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3D,4D and 5D Building Information Modeling for Commercial Building Projects

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Abstract - *The use of building information modeling has provided a means of increasing total product quality, providing accurate quantity takeoff and improving scheduling, consequently diminishing total project contingencies and costs. Building Information Modeling (BIM) has recently attained widespread attention in the Construction industry. BIM represents the development and use of computer-generated 5-dimensional (5-D) models to simulate the planning, design, construction and operation of a facility. It helps architects, engineers and constructors to visualize what is to be built in simulated environment and to identify potential design, construction or operational problems.*

In this paper, we had discussed What is BIM ? History of BIM development? How BIM works and process with Data requires and Data flow. Also benefits and Drawbacks of BIM are also discussed.

Key Words*: *BIM ,background, requirements, limitation and benefits.

1.INTRODUCTION

Building information modeling (BIM) is an intelligent 3D model based process that gives in architecture engineer and construction professional the insite and tools to more efficient plan design construct and manage the building and infrastructure. BIM is a complex multiphase process that gathers input from team members to model the components and tools that will be used during the construction process to create a unique perspective of the building process.

In India, the BIM application is not widely practiced till now has scope to use this technology in a much wider scale. In near future BIM is expected to change the whole scenario of Architecture, Engineering and Construction (AEC) industry. The existing infrastructure at present is sufficient to cater to the needs of only two-third of India's population and the quality of this existing infrastructure is too poor to withstand natural calamities. So, there is a greater need for better and more infrastructure facilities in near future. BIM is likely to emerge as one of the most revolutionary advancements that would transform the Indian real estate and construction sector. According to a recent McGraw-Hill Construction Report (2012), BIM adoption in the USA expanded from 49% in 2009 to over 71% in 2012. In the UK, the government introduced a progressive program for mandated use of fully collaborative BIM for government projects by 2016 to reduce project delays and cost overruns as part of the overall economic development (UK Government, 2011). In Singapore, the government provides BIM funds to promote a broader usage of BIM technology (Singapore Government, 2013).

Building Information Modeling (BIM) is the documentation process consisting of information about different phases of any project like design, construction planning, construction, facility management and operation. It is one holistic documentation process beneficial for operational visualization, and construction application such as estimating, scheduling and design coordination. Main advantage of implementing BIM application is the visual coordination of the building systems such as MEP (Mechanical, Electrical, and Plumbing) systems and it also identifies the possible conflicts between the building systems. By detecting the conflicts, problems can be resolved before actual construction which in turn saves money and time invested.

BUILDING INFORMATION MODELING

History of BIM

To trace the history of BIM and BIM systems, we have to go back to the early days of computing and dig through the conceptual underpinnings. Computer-aided design and computer-aided manufacturing (then machining) developed as two separate technologies roughly at the same time going into the 60s. At the time, no one foresaw that both CAM and CAD would eventually intertwine and emerge as powerful force in industrial world

Year	Progress of BIM development
1957	First commercial Software [Computer aided Manufacturing] used
1961	Design automated by computer system has developed
1963	Computer aided design with graphical user interface "Skechpad" was developed.
1975	Building Description system developed.
1977	Graphical language for interactive design (GLIDE)

1985	Graphisoft is developed which is 3D CAD application.
1986	Concept of Building Modeling published in papers.
1986	Really Universal computer Aided Production system has developed.(RUCAPS)
1987	First use of ArchiCAD in computers.
1995	the International Foundation Class (IFC) file format was developed to allow data to flow across platforms basically making a file compatible with different BIM programs
1997	ArchiCAD released its first file exchange based Teamwork solution
1999	1999 in Japan, Onuma allowed virtual teams to work on BIM through the Internet and created a database-driven BIM planning system.
2001	Naviswork developed which is 3D review software for navigation, collaboration and co-ordination.
2002	Autodesk acquired Revit, Naviswork and other small softwares.
2012	Mobile application developed,enables the conception of a BIM on mobile as appication.

