International Journal of Engineering Research and Technology. ISSN 0974-3154 Volume 10, Number 1 (2017)

Cost Control Technique Using Building Information Modeling (BIM) For a Residential Building

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Abstract: ***Main essence of the success of a construction project is information. The degree of accuracy and detailing provided at each and every stage of a construction project is very important. To achieve this, till today many information techniques are used by construction companies viz. MIS, ERP etc. Now there is a new technology is becoming popular in construction industry is BIM i.e. Building Information Modeling. BIM is a combination of VDA i.e. visualization design application & IPD i.e. integrated project design. Integrated project approach helps to improve bonding between different parties involved in a project and Visualization design approach improves project understanding and helps for clash detection at early stage of a project. The common issues faced by construction industry are time delays & cost overruns. This problem mainly because of incorrect and insufficient inputs and lack of information sharing. BIM will definitely help to overcome these conditions in construction industry. This paper is going to concentrate on the application of 5D BIM for cost control of a project. This tool facilitate with different cost related activities such as scheduling & monitoring of cost of a project.***

Keywords: Building information modeling, VDA, IPD, Cost control, 3D, 4D, 5D

I. INTRODUCTION

In order for the construction industry to achieve real gains in productivity, new work habits and workflows must be adopted. Fortunately, new tools and technologies can help with this process.

By storing and managing building information as databases, building information modeling solutions can capture, manage, and present data in ways that are appropriate for the building team member using that data. Because the information is stored as a database, changes in that data that so frequently occur during design can be logically propagated and managed by the software throughout the project life cycle.

BIM has many uses that can be of value for the user. The uses usually vary depending on the project delivery method and the timing of the user's initial involvement in a project. BIM can be a useful tool throughout the entire project. The construction uses includes, but not limited to: visualization of design, coordination between trades, visualization of construction sequences and extraction on quantity information from models.

Pertaining to the first use mentioned above, visualization is one of the main construction uses of BIM. Unlike the construction documents typically found at the job site, the BIM allows every member of the construction team to see the relationship between different elements of Construction in one place. The BIM Model is extremely helpful for understanding how different elements fit together. With this information in one place one is able to visualize each element which allows for more efficient communication, construction, and more accurate estimating. Another set of uses of BIM is Spatial Coordination, Clash Detection and Collision Detection. Early communication and coordination between trades potentially has the greatest impact on the project's cost and schedule. The ability to visualize the relationships between each construction element prior to starting construction allows for early procurement of materials, and with this information shop fabrication of equipment and the placement of each trade's work one could avoid clashing with that of the other trades and overall reduce cost and increase productivity.

There is also the Scheduling and 4D modeling use of BIM. The 4D Model is created when the element of time is added to the 3D Model by creating a link with the model and the critical path method schedule. This can be done using a single application or by combining model collaboration software with standard scheduling software. The 4D Model is an essential tool to the BIM Process because it identifies collision between construction activities. 4D Modeling is used to identify activities that are out of sequence, flow of trade work and relationships between construction equipment. The 4D Model can also be useful for analyzing different construction scenarios and determining the most efficient sequence of work and with this information one can tell whether the work is on time or whether the project is behind.

The Estimating and 5D modeling use of BIM entails using the data stored in the BIM to extract information and transfer that information into construction estimates. As the design progresses or changes occur, these estimates can be quickly updated based on information derived from the BIM model. There are many methods to link model quantities to estimating systems, but each company determines which methods suits them the best based on its internal estimating practices.

More ever now it's a need of a construction industry to integrate BIM technology with a cost control factor.

II. LITERATURE REVIEW

Hyunjoo Kim & Francois Grobler done the cash flow analysis using BIM, & they want to put forward with a

good thought of BIM coordination ie. contractors should be provided with BIM Model at the time of tendering only. So, they can also prepare their cash flow and can decide whether to accept the project or not, which can be a difficult process using traditional 2D drawing.

Amol Metkari & Dr. Attar studied on the application of the BIM in the process of project management & how it helps in time and cost saving of project.

A study of different cost control techniques is done by Arthi & ShashiKumar, & they reached a conclusion that Earned Value technique is the powerful cost control technique.

Ye Wen researched on cost control of construction project based on the theory of lean construction & BIM. He says that integrating lean construction technology & BIM can give better cost control in construction.

