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Implementing Advanced Software in Construction Project Management and Control

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Abstract. Construction industry is one of the largest industries in the world and construction project controlling is playing increasingly an important role within the development of construction industry. But unfortunately, poor management and controlling practices, makes cost overrun and construction delays, the most common and unavoidable scenario in the construction projects in Bangladesh. The research aim is to investigate the common practices in construction project controlling and thereafter to implement software-based project control system for the construction project in Bangladesh and to compare the impact of software-based controlling over the traditional manual system. The study concluded software-based controlling with an effective control system8 as a promising tool for construction controlling. The most significant benefits of software-based controlling are continuous and effective tracking of project evolution, scheduling and time Management, costing and cost management, resource allocation, quality inspection, visualization and documentation. It is recommended that software-based controlling should be introduced to construction industry in Bangladesh. Implementing advance software-based project controlling allows planners to maintain the cost of the total project and finish the construction work within time. Therefore, a more reliable and detailed work plan can be obtained which assists the project to complete within prescribed time and budget.

Keywords: Project controlling, Cost overrun, Delay, Quality inspection, Visualization

1. Introduction

The main challenges of any construction project are to finish the project within budget and on schedule while maintaining the quality requirements of the specifications. Meeting these challenges is not achieved without an adequate planning and control system. (Attalla, 1997). Project performance can be improved

if more attention is given to the issue of control.(Avison, Baskerville, & Myers, 2001). There is still an enormous disparity between execution and plan (Allen & Smallwood, 2008). A project control system aims to minimize the gap between project planning and project execution in order to achieve project aims, i.e., cost, time, and content.

The uniqueness of new construction projects and their increasing complexity make them highly challenging, and it is very difficult to control their cost, schedule, and quality of construction. This situation becomes even more complicated in the case of construction projects due to various additional factors, including space constraints, safety regulations, and coordination requirements (Krizek et al. 1996). As various techniques are available to control the cost, schedule, and quality individually, these three indicators of performance are highly interrelated and affect one another. Excessive lack or exceptional excellence in the performance of one aspect (e.g., quality) may both lead to poor performance in another aspect (e.g., cost). It is, therefore, desirable to determine the balanced combination of techniques that provide efficient control for the three aspects, simultaneously, considering the specific environment of construction projects. This scenario can be ameliorated if more attention is given to the control of project. On the other hand, Software based project controlling along with a proper control system can be a promising tool for controlling construction project. Therefore, an efficient and effective controlling system is intensively needed to enhance the project performance and to minimize the risk of cost overrunning and delays. However, implementing an appropriate construction project control system constitutes one of the most arduous challenges for construction project team.

1.1. Problem Description

A questionnaire survey was conducted in to identify the used control technique of different construction firms in their projects. About 52 projects were visited for the survey purpose. The findings are stated below:88

- No proper control system is developed.
- Absence of proper monitoring and performances measure accordance with plan.
- Performances are measured by using manual calculation and methods.
- Almost every project finishing with cost overrun and delay.
- The quality of the construction work is not satisfactory.

2. Research Methodology

This research studied the most common principles of project control techniques and the methodologies of project control. Three approaches were utilized to conduct this exploratory study: a comprehensive literature review, a questionnaire survey and

informal interviews with several construction practitioners.

The processes of the whole research are as following:

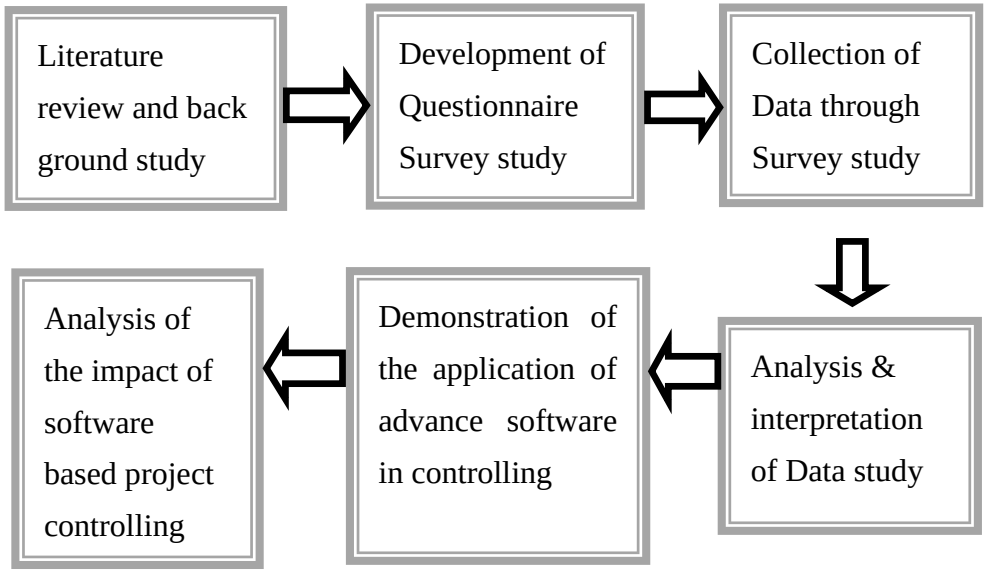


Fig. 1: Flow diagram of Research process.