In 1957, Pronto, the first commercial software computer-aided manufacturing (CAM) was developed by Dr. Patrick J. Hanratty. It was a numerical control machining technology that later grew into computer-aided manufacturing. A short time after that, he dabbled into computer-generated graphics and in 1961 developed DAC (Design Automated by Computer) which became the first CAM/CAD system that used interactive graphics and was used for General Motors' complex die molds.

In 1963, the first computer-aided design (CAD) with graphical user interface, "Sketchpad", was developed at the MIT Lincoln Labs by Ivan Sutherland. In the 70s and 80s, the two main methods born out of this were constructive solid geometry (CSG) and boundary representation (brep). The whole design process for this necessitated an intuitive connection to the design medium and presented the challenge of commanding the computer in a simple way.

In 1975, Charles Eastman published a paper describing a prototype called Building Description System (BDS). It discussed ideas of parametric design, high quality computable 3D representations, with a "single integrated database for visual and quantitative analyses". Eastman's paper basically described BIM as we know it now. Eastman designed a program that gave the user access to a sortable database information can be retrieved categorically by attributes (including material and supplier); it also used a graphical user interface, orthographic and perspective views . The BDS was one of the first projects in BIM history to successfully create this building database; it described individual library elements which can be retrieved and added to a model (Bergin, 2011). Eastman concluded that BDS would improve drafting and analysis efficiencies and cut the cost of design by more than fifty percent. BDS was the experiment that identified the most fundamental problems in architectural design for the next five decades.

In 1977, Charles Eastman created GLIDE (Graphical Language for Interactive Design) in the CMU Lab and it exhibited most of the characteristics of the modern BIM platform.The 80s came and several systems were being developed everywhere. They quite gained popularity within the industry and some were even applied to construction projects. It was in 1986 when RUCAPS (Really Universal Computer-Aided Production System) was used to assist the renovation of Heathrow Airport's Terminal 3. It was the first CAD program in the history of BIM to be used in prefab construction (or temporal phase construction, if you want to be technical). It is regarded as a forerunner to today's BIM software (Eastman et al, 2008).

In 1982, Gabor Bojar started developing ArchiCAD. With similar technology as the BDS, Bojar released Graphisoft's Radar CH in 1984 for the Apple Lisa OS. This was later relaunched in 1987 as ArchiCAD, making ArchiCAD the first BIM software available on a personal computer (Bergin, 2011.Backtrack to 1985, in the US, Diehl Graphsoft was developing Vector works, one of the first CAD programs, one of the first 3D modeling software programs, and the first cross-platform CAD application. Vector works was one of the first to introduce BIM capabilities. At the same time (1985), Parametric Technology Corporation (PTC) was founded in 1985 and they released Pro/ENGINEER in 1988, considered to be the first ever marketed parametric modeling design software in BIM history.

By 2000, the program had introduced Revit. Revit revolutionized BIM by using a parametric change engine made possible through object-oriented programming, and by creating a platform that allowed time attribute to be added. Robert Aish first documented the use of the term "Building Modelling" in a published paper in 1986. In this paper, he argued for what we now know as BIM and the technology to implement it. A few years after that, the first documented use of the term "Building Information Model" appeared in a paper by G.A. Van Nederveen and F. Tolman in the December 1992 Automation in Construction.

In 1995, the International Foundation Class (IFC) file format was developed to allow data to flow across platforms basically making a file compatible with different BIM programs. In 1997, ArchiCAD released its first file exchange based Teamwork solution. This revolutionized team collaborations and allowed more architects to work on a building model simultaneously. Updates on Teamwork later on allowed remote access to the same project over the Internet and allowed project collaboration and coordination on a larger scale.

In 1999 in Japan, Onuma allowed virtual teams to work on BIM through the Internet and created a database-driven BIM planning system that paved the way for future seamless cross-platform integration of BIM software and parametric technologies.

In 2001, NavisWorks developed and marketed JetStream, a 3D design review software that offered a set of tools to 3D CAD navigation, collaboration, and coordination. JetStream basically coordinated varying file format data and allowed construction simulation and problem detection. When Revit released its update, Revit 6, in 2004, this set the stage for larger teams of architects and engineers to collaborate in one integrated model software. As Autodesk raced to be on top of the BIM game, it acquired Revit in 2002, NavisWorks in 2007, among other "smaller" BIM systems. In late 2012, Autodesk developed format. Format is an application that enables the conception of a BIM model on a mobile device.

