Developing an Effective Project Concept in 5D Environment

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Abstract: Building information model (BIM) is a representation of virtually constructed building model which contain physical and factional features and characteristics of a facility. With the help of BIM an accurate virtual building model and precise geometry of a building is digitally constructed the completed BIM model contain the necessary data required to procure required material, Design the building, fabrication of component, and identifying construction activities.

To show the potential capacity of BIM in creating an effective project concept in 5D environment a real time case study is selected and the result showed that it is very easy and convenient to create effective project concept by obtaining required information from the single integrated model without referring to other information by inputting the cost and duration of tasks into the 3D model using Autodesk Navisworks manage.

IndexTerms - **5D, modeling, BIM, construction industry, project Management.**

I. INTRODUCTION

BIM is the illustration of the digital evolution from traditional 2D model to 3D mode and even to 4D model (scheduling) and 5D model (cost estimating) with an information throughout the building lifecycle. Special capabilities of constant parametric modeling and interoperability facilitate this evolution method. The advantages and outcome of BIM execution will be utilized to validate the necessity to push BIM within the AEC industry [3]. Edward (2007) claimed "One of the key edges of BIM is that it includes information concerning length, width, and volume, yet as info concerning content like doors, windows, and finishes, all of which might be used for estimation." Moreover, estimating depends on BIM eradicates overlooked details when undertaking quantity takeoff from 2D Drawings regularly with common updates which creates it hard to catch [4].

A relative new technology that is progressively getting accepted in the construction industry is BIM. It is playing a major role on improving construction management background. There are several factors that have made BIM technology popular in the construction industry. First, its popularity may be attributed to the accessibility of both software and hardware applications that are likely to minimize errors. Similarly, BIM technology has created very competitive markets for the modern construction [5].

5D-model task give careful and correct 5D estimates and living price plans. This help is provided to projects at any section from concept design through to construction and completion [6]. Certain software package providers are currently advertising that it's potential to develop cost planning through linking a 5D price Library to BIM model, which implements the function of an estimating database [7].

II. RESEARCH SCOPE AND OBJECTIVES

☐   The scope of this thesis work is only limited to 4D/5D modeling of a multi-story Residential Condominium Building which is in progress with traditional approach.

☐   Major objectives of the research are:

1.   To Study and understand the overall efficiency of Building Information Modeling and its framework.
2.   To generate & simulate virtual model for Residential Condominium Building.
3.   To Prepare a 4D/5D model for a practical problem by using time as 4th & cost as a 5th dimension.
4.   To understand the project concept effectively with respect to design, schedule and cost.

III. LITERATURE REVIEW

3.1. Definition of BIM

BIM is the development of a model to simulate the different stages of the project and it is based on a computer and software technology. This model is information storage from which, any user is allowed to extract and incorporate information increasing the reach of the model in terms of information [35].

BIM has often been used in the management of modern models that have 3D elements as their parametric elements. They fall into the following categories and subcategories (Family: Windows; Category: Wooden windows; Type: Wooden window). The wooden window has two layers. 2D/3D CAD refers to the graphical illustration of geometrically compatible elements. Many of these elements do not have a defined construction procedure. Similarly, they are devoid of additional information. Hence, one can only comprehend their design through the use of an external data [38].
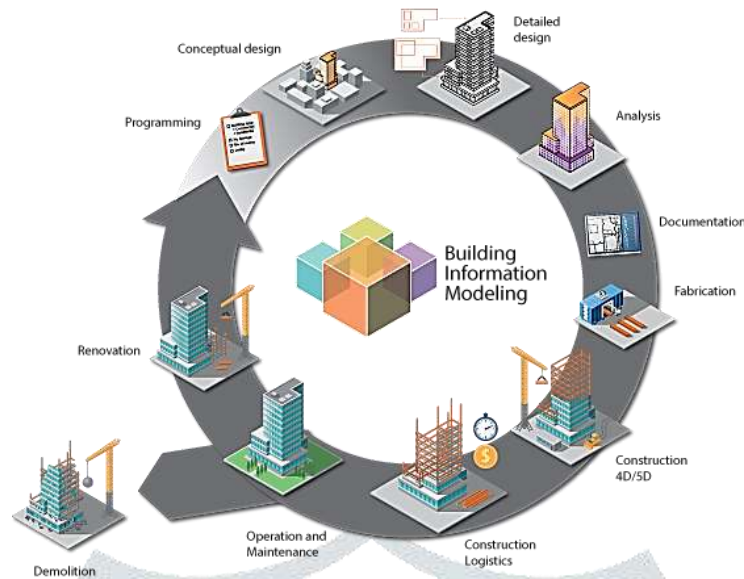
Figure 3.1:- BIM life cycle
(Source: https://Google image/)

3.2. Dimensions of BIM

Depending on the content of database we can distinguish higher dimensions of the BIM approach.

