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Application of 5D Building Information Modeling for Construction Management

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***Abstract*—**Construction industry is growing rapidly and new technologies are making the construction easier than before. Building Information Modeling is one of the rapidly adopted technology in India. The integration of different Models in one integrated model can give advantageous benefits to the stakeholders. Dimensions of BIM like 4D gives proper scheduling model which helps the project manager to have great efficiency during planning. BIM 5D gives cost related aspects with digital model which gives visual advantages to manage cash flow at different phases of project. BIM also has ability to generate automatic documents which leads in reduction of time for project management firms. Building Information Modeling is a technique which creates, manage and generate a model by taking physical and functional characteristics of building. This research is on Industrial Building performance with the BIM 4D & 5D applications. Comparison between traditional quantity & material take-offs method and BIM based quantity and material take-offs can list out the benefits and drawbacks of both methods. Automatic generation of documents can be possible in BIM based quantity and material take-offs which can give precise units as well as decrease time for the generation of documents.

Keywords- 4D Modeling, 5D Modeling, Building Information Modeling, Construction management, Quantity Take-offs, Scheduling

I. INTRODUCTION

Construction industry is going towards adoption of the new techniques for the efficient management of the work during whole lifecycle of the building. One of the technologies which implementing rapidly for the coordination, integration as well as manage the information is Building Information Modeling. Building Information Modeling is a method which creates, manage, control the data and made visualisation of the construction sequence with Modeling process by taking functional and physical characteristics of building. Stakeholders attached with project always want to visualise the concept and planning sequences with help of models to get the clear idea and knowledge about every aspects of project. BIM and its different dimension help to analyse the different aspects of the project before the execution of the project start. BIM also helps to make communication easier.

BIM 4D stands for the timeline or schedule. When the fourth dimension which is scheduling added with 3D model it is called 4D Building Information Modeling. 4D models provides a new vision in form of time simulation model. This helps stakeholder to visualise how project will develop with particular timeline and make decisions or to update any decisions on basis of that simulation.

Center of 5D BIM is based on the elements of the information model and being able to gain reliable financial data. Decisions should also involve the cost of capital, its related operating costs, and the cost of replacement or restoration. Such predictions could be decided on the bases of details and corresponding details connected within the Modeling framework to functional elements. This data helps budget managers to accurately derive the quantities of a particular items, applying costs to such quantities and achieving a cumulative production cost. 5D BIM combines design with calculations such as expense and involves quantity calculation (BOMs/BOQs), price growth and cost involved.

Fig. 1 shows the Implementation of BIM over building lifecycle.

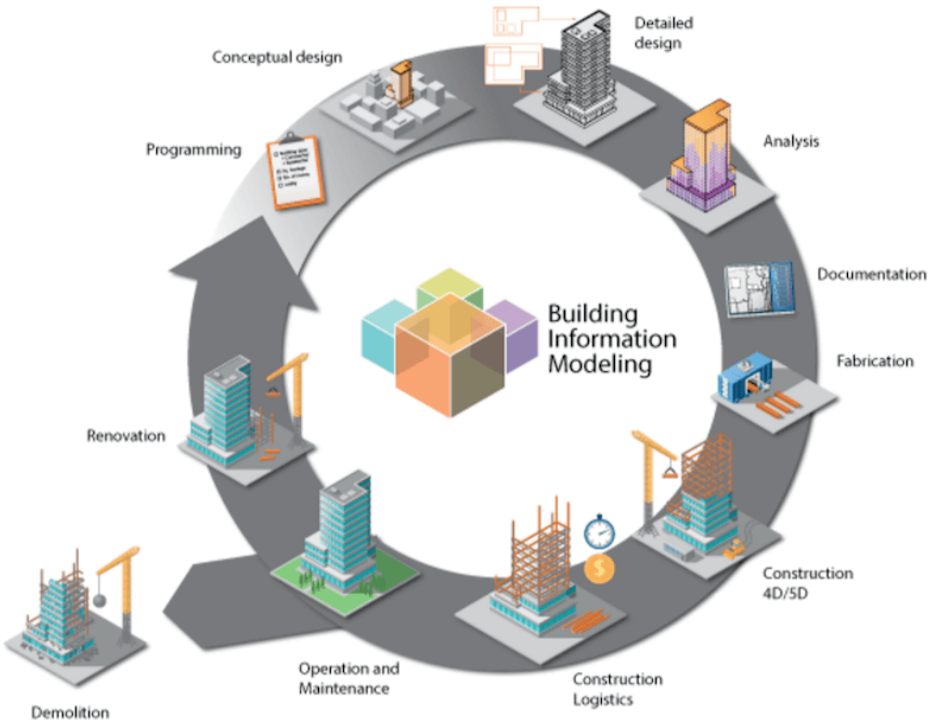

Figure 1. BIM Life Cycle [16]

BIM and Construction Management

Building Information Modeling is a vast methodology that can be utilise for every aspect and every field related to the building. One of the majorly advantageous field is to implement BIM for the purpose of construction management during its planning, execution and operation & maintenance phases. Project manager or construction manager can take the benefits of BIM to achieve the project goals with least barriers and with greater possibility of success in terms of time & cost.