2.1. Development of Questionnaire Survey

The survey was also aimed at exploring the used control techniques in construction industry in Bangladesh. The survey was conducted in the form of a questionnaire and structured interviews with a number of construction professionals to discuss the questionnaire.

The questionnaire survey process consists of following steps:

1. Questionnaire Development
2. Questionnaire Layout
3. The Survey Data Collection Process

2.2. Questionnaire Development

A comprehensive research of the principles of project controls was conducted in order to develop the questionnaire, whose focus was to investigate the use of control techniques and measure the Performance of construction projects. The developed questionnaire resulted in a set of practical, used and objective questions. The questionnaire utilized three core functions as the basis for measuring project performance. These three functions were cost, schedule and quality. The questions were structured in such a way as to avoid any subjective answers as much as possible. The questions were further structured to obtain quantifiable data that could be used to measure the cost, schedule and quality performances. The table 1 shows

the reviewed literatures.

Table 1: Literature source

Cost control technique	(Ahmed & Sobuz, 2019; Boukas, Shi, & Agarwal, 2000; Chang & Peng, 1972; Deepika, Anandakumar, & Krishnamoorthy, 2016; Kakosimos & Kladas, 2011; Mansor, Wahab, Hamid, & Kamarudin, 2019; Rodriguez & Emadi, 2007; Slegers, Kyle, & Costello, 2006; Tang, Hu, Jiang, & Lu, 2019)
Cost overrun	(Ahmed, 2018, 2019a, 2019b; Ahmed, Islam, Hoque, & Hossain, 2018; Ali & Kamaruzzaman, 2010; Alinaitwe, Apolot, & Tindiwensi, 2013; Enshassi, Al-Najjar, & Kumaraswamy, 2009; Islam, Nepal, Skitmore, & Kabir, 2019; Rahman, Memon, & Karim, 2013; Sheikhkhoshkar, Mir, Rahimian, & Kumar, 2019)
Scheduling technique	(Ballesteros-Perez, Elamrousy, & González-Cruz, 2019; Elazouni & Gab-Allah, 2004; Galloway, 2006; Harmelink & Yamin, 2001; Heon Jun & El-Rayes, 2011; Kakigano, Miura, & Ise, 2012; Li & Willis, 1992; Paz, Rozenboim, Cuadros, Cano, & Escobar, 2018; Sampson & Weiss, 1993; Steyn, 2001; Westney, 2017)
Project delays	(Aibinu & Odeyinka, 2006; Chougule, Mudgal, & Patil, 2019a, 2019b; El-khalek, Aziz, & Morgan, 2019; Fugar & Agyakwah-Baah, 2010; Golparvar-Fard, Hoiem, Lin, Han, & Degol, 2019; Ingersoll & Dvortcsak, 2019; Kikwasi, 2012; Koushki, Al-Rashid, & Kartam, 2005; Vereau, Rojas, Aderhold, Raymundo, & Dominguez, 2019)
Quality control technique	(Chin, Lee, & Lee, 2000; Cody III & Borgen, 1999; Gough et al., 2011; Hack1 & Ledolter, 1992; Jie, 2003; Martin, Tapsell, Batterham, & Russell, 2002; Van Esch et al., 2002)
Reworks	(Aiyetan, 2013; Balouchi, Gholhaki, & Niousha, 2019; Hossain & Chua, 2014; Hwang, Shan, & Tan, 2016; Oyewobi & Ogunsemi, 2010; Ye, Jin, Xia, & Skitmore, 2014)
Earned Value Analysis	(Eirgash, 2019; Eshghi, Mousavi, & Mohagheghi, 2019; Magar, 2019; Waris, Khamidi, & Idrus, 2012)