1) BIM 3D – A Parametric 3 Dimensional Model

BIM revolves around an integrated knowledge model from the numerous stakeholders like Architects, Structural Engineers; etc will extract and generate views and data in line with their desires.

BIM 3D helps participants to manage their multidisciplinary collaboration additional effectively in modelling and analysing complicated abstraction and structural issues. What is more, as a result of correct data may be collected along the project life cycle, and keep within the Building data Model, new value may be additional to predictive models permitting to resolve problems proactively.

2) BIM 4D - Scheduling

4D-BIM is an extended 3D model with one additional variable which is time. Tedious planning is replaced by parametric modelling, during which each part is appointed in an exceedingly sequence of assembly. BIM 4D generates new chances for info modeling the division of the project into phases, mental image of phases, correct planning for delivery time of materials and simulation.

3) BIM 5D - Estimating

5D BIM is a 4D extended with one another additional variable which is cost. BIM 5D allows a quantity surveyor to make quick estimation of quantity for conceptual designs and it can also help to conduct accurate cost estimations the model. With facilitate of BIM 5D we are able to simply compare execution time and total prices of varied alternatives in terms of materials and technology, what will promote optimization investment cost.

4) BIM 6D - Sustainability

Software compatible with BIM 6D permits for integration of information associated with surroundings protection or energy consumption, i.e. with facilitate of special programs the analysis of building energy consumption is feasible.

At the beginning of design process 6D BIM allows to carry out energy consumption analyses for the project this may result in additional correct and complete energy estimates. It conjointly permits for measuring and verification throughout building occupation, and improved processes for gathering lessons learned in high performance facilities.

5) BIM 7D - Facility management application

The 7D-BIM permits participants to extract and track relevant asset data like maintenance/operation manuals, element standing, guarantee information, specifications etc. the use of 7D-BIM technology may result in easier and faster elements replacements, optimized compliance and an efficient asset life cycle management over time. 7D BIM provides processes for managing subcontractor/supplier information and facility component through the whole facility life cycle [34].

3.3. Status of BIM in India

Indian economy is highly supported by the construction industry which is the second largest industry in the country. A survey done by two Indian firms IBE and KPMG recognized that 22% of respondents at this time use BIM, 27% respondents are aware and they are planning to use BIM. Unexpectedly 43% respondents have an idea about it, but showed unwillingness to adopt in near future. Moreover, 8% respondents have no idea about what BIM really is [15].
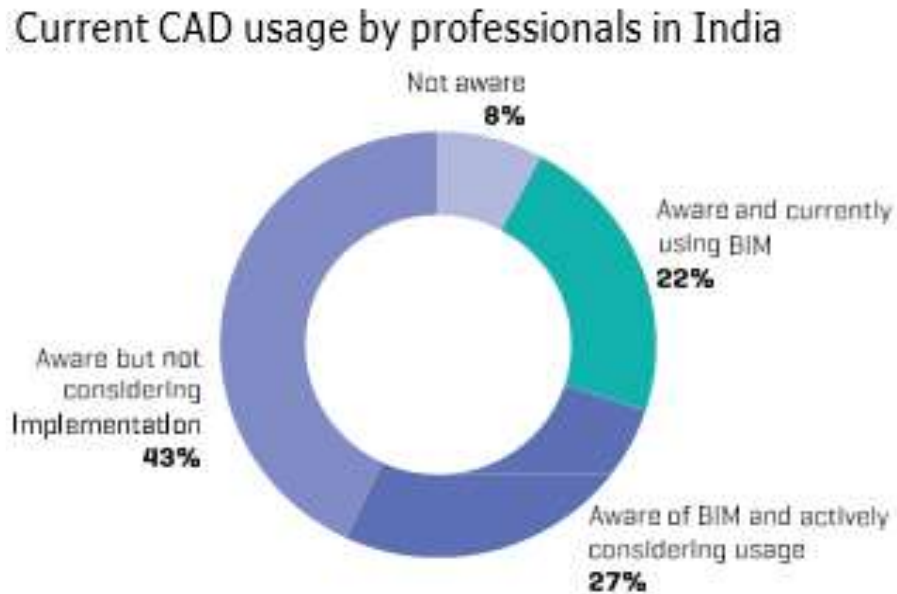
Figure 3.2:- BIM Status in India.
(Source: State of BIM Adoption in India May 2014)

