5D-BIM: METHODOLOGY, ADVANTAGES AND OBSTACLES FOR PRATICAL IMPLEMENTATION ALONG WITH IMPROVEMENT MEASURES – A REVIEW

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ABSTRACT: Building Information Modelling is a scientific gear which facilitates a cutting edge in revolutionizing the construction field. BIM models are mutual and parametric in construction. Since Building Information Modelling revoloves around the three important factors such as quality,time and cost it has become an inevitable parameter in construction projects. To improve the quality and sustainability of construction projects and to save time and cost, multi-dimensional information regarding the project must come in time and has to be accurate enough to meet the demands of the project. This paper reviews the traditional construction management,the significance of creating 5D BIM and the parameters needed to develop the 5D BIM. This paper aims at presenting the advantages of 5D BIM models and pratical obstacles in implementing it. Some suggestions are proposed to overcome some of obstacles and is recommended to carryout researches to overcome other hurdles.

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Keywords **–Traditional cost management, 5D BIM, Stages of 5D BIM, Virtualisation, 5D Implementation barriers**

1. INTRODUCTION:

A successful construction project is built upon effective administration of quality,time and cost.The major components that bother civil engineering project clients are:pleasing view,defect free completion,timely delivery,usability,acceptable running cost and gratifying durability [1]. A lot of inconsistent information is generated in construction projects. This causes difficulty in project planning that may lead to misconceptions and mis-judgements related to project results [2]. Despite their huge investments,the clients will be at the receiving end of ambiguous outcomes.This ambiguity is to be reduced to make the construction industry adaptable to a rapidly changing society.Since early 90's,various researches have focused on the possibility of linking the planning and drafting process [3] as a substitute to mock ups and have looked at the option that are available in the near term data [4]

In recent years,the most blooming technology in the construction sector is Building Information Modelling.BIM is a digital portrayal of a structure's geometric and non geometric data [5]. The basic objective of BIM is to afford the stakeholders wilth the competence to consolidate,evaluate,simulate and visualize the geometric and non-geometric information of a structure.The motion was first highlighted by Fastman in 1975. [6].This technology can promote the transfer and interoperability of information [7].

2. TRADITIONAL COST MANAGEMENT

Cost management aims at controlling and reducing the operating or production expenses in order to make it less expensive to the clients.The activities that are concerned with cost management are planning,estimating,budgeting,financing,funding,managing and controlling costs which lead to the completion of the project within the approved budget. Therefore, effective estimating and costing becomes important factors of a construction project success [8]

Initial cost which is viewed in relation to the product instead of the function,serves as an antagonist to the project value preposition [9].This culminates in inaccuracy and uncertainty in the estimation of cost management .The project scope often has missing information issues causing cost uncertainity. [10]

Project delays are another paramount factor that has a significant effect on the initial time and cost estimate of construction projects.They are also accompanied by cost and time overruns.[11]. Construction delays are considered as time lag in the completion of activities from its specified time as per contract or can be defined as late completion or late start of activities to the baseline schedule, directly affecting specified cost.Defining project delay from the view point of an owner,it is the loss of revenue due to the insufficiency in production facilities and rentable space or a dependence of present facilities [12].From the contractor's side, it could be defined as the cost overhead as a result of longer work period,higher material cost through inflation and labour cost [11].

There are also certain issues that influence cost management: failure to forecast,failure to emphasize the improved opportunities and poor support to inter-organizational cost management [13] While looking into the impact of technology in the cost management of construction projects,its effects are found to be very limited.Computer Aided Design(CAD) has been mainly used for drafting,modeling and measurement purposes [14] and 2D drawings only provide geometric data [15] that has no visualization and limits the understanding of the project.

The failures in responding to the variations,dearth of cost data review and maneuvering basic isolated systems are the causes for low reliability of estimates.Four estimating methods are commonly used in construction namely functional,size

related,elemental cost analysis and the units rate method [16]These methods are mainly concerned about the established budgets and finished elements. The detailed methods that tend to provide value are not used because of unfamiliarity and lack of technical support[17]

In order to overcome the challenges faced in the traditional cost management, that includes disruptions in the process,design liability,lack of collaboration,inadequate design reviewing,isolated decision making,use of traditional cost accounting methods,project delays and lack of automated process [18-20] Building Information Modelling is induced to eliminate the factors that causes the incompetency of cost management.

