

Study of Integrated Project Delivery (IPD) Using Building Information Modeling (BIM)

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Abstract— One of the major challenges that the construction industry facing is how to improve the effectiveness and performance of construction projects which become more dynamic and uncertain. For this reason, more projects are adopting lean principles which focus on collaboration and work flow reliability. Due to the limitations of other project delivery methods such as Design-bid-build including competitive bidding strategy and fixed price contracts, an innovative project delivery, so called integrated project delivery (IPD) has been adopted by project owners. The building information Modeling (BIM) is act as key for successful implementation of IPD. In this paper, the researchers discuss about advantages of IPD and BIM over the current state of project delivery. The research is expected to provide a practical view on the opportunities and challenges in applying IPD to construction projects.

Key words: Integrated Project delivery (IPD), Building Information Modeling (BIM), Design and Construction, Construction Management, 4D and 5D scheduling

I. INTRODUCTION

A successful project is the one in which the schedule and cost parameters are controlled within the acceptable limits. In construction projects the time taken to complete each phases are grouped to form the entire duration of the project. Construction projects, today frequently suffer from adversarial relationships, low rates of productivity, high rates of inefficiency and rework, frequent disputes, and lack of innovation, resulting in to too many projects that cost too much and/or take too long to build. All project delivery systems have three basic domains within which they operate: the project organization, the project's "operating system," and the commercial terms binding the project participants.

In traditional construction projects, the maximum effort and cost are usually applied in the 'Implementation of Documents' phase. Traditional construction projects which are using approaches like Design Build (DB) and Design Bid Build (DBB) face a lot of challenges in the coordination and collaboration during the entire life. In order for the delivery system to be coherent, the structure in each of these domains must be aligned or in balance.

Integrated Project Delivery (IPD) is an approach where the Organization takes an integrated structure to ensemble Architect Engineer Construction (ACE) professionals into a process that combines the value of individual talents into a combined outcome tied to project goals constructed for a life cycle.

Building Information Modeling (BIM) is a digital, multi dimensional model, which uses a database as a communication tool for the participants to store all kinds of project information in the life cycle. The uniqueness of this

approach is to provide an interdisciplinary work environment among the project participants to create and accomplish successful project outcomes by working together and following unique goals from the conceptualization stage and continuing through to close out of the project. The main aim is to study important time and money saving aspects of BIM and issues to anticipate and how to resolve them when integrating BIM into project planning. There are IPD principles that are used to develop contract agreements according to the type of the project. Every project team comprises of Primary (Owner, Designer, Constructor/ Contractor) and Secondary Project Participants. It can combine the design, cost and schedule information, energy analysis test results and project management logistics in one database, throughout the project's design and construction with successful collaboration. The model can also be used in the facility management of the building by the owner to perform energy analysis, space coordination, locating building components and maintenance of data.

Apart from this, the non-technical aspects of BIM like risk management, Return on Investment are also studied.

II. DEFINITIONS

AIA (American Institute of Architects) National (2007) provides information and guidance on principles and techniques of integrated project delivery (IPD) in designing and constructing projects. According to AIA "Integrated Project Delivery (IPD) is a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to reduce waste and optimize efficiency through all phases of design, fabrication and construction".

A Building Information Model (BIM) is "a digital representation of physical and functional characteristics of a facility. First and foremost, BIM is not software; moreover, you cannot purchase BIM. There are several CAD software packages, like Revit, that help designers achieve a BIM design, so you could conclude that some software is more BIM-capable than others. Secondly, BIM is not just for building design. The original definition of BIM may have applied solely to building models, but this concept of smart Modelling is permeating out to other disciplines. There is not an equivalent acronym to describe civil models, landscape models, and mechanical models, so many people use BIM concepts to describe non building models. I believe the concepts discussed below can be applied to almost any field of design, but for conciseness, this paper will focus on the architecture discipline.