3.4. 4D BIM

The concept of 4D Model was initially mentioned by Egan John (1998) that was ready to realize the unity of the initial schedule, detected the inconsistencies within the level of detail and see the not possible schedule sequence. They tried that 4D models are ready to measure the effectiveness of the project schedule and anticipated the longer term improvement in 4D tools [27].

After creation of the tasks and attaching parts to them, the sole procedure left is to set the beginning and the finish dates of every task. Having set all of them it's currently very straightforward to form animation of the building construction. Visual settings of the materials are traced from Revit, therefore if everything has been set properly there's not much more work to do.

Project planning (4D modeling) in BIM is to link a BIM model to a schedule to see the schedule of the construction. The employment of planning function in BIM (4D Model) will facilitate the users establish optimized schedule of the project in a 3D surroundings that additionally permits the users to own a virtual view of the complete project.

3.5. 5D BIM

The fifth dimension added to the 4D-BIM model is cost. A 3D BIM model has all the geometrical information considered necessary to carry out a quantities take-off [38]. According to Smith, (2014), 5D in BIM ought to include schedules, quantities and prices during the process of cost planning.

Mitchell (2013) define that the most important advantages offered by BIM on 5D are the automatic extraction of data from the model, which increases the productivity and eliminates errors. The better visualization of the model, the 3D view optimizes its understanding and provides more accurate details and finally, the possibility for linking the 3D model with specific tools offers the chance of making an endless number of estimations when the model suffers modifications.

The completed 5D BIM model can be used by the project team to give feedback about a project cost faster than the traditional method planning and construction, allowing the project planner and designer to adjust the project design and requirement to fit the budget. The 5D BIM model can provide the client and the project planning and design team with greater transparency in looking the contractor's budget for the project participants and various stakeholders of a project. A smaller amount of contingency are require on behalf of the owner for Projects using 5D BIM [11].

According to McCuen (2008) estimators with a good BIM knowledge can gate advantage from the 5D BIM function by automatic quantification and creating quicker cost estimates.

3.5.1. Benefits of 5D BIM

Application of 5D BIM in different construction phases has the following benefits in facilitating the construction management.

1. Design and planning:

Use of BIM within the project programming permits project team to analyse area and perceive the complexness of area standards and land regulation that saves time and supply them with chance of doing additional worth accessorial activities [30].

BIM constructs the building virtually before actual construction. Hence owner or user can suggest the modification early in the planning and design phase according to their requirement. Also contractors can participate early in the design phase to contribute his field experience.

2. Quantity estimation:

Provided with the ability for extracting counts of building components, volumes and spaces, BIM amount take-off tools enable a faster extraction of a lot of detailed spatial and material quantities data [34]. As quantities extracted from model are more accurate, owner is protected from over budget project.

3. Prefabrication:

BIM provide manufacturers of building elements detailed and information rich models, which might be interrogated for producing details, will scale back data request and improve output quality.

4. Collision detection

Collision check includes two types of hard collision and soft collision. With BIM 5D collision check function, the installation, plumbing, fire and different integrated along, the important simulation of the particular construction of the scene, through the collision check, the drawings may be found ahead and therefore the construction might seem unreasonable place, modification the design drawings or construction program, that avoid modification and rework, reducing construction prices and saving time [2].

5. Construction simulation

According to the construction organization, the development method is simulated 1st, then the development sequence and construction technique are adjusted and optimized, and therefore the construction method is refined to get the best construction plan. Construction simulation includes construction schedule simulation, construction program simulation, and construction site layout and so on. Through construction simulation can not only control the construction schedule, but also to ensure the quality of construction and avoid the extension of time limit [31].