Zhao & Wang gave a comparison study of using traditional cost estimating software & BIM for construction cost control. Result from their study says, that BIM has some limitations to full atomization for cost control purpose, still they do not neglect the importance of BIM in whole.

One more research helped me in my work & ie. done by Emad Elbeltagi, Ossama Hosny, Mahmoud Dawood, & Ahmed Elhakeem. It is about BIM based cost estimation & monitoring for building construction. They feel that BIM visualization is a powerful tool which enables effective cost control.

III. PROBLEM STATEMENT

Timely & accurate feedback of actual cost enables project managers to take appropriate corrective actions that would minimize cost overrun in a timely manner. As project progress a process of construction monitoring & control gets more sophisticated, complex & challenging due to the huge amount of information that need to be measured & analyzed.

An effective monitoring & control system should include a data management system to cover the large sets of data associated with the different project components.

Accordingly developing an integrated visualized cost estimate & control models to track construction projects performance would be an important advance in the area of construction project monitoring & control.

IV. OBJECTIVES

To develop the structural BIM model and architectural BIM model of building of a case undertaken for research study.

This research aims to introduce a model that integrates quantity estimation & cost of each element of building with the advances in data visualization to provide decision makers with a tool for better monitoring and control of their construction projects.

To compare the traditional cost estimation and cost control system with BIM based cost estimation and cost control system.

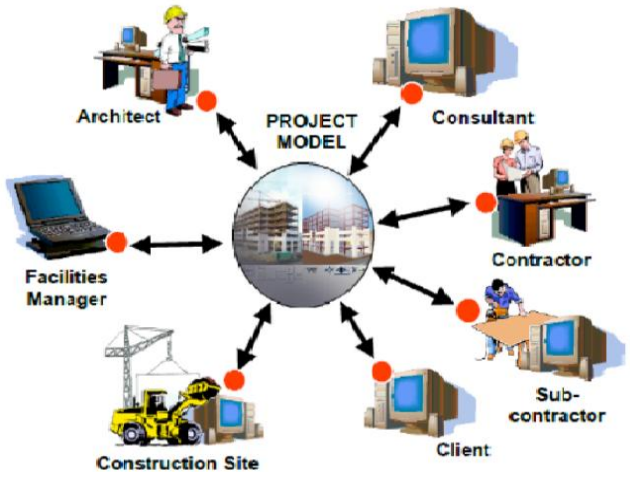
To compare the actual cost variance with BIM based cost and cost of project with traditional method (from 2D drawings).

To create a simulated view of cost control to enhance decision making over cost variances.

V. THEORY OF BIM

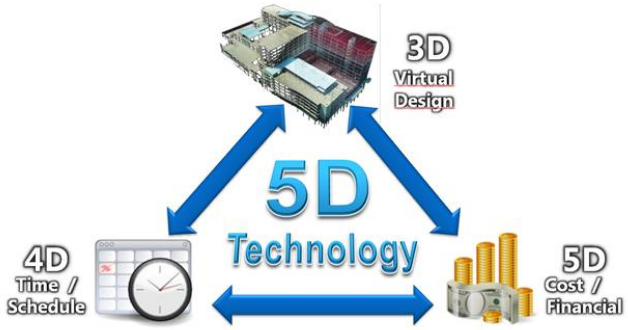
A] DEFINITION OF BIM

There is no universal definition of BIM and definitions continue to evolve. However BIM is not software. It is much more than 3D-modelling. It is a business process, and therefore you cannot go out and "buy BIM". BIM is a digital representation of the physical and functional characteristics of a facility in order to work out problems, and simulate and analyze the potential impacts. BIM is both technology and a new way of working, i.e. tools which improve delivery of outputs, and implementation of a collaborative culture.BIM is about information, communication and delivery, with greater emphasis on "information". BIM is a shared knowledge resource, forming a reliable basis for decisions during a facility's lifecycle.



B] BIM CAN BE DEFINED IN TERMS OF THE MULTI-DIMENSIONAL FUNCTIONS.

