American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)
ISSN (Print) 2313-4410, ISSN (Online) 2313-4402

http://asrjetsjournal.org/

Development of Better Time and Cost Plan by Integrating Information in a Construction Project

Thet Thet Soe[a]*, Aye Mya Cho[b]

[a]*Thet Thet Soe, Department of Civil Engineering, Mandalay Technological University, The Republic of the Union of Myanmar*

[b]*Aye Mya Cho, Professor in Department of Civil Engineering, Mandalay Technological University, The Republic of the Union of Myanmar*

[a]*Email: thetthetsoe87.eng@gmail.com*

[b]*Email: amcho.civil@gmail.com*

Abstract

Commonly, there are no compactible and integrated models among architecture, structure and mechanical and electrical engineering yet before actual construction starts. As a consequence, many problems such as time and cost overruns, quality improvement, etc occur in almost every project. This study aims to reduce problems in construction mentioned by the aid of advanced technique BIM (Building Information Modelling). As a case study, commercial building construction in Mandalay is selected. Firstly, time and resource scheduling and cost estimations are done by using collected datas based on individual drawings from different designers such as architects, structure and M&E engineers. As a result, estimated construction time is about seven years and total construction cost is 58571 lakhs. As an alternative way, firstly, clashes due to inconsistencies among architectural, structural and M&E drawings are checked by using Revit software. Then, the coordination is done by using interference check. At the end of the check, the coordinated structure (structure with elements at right positions) is obtained and depicted in accordance with phases of construction. Then, time and resource scheduling are done by using Microsoft Project software based on the construction phases. As a result of Microsoft Project software, the estimated time is five years and construction cost is 54325 lakhs. So, estimated time and cost by applying BIM technique are 30% and 10% less than usual estimation respectively. This paper concludes that time and cost control can be best done with the aid of BIM technique.

Keywords: Building Information Modelling; Scheduling; Time control; Cost control.

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* Corresponding author.

1. Introduction

The importance of developing a constraint-free and reliable work plan has long been recognized by the industry. Numerous construction projects are still plagued by delays and cost overruns, which can frequently be traced to ineffective identification treatment of constraints in tradition. The construction industry being one of the most complex, fragmented, schedule and resource driven industry, is always facing serious problems like low productivity, low quality, delay and cost overrun etc. There are many problems in construction such as unforeseen site conditions, less of labors' skill, overlapping of activities during construction stage and inadequate planning, etc. In real, the proposed project is facing the problems; there is weak in construction planning and scheduling in advance, inadequate meeting and cooperation among clients, designers, contractors, subcontractors, structural, architectural and M&E engineers before construction starts. So many changes occur in almost every project. Construction project cannot be seen during preconstruction stage in advance by all project participants. Time and cost overruns occur due to the above mentioned facts. Therefore, this study intends to find how to cope overruns by using BIM. The development of efficient techniques which could be engaged throughout the lifecycle of a construction project is highly required. Researchers and engineers worldwide have continuously made their valuable contributions in this field. Recently, Building information modelling (BIM) has been developed and gaining popularity in this area [4]. With the rapid development of construction industry recently, although the large-scale construction enterprises advantages gradually emerged, it is common of low management efficiency, low profitability, backward construction management and risk response ability and other reasons. Construction enterprises win the project through competition and lower price, leading to the enterprise's internal core competitiveness has not been taken seriously, which resulted in the weakness of construction enterprise management capacity. Therefore, it is the direction of research and application of BIM technology in construction industry to realize the sharing of construction model through the integration of BIM platform for all information of construction project, unified modeling norms and modeling standards [2].

2. Literature Review

2.1. Time, Planning and Scheduling of Construction

Scheduling is the very essential part of construction management point of view. Without proper planning and scheduling successful completion of any project of any organization will not be possible. Proper scheduling of the various activities before beginning of work and controlling the operations in systematic manner is the heart of planning [2]. Modelling combined with time is a planning process to link the construction activities represented in time schedules with 3D models to develop a real-time graphical simulation of construction progress against time. Adding the 4th dimension 'Time' offers an opportunity to evaluate the build ability and workflow planning of a project. Project participants can effectively visualize, analyse, and communicate problems regarding sequential, spatial and temporal aspects of construction progress. As a consequence, much more robust schedules, and site layout and logistic plans can be generated to improve productivity [7].

2.2. Cost Estimation

Cost estimating is yet another aspect of the building process that can benefit from computable building information. Designing a building is the responsibility of architects, whereas assessing the cost to build it is the domain of estimators. In general, the architect's scope of work doesn't extend to material takeoffs or cost information. That's left to the estimator. When preparing their cost estimates, estimators typically begin by digitizing the architect's paper drawings, or importing their CAD drawings into a cost estimating package, or doing manual takeoffs from their drawings. All of these methods introduce the potential for human error and propagate any inaccuracies there may be in the original drawings. Therefore, time and cost overruns occur more or less in every project. By using a building information model instead of drawings, the takeoffs, counts, and measurements can be generated directly from the model. Therefore the information is always consistent with the design. And when a change is made in the design – a smaller window size, for example – the change automatically ripples to all related construction documentation and schedules, as well as all the takeoffs, counts, and measurements that are used by the estimator [5].

3. Tools Used in The Study

The following tools or softwares are used in this study to find clashes among various drawings, coordinate elements and to present right and accurate plans and schedules and cost estimations.

3.1. Selected Softwares for Creating Model

Selected softwares used in this case study are stated as follows:

1. Autodesk Revit 2017: Revit is database structure and object definition Modelling, it is effective Modelling software the preferable work practice is of course when all the Modelling is performed internally within Revit. In order to satisfy the specific needs of the diverse types of specialist for Revit, Autodesk distributed the product into three types – Revit Architecture, Revit Structure and Revit MEP. The 3D model of case study was created in Revit Architecture 2017.