6. Model updating

As the construction stage, it is frequently that causes design changes, changes in construction contracts and other construction models and site construction not matching the situation due to the requirements of owners or construction requirements and other reasons. Model need to be modified by project management personnel according to the changes, ensuring that the model consists with the actual design, construction and contract requirements, ease of decision making[31].

7. Commercial advantage

The implementation of 5D BIM is commercially advantageous for two different reasons: in gaining a competitive advantage over competitors through client recognition, and also in gaining a commercial advantage by discovering and overcoming all the issues associated with 5D BIM before competitors decide to implement it themselves; thus they are always a step ahead which means they can perform the service more efficiently [7].

IV. RESEARCH METHODOLOGY

The study was initiated to collect information on the 5D BIM, as well as perform a literature review on the traditional cost planning process. In order to achieve research objectives, a BIM model of a Construction project on progress will provided as a case study in this research to demonstrate the process of cost planning and simulation in 5D BIM. The core intention of this study is developing an effective project concept in 5D environment for Hostel building by preparing a 3D model, construction schedule and cost estimation to generate & simulate virtual model using project design software and project management software.

This research work uses literature review and case study with demonstration of the chosen cost data model consisted in the 5D BIM application. Case studies usually represent a phenomenon as accurately as possible.

4.1. Data Collection

The data collection was carried out from a Residential Condominium Building found in Bole Ayat, Addis Ababa, Ethiopia which is currently in progress with traditional approach. From the project fresh data of total estimated project time and the total estimated cost of project estimated in the designing phase is gathered.

The following list of data's are gathered from Residential Condominium Building found in Bole Ayat, Addis Ababa, Ethiopia which is currently in progress with traditional approach.

1. 2D CAD drawings (softcopy)
2. Detailed specification
3. Duration of each activity
4. Unit rate for each activity
5. Other various important details.

4.2. Case Study Site

The following are detailed description of the project from where listed data's are gathered for the research.

1. Project Name: - 40/60 Addis Ababa city saving house's project
2. Project Type: - Multistory Residential Condominium Building
3. Project Location: - Bole Ayat, Addis Ababa, Ethiopia
4. Client: - Saving Houses Development Enterprise of Addis Ababa City Government
5. Construction Cost: - 21 million Ethiopian Birr
6. Overall Scheme: - Basement + Ground + Nine Stories (B+G +9)
7. Typical Floor Area: - 22423 sq. ft
8. Period of Construction: - 224 calendar days

V. DESIGN OF BIM MODEL

5.1. Design of 3D BIM model

These drawings are modified first according to the requirement into Autodesk AutoCAD and then exported into dwg file. Autodesk Revit Architecture facilitates the user with so many formats to export and import of different related files in Revit software.

Autodesk Revit architecture provides inbuilt 3D elements like different types of wall, beam, column, slab, foundation, roof, stair, door, and window. We can easily pick each element and put at the exact location of the 2D CAD drawing with required height. We can also modify the geometry of each 3D element according to requirement and once the 3D model is completed export into NWC (Navisworks cache file) by using add in tools on Revit architecture then the exported 3D NWC file will be imported into Navisworks manage to develop 4D/5D modeling and simulation.

Figure 5.1 A 3D view of 40/60 Addis Ababa city saving house's after Revit Rendering 1

Figure 5.2 A 3D view of 40/60 Addis Ababa city saving house's after Revit Rendering 2

5.2. Generate 4D/5D BIM model and project simulation

The following procedures are followed to Generate 4D/5D BIM model project simulation for the case study site from the created 3D model, project schedule and cost estimation.

1. Create a set for all elements on the 3D model
2. Generating model based quantity takeoff by using Navisworks manage
3. Import the project schedule and cost data which is prepared by Ms Project
4. Link or attach the created sets with the imported schedule
5. Run a 4D/5D simulation

5.2.1. Create a set for all elements in the 3D model

Creating sets for the developed 3D model is a time taking activity which required the selecting and creating a group of similar elements in the model which is considered as a single activity during scheduling. Creating sets for the created 3D modal is depends on the prepared schedule for 4D/5D simulation because each created sets is attached to the activities on the prepared schedule to

show during simulation according to the sequence of the schedule for batter visualization and to identify impossible sequence of tasks in the schedule.

5.2.2. Generating model based quantity takeoff

We can easily carry out quantity calculation of designed 3D model with Autodesk Navisworks manage quantification tool which can be permit to choose the element of 3D building model needed to extract quantity takeoff. After carrying out quantity calculation a tree like structure is created which can give us perfect categorization of each and every element of 3D model and can export automatically the quantity sheet in MS Excel file.