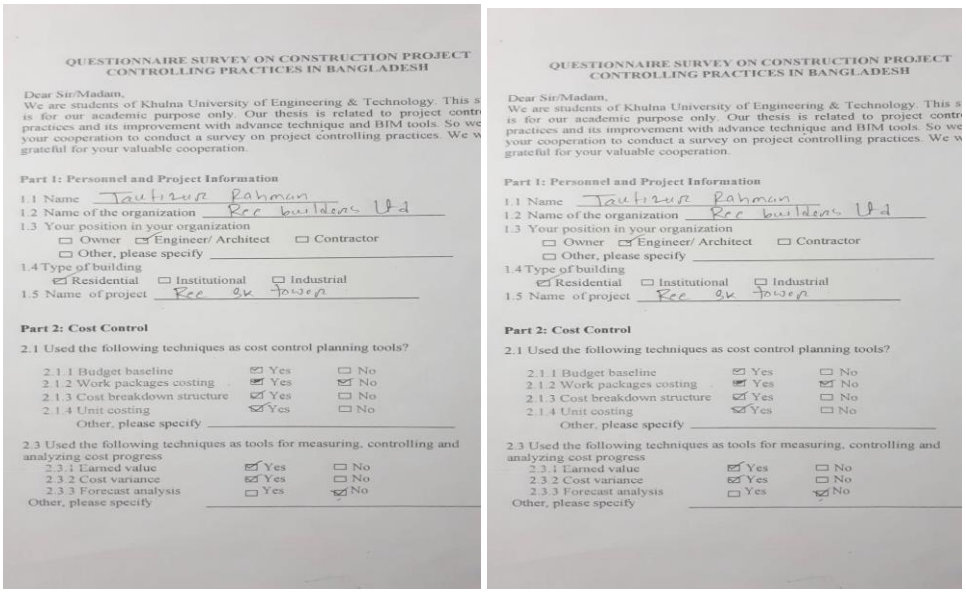
2.3. Questionnaire Layout

All questions were of the forced-response variety, Yes or No, in order to reduce the interview time and encourage more people to participate. Space was also provided, so that any additional data could be obtained in a free format. The questionnaire

focused on the performance of three main control functions: cost, schedule and quality. These functions are considered by most construction professionals the main indicators of the overall project performance.

2.4. The Survey Data Collection Process

Initially, the plan was to collect the data using the telephone and facsimile as the communications tools. The advantage of using this procedure was to encourage the project participants to complete the questionnaire at their own convenience. The data received through this method, however, was insufficient and there were some obvious misunderstanding of some questions. Therefore, interviews were conducted on a one to one basis with the project manager or the project administrator of the organization- In these interviews, the questions were utilized as a vehicle to direct the interviewees towards different aspects of construction. In some interviews, more than one project was discussed and examined. However, a separate questionnaire was completed for each individual project. The need for confidentiality of certain date provided for this research was recognized. The participant companies and individuals were assured this confidentiality by means of a letter directed to them (copy of the letter is included). This procedure assisted the research in obtaining reliable project data without compromising the confidentiality of proprietary data. The firms also became comfortable entrusting this data to the researcher.



QUESTIONNAIRE SURVEY ON CONSTRUCTION PROJECT CONTROLLING PRACTICES IN BANGLADESH

Dear Sir/Madam,
We are students of Khulna University of Engineering & Technology. This s
is for our academic purpose only. Our thesis is related to project contr
practices and its improvement with advance technique and BIM tools. So we
your cooperation to conduct a survey on project controlling practices. We w
grateful for your valuable cooperation.

Part 1: Personnel and Project Information

1.1 Name Jaufizur Rahman
1.2 Name of the organization Ree buildcons Ltd
1.3 Your position in your organization
☐ Owner ☑ Engineer/ Architect ☐ Contractor
☐ Other, please specify
1.4 Type of building
☑ Residential ☐ Institutional ☐ Industrial
1.5 Name of project Ree 9x Tower

Part 2: Cost Control

2.1 Used the following techniques as cost control planning tools?

2.1.1 Budget baseline	☑ Yes	☐ No
2.1.2 Work packages costing	☑ Yes	☑ No
2.1.3 Cost breakdown structure	☑ Yes	☐ No
2.1.4 Unit costing	☑ Yes	☐ No

Other, please specify

2.3 Used the following techniques as tools for measuring, controlling and analyzing cost progress

2.3.1 Earned value	☑ Yes	☐ No
2.3.2 Cost variance	☑ Yes	☐ No
2.3.3 Forecast analysis	☐ Yes	☑ No

Other, please specify

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Other, please specify

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2.3.1 Earned value	☑ Yes	☐ No
2.3.2 Cost variance	☑ Yes	☐ No
2.3.3 Forecast analysis	☐ Yes	☑ No

Other, please specify

Fig. 2: Site survey questionnaire sample document.