2. Autodesk Navisworks Manage 2017: The Autodesk Navisworks helps architecture, engineering, and construction teams to develop better control over the outcome of their projects. Navisworks enables user to interrogate and utilize this information throughout the design, build, and operation stages without the need for a design application. For this case study exporting 3D model to Navisworks, preparing work break down structure in Navisworks and giving time to the each task are included [8].

3. Microsoft project: This is software used for scheduling and planning and estimation of cost imported into Naviswork Manage software [8].

4. Schedulling, Simulating and Cost Estimating Results

According to the data collected from the site, firstly time and cost estimation is done by using Microsoft Project.

As an alternative way, the building is first checked inconsistencies among various designers by using Revit software. Then, these inconsistencies are corrected by asking all designers' agreement. After compromising among all designers, the complete and correct building design comes out. Again, scheduling is done by using this correct one.

4.1. Time and Cost Estimation by using Traditional Method

Commonly, it is found that traditional method is used for time and cost estimations in Myanmar. Moreover, clients, project managers, consultants, contractors, subcontractors, structural, architectural and M&E engineers are not collaborative as a coordinated team in this method. So, time and cost overruns in construction project are found. The followings are described by using it.

4.1.1. Time, planning and scheduling of construction according to Traditional Method

The time duration of the building is described by the following bar chart.

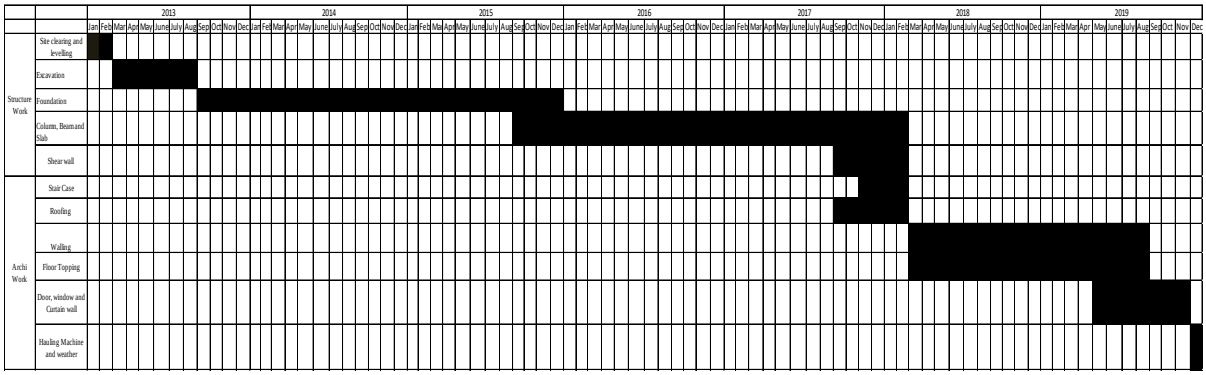

Figure 1: Bar chart of the building

Figure 1 shows the time schedule of the proposed building. The duration of the building based on data is taken as seven years according to the schedule shown in figure 1.

	Complex Building Project	2242 days	Tue 1/1/13	Fri 2/28/20	
	Site Clearing and Levelling	24 days	Tue 1/1/13	Mon 1/28/13	
	Excavation	52 days	Tue 1/29/13	Fri 3/29/13	2
	Foundation	98 days	Sat 3/30/13	Mon 7/22/13	3
	Basement Level Column	23 days	Tue 7/23/13	Sat 8/17/13	
	Ground Level Beam and Slab	43 days	Mon 11/25/13	Mon 1/13/14	35
	Ground Level Column	36 days	Tue 1/14/14	Mon 2/24/14	6
	Ground Floor Level Beam and Slab	39 days	Tue 2/25/14	Thu 4/10/14	7
	Ground Floor Level Column	29 days	Fri 4/11/14	Wed 5/14/14	8
	Level 1 Beam and Slab	38 days	Thu 5/15/14	Fri 6/27/14	9
	Level 1 Column	25 days	Sat 6/28/14	Sat 7/26/14	10
	Level 2 Beam and Slab	39 days	Mon 7/28/14	Wed 9/10/14	11
	Level 2 Column	30 days	Thu 9/11/14	Wed 10/15/14	12
	Level 3 Beam and Slab	39 days	Thu 10/16/14	Sat 11/29/14	13

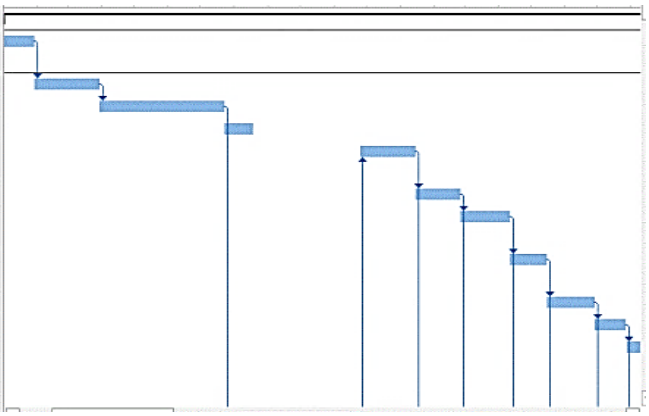

Figure 2: Schedule by using Microsoft Project Software

From the above figure 2, the duration is calculated based on each activity obtained from work breakdown

structure by using critical path method in MS project. The total duration of the building is 2242 days. The start date is 1.1.2013 and end date is 28.2 2020. This schedule is obtained based on the bar chart. So, the total duration of the building is seven years.

4.1.2. Cost estimation of building by using Traditional Method

Cost summary for building is shown in the following calculations.

Material cost	= 3727780250
Machine	= 14305000
Labour cost	= 1673648754
Total direct cost	= 5415734004
Contingency (5%)	= 270786700
Engineer supervision fee (3.15%)	= 170595621
Overall total cost	= 5,857,116,325
Say	= 5,857,100,000

So, the total cost of building is 5,857,100,000 according to traditional method.