- 3D – parametric design models and space programming tools, i.e. use of spatial dimensions of width, length and depth to represent an object, which enables 3D visualisations and walkthroughs, clash detection and coordination, and item scheduling.
- 4D – this is 3D plus "time". The ability to link the individual 3D parts or assemblies with the project delivery timeline, including scheduling of resources and quantities, and modular prefabrication to assist tracking and project phasing. In addition to collaboration, 4D simulations function as communication tools to reveal potential bottlenecks. Both planners and contractors can use BIM onsite for verification, guidance and tracking of construction activities.
- 5D – this is 4D plus "cost". Integration of design with estimating, scheduling and costing, including generation of Bills of quantities, and derivation of productivity rates and labour costs.



C] THE BENEFITS OF BIM

- Enhanced information exchange and added document control, including sharing models, meeting minutes, project images etc.
- BIM aids design of sustainable facilities. Environmental Performance Modeling entails analytical and simulation technologies. Simulations can be used to find the ideal building orientation, and to calculate the potential return in energy and the feasibility of each system, until performance is optimized.
- Interoperability, i.e. the ability to share data across applications.
- Elimination of unbudgeted changes on projects.
- Cost estimation accuracy to within 3%.
- Up to 80% reduction in time taken to generate a cost estimate.
- Clash detections, particularly services, providing time and cost savings.
- Reduction in project delivery time.
- Reduction in remedial works due to enhanced quality control and design coordination.

- Built-in structural analysis capabilities, which are key for fabricators.

D] IMPLEMENTATION OF BIM

- An organization must first determine its business processes, then buy the software that will support those business processes, and not the other way round.
- At project level, there should be a willingness to share information and work collaboratively, i.e. integrate design with construction.

***BIM IMPLEMENTATION IN UK*: -**

The UK government recently announced that public projects will now be expected to employ BIM processes.

Paul Morell, the government's chief construction adviser said, "Within five years, all government procurement will be within 3D collaborative BIM, with specific exceptions where the cost might exceed the benefit, although I have to say I am struggling to think of obvious examples of that".

The Office of Government Commerce's "Achieving Excellence in Construction" initiative requires central government departments and public sector organisations to commit to maximising efficiency, effectiveness and value for money through continuous improvement. A holistic BIM approach aids this initiative through improved efficiencies, collaboration and waste-reduction.

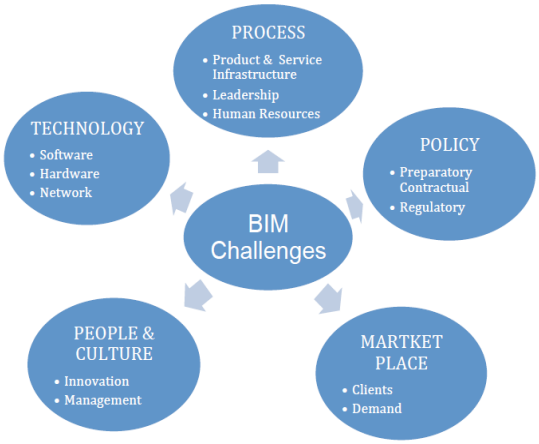
BIM IMPLEMENTATION IN INDIA: -

In India BIM is also known as VDC: virtual design and construction.

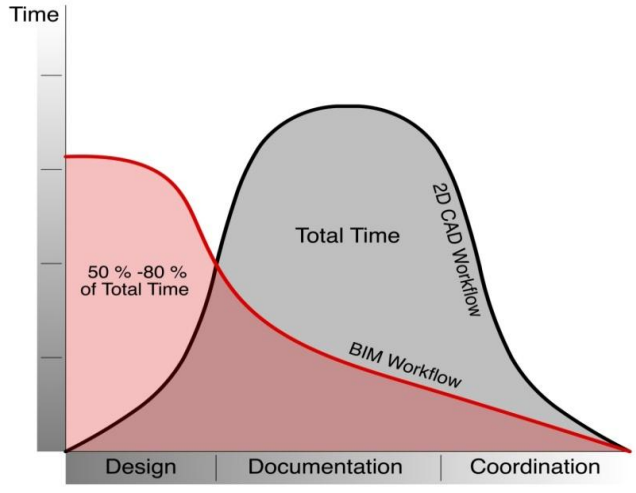
India is an emerging market with an expanding construction market and huge potential for large scale residential and commercial development (because of population and economic growth).

