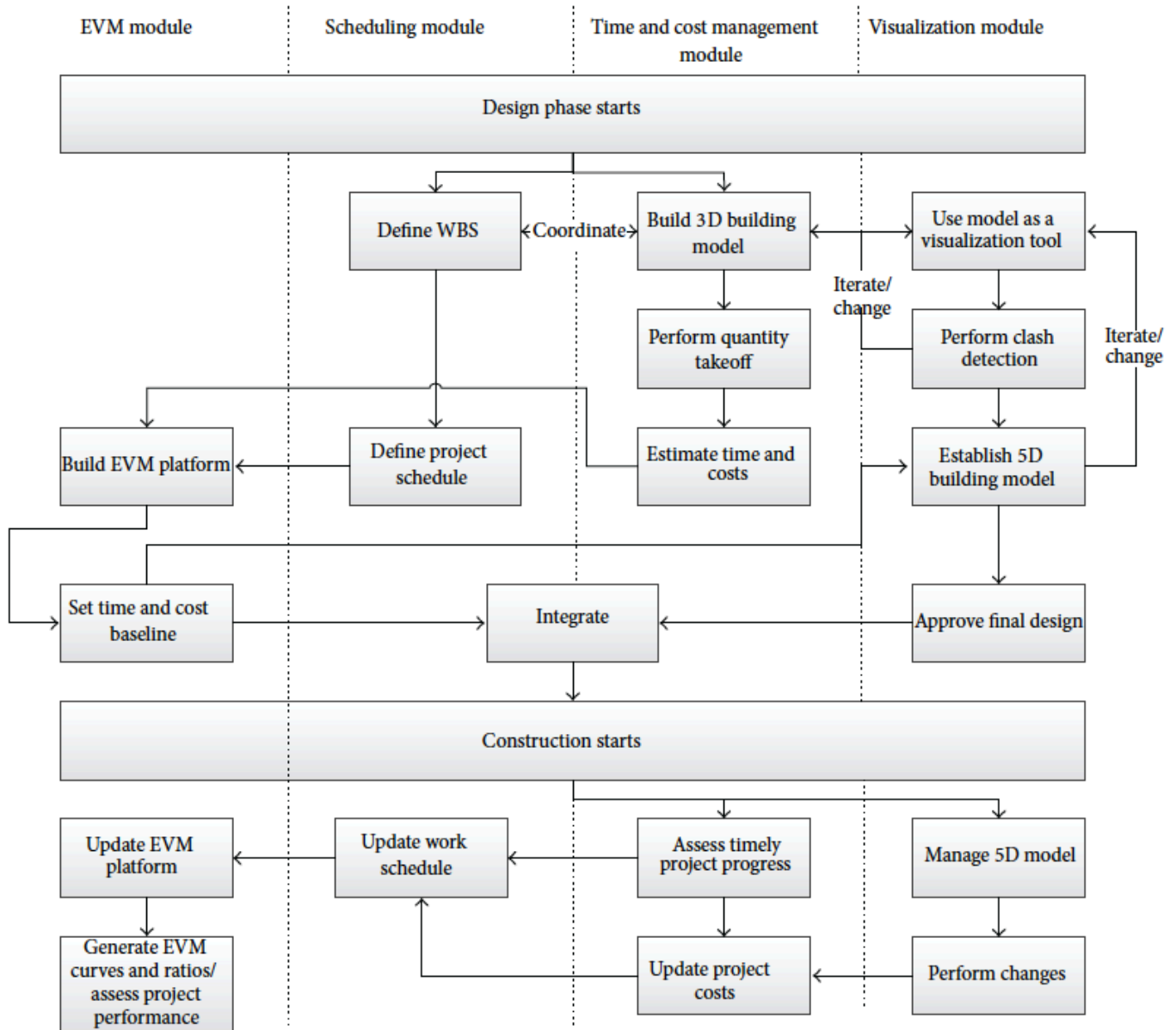


Fig 3.5 Integrated Time Cost Management System Workflow

The proposed ITCMS will ensure a good flow of information and will foster good collaboration within the project team. Furthermore, the technical work associated with this proposed system needs to be well integrated to limit rework where automation is a key to success. The resulting work will allow the design team to construct a building model with high level of constructability and the construction manager to assess project's performance in terms of budget and schedule progress at any point of time of the project. The proposed system includes four different modules that are interrelated to each other and continually interact within the inherent system's iteration processes.