4.2. Coordination of the results in BIM

Here, two dimensional drawings can't be performed the coordination and collaboration of the building so errors can be found in actual site condition and cause delays. However, three dimensional drawings can be as basis for the coordination and collaboration of the building. So errors can be reduced in actual site condition. The building is checked all structural, architectural, electrical and mechanical designs to find clashes among them by using Revit software. Then, all designers work together to solve these clashes. Finally, coordinated building design is obtained by eliminating clashes. The following figure 3 shows the coordinated building.

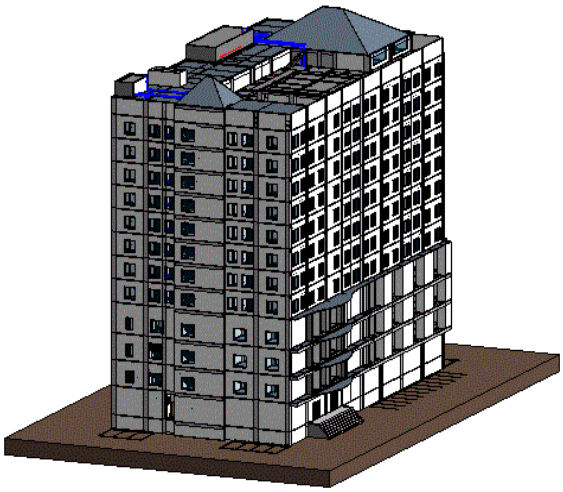

Figure 3: Coordinated building of architectural, structural and M&E model

4.2.1. Time and Cost Estimation by using BIM

Time estimation is done by using 3D Model, Microsoft project schedule and Navisworks Manage based on the coordinated building design.

1. Schedules according to MS project in construction

As an alternative way, time and cost estimation is done by using the coordinated building obtained above. Activities are carried out by using this coordinated structure. Then, these activities are provided to MS project software as inputs. As an output, durations of each activity are set up together with corresponding time and resources as shown in figure 4.

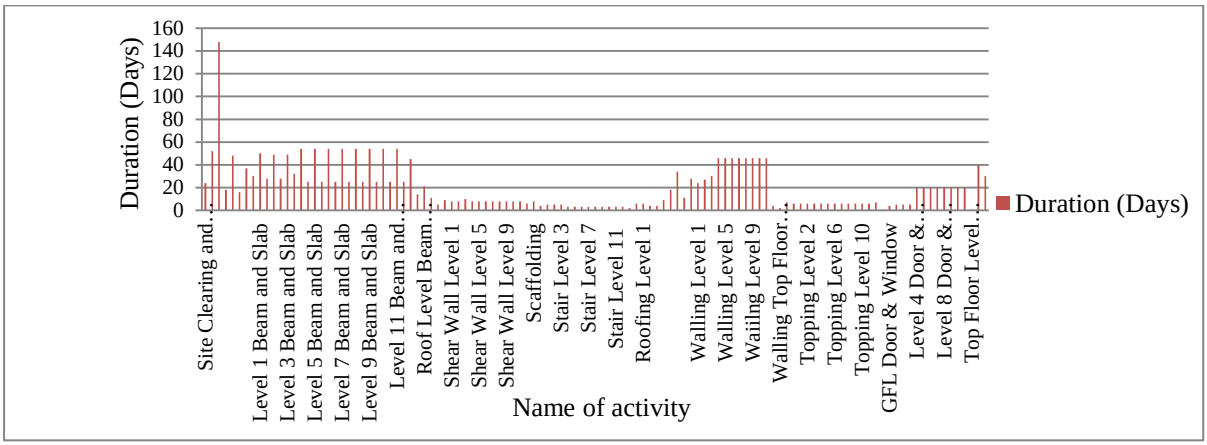

Figure 4: Durations of each activity

From the above figure 4, the duration is calculated based on each activity obtained from work breakdown

structure by using critical path method in MS project. The actual total duration of the building is 1541 days. The start date is 1.1.2013 and end date is 2.12 2017. So, the total duration of the building is about five years.

These schedules with respective to phases can be seen in advance before actual construction starts. They make themselves sure to implement and there are error less to start actual construction. This feature of Naviswork enables to visualize the task and pre-plan the requirements without any error. This feature appears in Naviswork as shown in the figure 5. The simulation model is described in figure 6.