2.5. AutoCAD 2D plan from the existing project

The drawings or floor plans were collected as 2D CAD drawings (dwg file) from NANNU PROJECT, Dhaka. The floor plan is given below:

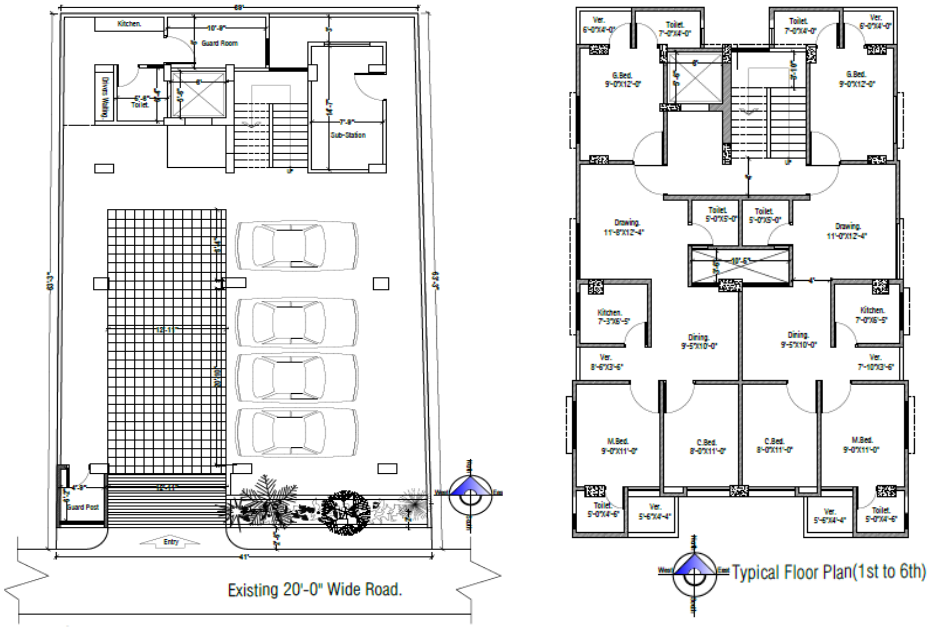


Fig. 3: Typical Floor plan of an Existing Project.

2.6. Cost Control Techniques

Date : JANUARY 10, 2017

PROJECT : SEVEN (07) STORIED APARTMENT BUILDING.
AT PLOT NO.48, ROAD NO # 2, BLOCK# C,
AFTABNAGAR, DHAKA.

Subjects: Cost Estimation of Construction Works.

Sl No	Description of Works	Amount Taka
1.	Cost Estimation of Architectural, Structural, Electrical & Plumbing Works of Seven (07) Storied Apartment Building.	22,379,974
	Grand Total Amount =	22,379,974

IN WORD: TWO CRORE TWENTY THREE LAC SEVENTY NINE THOUSAND NINE HUNDRED SEVENTY FOUR ONLY.

Fig. 4: Existing project Manual Report.

From the existing project we collect the estimation data that was used for the project. The project estimation was done by hand calculations by the help of unit costing. No advance software was used for making the cost estimation. For this research we estimated the project cost excluding electrical, plumbing, mechanical and sub-structures due to lack of data and shortage of time. Information models are used to generate accurate quantity take-offs and cost estimates at a faster rate of modelled

materials.

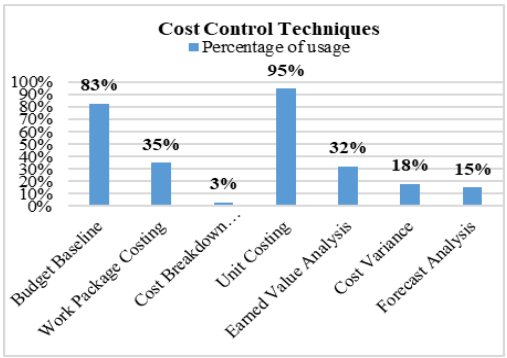
2.7. Structural and Architectural Design by Autodesk Revit

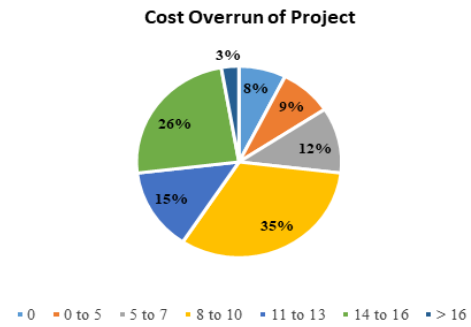
From 2D CAD we import the dwg file to Autodesk Revit for making the Structural Design of the existing project. Using the dwg format we recreated analytical model in Revit.

