4D Simulation of MEP using BIM for Residential Building Project

Kalvakolu Suryaprakash Reddy

Mechanical Engineering, CVR College of Engineering, Hyderabad

ABSTRACT - Project management is a major part of any project in the world. A better project management leads any project to its optimum output. For better project management we should know different techniques used for project completion and must have thorough knowledge of all aspects of resource management.

Different methods were used for project management, for example, use of Bar Chart, Milestone Chart, Gantt Chart etc. and project planning was done accordingly. In the meantime, the whole work was divided in different segments like Plan, Design, Bid and Build, which required through specifications of concerned work. To achieve the same use of 2D drawings, contract documents, specifications, codes and manuals were prepared.

BIM reflects the development and use of computer generated n-dimensional models. It helps to simulate the planning, design, construction and operation of a facility. It helps architects, engineers and constructors to forecast what is to be built in simulated environment and to identify potential design, construction or operational problems. This report focuses on 4D simulation of MEP using BIM on a residential building

Key Words: BIM, MEP, Scheduling, Navisworks, Simulation.

I. INTRODUCTION

Project management is a vital part of any project in the world. A better project management leads any project to its optimum output. For better project management it is necessary to know different techniques used for project completion and must have thorough knowledge of all aspects of resource management.

Different methods were used for project management, for example, use of Bar Chart, Milestone Chart, Gantt Chart etc. and project planning was done accordingly. In the meantime, the whole work was divided in different segments like Plan, Design, Bid and Build, which required through specifications of concerned work. To achieve the same use of 2D drawings, contract documents, specifications, codes and manuals were prepared.

1.1 Aim of the Project & Paper

The purpose of this project is to simulate project scheduling with its 3D model to obtain 4D model and working Building Information Modeling, MEP designing, Time scheduling and 4D simulation in a residential building project.

1.2 Objective of the Project & Paper

The objective of this project & paper is

i. To study conventional method of preparing 2D/3D drawing and project scheduling.
ii. To study BIM (Building Information Modelling) for preparing 3D model in Revit Autodesk
iii. To study MEP for detailed drawing of Mechanical, Electrical & Plumbing.
iv. To study the Autodesk Nevisworks for the simulation of prepared 3D model with MEP detailing and its scheduling.
v. To study the benefits of BIM applications for project scheduling and additional requirements if any, to be put in to the model to get more benefits in terms of project scheduling.
vi. To compare the conventional methods and BIM applications for project scheduling. vii.To study the barriers of an effective implementation of BIM application for project scheduling.

II. LITURATURE REVIEW

Following is the list of researchers who have worked in the same area

Saeed Rokooei (2015) in his paper proposed different views of BIM including time, cost, wastage reduction and time reduction of a project. It also shows the similarities between BIM and project manager.

RoshanaTakim, Mohd Harris, Abdul HadiNawawi (2013) in their paper they clears the

use of computer generated model in simulation and also use of BIM in construction industry can make the industry more efficient.

Pawel Nowak, MariolaKsiazek, Marcin Draps, Jacek Zawistowski (2016) they have introduced a paper on decision making with use of Building Information Modeling. In which they state that BIM allows for fast and easy access to different and almost all characteristics of components and energy analysis.

IreneuszCzmocha, Adam Pekala (2014) This paper is based on the traditional design versus BIM. In which history and development of traditional work and idea and practical benefits of BIM are defined. Paper also states difficulties during implementation of BIM and its benefits also.

ZbigniewKacprzyka, Tomasz Kepa (2014) introduces 4D Modeling Technology which shows the project made by using 4D BIM. 4D is 3D modeling in addition with scheduling. 4D schedule is prepared in Autodesk Navisworks. Scheduling starts by importing data from Revit model.

Dr. Kihong Ku and Thomas Mills have introduced their paper on research on BIM for construction safety. There is lack of resources.

III. PROBLEM STATEMENT

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

ii. As project progresses, the process of construction monitoring & control get more complex due to the huge amount of information that need to be measured and analyzed.

IV. METHODOLOGY

The objectives of the research will be achieved by implementing the following steps:

i. Studying Building Information Modeling and its framework.

ii. Comparing Building Information Modeling and traditional methods used in construction work

iii. Studying Autodesk Revit and preparing 3D model for building

iv. Applying MEP to the 3D modeling of the proposed building.

v. Studying Autodesk Navisworks manage and simulation.

vi. Detection of clashes

V. BIM MODELLING

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

5.1 BIM Modeling from 3D (Modeling) to 4D (Project scheduling)

The use of the term 4D is intended to refer to the fourth dimension; time i.e. 4D is 3D+Schedule.