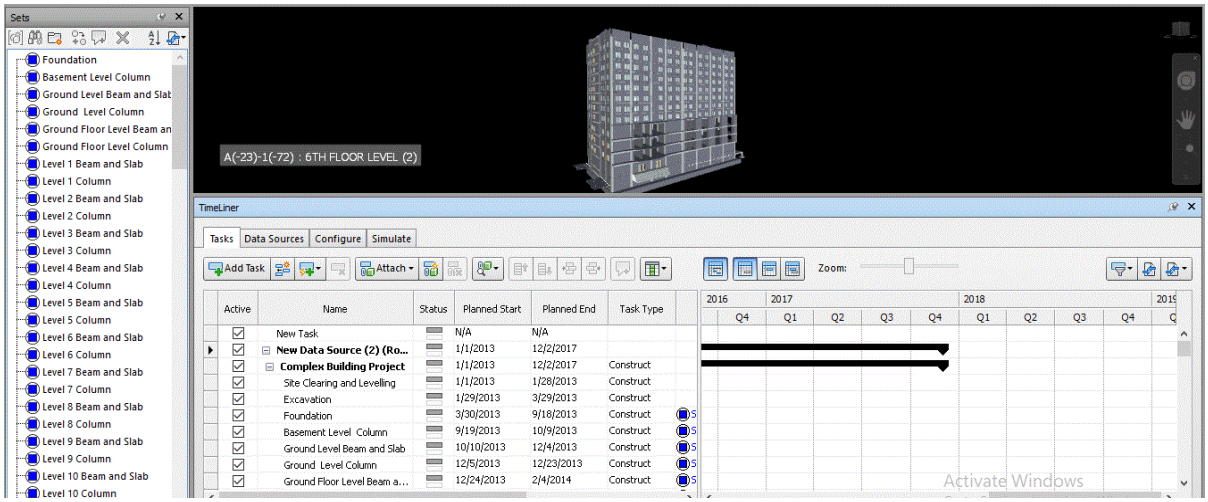

Figure 5: Showing the selection set and timeliner for simulation

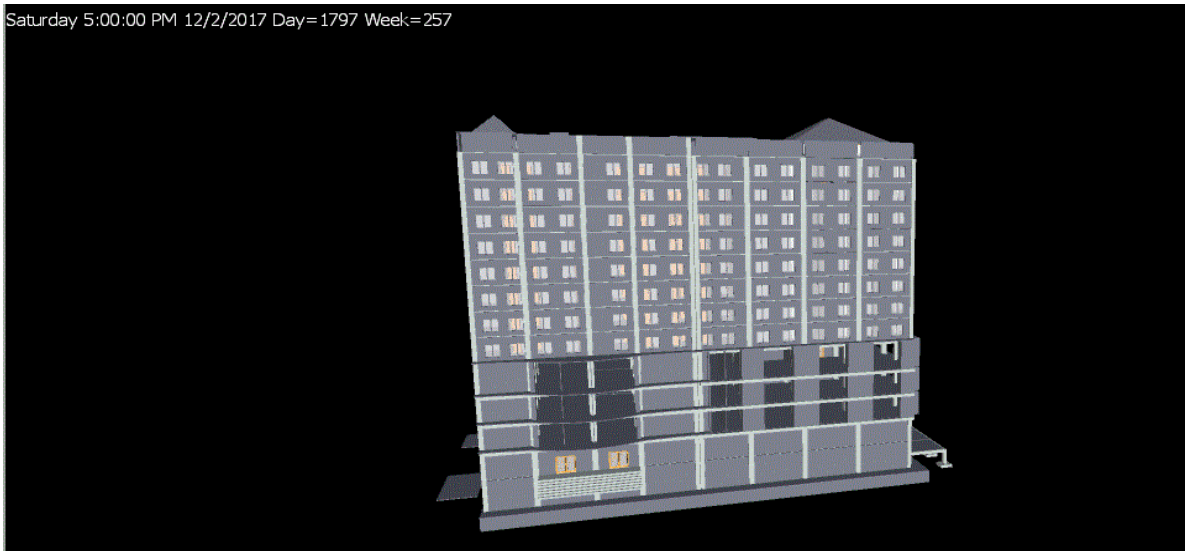

Figure 6: Simulation on day-12.2.17

4.2.2. Labor and material cost results

Labor and material costs are calculated by using Microsoft Project schedule. Results of cost estimating for labor and materials costs are shown in the following figures.

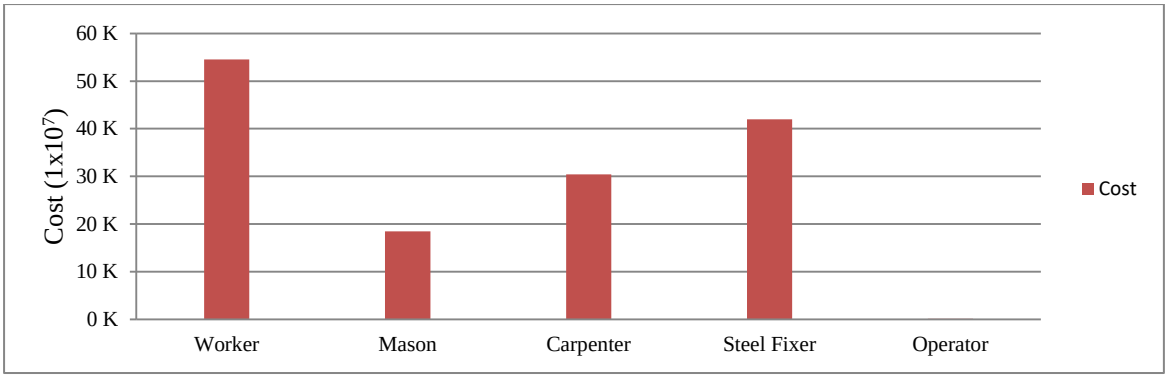

Figure 7: Each Labor Cost for the Building

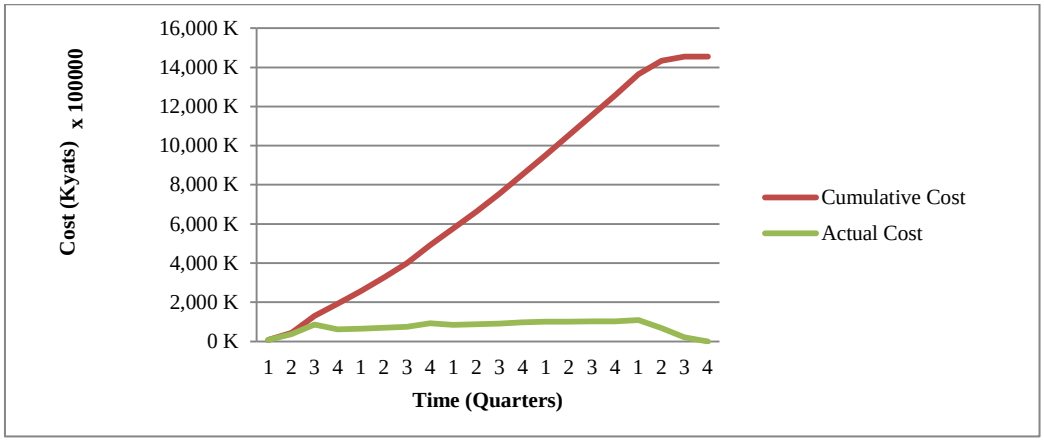

Figure 8: Cumulative Labor Cost for the Building

The figure 7 and figure 8 show the project's labor cost and the cumulative cost for all workers. The total labor cost is about 14544 lakhs.