III. MOTIVATION

The present condition construction industry in India there is wide scope for real estate sector due to growing population need. Due to this huge infrastructural developments are taken under construction so as to meet the demands. But there is lot of weaknesses in traditional “design –bid –build” project delivery methods .The conventional design-bid-build project delivery method is based on an owner having the design prepared by a design team (an architect and consultants) so that several construction companies can bid on the construction of the project after the plans (construction documents) have been completed. This method is creating lots of confusions and lack of conversations in each participant of project. This defect will lead to problems like delay the schedule of projects, increasing the cost of construction, overhead charges, wastage of materials, reduction in productivity and quality control, etc. This motivates us to study a new project management technique so as to remove the weaknesses in current project delivery systems in Indian construction industry.

IV. OBJECTIVES

The primary objective of the study would be to provide solutions to the problems faced by the project team on information and analysis front using BIM in conjunction with IPD. Identify the characteristics of IPD and to provide specific information and guidance on how to utilize IPD methods to achieve better projects. study the benefits from integrated governance, and many, probably most, IPD projects use some form of leadership by executive committee, variously called the Core Group, Project Management Team, Management Group.

V. LITERATURE REVIEW

To focus on providing open and interoperable information exchange, guidelines, recommended practices and specifications are applied for framing philosophies, plans and working methods of data through the entire project life cycle. National Institute of Building Sciences committee published the NBIMS standards (2007) [2] and presented the need and improvement of utilizing project information in all phases (planning, design, construction, operation, and maintenance) of project life cycle. AIA (American Institute of Architects) National (2007) [1] provides information and guidance on principles and techniques of integrated project delivery (IPD) in designing and constructing projects.

The potential of using BIM in all phases of the project life cycle is evident from Burcin Becerik-Gerber (2010) [4] where the author from the survey identified, the positive impact research topics that are ‘adopting BIM throughout the project life cycle’, ‘sustainable practices for design and construction’, ‘information management using BIM’, ‘management and organizational issues’ and ‘impact of ROI on Investment (ROI)’. The topics of interests that were identified by the practitioners and students for the design, construction of the project life cycle were summarized in this paper. Practices to develop a strategy to fully integrate BIM through a framework and IPD were also specifically addressed by the practitioners that could address

the interoperability in the adoption of BIM in the construction sector.

Brittany K. Giel (2013) [9] presented a study to show a positive ROI (Return on Investment) while adopting BIM in construction projects overcoming its high initial investment cost. The benefits of adopting BIM is studied by Azhar (2011) based on the questionnaire survey attended by AEC professionals. The key findings are positive impact (82%), improved outcomes (79%), winning projects (66%) and increased usage (62%).

The challenges faced from the study of Saeed Rokooei, (2015) [6] in adopting BIM enabled construction Management are ‘incorporating roles and duties to the participants’, ‘Diversity in use of BIM tools’, ‘Lack of collaboration’, Cultural barriers’ and ‘Lack of framework’. Brittany K. Giel (2013) [9] states that the lack of understanding and knowledge of BIM specific project remains a major barrier for the owner to implement the tool in the projects. It has changed the framework of working environment among multiple stakeholders.

A. Difference between Integrated and Traditional Project Delivery:

In a truly integrated project, the project flow from conceptualization through implementation and closeout differs significantly from a non-integrated project. Table 1. Shows the difference between the Integrated and Traditional Project Delivery

	Traditional Project Delivery	Integrated Project Delivery
Phase	Design, Implementation	Design, Implementation
Term	Hierarchical; consultants engaged on an only-as-needed basis	Collaborative; consultants engaged earlier in design process
Work Efforts	Surge of work efforts occurs late in process	Surge of work efforts occurs early in process
Decision Making	Late	Early
Team knowledge	Surge of work efforts results in knowledge drop-off	Earlier surge of work efforts results in earlier knowledge dropoff
Collaboration	Limited collaboration between silos and expertise	Increased collaboration mutual respect between parties
Data Shearing	Allowed	Encouraged
Technology	2D/3D CAD	4D/5D BIM
Agreements/ compensation	Standard agreements: goals and objectives are misaligned	Goals and objectives ore aligned through three party agreements
Risk	Higher	Lower
Performance matrix	Schedule / Cost / Quality	Schedule / Cost / Quality Sustainability