The prepared quantity takeoff is depends on the created sets first go to item catalog and create folder according to required structure and name once completed select the required group of element in a set then go to quantification work book required folder and select take off to selected automatically the quantity for the selected elements are generated on the quantification work book which is very accurate and easy to calculate.

Similarly quantities for all created sets are prepared in quantification work book and once completed exported in to excel file format for batter management and edit the prepared quantity takeoff sheet.

5.2.3. Import the project schedule and cost

The created task hierarchy and duration with MS Project to check the possibility of sequence of tasks in 4D simulation is improved by adding cost data's to each activities in the schedule. The estimated cost for each activities are rolled up and gives the total project cost once its completed imported into Navisworks manage software and used in 5D simulation for better visualization and planning of cost and time.
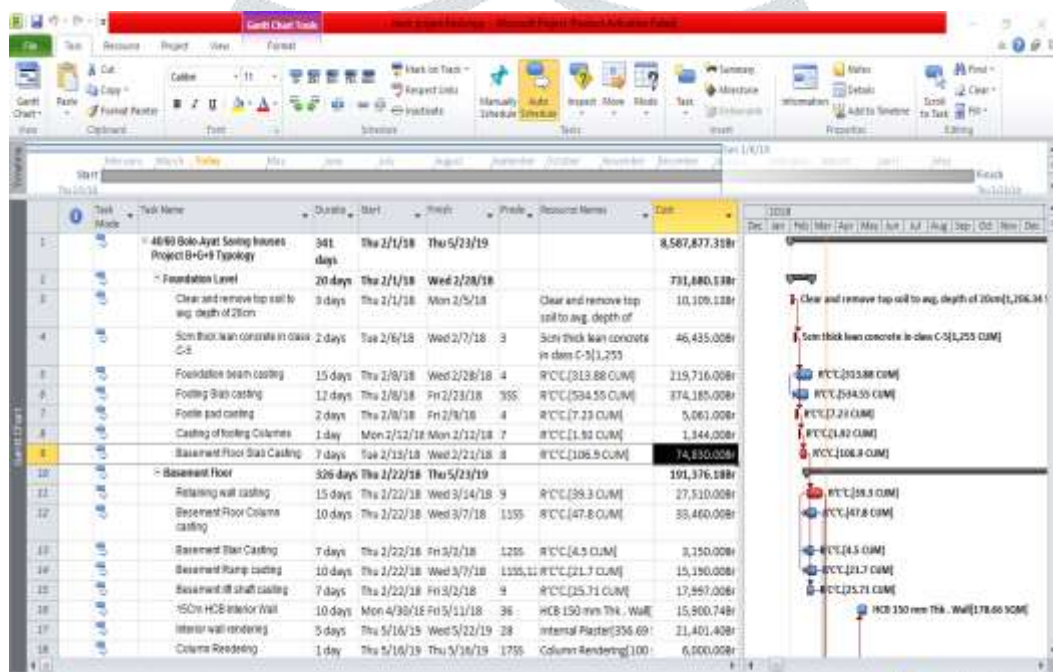