It has many qualified, trained and experienced BIM professionals who are implementing this technology in Indian construction projects and also assisting teams in the USA, Australia, UK, middle east, Singapore and North Africa to design and deliver construction projects using BIM. In spite of this, and India's vibrant building sector, BIM usage was reported by only 22% of respondents to a 2014 survey

E] CHALLENGES IN BIM



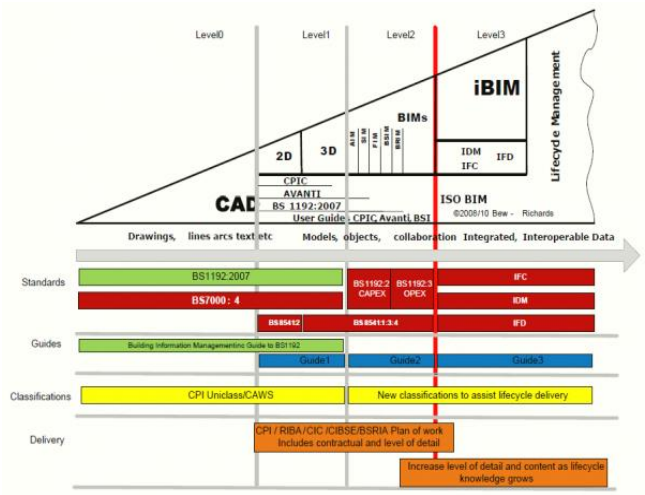
F] TIME DISTRIBUTION TO WORK WITH BIM



G] IFC

IFC (Industry Foundation Classes) is an open-data format developed by BuildingSMART, formerly known as the International Alliance for Interoperability (IAI). IFC is a neutral and independent file format that does not belong to any particular software vendor. The IFC is also independent of any vendor's software development plans. The goal with IFC is to facilitate the information exchange between different programs developed by different software companies.

H] LEVELS OF MATURITY OF BIM



Level 0- ADHOC

– Usage of BIM softwares

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

Level 1- DEFINED

– 3D coordination

Stage 1 in the BIM maturity levels implies a well functioning coordination between different disciplines. As the building information models of different disciplines are interconnected, clash controls can be performed.

An example of an additional service that can be provided at this level is identification and organization of information flows within the project, which is a prerequisite for creating a common understanding regarding goals in the project.