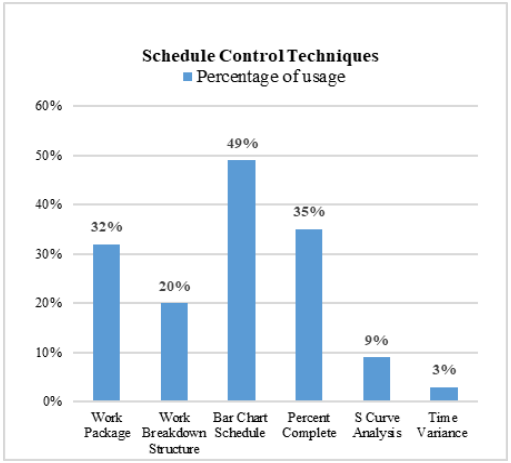
Fig. 5: Architectural Model of the project by Revit.

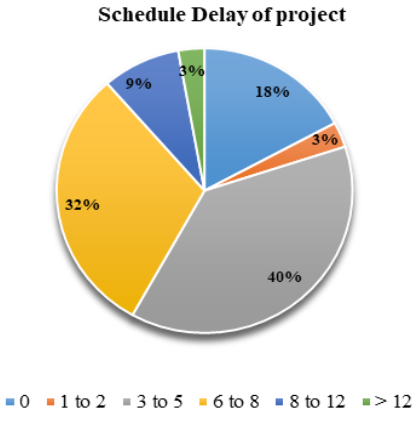
3. Result

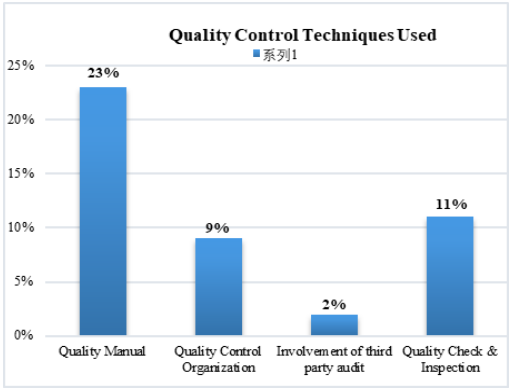
The analysis of survey data from which we got the used project control techniques for cost, schedule and quality in Bangladesh and the percentage of their usages. The percentage cost overruns and delays in construction project is also shown.











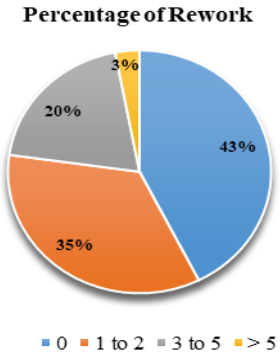
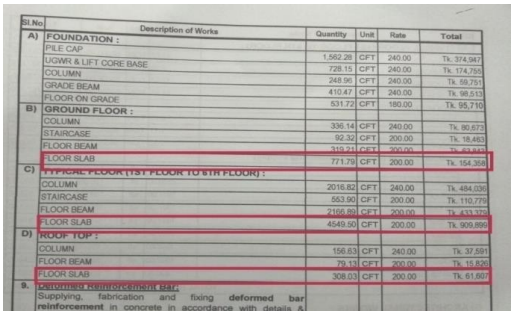


Fig. 6: Analysis of survey data in Bangladesh.

3.1. Costing and Cost Management

From the existing project we found the total cost manual of the project which is done by unit costing. Manually the total concrete work of floor slab is around 1150000 BDT which was from 1st floor to 6th floor. Quantity of work taken off using Revit is around 1088000 BDT, **which is 3.07% less than manually calculated value.**

By adopting advance software approach help to take managerial decision in planning, scheduling, tendering, estimating with visual analysis. Easily help to justify PM & contractor tender estimation.



Sl.No	Description of Works	Quantity	Unit	Rate	Total
A)	FOUNDATION :				
	PILE CAP	1,562.28	CFT	240.00	Tk. 374,947
	UGWR & LIFT CORE BASE	728.15	CFT	240.00	Tk. 174,756
	COLUMN	248.96	CFT	240.00	Tk. 59,751
	GRADE BEAM	410.47	CFT	240.00	Tk. 98,513
	FLOOR ON GRADE	531.72	CFT	180.00	Tk. 95,710
B)	GROUND FLOOR :				
	COLUMN	336.14	CFT	240.00	Tk. 80,673
	STAIRCASE	92.32	CFT	200.00	Tk. 18,463
	FLOOR BEAM	319.21	CFT	200.00	Tk. 63,843
	FLOOR SLAB	771.79	CFT	200.00	Tk. 154,358
C)	TYPICAL FLOOR (1ST FLOOR TO 6TH FLOOR) :				
	COLUMN	2016.82	CFT	240.00	Tk. 484,036
	STAIRCASE	563.90	CFT	200.00	Tk. 110,779
	FLOOR BEAM	2166.80	CFT	200.00	Tk. 433,360
	FLOOR SLAB	4549.50	CFT	200.00	Tk. 909,899
D)	ROOF TOP :				
	COLUMN	156.63	CFT	240.00	Tk. 37,591
	FLOOR BEAM	79.13	CFT	200.00	Tk. 15,826
	FLOOR SLAB	308.03	CFT	200.00	Tk. 61,607
9.	Deformed Reinforcement Bar: Supplying, fabrication and fixing deformed bar reinforcement in concrete in accordance with details &				