In 2003, Bentley Systems developed Generative Components (GC), a BIM platform that focused on parametric flexibility and sculpting geometry that supports NURBS (non-uniform rational B-spline) surfaces.

In 2006, Gehry Technologies released Digital Project, a program similar to GC. Both Digital Project and GC spawned a revolution in architectural designs. These two platforms are revolutionary, in a sense, as they can produce especially complex and provocative architectural forms, paving the way for parametricism. Patrick Schumacher coined "parametricism" and the movement of building parametric architectural structures in 2008. He pointed out in the Parametricist Manifesto the importance of mastering the modern BIM platforms (DP and GC) in competing in the modern architecture scene.

With all the parameticist view and the "older tradesmen" values, there is a generational drift that is being subtly created by technology integration. For example, an "entry-level" designer who knows basic commands on a software can produce more work than a highly experienced architect who is inexperienced with program interface and concepts. Since all these are learnable skills and techniques, architectural schools and even software companies provide specific training for specific software. Being "outdated" as a worker is a myth since all these new technological integrations can be learned

As BIM celebrates at least 40 years of its general concept and technology, it seems to just be realizing its massive potential to the architecture, engineering, and construction sector. We are slowly witnessing the integration of virtual design and construction with "sustainable design practices, human-computer interaction, augmented reality, cloud computing, and generative design" (Bergin, 2011). These trends are continually and rapidly influencing the evolution of BIM. It is actually an exciting time to be alive and to witness the rise of the construction tech.

This piece is part of a series covering building information modeling (BIM). Supplement this with articles discussing what BIM is and its benefits to the construction industry, the roles in a BIM project cycle, the challenges and potentials of this emerging construction technology, what are its future implications, and the common myths surrounding its use. Supplement your BIM knowledge by downloading the free ebook on increasing productivity on the construction work site. Keep feeding your knowledge of BIM and IPD model of construction management and delivery.

BIM for 3D , 4D and 5D Modeling

Building information modeling is a tool from which we can convert a 2D model into a 3D model. Also from this 3D model we can make it as 4D. This fourth Dimension is Schedule of a project and fifth dimension is quantity take off .

a) Data required:

BIM requires following data for making 3D, 4D and 5D model and simulating it. Following figure shows the data requirement. The use of BIM tools and BIM workflows has huge potential to affect most processes in design, construction and operations.BIM represents a new way of collaboration. With BIM we share more information both across disciplines but also across phases. With this big change in how we do things we need to update or amend our contracts.

As per following figure the data require for BIM is legal data, Financial data, specifications data, environmental data designers data, etc. These kind of data requires for BIM because it simulate all the data input and gives best possible results.

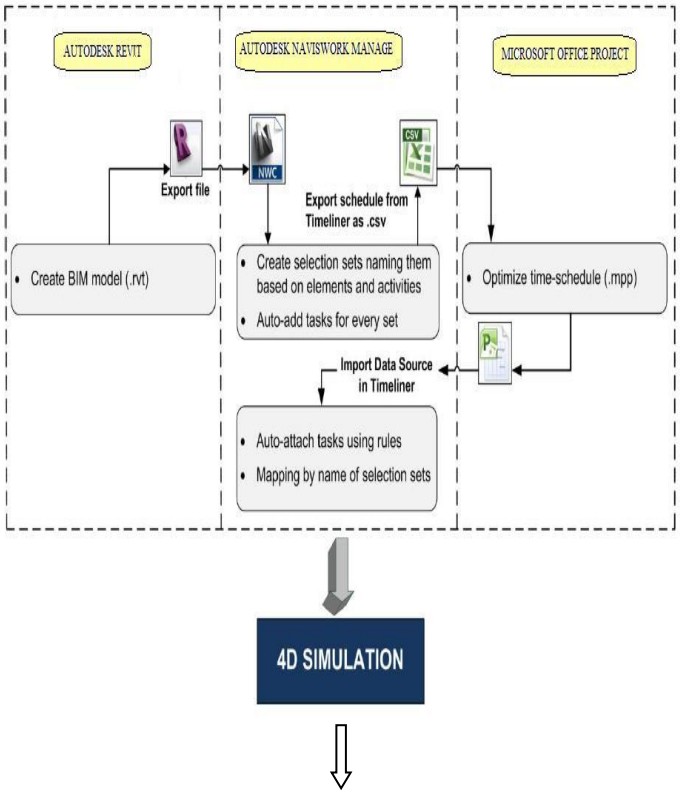
b) Data Flow:

The creation of a 3D housing model using the Revit Architecture 2014 had shown the powerful features of BIM. For making 3D model of any project we must have 2D drawing of that project then only we can make it s a 3D model. Also for designing walk through view 3D model is necessary. From that we can visualize the structure inside

and can make changes if want before starting construction.

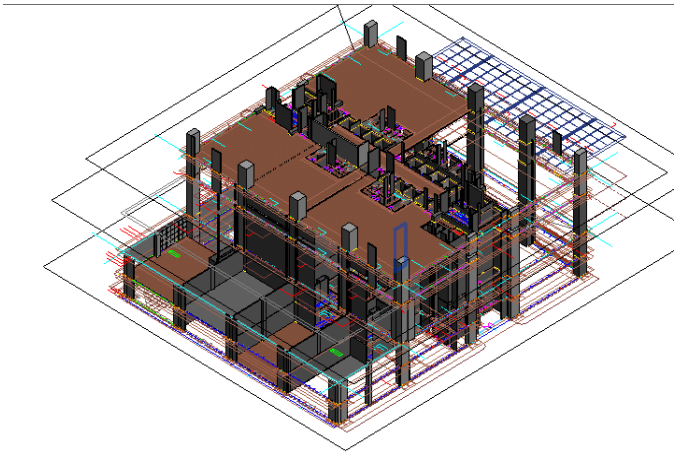
For making 4D model, we should know the schedule of the project. By making XL sheet or MSP schedule one can input these either of two into BIM system. After schedule file is taken in the form of project planning software, it can be imported in Autodesk Naviswork and tasks can be linked with building objects due to automatic linking option to obtain construction sequences.

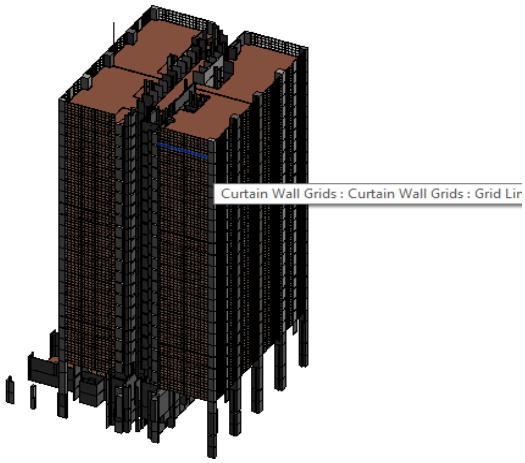
By using BIM instead of drawings, the takeoffs, measurements and counts can be generated directly from the underlying model. Therefore the information is always consistent with the design and when a change is made in the design – a smaller window size, for example – the change automatically ripples to all related construction documentation and schedules, as well as all the takeoffs, measurements and counts that are used by the estimator.



Preparation of 5D model by introducing quantity takeoff to 4D model

The below figures shows hoe a 3D model of BIM will look like to be. This model is model of Commercial building in Kolkata. It is a partiallly completed architectural 3D model which we can further use it for BIM.





C) Benefits and drawbacks of BIM in commercial construction project

BIM has a significant benefits in construction industry.BIM can be used in every aspect of construction or at every phase of construction i.e at initiation, planning, execution, performance and monitoring , finally at closure. Also,BIM can be used in maintenance phase of project. When construction projects are managed with traditional methods and paper-based tools, it may be difficult to finish project on time and under budget. With the BIM technology, architects show every little detail in model and by minimizing the reviews and reworks, time can be saved and projects can be completed under budget by saving time and money and productivity in construction projects can be increased, collaborative design and coordination can be achieved. Accurate and faster design decisions can be done at early stages, accurate and faster quantity takeoff can be obtained automatically, material wastes can be minimized because with the ability of BIM technology design conflicts can be determined before construction starts on site and errors can be minimized that can reduce delays and cost overrun.