A 5D model will also be created by the construction team by incorporating the costs and schedule in Autodesk Navisworks software, the model being then used as a visualization and clash detection tool to iterate the building model during the planning phase until project's objectives are met. The project team will evaluate the building model in accordance with the budget and schedule parameters and iterate until final acceptance is achieved by all the parties (use model as a visualization tool, perform clash detection, and establish 5D building. At this point, the EVM platform will be built and the time and cost baselines will be set before the construction begins.

4.1 CONCLUSION

The following points are concluded from this research:

- Manual work is hectic, time taking and there are much chances of error, whereas estimation on Revit Software is fast, easy, efficient, automatic, and have less chances of error.
- The manual work includes manual calculation work and there are chances of error because some formulas are long and complex, while in Revit Software there is no need to calculate manually, just model can be drawn and measurements can be inserted to get material quantities.
- In manual work each task has to be considered e.g. quantities calculation, material calculation, abstract of cost etc. while in Revit software it is be automatic.
- It is difficult to rectify errors or to make changes in manual, while in Revit Software it is very easy.
- The usual practice in the field for doing manual cost estimation is that full room sizes are considered, whereas, for the BIM software cost estimation due to subtracting wall plasters, the room sizes are reduced. This causes the difference of cost for BIM based cost estimation approach.

4.2 RECOMMENDATIONS

BIM is applicable in every aspects of the AEC industry. The scope of this thesis is limited to 5D BIM modeling, which is only applicable for constructing the building, but the level of detailing (LOD) can be increase by integrating Mechanical- Electrical- Plumbing(MEP) works, sustainability(6th Dimension), operation & maintenance(7th Dimension) and so on to make the model more rich in information. BIM also helps in Procurement planning, Location based 5D BIM model which incorporates the men, material to reduce the time management In recent study, safety is also considered to be an important aspect and is considered as 8th dimension in modeling. This thesis only considered the time and cost aspect, whereas there are many other factors that can influence the quality, decision, such as environmental aspect, safety aspect and so on. It not only help the construction industry but also the environment by using LEED tools for energy efficient designs and to human energy by reducing the use of materials and skilled labour.

Table 17.1 BIM Applications

PRODUCT NAME	MANUFACTURER	BIM USE	PRIMARY FUNCTION
Revit Architecture	Autodesk	Creating and reviewing 3D models	Architectural modelling and parametric design
Bentley Architecture	Bentley Systems	Creating and reviewing 3D models	Architectural Modelling
TeklaStructures	Tekla	Conceptual 3D modelling	Architectural 3D model application
ArchiCAD	Graphisoft	Conceptual 3D architectural model	Architectural model creation
Vectorworks Designer	Nemetschek	Conceptual 3D modelling	Architectural model creation
LOD Planner	Plannerly	Procurement Planning	3D conceptual modelling with real-time cost and time estimation
Vico Office	Vico Software	Conceptual 5D modelling	5D conceptual model, cost and schedule data
Revit Structure	Autodesk	Structural	Structural modelling and parametric design
Tekla BIMSight	Tekla	Model Viewer	Models combination, clashes checking
Navisworks Manage/Simulate	Autodesk	Model checking and validation	Clashes checking, 4D simulations of construction progress
RIB ITWO 5D BIM	RIB groups	Location based 5D BIM	Construction execution and Planning control
Navisworks Freedom	Autodesk	Model viewer	IFC files opening and viewing
Solibri Model Checker	Solibri	Model checking and validation	IFC files opening and viewing
SDS/2	Design Data	Structural	3D structural modelling and detailing

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