3. BUILDING INFORMATION MODELLING:

BIM is helpful in shifting the working pattern from 2D based drawing information system to a 3D based object information system [21].This revolution changes the documentation method from manual mechanisms [22] to digital descriptions of structure's elements which consolidate other information life time and cost. [23]This framework is known as n-dimensional [n-1]modeling,where different dimensions of information are collected and fused into a digital building model [24]. Therefore,the BIM framework was advanced to characterize the output for construction sector stakeholder and to attain integrated project delivery [25]

3.1. 4D-BIM-TIME:

The fourth dimension included in the traditional 3D-BIM model is "time".This enables the 3D assemblages inherent to a BIM model to be combined with the construction schedule.This 4-D model creates a virtual simulation of building the BIM model delivery [26]. These simulations are used to convey the work sequence to avoid rework and to identify congested or constrained areas due to too many trades being in one place at the same time,well ahead of time.

As different trades involve various specializations, coordination between the trades has become very significant in the construction industry.A big challenge in the construction project is to optimize the time and space in the building where services such as water,fire safety, service and electrical systems are located.Under such conditions,contractors installing these systems are to be coordinated so that each party has enough time and space to install their respective services.

The simulation of the construction sequences by 4D-BIM can optimize the process and allows maximum rework and alteration.4D-BIM also entitles the project managers to optimize the movement of materials,machinery and human resources on a site well in advance.

3.2. 5-D BIM:

The fifth dimension of BIM added to the 4D BIM in cost and 3D BIM model contains the geometrical information needed to perform a material quantity lack-off. A 4D BIM model has all the activities required for the completion of a project.By incorporating the cost database to the 4D-BIM model and by assigning actual costs of the materials, equipment and personnel,a 5D BIM model can be developed to provide the construction project team with a useful tool [27].

. 5D-BIM model helps the construction professionals to give faster feedback about the project cost so that the project design may be adjusted to fix the budget.Often,the estimated project project cost exceeds what the owner can afford.This leads to significant design changes that results in losing the most architectural element of the design.The 5D-BIM model provides the owner and the design team with higher transparency in viewing the contractors's budget,which increases the reliability among various stakeholders.

4. Methodology [28]

Thre different parameters are incorporated into BIM in the following stages. The first stage involves the collection and input of building information into 3D model. This process starts with clients briefing on their requirements that lead to an initial proposal. The 3D model contains information that specifies each and every component. The second stage commences after clients are satisfied with the initial design that comply to the specified requirements. Quantity surveyors or cost engineers will input the information for cost estimation into the 3D model. The cost estimation is done by automating quantification of building elements with unit price. At this stage, 4D BIM is very useful to assist clients in refining their priorities from the perspective of cost estimation. The third stage will proceed when the clients are satisfied with the concluding 4D BIM. Project managers will create Work Breakdown Structure (WBS) for all types of construction activities. Since the integration is done with BIM, it can cater for a huge amount of information, with WBS containing more levels compared to a conventional system. Some of the critical factors such as construction method, human resources, material procurement and supply will affect the project time scheduling. At this stage, all the necessary information is integrated as 5D BIM.

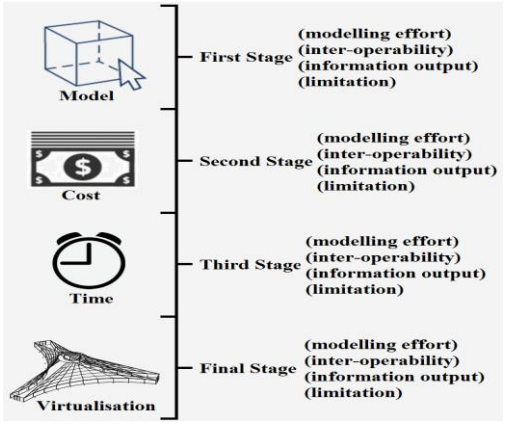

Figure 1. 5D BIM Major Components [28}

4.1. Practicable 5D Building Information Modelling Through Virtualisation:

Construction project data such as time and cost in the segregated form without integration communicate little meaning. Integration of cost and schedule framework shaped schedule and cost management systems [29] and repetitive construction processes [30]. 5D BIM which combines building information model (3D), time (4D) and cost (5D) is aligned with such a framework, integrating the isolated data into smart information useful for various purposes. 5D BIM in the form of multi-disciplinary performance models can be further utilized through Virtual Design and Construction (VDC), defined as the use of design-construction projects [31] to support business objectives. Project VDC usually emphasizes those aspects of the project that can be designed and managed, so that the team will be able to define, design, construct and operate the models [32]. Such performance models can accurately relate the predicted performance in relationship to the actual project result [33]. The virtualization of BIM can improve the quality of information sharing, comparison and project integration by the stakeholders. The VDC will also able to provide a graphical coordination of the design, operation and construction of the building, including its fabrication and assembly details [34]. The process involves using BIM software that allows building information model to be presented by combining building components (3D), time scheduling (4D) and cost estimation (5D) [35].