1) Increased Accuracy:

BIM has integrator to improve accuracy of quantity calculations. Data attached to objects allows to accurate price modeling and counting, improving the accuracy of bids and pricing of project. Designers are receiving few requests for information and change orders. Integrator scheduling based on material availability and construction progress can be mapped visually. Project managers can quickly optimize construction schedules with ever changing, seasonal costs, availability and material deliveries.

2) Better visualization and documentation:

BIM software‟s Revit, AutoCAD provide to the users more better visualization comparing to the old 2D design software. With the 3D view, it is easy to get the general ideas of the site condition surrounding to proposed building look likes after and during construction. The new released software also included the alignment layout and tools that makes sharing of design standards easier across the organizations. The corridor includes tools that streamline corridor editing provided in plan, profile and section view simultaneously. The creating 3D site model could be publishes to Google Earth or to exported as DWG files to help communicate design. In addition to this the Civil Visualization Extensional is available, which subscribed by the Autodesk to download, which provided to take 3D surface and corridors, easily incorporate them in 3Ds Max design, so that we can create a compelling visualizations.

3) Improved Efficiency:

BIM help to reduce errors and omissions (E&O) which are in turn reduce E&O claims and professional liability. A reduction in insurance costs, positive impact and bonding fees on firm reputation should increase the number, scale and variety of opportunities available to design and integration firms. Prefabrication that reduces accidents, increases efficiency, and reduces labour time in the field.

4) Accurate Cost Estimating and Cost Management:

The use of BIM allows estimators and quantity surveyors to accurately estimate building costs, which is based on the quantities and schedules generated from the BIM model. These measures was also automatically updated by the BIM software whenever changes are made in the model ensuring schedules of quantities are always accurate. If this 5D data are incorporated into the BIM model in the early concept design stages of a project, it helps to show clients financial effects of change requests and other variations. The accuracy of cost estimating with the BIM depends on the BIM model being modeled accurately by the designers. When quantity takeoffs and estimates was performed using BIM, the quantity surveyor must be careful to understand exactly what the areas and numbers represents.

Other than these benefits BIM is also help to faster and more effective processes for project information, value added and reused. It develops better design of building and proposals are analyzed easily with quickly simulations performance, enabling improved and innovative solutions. It also helps for developing automated assembly, better customer service and lifecycle data of project.

5) Improved Coordination and Clash Detection:

A benefit of BIM are improves the coordination of documents between the various designers and engineers involved in the design phase of a project, as well as the coordination of structural elements, and with building services systems. Khanzode, Fischer, and Reed found that labour savings of up to 30% were possible due to improved services coordination of BIM. The coordination benefits of BIM was found to apply the specialist trade subcontractors such as precast concrete and structural steel manufacturers, found that “pre-building” is their part of the project, and it can help significantly to “reduce the likelihood of errors” that occurs on the construction site.

6) Interference checking, less collisions:

Some of the BIM software‟s carry this functional tool: interference checking. The well defined site model with existing underground condition and the excavation pad on site, this tool could simply allow the user to identify the following two situations and can play a significant role in reducing possible collisions during future constructions.

A) If there is any interference between different pipe network.

B) If there is collision between the excavation and the existing underground conditions.

7) Energy Saving Design (BIM for Sustainable Design):

BIM helps to the civil engineers to create more sustainable land development, environmental, and transportation projects. Some of the civil engineering BIM software allows the user to analyze the storm water runoff to design solutions. For example, AutoCAD Civil 3D, this would limit the disruption of natural hydrology. For landscape architects, brings BIM to landscape can make the site design much easier, through taking advantage of the 3D model, they would maximize the possible open space and minimize site disturbance during construction.