Level 2- MANAGED

– Analyzes, time and cost estimation

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

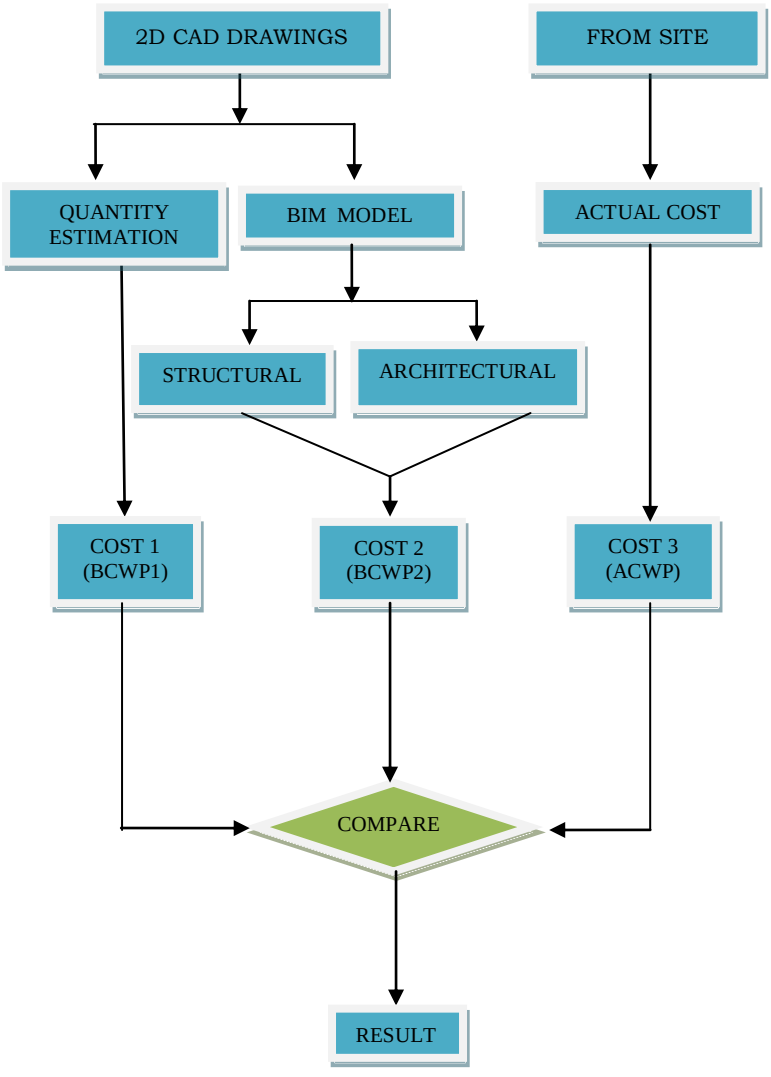
Level 3- INTEGRATED

– Integrated model

In order to operate at level 3, more advance models are required. Services from both level 1 and 2 are provided with a highly integrated model between the different disciplines.

Examples of services which can be provided at level 3 are more advanced time and cost estimation, programmed with a parametric design, as well as maintenance models which is fully integrated with the client's management and maintenance systems.

VI. METHDOLOGY



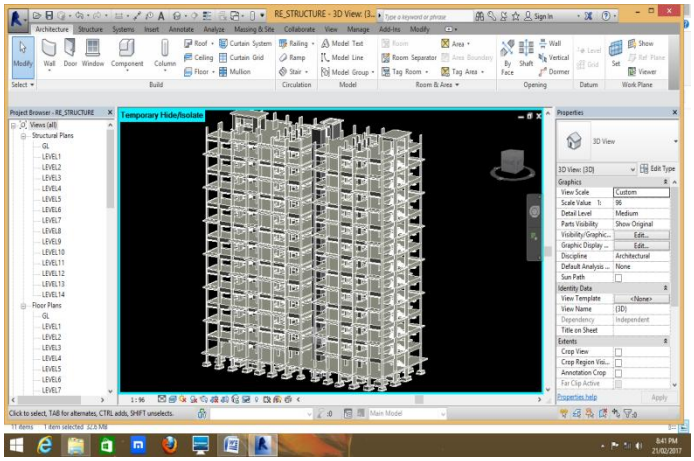
Preparation of 3-D BIM model using **Autodesk's Revit Architecture** software for given building plan with details. Quantity Estimation and cost for different items from 3D model using **Autodesk's Revit Architecture** software. Put these details in a **Microsoft Excel** sheet (.xml format) for further use.

Preparation of MSP schedule for construction activities using **Microsoft Project.**
Using **Autodesk's Nevis Work Software**, integrate both the MSP Schedule and Cost data for each item from excel sheet.
Obtain simulated view of project in terms of time and cost as 4D & 5D model.
Feed the Actual data of construction site using Microsoft Excel sheet to Nevis Work to obtain the variance of time and cost to observe the critical area for cost variance by simulation.
Collecting the details of quantities and cost items with traditional method from office to verify the difference with respect to BIM model.
Calculate the difference of traditional method over BIM model and compare.
Observe which method is meeting to actual expenditures.

VII. CASE STUDY

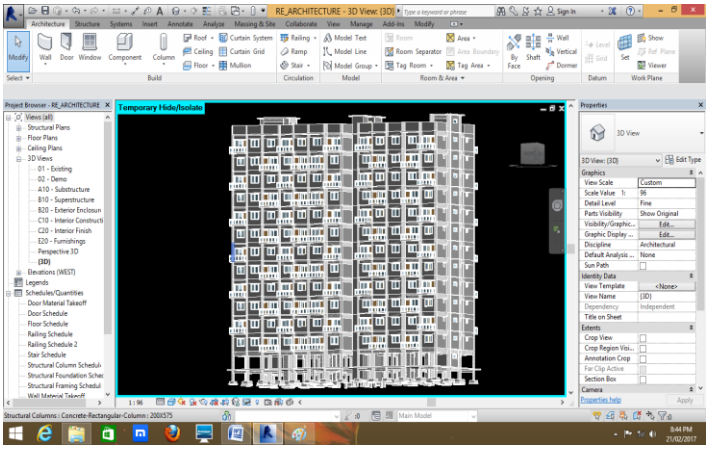
For research work a case study was undertaken. With following information.
This project is located in Wagholi, Pune. It is a 12 storied residential building with total construction area is about 15,000 m^2. This has alternate floor designing same. Framing is RCC and wall structure is in light weight concrete bricks.
Designing is done in 2D Auto-CAD drawings, Scheduling is in Microsoft's project software.