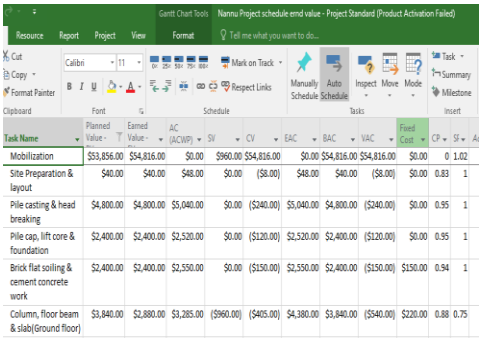
Family and Type	Volume	Cost	Total Cost
Floor: 6" concrete	748.52	200	149704
Floor: 6" concrete	734.2	200	146840
Floor: 6" concrete	734.2	200	146840
Floor: 6" concrete	734.2	200	146840
Floor: 6" concrete	734.2	200	146840
Floor: 6" concrete	734.2	200	146840
Floor: 6" concrete	734.2	200	146840
Floor: 6" concrete	290.89	200	58178
		Total=	1088922

Fig. 7: Justifying PM & contractor tender estimation through Autodesk Revit.

3.2. Earned Value Analysis

EVA is an industry standard method of measuring a project's progress at any given point in time, forecasting its completion date and final cost, and analyzing variances in the schedule and budget as the project proceeds.

Earned Value analysis is done by MS Project which is an advance software used in our research. By using MS Project we can enter Actual Cost, Planned Value, Earned Value, Schedule Variance, Cost Variance, Budget Base Actual Cost for each segment of total construction work. From this input we can enable to see the total project progress in a glance, which help us to minimize the cost overrun and construct the project in time.



Task Name	Planned Value	Earned Value	AC (ACWP)	SV	CV	EAC	BAC	VAC	Fixed Cost	CP	SI
Mobilization	$53,856.00	$54,816.00	$0.00	$960.00	$54,816.00	$0.00	$54,816.00	$54,816.00	$0.00	0	1.02
Site Preparation & layout	$40.00	$40.00	$48.00	$0.00	($8.00)	$48.00	$40.00	($8.00)	$0.00	0.83	1
Pile casting & head breaking	$4,800.00	$4,800.00	$5,040.00	$0.00	($240.00)	$5,040.00	$4,800.00	($240.00)	$0.00	0.95	1
Pile cap, lift core & foundation	$2,400.00	$2,400.00	$2,520.00	$0.00	($120.00)	$2,520.00	$2,400.00	($120.00)	$0.00	0.95	1
Brick flat soiling & cement concrete work	$2,400.00	$2,400.00	$2,550.00	$0.00	($150.00)	$2,550.00	$2,400.00	($150.00)	$150.00	0.94	1
Column, floor beam & slab(Ground floor)	$3,840.00	$2,880.00	$3,285.00	($960.00)	($405.00)	$4,380.00	$3,840.00	($540.00)	$220.00	0.88	0.75

Fig. 8: Earned Value Analysis using MS Project.

3.3. Scheduling and Time Management

A project schedule is a strategic and an important tool in a project manager's portfolio for guiding a project successfully to its target completion date. For simple projects, a project schedule is basically a timeline or calendar which lists tasks and activities with expected start and finish dates.

For our existing project we use advance software like MS project we can

visualize the total working progress of each segment of the construction work easily. We input the resource name of each task. Like Site preparation & Layout, Pile casting are belongs to the Sub Contractor of the project. It becomes easier to figure out the eligible person of the individual segment of construction work.