8) Time Saving Utility Design:

AutoCAD is the powerful function to create, swap or move pipe networks in the plan view; we can easily define pipe networks to contain pipes only, structures like in this case, both pipes and structures according to the real site conditions. Multiple pipes and structures are ready to use, the size and style should be always redefined after the network has been set up. For some special parts that not exist, the user can creates a part comprised of only the parts of items and save it for future use. Not like 2D paper work, by using the similar tools, the entire pipe with the same properties could be changed only one time, which saves a lot of time for engineers, and also reduces the potential mistakes.

9) Single and integrated information resource:

Site linked BIM models integrate information from different project parties together as a single information resource. Before the site-linked BIM models were built, the project has more pieces of information resource, the paper drawings and structural building models. As there are pieces of information, this information can be bringing in the BIM model and all of this information could be carried by 3D site linked building Model. This resource can be shared by all the users, which will save lot of paper work, as well as improve the coordination and cooperation between the project team.

LIMITATIONS OF BIM:

BIM have the potential to improve the communication and coordination between the different stakeholders of a project. The benefits of BIM range from simple improvements in coordination and efficiency to greater client satisfaction . It should also be aware that there are number of current limitations of BIM that must be taken into account.

1) Cost of Training:-

There is more demand of train staff quickly in market with the new software. It is not realistic with CAD proficiency will be learn new BIM software quickly or without training. The fundamental differences between BIM and CAD, training should be required for all professionals involving with designing and producing documentation. BIM provides ability to every member in the team to involve in the design and modeling process, with the complete control of the end product.

2) Cost of Software and Hardware:-

Every industry currently using 2D or 3D CAD drafting software can be attribute a cost element against purchasing, upgrading software licenses and maintaining. In current market the cost of BIM software is more than the CAD software available. With the BIM software, the requirements of hardware are increased. Currently, CAD software can be operating with limitations on majority of laptops. The BIM software dedicated high-specification, equivalent to advanced modeling and rendering software. A software and program requirement is ahead of hardware availability. With the BIM software, it is know exactly what parameters of hardware improve performance.

3) Compatibility between Software Platforms:-

This is one of the biggest issue with early adaptors of BIM is of entire product compatibility. Due to the competition in the market, every software manufacturing company are doing something different with its software. The interoperability issues are not limited to different software platforms; due to the rapid development of the BIM software industry newer version of program within the same platform to have interoperability issues. One of the alternatives of current product specific models was vendor independent, neutral-file format.

4) Innovation:-

The goal of BIM is to assign constrain and parameter to intelligent objects to improve the efficiency, there are potential to inhibit innovation which are possible to the automated process and shared knowledge that BIM provides. Those firms are implementing BIM should view the parameters and data constraints as a global database that allows designer to save time associated with the update and configure product data repetitively for different projects, hence increasing the amount of time spent on system design and innovation.

5) Transition from Drafting to Modeling :-

When moving from CAD drafting to the BIM modelling , a change in workflow will be surrounded that what should be used to simple drafting tasks. These tasks require higher-level skilled design drafters who understand the project and the materials used. With no knowledge of the trade, the costs associated with training and maintaining a skilled design modeler is higher than a draftsman. Some companies may be compelled that to stay out of the BIM due to the time and knowledge intensive nature of BIM. The CAD also increasing level of responsibilities on the designer to the entire system component is coordinated with the other design professionals such as engineering and architecture services and that site issues are reduced. Company has a different business models to consider when thinking about staff training with respect to BIM.

The first option involves the training of designers to understand all design work in the BIM. The second option involves skill of drafting staff to higher technical level to understand design responsibilities. The third option is

combination of the first two where is a specific set of rules and guidelines so that design can be translated into the model clearly and effectively.

CONCLUSIONS

Construction projects are getting difficult in recent years , specially construction projects are very tedious to manage by conventional method. There for Building Information Modeling is a very effective tool for managing all construction activity for large projects. Building information modeling gives precise results with improved accuracy, saves time and money, 3D vizualsation gives views close to reality. It reduces the disputes which can be arise between builder/developers and contractors.

As BIM is very popular in developing countries. This will have a great future ahead. So, we an say that recently more construction companies accepting the building information modeling will become a integral part of project.

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