Figure 5.3 Microsoft project schedule and cost estimation

5.2.4. Link or attach the created sets with the imported schedule

Linking or attaching the created schedule and cost data to the sets in Navisworks manage is the most time taking activity which requires selecting and attaching each and every element of the 3D model in its position in the schedule to upgrade the 3D model into 5D by adding time and cost data into the 3D model.
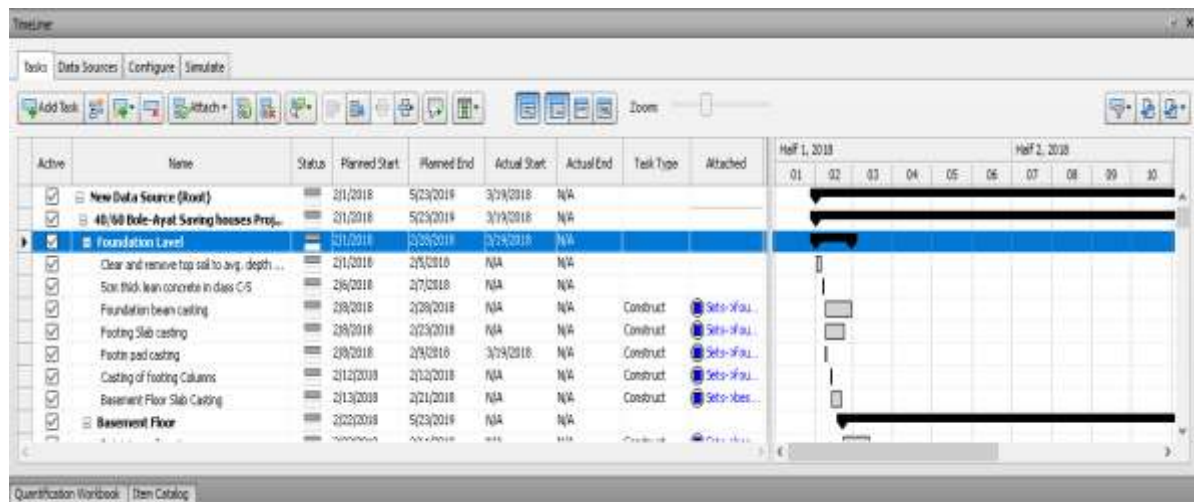
Figure 5.4 Navisworks manage timeliner attached tasks on imported schedule

5.2.5. Run a 4D/5D simulation

5D BIM makes possible to visualize how the building and site would look like at any point in time by simulation the construction process and also shows cost information of the project through time. 5D tools allow planners to visually communicate and plan activities in the context of time, cost and space.