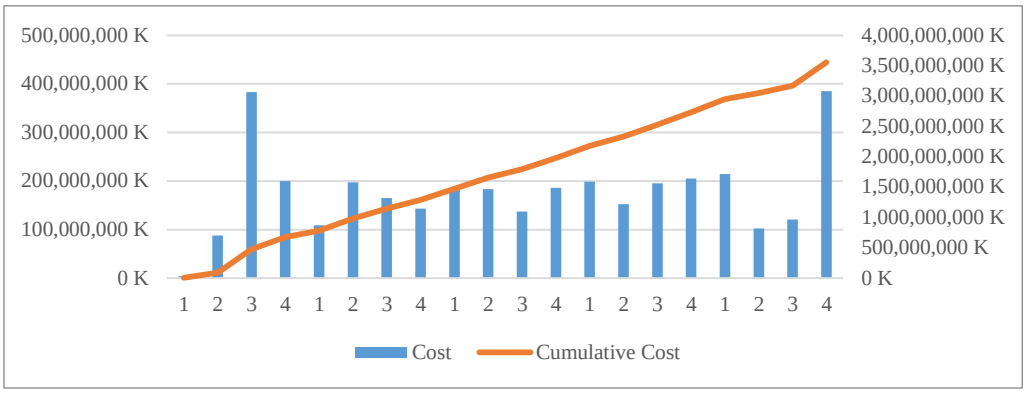

Figure 9: Material Cost for the Building

The above figure shows the project's cumulative cost and cost for materials. The total material cost is about 3,554,7 lakhs.

4.2.3. Cost estimation of building by using BIM method

Cost summary for building is shown in the following calculations.

Material cost	= 3554728345
Machine	= 13976000
Labour cost	= 1454412000
Total direct cost	= 5023116345
Contingency (5%)	= 251155817
Engineer super vision fee (3.15%)	= 158228165
Overall Total	= 5,432,500,327
Say	= 5,432,500,000

So, the total cost of building is 5,432,500,000 from MS Project method.

4.3. Comparison of results by using traditional and BIM methods

4.3.1. Comparison of time consuming in two methods

Figure 10 describes the time schedule of traditional and BIM methods.

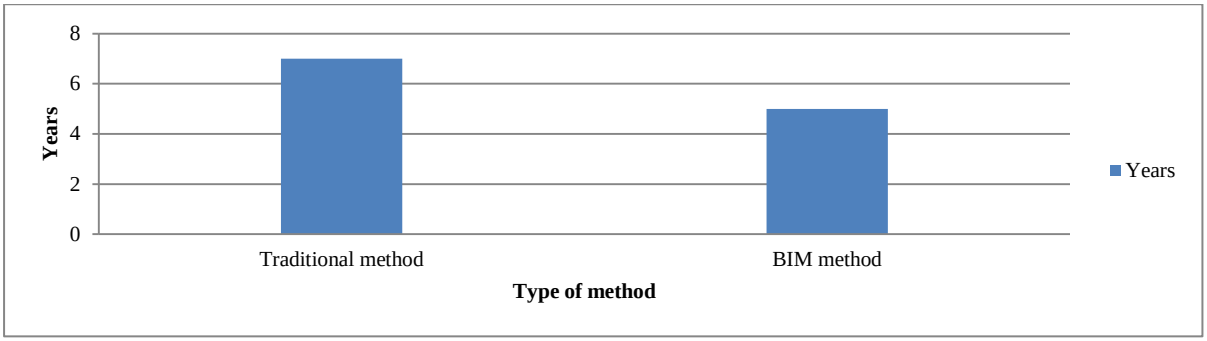

Figure 10: Comparison of time schedules

From the above figure, construction time calculated by using traditional method is longer than by using Microsoft Project 2013.The duration of the construction which is of about seven years according to the traditional method. According to BIM, the duration of the construction is five years. So, it is observed that the difference of these schedules is 30%.

4.3.2. Comparison of cost results obtained from two methods

The following figures describe the results of labor, material, machine and overall costs obtained from two methods.