Different field of management have some different advantages with Building Information Modeling. Clash Detection facility of BIM can help to resolve clashes between different component of building like columns, beams, slabs, pipelines, HVAC systems etc. this can be performed to achieve greater accuracy of quantity. Simulation model is the perfect example of how construction manager can achieve greater accuracy in scheduling and cost control with different time periods. BIM plays major role in schedule management and cost management with facility of simulation Modeling. BIM has ability to autogenerate the documents and store that data within the system which is more reliable for the accurate and effective

documentation control over the project. These functions of BIM give more accurate ideas, visualisation and confirmation over different queries related to project. Construction manager, planning engineer and different stakeholders attached with project can take the worthy decisions by utilising Building Information Modeling.

BIM Maturity Level:

Building Information Modeling maturity level represent the different platforms for information exchange and how to coordinate and collaborate different data with each of the stakeholder.

Fig. 2 shows the different Maturity level of BIM.

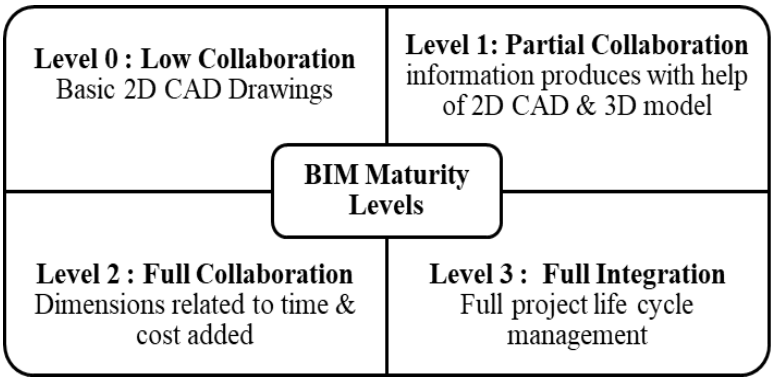

Figure 2. BIM Maturity Level

BIM Dimensions:

Building Information Modeling has some amount of data or information which is attached with model and this data are differentiate with help of different dimensions which is shown in table 1.

TABLE 1. BIM DIMENSIONS

Dimensions	Data	Functions
3D	3D model	CAD modeling, Visualization, Clash Detection
4D	Time	Project Phasing scheduling, Project scheduling, Plan of Resources, Payment Scheduling
5D	Cost	Quantity Takeoffs, Cost Estimation, Project Costing, Material Costing
6D	Sustainability	Energy Analysis, Environmental Impact, Sustainability Tracking, Green Building Certification
7D	Facility Management	Lifecycle strategies of building, Operation & Maintenance plan, Facility Management

II. SCENARIO OF BUILDING INFORMATION MODELING FOR CONSTRUCTION MANAGEMENT

The paper containing the work done by various authors and the outcomes of various research papers. Paper published in various national and international journals, Ph.D. Thesis, reports and books have been studied. This paper enhances knowledge to understanding the subject and provide extensive background to carry out work ahead in proper flow.

Amol A. Metkari et al. (2013) stated that Building Information Modeling (BIM) is an innovative method that build project virtually before its execution. It helps to autogenerate information digitally like quantity documents of construction, decision making, Planning, scheduling document & cost related documents. BIM 3D has three primary parameters which are length, width and height/depth. When time is added with these three dimensions it is called 4D BIM. When cost added with 4D BIM, the modeling is called 5D BIM. 4D simulation can monitor and control the scheduling with the planned schedule. 5D BIM can extract the quantities of materials for the building and can generate the cost for corresponding quantity. Real time simulation can help the construction management field. Construction manager can easily compare the planned and actual progress of the project. [1]

Mehmet Yalcinkaya et al. (2013) found out that Building Information Modeling (BIM) is an approach for digitally carry out facility management including physical and functionally applications of building. The BIM and construction management has vast opportunities to manage as well as control the project without delay and overpays. Construction manager can experience real time simulation for the accurate scheduling purposes. Also, BIM enhancing performance of construction managers and another stakeholder attached with project. BIM and Construction management can manage different field of project like Contract management, Cost management, Schedule management, Site planning management, material and equipment management, risk management, resource management, quality management, decision management, information management, safety management etc. [5]