➢ STRUCTURAL BUILDING INFORMATION MODEL



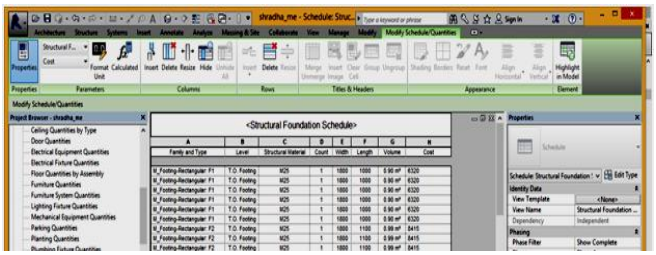
For construction of Structural Building Information Model detailed structural drawings are referred. With the help of Revit Architecture 2014 software, and other available details such as, material used and cost of respective materials etc. the model is completed.

➢ ARCHITECTURAL BUILDING INFORMATION MODEL



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

➢ QUANTITIES AND COST FROM REVIT ARCHITECTURE 2014



And all the project item details are transferred to Excel sheets. Around 10 to 12 building items are taken in to consideration for the research study from BIM model and those items only are compared to actual cost. These costs with BIM model are named as **COST 2**.

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

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

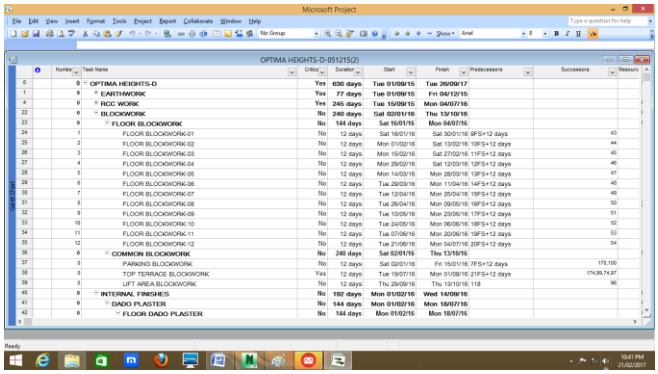
Now as per EVA (Earned Value Analysis) method the variances are calculated.

Variance1 = COST 1 - COST 3

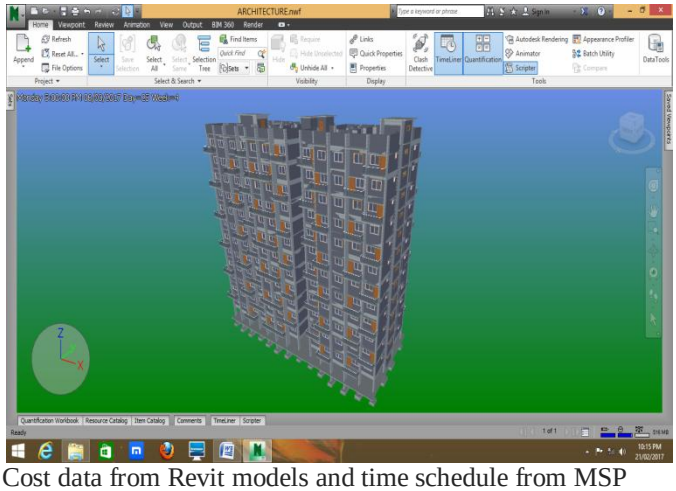
Variance 2 = COST 2 - COST 3

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

➢ MSP SCHEDULE FOR PROJECT



- **5D BIM MODELING IN AUTODESK'S NEVISWORKS**



Cost data from Revit models and time schedule from MSP software is imported to Nevisworks for simulation and better visualization purpose.
Then a three color simulation is obtained as,
Green - before time and within cost
Gray - behind time and within cost,
Gray - before time and over cost,
Red - behind schedule and over cost.

VIII. CONCLUSION

Although developing 5D(cost) - BIM model with minor details is very time expensive, but then cost control process is very much beneficial with BIM than a traditional method throughout the project cycle.
Simulation proves to be a powerful tool to find out critical areas of project with respect to time and cost, so it helps in decision making in cost control.

ACKNOWLEDGEMENT

The authors would like to thank to the consultant AVANEE VEDA for providing project data & support. Also grateful to BSCOER for providing necessary facilities for the study.

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