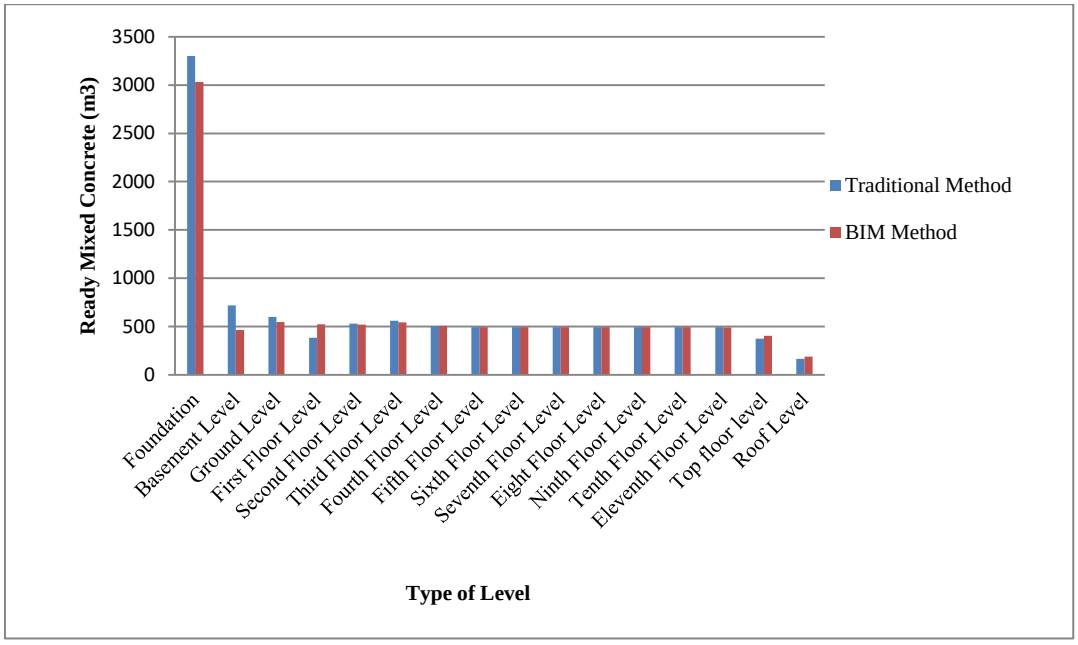

Figure 11: Quantities of ready mixed concrete in each level

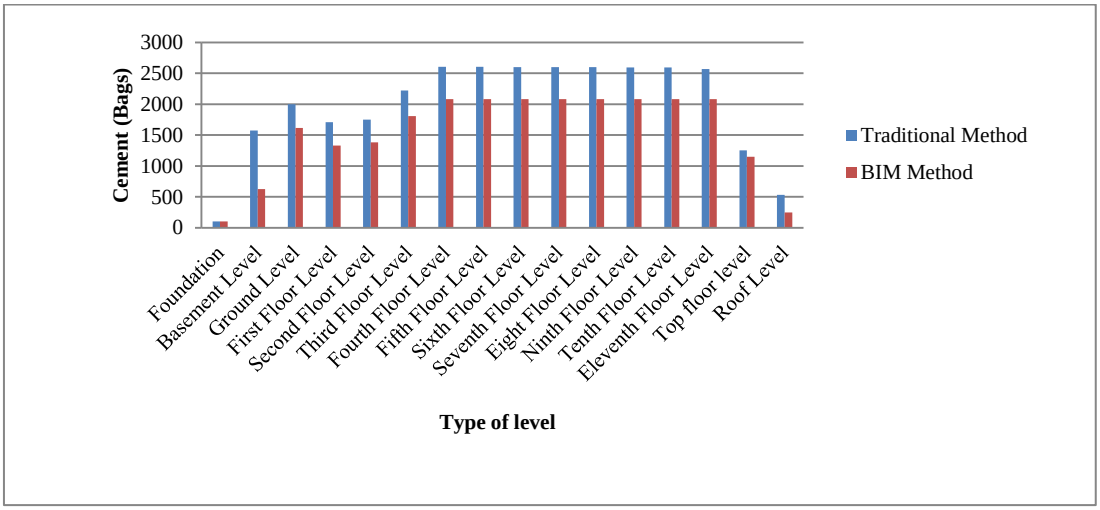

Figure 12: Quantities of cement in each level

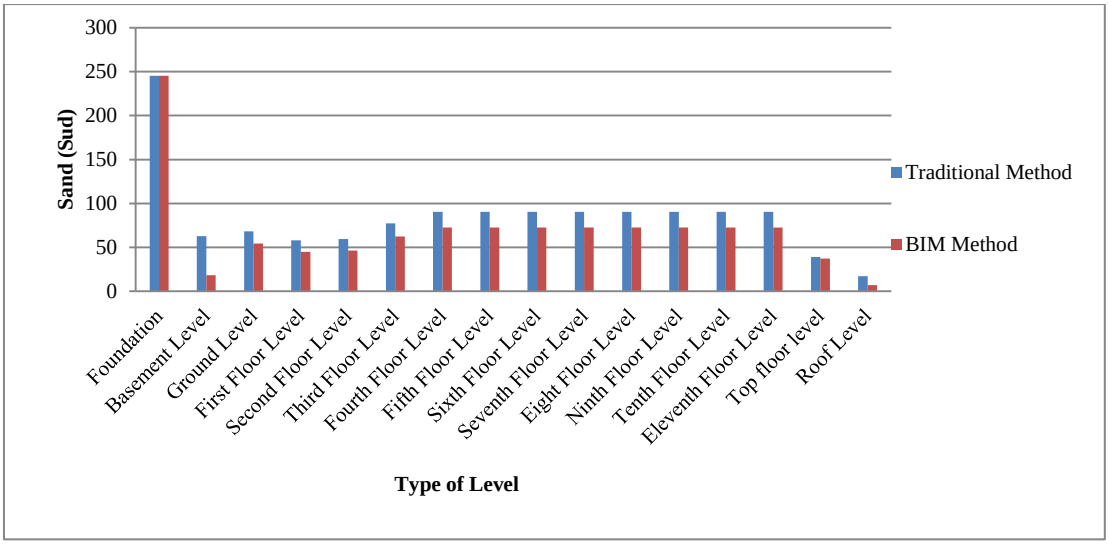

Figure 13: Quantities of sand in each level

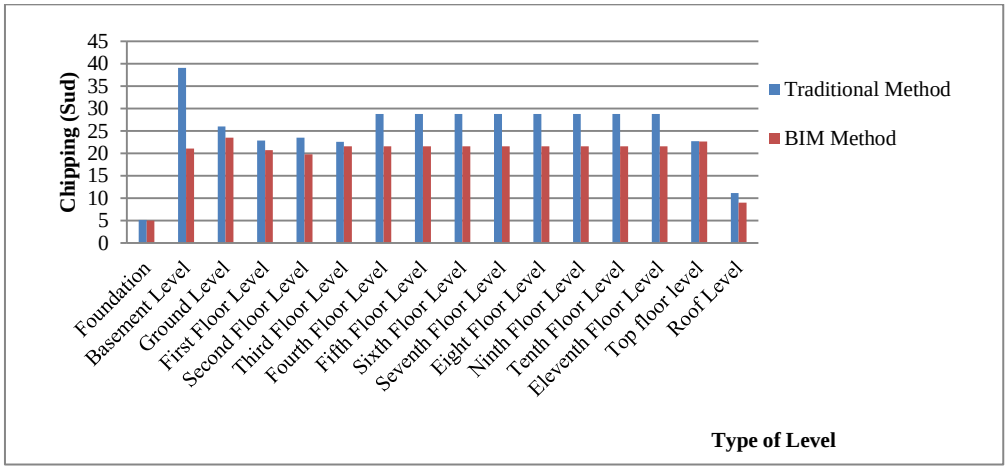

Figure 14: Quantities of chipping in each level

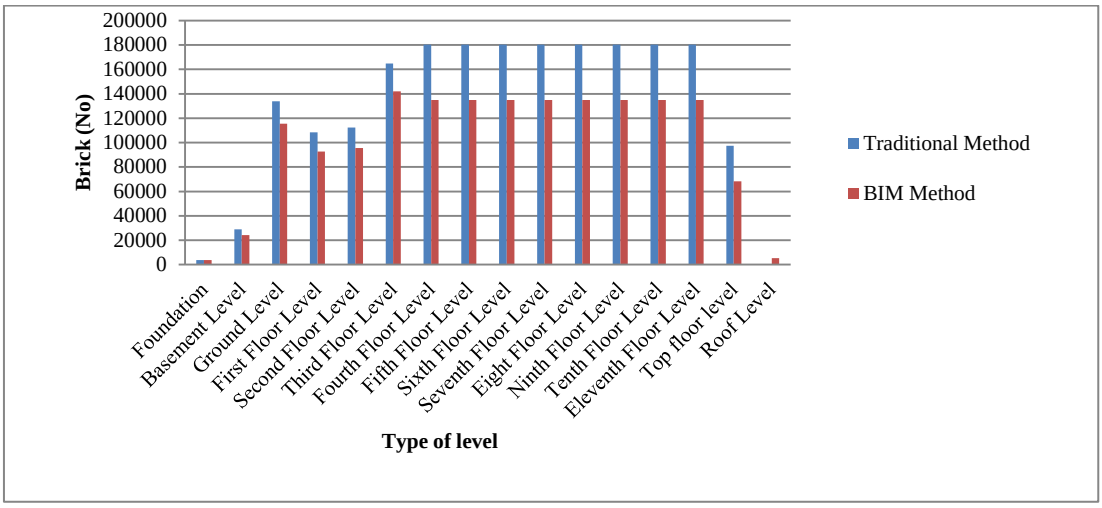

Figure 15: Quantities of brick in each level

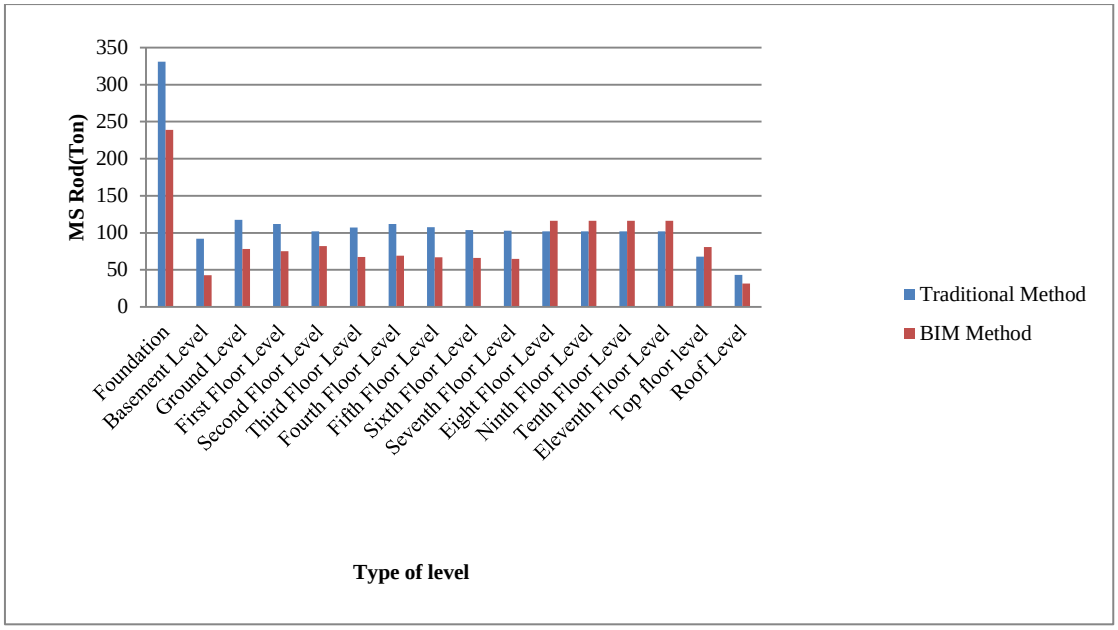

Figure 16: Quantities of MS Rod in each level

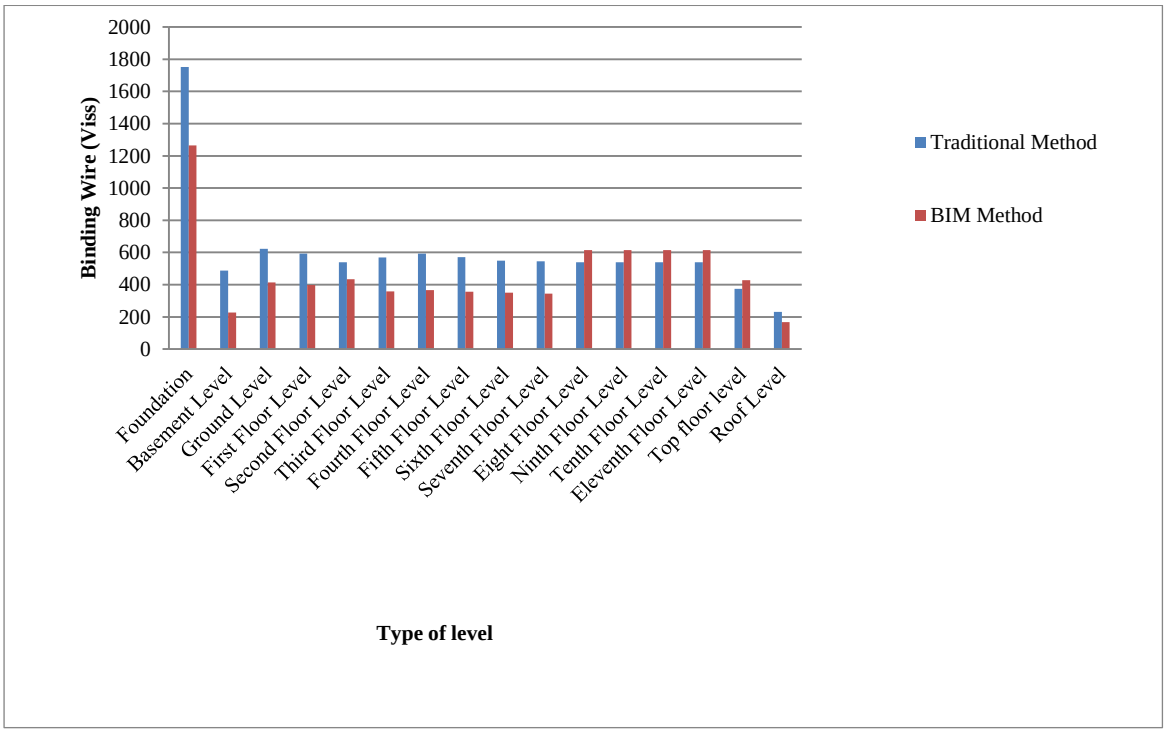

Figure 17: Quantities of Binding Wire in each level

From the above figure 11 to 17 results, it can be found that materials estimated in each level by using BIM method are less than that used in traditional method. So, unnecessary problems are eliminated after coordinating all of members.

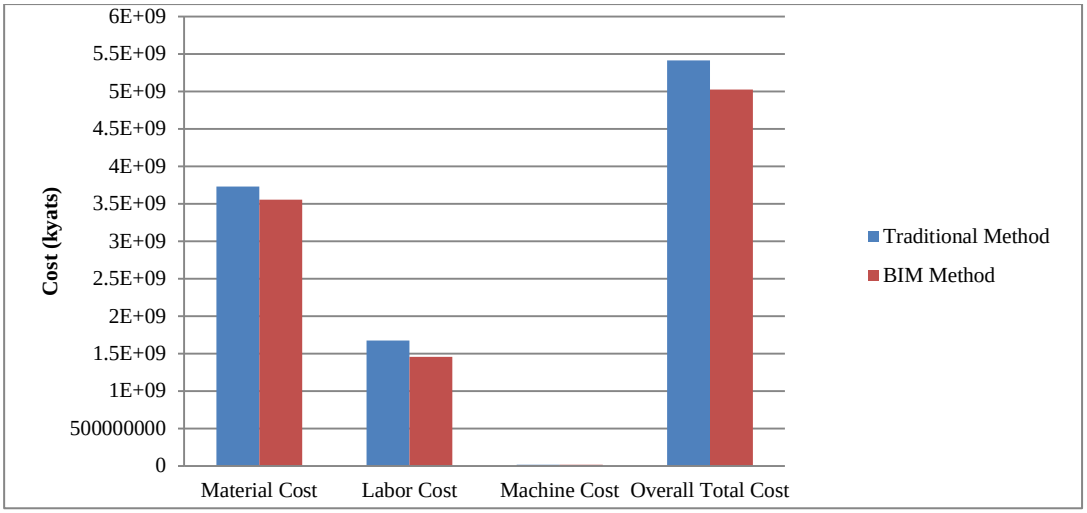

Figure 18: Comparison of two methods

From the results as shown in figure 18, estimated material costs and labor costs by using BIM method are less than that of traditional method. Besides, machine cost is almost equal in both of two methods. Moreover, overall total cost by using BIM method is less than that of traditional method. The difference in cost between these two methods is approximately 10%.

5. Discussion of Results