Conrad Boton et al. (2015) investigated that 4D modeling concepts are widely used for implementation of Building Information Modeling (BIM). To set the norms & standard is the first step towards setting BIM workflow or framework. Data needed in condition of spatial & schematic data is implemented for the successful application of BIM. Different levels of information are to be described for the effective 4D application and framework related to level of development (LOD) is also important aspect for BIM implementation. [2]

Peter Smith et al. (2016) discussed that there are so many technical barriers to keep the project on right cost management plan but it can overcome with use of building information modeling. BIM has developed many ways for cost experts to increase efficiency, effectiveness & cost decision for successful completion of project within budget at different stages of project. The main challenge with implementation of BIM is lack of software skills and expenses related to educate employee with emerging software. The performance of BIM has issue because, there is no full access to the designers. To implement the BIM significant strategy can be made and this can be varying with different project and different purposes of project. [7]

Jiang Xu et al. (2017) observed that in the project construction design process, BIM 5D should be adopted to get better rewards. By applying BIM, construction process assures that wasting of time, cost & resources should be minimized & performance of construction quality can be increased. BIM 5D process and workflow is described first, BIM technique and theory for development of this technique to take the fruitful benefits of BIM is to be developed for careful management and control of project. BIM gives combine facilities like management, visualization, clash detection, simulation etc. [3]

Julie Jupp et al. (2017) indicated that Building Information Modeling (BIM) simulation models can build up construction planning, timeline to compete project, protection to site, minimize wastage on site. Increasing adoption of BIM 4D functions the hidden skills of software as well as analysis power of the BIM tools. Environmental impact of the project can also analyze by the BIM process and sustainability parameters can also achieved. Advantageous application of BIM can also make standardize norms and

framework for successful sustainable planning. 4D BIM frameworks needed to be prepared for implementation of Building Information Modeling. [4]

Zhang lizhu et al. (2017) studied that Building Information Modeling (BIM) has ability to manage complete project lifecycle effectively during pre-construction, construction & post-construction phases of project. Application of BIM tools & features for complete project life cycle can give enormous advantage to take a view at realistic condition of project. Main issue for project management lifecycle through BIM approach is necessity of owner, economic criteria and cost related criteria which can leads in cost-overrun. [17]

Rabia Charef et al. (2018) carried out study for the BIM implementation and BIM measurement for twenty-eight countries of Europe. Different dimensions of BIM application are the main parameter and finding out the adoption of BIM in Europe is carried out. Most of the representators are widely using BIM for Scheduling (4D) & Cost-Estimation (5D). 4D gives advantages over time delays of the construction project and gives project manager to keep project on time while 5D deals with the cost related parameters which can helps to eliminates cost-overrun problems for the project managers. 5D also gives the cost for different phases of the project with the visual simulation model. [9]

Sarita D. Patil et al. (2018) studied that India is developing country and construction industries in India accepting recent trends and technology rapidly. ACE industry is now mainly depending on new technologies like BIM and other trends. BIM is not just a model but it is whole modeling process which has more potential than only 3-dimentional model. BIM can autogenerate different documents like Quantity takeoff and material takeoff. BIM has potential to generate the quantity of material and has advantage over traditional method. BIM based method gives result for quantity about 2-3% less than the traditional method. Tools like Autodesk Revit, Autodesk Navisworks, Autodesk Quantity takeoffs & MS-Project are used to produce quantity takeoff, scheduling, cost estimation & simulation model for BIM 4D & 5D. [11]

Somnath D. Khochare et al. (2018) observed that application of Building Information modeling has enhance the success of project, generate more accurate quantity takeoffs, gives more accurate scheduling process & control the cost related data and expenses of project. BIM gives advantages like better visualization, clash detection, effective schedule and cost management by use of 4D & 5D dimensions. Simulation model also helps in facility planning, design & construction. Moreover, digital illustration of building before its construction makes possible to eliminate problems related to design, construction and operations. [13]

Yash K. Patel et al. (2018) noted that 5D Building Information Modeling is automated process which helps to create the virtual digital model for the information. Scheduling (4D) & Expenses (5D) related data is also attached with the model. Application & implementation of BIM up to five dimensions is not that much difficult but when more that these five dimensions are added at that time to manage the information is large barrier for the implementation. This 5D BIM simulation model helps the project team to making decision effectively. [15]

Yohannis Fekadu Aynalem et al. (2018) discussed that better visualization with help of BIM can bring improvement over the traditional process for cost control and many more parameters. Practical ability of BIM for implementation of 5D strategic framework shows the effective and efficient management of scheduling, budget and quantity takeoff documents. By application of different information in 3D model like expenses and time to complete construction of the component, one can create the single source of information. [16]