Table 1: Difference Between The Integrated And Traditional Project Delivery

B. BIM Project Execution Procedure:

This outlines a four step procedure to develop a detailed BIM Plan. The procedure is designed to steer owners, program managers, and early project participants through a structured process to develop detailed, consistent plans for projects. The four steps, shown in Figure 1, consist of identifying the appropriate BIM goals and uses on a project, designing the BIM execution process, defining the BIM deliverables, and identifying the supporting infrastructure to successfully implement the plan. These steps are introduced in the following sections, and this part is dedicated to explaining the details related to each step.

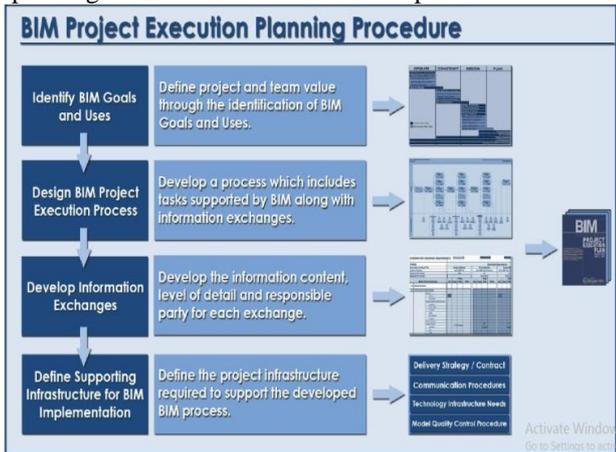


Fig. 1: BIM Execution Procedure

C. 4D and 5D Co-ordination:

The construction planning involves the scheduling and sequencing of the model to coordinate virtual construction in time and space. The schedule of the anticipated construction progress can be integrated to a virtual construction. The utilization of scheduling introduces time as the 4th dimension (4D). There are two common scheduling methods that can be used to create 4D Building Information Model. These are critical path method (CPM) and line of balance. In the Critical Path Method, each activity is listed, linked to another activity, and assigned durations. Interdependency of an activity is added as either predecessors or successors to another activity. Moreover, the duration of the activities are entered. Based on the dependency and duration of the activities, the longest path is defined as the most critical path.

The utilization of quantities introduces cost as the 5th dimension (5D). The two main elements of a cost estimate are quantity take-off and pricing. Quantities from a Building Information Model can be extracted to a cost database or an excel file. However, pricing cannot be attained from the model. Cost estimating requires the expertise of the cost estimator to analyze the components of a material and how they get installed. If the pricing for a certain activity is not available in the database, cost estimator may need a further breakdown of the element for more accurate pricing. Figure 2 explains complete procedure of BIM model making.

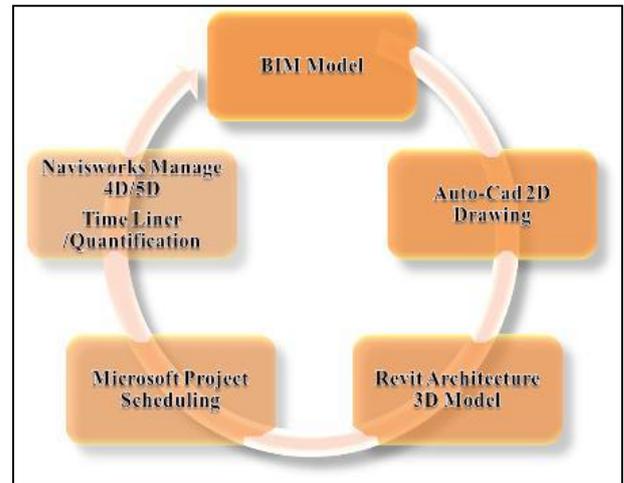


Fig. 2: Process for developing BIM model

D. BIM Tools to be used:

There are plenty of Building Information Modeling tools. BIM tool represents the development and use of computer generated n-dimensional 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. BIM has recently attained widespread attention in the Architectural, Engineering and Construction (AEC) industry. The following table no.2 depicts the BIM authoring tools and their primary functions which are popularly used over the world. The list includes MEP, structural, architectural, and 3D modeling software's. Some of these software's are also capable of scheduling and cost estimation.