5. **ADVANTAGES OF 5D BIM :**

5.1. Visualization

Visualization was seen as beneficial to Quantity Surveyors who can better able to understand the project they are involved in, as they can see and interact with the 3D model [36] The building can be viewed from any perspective in 3D, allowing Quantity Surveyors to make fewer assumptions about the design [37]

5.2. Collaboration

The use of the 5D for cost management encourages collaboration on projects, and aids the management of the project overall. In order to achieve effective 5D, designers need to simulate suitable 3D information, and this needs to be checked for conflicts by the construction team. 5D software also has the ability to check for conflict identification, and in this way a collaborative atmosphere is further encouraged [38].

BIM depends on a collaborative approach, ideally through the use of a centralized model, where design changes are automatically updated and coordinated amongst the project team. Collaboration can be attained by two different approaches: the first is where project teams utilize one model software from one vendor that contains all relevant design and cost information. The second approach is where project teams use proprietary or open-source software from different vendors, that contain mechanisms to ensure that data is fully exchangeable [7] As the software can be utilized across different departments, the model can be transferred between different professionals like architects, engineers and other consultants. This allows for real time changes to be suggested and made electronically during construction [39].

5.3. Project Conceptualization

BIM enables the involvement in the design at an earlier stage than on traditional projects, allowing the design team to produce more design options, which enables to quickly and efficiently produce advice to the design team and client of the cost of each option in a manner that enables direct comparison to be made [40] BIM is used at the tendering stage of projects for showing customers footage of the construction process [41]

5. 4. Analysis Capability

Due to the nature of the information contained in 5D models, it is possible to use the model to print out design details, and to generate reports that are useful to other members of the project team, i.e. design changes to be made by architects, and changes to the construction program [42]

5.5 Efficiency of Takeoffs during Budget Estimate Stage

The extraction of quantities for preliminary budget estimating is relatively simple, but it is critical that the items missing from the model can be identified at the time of extraction [40] 5D BIM can provide a high level of cost detail which can be useful in the early design stages, and certain software providers are now making it possible to develop detailed cost plans by live linking the model to a 5D cost library [37]

5. **6: Efficiency of Cost Planning during Detailed Cost Plan Stage**

The ability to automatically extract quantities from the BIM model reduces the time required to generate cost plans, the extraction of quantities is extremely complex due to the model containing unreliable information and an expert is often required to operate the resource [43] Even when detailed estimates are produced by relatively inexperienced estimators, 5D was more effective than that of the traditional 2D estimating methods, especially with a reduction in errors and time taken [44]. BIM is able to process vast amounts of data relatively quickly and has the potential to make work easier. When required, the data can be used to cost the items measured from within the one piece of software. One of the benefits of these integrated, cost databases is that all relevant information is stored in one location [36].

5.7. Risk Identification

BIM offers earlier risk identification like potential clash detection is improved at an earlier stage than with traditional approaches. These researches seem consistent with a suevey in Korea ,where it was found that conflict detection was used in over 70 % of the projects [38] This indicates a clear connection between BIM and the ability to reduce risk on projects. The importance of identifying risks early on in projects is thought to be a vital element to a project's success. The clash detection is a key benefit of BIM for cost consultants. By finding problems early, it may be possible to save both time and money.

5.8. Estimating and Project Options

By considering project options early, fewer deviations are likely to occur during construction. BIM allows professionals to identify factors that have an economic benefit or consequence on various design options in order to select the most suitable and cost efficient proposal [14]

6. OBSTACLES TO 5D BIM IMPLEMENTATION:

6. 1.Software Compatibility

A lack of software compatibility restricts the use of BIM, which may indicate that lack of interoperability is an obstacle to the use of 5D BIM .Interoperability is the smooth exchange of information across all BIM disciplines involved, which is required to maximize the benefits that BIM offers [37] However, triggered by the isolated construction industry, vendors often run software in proprietary type formats that restrict the exchange of critical building data between multiple organizations, and such incompatibility between the BIM model and estimating platforms is seen as a major barrier to 5D BIM implementation [14]

To overcome this challenge, advancement is being made to improve the interoperability of data exchange between BIM models and costing tools through open data standards such as Industry Foundation Classes (IFCs). IFC standards have been generated by the International Alliance of Interoperability (IAI) to help govern the exchange of data between CAD software tools, estimating software tools and other construction application software tools by creating a neutral file format. IFCs are believed to be important for cost consultants, as without complete interoperability, items will be missed from the BIM model as they are combined, and therefore missed from estimates and schedules of quantities. [37]

6.2. 5D Setup Costs, i.e. Software, Training & Hardware Costs

Software and hardware upgrades are considered as significant obstacles to BIM implementation, particularly for small-medium enterprises [45]. A strong training requirement associated with BIM implementation, which, although time-consuming and difficult,is considered critical to BIM's adoption.