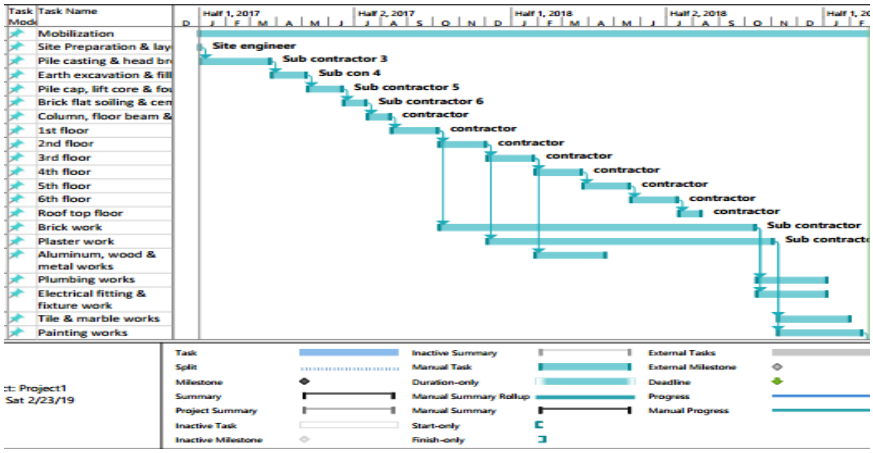


Fig. 9: Project Scheduling by MS Project.

3.4. 4D Construction Simulation & Better Visualization

By using Naviswork for the simulation of total project which is normally known as built before built. We convert the Autodesk Revit file to the Naviswork and add the schedule from MS Project to the Naviswork timeliner. These processes show us the actual progress of a project by time to time before the construction. So that it can minimize the error and the cost overrun and delay of a project.

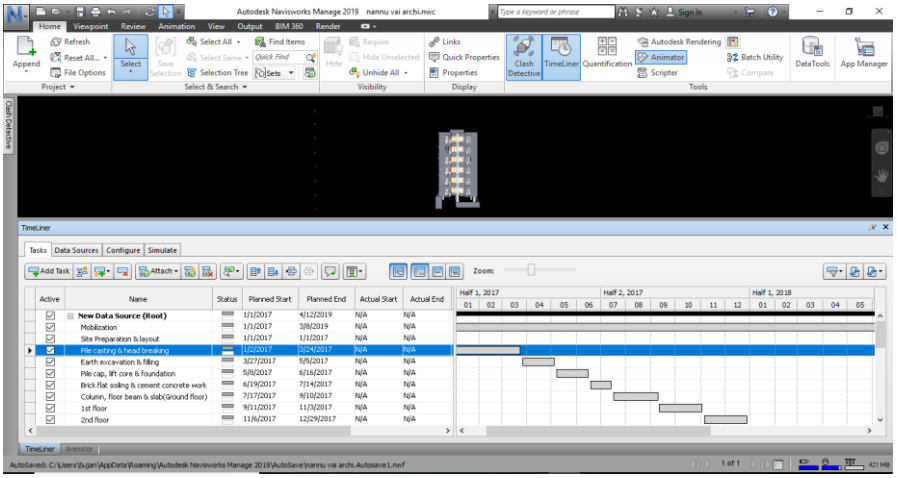


Fig. 10: 4D Simulation through Naviswork.

3.5. Real-time Project Status

Using BIM 360, the project team can communicate to each other with real time

updates from the site. The central management can overview the entire project by regular updates from site engineer. Site engineer will inspect the work and find if there is any occurrence happening. For example, if there is any fault in the construction of stairs, the inspector can create an issue in BIM 360 field app and also attach real time image to the issue.

3.6. Faster and Automated Quality Inspection

BIM 360 Field ensures better monitoring of the quality of work according to the standards and provides conformity or non-conformity report instantly by checklist observation list.

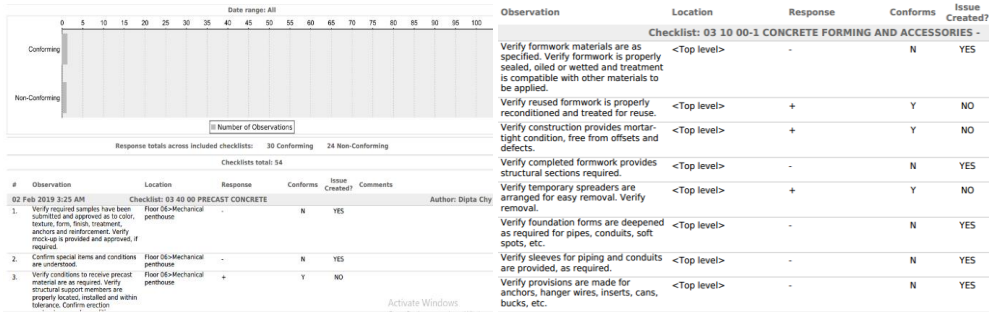


Fig. 11: Conformity or Non-conformity report by BIM 360 Field.