After the above all activities are completed Navisworks manage can simulate the project in a 5D environment during simulation the construction sequence of the 3D model will be shown according to the schedule also Cost and duration of the project is a displayed on the simulation screen. During simulation if impossible sequence of tasks is shown proper adjustment can be taken to make the schedule more applicable and practical.
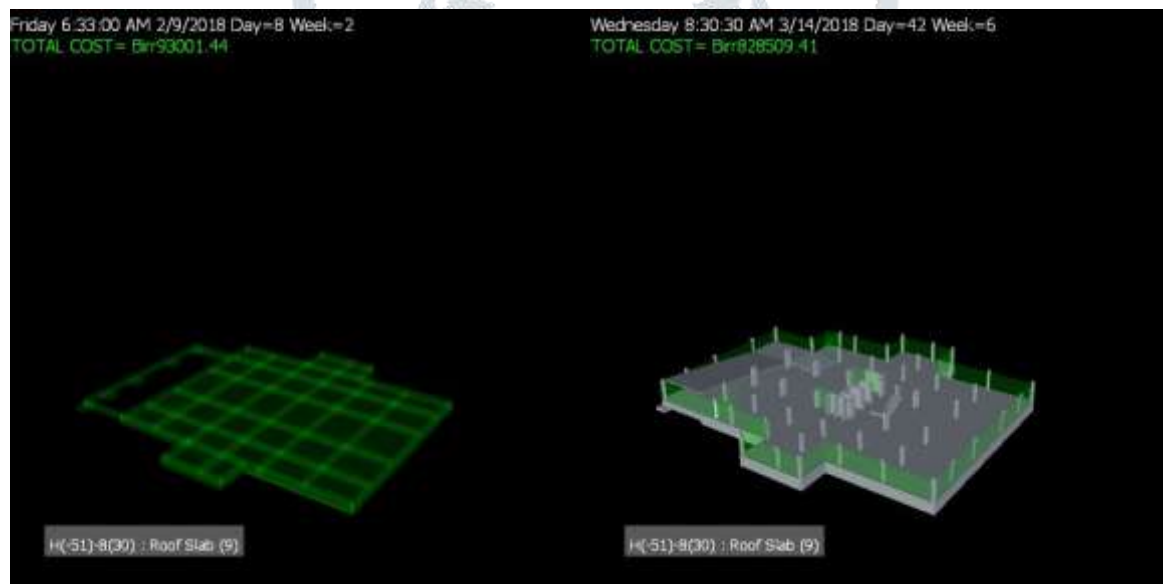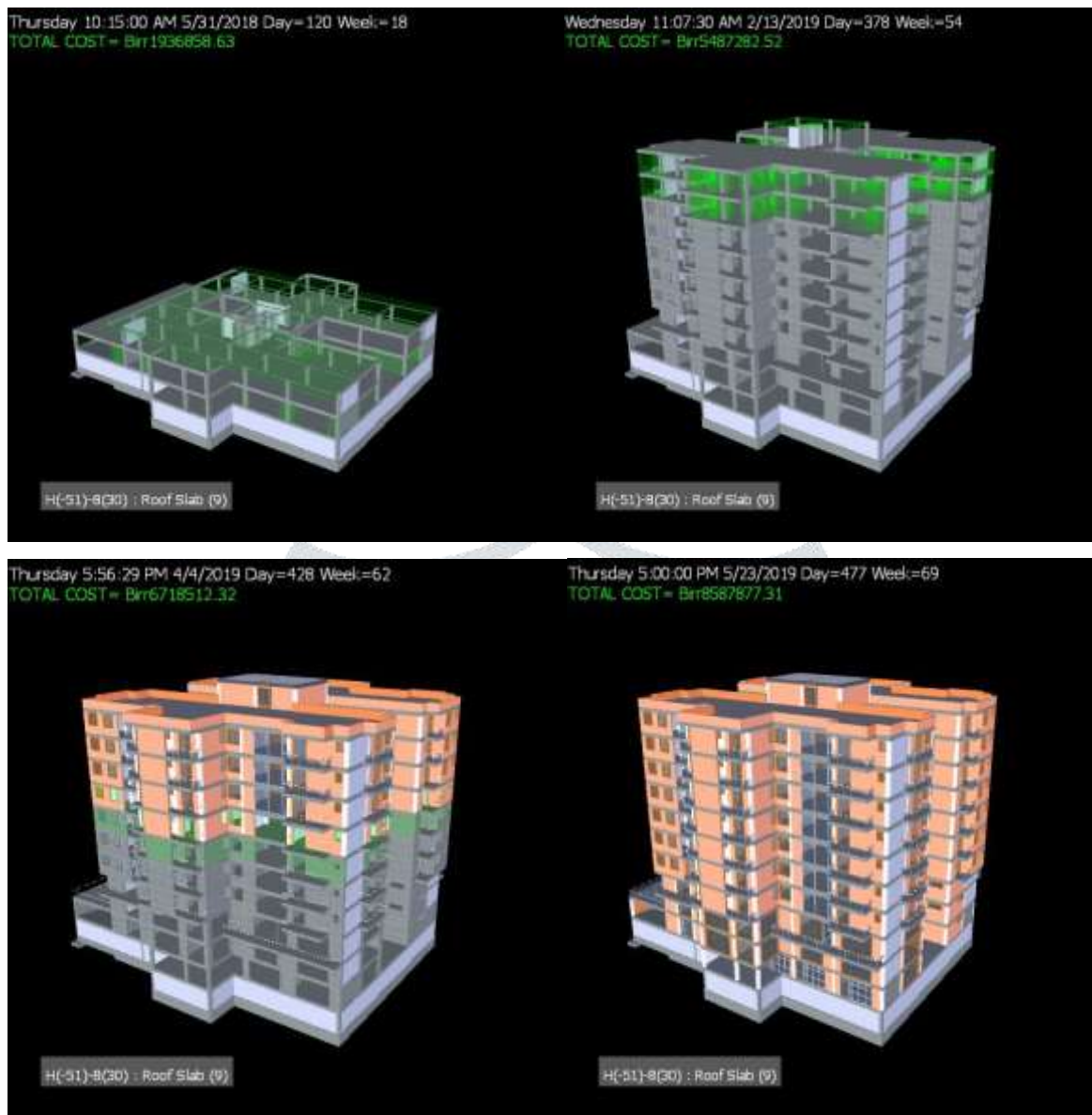
Figure 7.18 Navisworks manage 5D simulation view of the case study site

VI. CONCLUSION

It is very easy and convenient to create effective project concept by obtaining a required information from the single integrated model without referring to other information by inputting the cost and duration of tasks into the 3D model using Autodesk Navisworks manage, the 5D BIM software able to the users to easily defines the forecast interval and can generate cash flow forecast monthly, weekly, daily or even hourly in the simulate on, which is very difficult to achieve in the traditional approach.

BIM technology also allows collaboration and integration of different interrelated design software tools, which makes this technology more universal and more adoptable. Thus, in today's modern construction industry BIM helps to develop an effective project concept and satisfy the need of successful completion of project within available time and cost.

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