6.3 Cultural Resistance

Cultural resistance in its aspect, hinders BIM's effectiveness for cost. Several BIM-capable project participants are not prepared to share BIM information between firms [45]. This type of culture on projects may pose another barrier to successful BIM adoption and use of 5D BIM and cultural transformation is a much greater challenge than any technological challenge arising from BIM; there is some reluctance from older employees to use 5D BIM, but younger employees are much more optimistic [40]

6.4 Incompatibility with Industry Recognized Cost Planning Element Formats

5D BIM's incompatibility with the industry recognized elemental format for cost planning, prevents companies from adopting the software.It was found that estimating using 3D software contrasted with traditional 2D estimating and it resulted in reduced errors and duration. [44]. BIM models currently contain numerous design errors and often have important information missing from them, which hinders BIM's use for producing 5D cost services, as the data is too incomplete or inaccurate to use. [40]

6.5 Lack of Integration in the Model

A lack of integration in BIM models decreases the reliability and effectiveness of 5D. A balance needs to be found between the information architects. This underlying issue i.e.,lack of integration, where parties in the industry are said to work separately, and as a result this also separates the information required for BIM - is thought to be a major barrier to 5D BIM implementation [46]

6.6 Current Software Meets Needs

Some companies feel their current software meets their needs, so they don't foresee any need for change. Smaller firms perceive 5D not to be a viable option at present. This characteristic of smaller consultant firms is shown in a study of small-medium enterprises (SMEs) which found that 73% of respondents think that BIM implementation presents serious cost and commercial challenges, and 76% of small firms are not BIM-experienced, and so have little understanding of the finer details [47]

6.7 Fragmented Nature of the Construction Industry

The fragmented nature of the construction industry limits the potential of BIM. 5D BIM requires the collaboration, database integration and commitment of companies to the use of BIM software, as these areas are still in a separated and fragmented state, it further limits the effectiveness of 5D BIM. [14]

7. SUGGESTED MEASURES:

Since BIM-5D is highly involved in software setup and the ideologies concerned with it,some of the strategies to bring down its disadvantages are suggested

7.1 Software training and funding

Software and hardware applications need to be collaborated for sharing BIM models.Proper investigation of where the costs are exhaled can provide a solution to this problem. The engineers and project managers have to be trained by hiring BIM consultants or by using software tutorials,from co-workers and from authorized training centres to facilitate effective utilization of BIM in both smale scale and large scale project firms.Though implementing BIM is quite expensive,which includes software licenses,new hardwares,hiring staffs with basic BIM knowledge and software training should be considered as an initial investment.Government funds for BIM startups in business firms will encourage a myriad of new ideas and will bring about a rapid technology change which would also help in narrowing down the implementation cost and enable faster dissemination of the technology to every part of the construction worldwide.

7.2 Solution to cultural resistance among big and small firms

Since most of the well established business firms with strong base of BIM technology have numerous fields under their leadership ,the fear that the data relating to each of the sub departments inside the firm might get disclosed leading to a significant hault,encumbers the lead business firms from divulging the information to other firms.This issue cannot be sorted out to a greater extent because it wholly depends upon the ideologies of the respective fimrs.Legal backing from authorities could serve as an partial solution.This might help well established firms in disclosing certain details which might be of great advantage to the smaller firms.Authorization and patenting of the work done in BIM by the major firms could bring relief to the firm privacy and also enable trusted working environment to the project managers from preventing their data to be manipulated in any form.

7.3 Sorting out the incompatibility issues

Since BIM-5D has got its own standard formats ,adaptation of the same is the major cause for elemental format of cost planning.If the BIM standard formats can bridge the gap between the traditional cost formats,the incompatibility issues can be alleviated.The problem involved in data lapses can be sorted out by proper installation of softwares that is necessary for cost estimate and regular upgradation of the data that is used on a daily basis.Since the data is being fed by humans,there is every chance that human error is prone to occur.If BIM models are flexible,then its compatibility can be increased.

8. Conclusions:

Since 5D-BIM is multidisciplinary and includes various platforms and related integrations,successful research on each of its aspects and its viability could help construction sector in India to leap from its traditional method to the concept of Building Information Modelling.Thorough insite and the implementation cons of the 5D-cost management should be deeply discussed and the above suggested measures for some of the factors could find a solution to the prevailing problem.The biggest achievement of cost management through BIM could reach its zenith only if the fear of its implementation is detached and its establishment is flexible to all the construction companies in the world. More explorations are to be done to overcome the pratical difficulties in integrating more parameters like safety, sustainability, resource management, ris etc.,

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