Theory of BIM

There is no universal definition of BIM and definitions continue to evolve. However BIM is not software .It I much more than 3D-modelling .It is a business process ,and there fore 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 are liable basis for decisions during a facility'sLife cycle.

Fig. 5.1 BIM in multi dimensional function

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 visualizations and

walkthroughs, clash detection and coordination ,and item scheduling.

4D–this is3D plus "time". The ability to link the individual 3D part so reassemblies 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.

A-Introduction to Autodesk Revit:
➤ Autodesk

John Walker, one of the inventors of AutoCAD, found Autodesk in 1982. AutoCAD was their first product and remains the most popular one. But in last three decades they have developed several notable products including Sketchbook, Pixlr and Revit. Except CAD and Building Information Modeling platforms AutoCAD produce also media and entertainment software like Maya, 3D animation software.

➤ Revit

After introducing the most popular Building Information Modeling software and Autodesk as company that develops Revit, the spotlight will move now to Revit itself. In 1997 ReonidRaiz and Irwin Jungreis founded the company Charles River Software, which started building Revit. Their main goal was to include parametric modelling to existing idea of CAD, and to allow the user to determine the parametric components graphically, instead of having to use a programming language.

This idea of bidirectional associativity is the concept that distinguished Revit from other Building Information Modeling software platforms for a certain period of time, until the competition caught up. Bidirectional associativity means that when u change a certain component of your model (for example wall) all components in relation with the modified one will automatically adjust themselves to applied changes. For example if a floor level is moved further up all walls connecting it with the lower level will become higher, the ceiling of the lower level will move up, walls of the current level will shorten and etc. This concept of bidirectional associativity makes the software more intuitive and therefore easier to work with for the user. It also saves enormous amount of time when applying changes to an existing model.

In order to satisfy the different needs of types of specialist using Revit, Autodesk divided the product in to three main branches- Revit Architecture, Revit Structure, Revit MEP.

• Revit Architecture

As the name suggests this branch of Revit is specifically designed to support the work of architects and building designers. The architecture section is mostly a CAD platform that facilitates building and site planning.

• Revit Structure

This part is focused on aiding structural engineers and designers. Here the user has the possibility to perform analysis on the structure, plan structural reinforcement and generally perform all necessary actions to guarantee the structural stability and reliability of the building.

• Revit MEP

Mechanical, Electrical and Plumbing (MEP) section of Revit allows mechanical electrical and other similar types of engineers to design and simulate different kinds of technical systems. Piping and electrical systems can be modelled and integrated into a building with Revit MEP. Energy analysis of a construction can also be performed in MEP Revit.

B-Introduction to Autodesk Navisworks Manage

Navisworks helps architecture, engineers and construction teams to improve and gain control over the outcome of AEC projects. By utilizing the application solution, detailed design models can be aggregated and reviewed by all project stakeholders, helping users to benefit from the competitive advantages of BIM workflows. Used primarily in the construction industries to compliment 3D design packages such as Autodesk Revit, AutoCAD, Navisworks allows users to open and combine 3D models, Navigate around them in real time and review the model using the set of tools including comments, redlining, viewpoint, and measurements. A selection of plug-ins enhances the package adding interference detection, 4D time simulation, photorealistic and PDF-like publishing.

Navisworks is a viewer of BIM models and has many useful applications in almost all phases of the deployment of a BIM model. The application work much like a video game and since it is not a modeller it also limits the severity and number of things that can go wrong in a BIM analysis.

Autodesk Navisworks Freedom is the free counterpart to the expensive Autodesk Navisworks

Manage. It allows to visualise the 3D model and to see the collision mark-ups created with Navisworks Manage. Navisworks Manage is the most expensive of all the Navisworks family packages. However it is also the one that is capable of performing all functions (combining files, simulation, animation, visualization), but also interface checking provides the ability to detect not only hard clashes between objects, but also check for items or objects that interface with required clearances around objects.