Pathan. Md Rafi et al. (2019) concluded that lack in using new technologies delay the project completion. Concern related to owners, consultant, contractors, designers are mainly affecting the construction. Provision of BIM makes the common platform to share the data between different authorities of project which can help to make communication better and more effective as well as this can help to integrate different data from different designers. Implementation of BIM 5D wants the proper approach as well as structured preparation. Scheduling and cost estimation is also important part for this. Also, in construction industry, the development process must be achieved to reach the quality & standard with use of BIM process. [6]

P Mesaros et al. (2019) shown that in this rising era of technology, Building Information Modeling is tremendously implementing in AEC industry. BIM is an efficient, model-based methodology that integrates a framework for management team and approaches for more efficient planning, construction process optimization, development and contract management of infrastructure. Most important aspect of BIM is to control cost. BIM 5D model knows as cost model is used for economic estimation of various quantities automatically. 5D modeling gives more effective and efficient cost related data for all levels of the project. [8]

Rafaela Bortolini et al. (2019) clarified that Building Information Modeling (BIM) can play significant role for increasing in demand for prefabricated system of construction. BIM and Lean Management concept can also come up with each other for the construction projects. BIM 4D modeling process can enhance the strategic site planning and controlling. It also fruitful to manage the prefabricated component on site as well as it can also generate the order details of each of component. [10]

Savio Santana Martins et al. (2020) explored that advance construction technology & techniques increases accuracy of timelines, cost, value of project. Modern AEC (Architecture, Engineering & Construction) industry is more reliable on digital platform. Building Information Modeling (BIM) is widely used in this modern era. BIM play major role in decreasing project delays and cost overruns. BIM can also give the effect from the construction of project on surrounding environment. [12]

Thibault Mazars et al. (2020) claimed that on early-stage BIM is used only for designing & architectural perspective but from past few years it is used for many areas including designing, construction management, scheduling, sit e management etc. Activities attached with 3D model develops 4D simulation model which gives competition of construction on different phases of project. BIM had proved many advantages but on the other hand the implementation of the Modeling approach has some constrains in terms of time, skills and efforts of individuals. [14]

Table 2 shows the Comparison based on BIM Dimensions & Types of building.

TABLE 2. **COMPARISON BASED ON BIM DIMENSIONS & TYPES OF BUILDING**

Author	Year	BIM Dimensions		Type of Building			
		4D	5D	Residential	Commercial	Industrial	Public Building

Amol et al. [1]	2013	*		*			
Conrad et al. [2]	2015	*			*		
Jiang Xu et al. [3]	2017		*		*		
Sarita et al. [11]	2018		*			*	
Somnath et al. [13]	2018		*		*		
Yash et al. [15]	2018		*		*		
Yohannis et al. [16]	2018		*	*			
Pathan et al. [6]	2019		*				*
Savio et al. [12]	2020	*		*			
Thibault et al. [14]	2020	*		*			

Table 3 shows the Comparison based on BIM Tools for different aspects like 3D modeling, Scheduling & 4D/5D Modeling.

TABLE 3. **COMPARISON BASED ON BIM TOOLS**

Author	**Year**	**BIM Tools**						
		3D Modeling		**Scheduling**			**4D/5D Modeling**	
		Revit	**SketchUp**	**MS-Project**	**Primavera**	**Microsoft Visual Basic**	**Navisworks**	**4D Virtual Builder**
Amol et al. [1]	2013	*		*			*	
Conrad et al. [2]	2015		*					*
Jiang Xu et al. [3]	2017	*					*	
Sarita et al. [11]	2018	*		*			*	
Somnath et al. [13]	2018	*		*			*	
Yash et al. [15]	2018	*		*			*	
Yohannis et al. [16]	2018	*		*			*	
Pathan et al. [6]	2019	*			*			
Savio et al. [12]	2020	*		*			*	
Thibault et al. [14]	2020	*				*	*	

III. CONCLUSION

1. Building Information Modeling (BIM) is a technological approach that enables a design to be generated digitally before it is built physically. It produces and uses accurate, structured, calculable information about a construction project.
2. Project time delays & cost over runs can reduce by the use of Building Information Modeling.
3. Building information modeling automatically generates the accurate quantity takeoffs and reduce scheduling problems which helps to reduce overall project barriers and increase the success of projects.
4. The 4D-Time simulation model includes scheduling of activities with 3D component of model and scheduling is mainly depends on quantity take off obtain from 3D model.

5. The 5D-Cost simulation model is used for budget management and estimation of cost for different quantities at various stages of project.
6. Building Information Modeling includes many data dimensions like models, timeline, cost, sustainability etc. but excessive data can increase complexity which is challenge to implement BIM.

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