Product Name	Manufacturer	Primary Function
Revit 2016	Autodesk	3D Architectural Modeling, structural and parametric design.
Microsoft project 2013	Microsoft	Construction Scheduling, CPM network
NavisWorks 2015	Autodesk	Simulate for whole-project review & generate 4D and 5D model based scheduling Clash detection.

Table 2: BIM Authoring Tools

VI. METHODOLOGY

Since the information exchange among the project participants during the various phases of the project cannot be the same for all construction projects in the world, working of each project is independently unique depending on the size, nature and complexity of the project. Current construction trends involve modern techniques to be adapted for their facility. Executing the project with BIM proved to be both advantageous and simultaneously more challenging such as interoperability, lack of industry standards, owner's unwillingness, learning curve of BIM technologies, cost of investment, poor collaboration among project participants and reluctance to openly share information.

The above problems are overcome-able by the effective use of BIM tool in properly documented IPD approach. From the study of investigation of adoption of BIM in Indian AEC industries, it is evident that integrated project structure leads to wide use of application of BIM. Hence, this study takes into consideration of only residential projects.

The different pilot studies of construction or renovation of residential projects are studied so as to know the different parameters and actual practices under the IPD and BIM. The goal of this project is to examine the uses and benefits of IPD and BIM for construction management and analyze BIM based scheduling and costing. There will be two case studies presented in this project at different locations, Designs, budgets and schedule which are constructed with traditional project delivery approaches. An BIM model of these cases will be prepared by researcher using Autodesk Revit 2016. These models will be exported in Autodesk NavisWorks2015 for BIM based scheduling (4D and 5D approach) along with an simple schedule of project generated in Microsoft Project 2013.

The results will be obtained in terms of optimized time and cost required for completion of project. The results also include reports of clash detection analysis and return on investment (ROI) analysis.

A. Clash Detection Analysis:

In BIM the coordination between the architectural and structural components as well as various services is smooth and can be carried out well in advance, thus saving time delays during execution. Clashes between various disciplines can be identified prior to construction and delays at site can be eliminated. Clash detection is one of the biggest benefits that BIM offers and has been the largest contributing factor for widespread BIM usage in India.

B. Return on Investment (ROI) Analysis:

ROI is one of many ways to evaluate proposed investments because it compares the potential benefit or gain from an investment to how much it costs. As shown in following equation ROI is calculated by taking a ratio of profits received as a result of an investment over the price of the investment and then multiplying it by 100 in order to establish a percentage that can be used as an indicator of performance. When applied to BIM, it is suggested that ROI be measured as a ratio of net savings to costs because the potential savings that result from this technology are considered profit to contractors, designers, and other stakeholders

$$ROI = \frac{\text{Gain From Investment} - \text{Cost of investment}}{\text{Cost of investment}} \times 100$$

With the advent of building information Modelling (BIM), the building industry is coming to appreciate that technology can radically transform the process by which a building is designed and constructed. But before committing the funds to purchase that technology, the bean counters in an organization will probably insist that an ROI analysis be done. At that point, the folks tasked with producing the numbers usually grimace in pain and start twitching But there's an upside to an ROI analysis. Although primarily used to justify a purchase, calculating the ROI for a technology investment forces those involved to reach an

agreement about why the money is being spent and what are the expected results.

VII. CONCLUSION AND DISCUSSION

IPD is a growing need of construction industry so as to improve the effectiveness and productivity of the construction projects. BIM is an important tool in increasing the success of project outcomes with successful co-ordination of project participants and their roles and responsibilities are designed on based on IPD approach. In this paper it will be conclude that there is cost and time optimization when successful implementation of IPD through BIM. It will reduce the confusion between different project participants and lead to improve proper communication, collaboration, decision making process.

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