C-Introduction to Autodesk Revit MEP

☐   What is Autodesk Revit MEP

Autodesk Revit MEP is Building Information Modeling (BIM) software created by Autodesk for professionals who engage in MEP engineering. MEP stans for Mechanical, Electrical, Plumbing, which are the three engineering disciplines that Revit MEP addresses. By utilising BIM as opposed to computer-aided drafting (CAD), Revit MEP is able to be accurately designed and documented in a shorter amount of time. Each intelligent model created with Revit MEP represents an entire project and is stored in a single database file. This allow changes made in one part of the model to be automatically propagated to other parts of the model , thus enhancing the workflow for Revit MEP users.

6. SOFTWARES USED

The following are the software used for the sample preparation of case
study for BIM integration 3D with 4D
i.   Autodesk Revit Architecture- For 4D
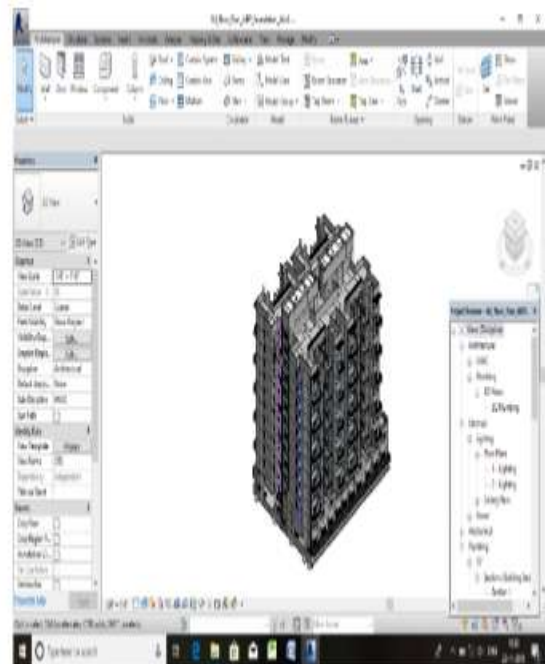ii.   Autodesk Revit MEP
iii.   Autodesk Navisworks

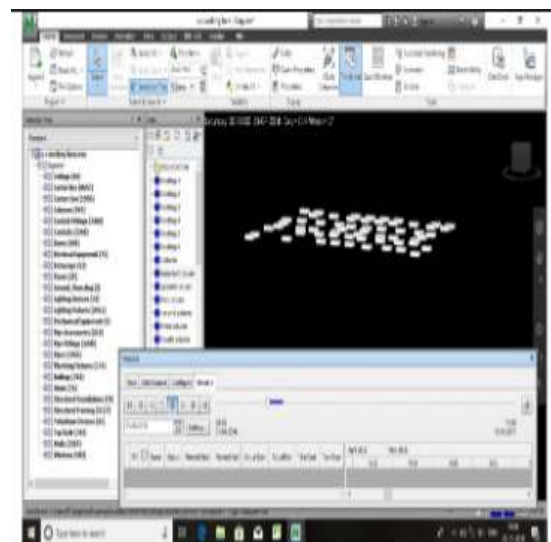**Fig. 1** Architectural Building Information Model

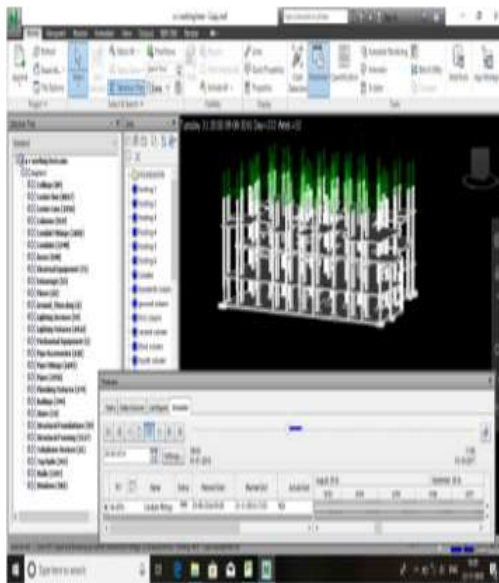**Fig. 3** Simulation on 23rd April 2016

Fig.4 Simulation on 9th August 2016

For construction of Architectural Building Information Model detailed AutoCAD drawing are referred with the help of Revit Architecture 2014 software and another details are completed.