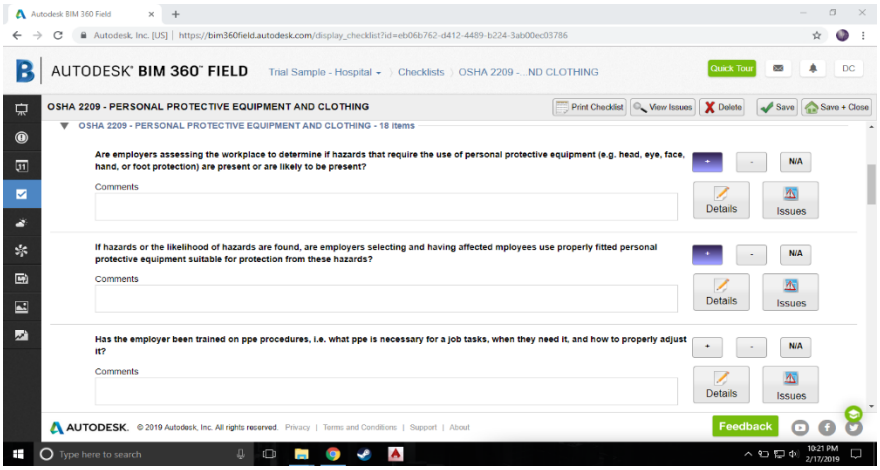


Fig. 12: Occupational Safety & Health Administration (OSHA) provided observation checklist in BIM 360 Field.

BIM 360 Field is a quality checking online base software. The company's QA/QC program is developed by utilizing the data in BIM 360 Field software to identify the recurring issues from project to project, or even from region to region. Capture the root cause of issues within BIM 360 Field software during the course of a project, and review the results at project completion.

It will help perfect quality checking for a project. We can easily document the observation checklist by using BIM 360 Field and get the result instantly.

3.7. Tracking of Project Evolution

Use of MS Project tracking grant chart, ensure the faster and accurate tracking of project evolution & illustrate the present condition of the activities.

Tracking of project evolution using MS Project, Shows the percentages of work done of each activities of project and indicate whether the works completing in time or not.

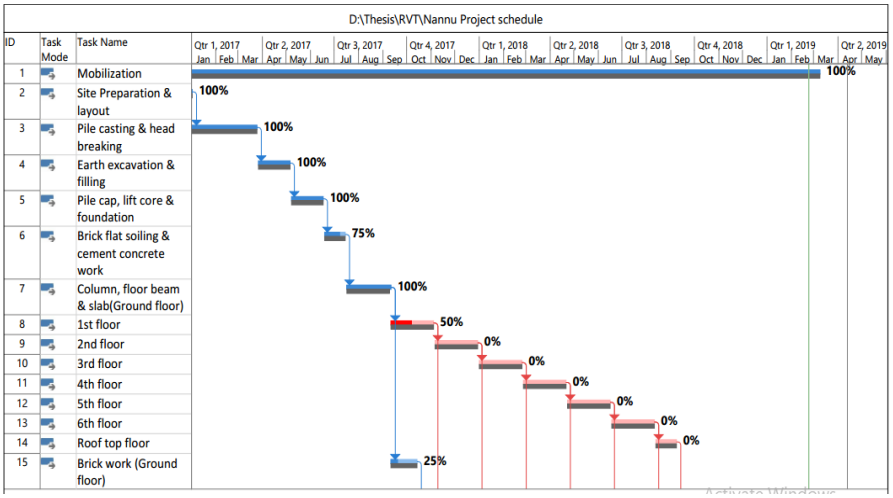


Fig. 13: Tracking of project evolution using MS Project.

4. Conclusion

The resulting work will allow the design team to construct a sound building model with high level of constructability than traditional and construction manager to assess project's performance in terms of schedule, cost and quality progress of the project virtual environment and budget if we use advance software base project controlling.

Finally, from the research the following concluding remarks can be made:

1. Quantity of work taken off using Autodesk Revit is 3.07% less than manually calculated value.
2. Work breakdown enables early start of works and concurrent working which reduce the project duration about 9% for this particular project.
3. BIM 360 Field ensures better monitoring of the quality of work according to the standards and provides conformity or non-conformity report instantly by checklist observation list.
4. Tracking of project evolution using MS Project, Shows the percentages of work done of each activities of project and indicate whether the works

completing in time or not.

5. Recommendation for Further Research

1. It will be more effective if the quality standards can be checked by the rules provided by the government incorporated with 3D model. (i.e. ISO 9000)
2. The research cannot be conducted with the merged with both the Scheduling with the 3D model. So it will be more effective if Earned Value Analysis of MS project can be incorporated with 3D model.

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