Based on this study, the following facts are caused time and cost control by applying building information modeling (BIM).

- After doing coordination, the coordinated model is depicted in accordance with phases of construction.
- According to traditional method, the estimated time is seven years and total construction cost is 58571 lakhs.
- After applying BIM, the estimated time is five years and construction cost is 54325 lakhs.
- So, estimated time and cost by applying BIM technique are 30% and 10% less than usual estimation respectively.
- So, application of building information modeling (BIM) leads to control time and cost. In addition, every project participants can do negotiation to eliminate unnecessary clashes during designing periods and see the perfect model since preconstruction stage.
- Then, time and resource scheduling can be done by using Microsoft Project software based on the construction phases.

6. Conclusion

Coordination among various construction teams is well established after detecting clashes by using BIM. This research proposed a simulation-based 3D modelling approach for planning and scheduling of commercial building by integrating simulation and modelling techniques. This approach can be a useful system to avoid

delay in project delivery and hence can also avoid loses incurring due to delays. The case study shows that BIM technology brings many advanced construction management skills to project scheduling, monitoring and even project controls for project team. The duration of the construction that was of about 7 years according to the traditional method. According to BIM, the duration of the construction is five years. So, it was observed that the difference of these schedules were 30%. It can be seen that time control makes cost control. Clients, owners, engineers, contractors, sub-contractors and managers can see the building clearly during the construction planning by using Revit phasing, MS project scheduling and Navisworks simulation. Moreover, it is observed that the difference cost of these methods were 10%. Utilizing BIM technology has major advantages for construction that control time and cost. An accurate building model benefits all members of the project team. It allows for a smoother and better planned construction process that saves time and money and reduces the potential for errors and conflicts. Therefore, nice time and cost control will significantly reduce as well as quality improvement will dramatically achieve in construction.

Acknowledgements

I would like to express heartfelt gratitude to Dr. Nilar Aye Professor and Head of Civil Engineering Department and all of my teachers at Mandalay Technological University for their encouragements and suggestions.

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