VI. CONCLUSIONS

8.1

i. A careful review of the case study shows that BIM technology brings many advanced construction management skills to project scheduling, cost estimating, and project controls for contractors

ii. 4D BIM makes a perfect visualization tool to monitor the project progress. It is very easy and appropriate

iii. All the steps of construction could be modified and managed at any point of time by simply clicking on

iv. tool to be used for construction scheduling.

v. Clash detection for any two parameters can be carried out to avoid overlapping of the one or more objects.

the element and activity. Using this technology, time, cost and labour management becomes smooth and feasible**.**

v.Building information modelling for a residential building is a time consuming process, as it requires minute details and it shows dimensions, structural design, and materials used and its other parameters such as time.
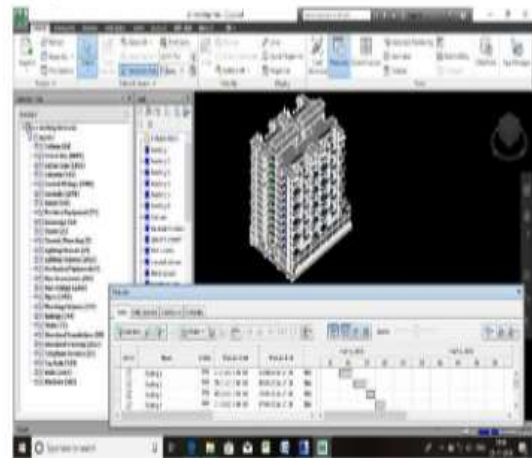

Fig.5 Simulation on 8th March 2017

8.2 Case study Conclusion

i. Clash detection is done for the detailed BIM MEP drawing. But as followed drawing is approved it did not show any clashes. Figure 6 shows no clash detection for conduits and pipes. Figure 7 shows the clash detection of conduit and lighting fixtures (

ii. The proposed 3D model of case study is not only shows graphical design but also a virtual representation of building. Visualization provides a better understanding of what the final product may look like.

iii. The Client got the whole picture of project progress from 5D model which is not understood by 2d documents
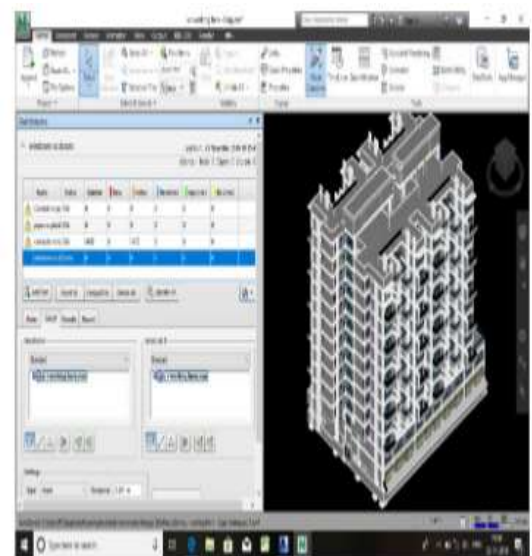

Fig.6 Clash detection in Navisworks conduits and lighting fixtures always overlaps and work together)
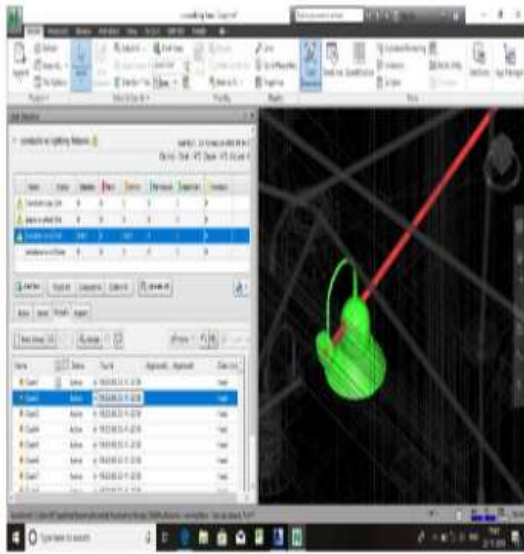
Fig.7 Clash detection of conduits vs lighting fixtures Engineering and Construction (AEC) industry, xv.   Zbigniew Kacprzyk, TomaszKepa:- Building Elsevier Ltd. 2013 Information Modeling – 4D modeling technology on the example of the reconstruction stairwell,Elsevier

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