Implementation 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. 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.

IV. 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. 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 1 explains complete procedure of BIM model making.

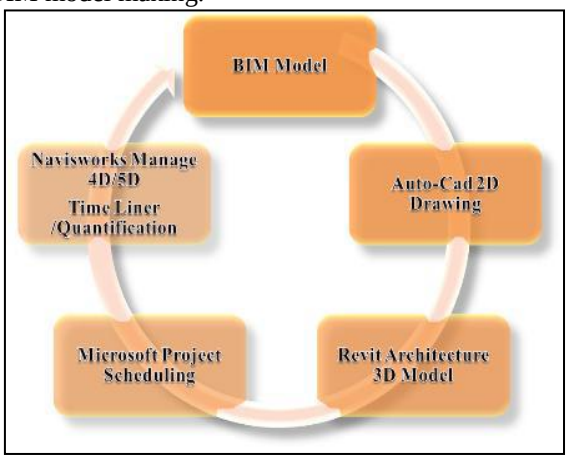

Fig 1: Process for developing BIM model

V. 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 located at village Ashta and village Nagaow in Kolhapur region of Maharashtra with different 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 2017. These models will be exported in Autodesk NavisWorks2017 for BIM based scheduling (4D and 5D approach) along with a simple schedule of project generated in Microsoft Project 2010.

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

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

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.

VI. OVERVIEW ON CASE STUDY

A. Case study 1:- Parthesh Duplex Bungalow, Ashta, Sangli.

1) Project Description

The project is an G+1 residential duplex bungalow. Site is located at village Ashta in Sangli district. Site has land area of 3443.25 square feet and total built up area is 2560 square feet. FSI consumed by the project is 0.74. The site is connected with local water supply, sanitary, and electrical supply. The structure of project is RCC framed structure.

2) 3D BIM Modeling (Revit Models)

First, a new Revit file was created and saved. Then, the perimeter walls were created. Once the perimeter walls were completed, the interior walls are created. Then, the foundation walls, flooring, doors, windows, roof, stairs, deck were created. Furthermore, the rooms were tagged. Also electrical and plumbing elements were created for this study. The differences of 3D modeling and 2D drafting were reviewed. Furthermore, the granularity of objects including the decomposition of the elements was explored. Figure No.2. Depicts the prototype Revit building model created for this project.

Fig. 2: fully rendered architectural model of Parthesh duplex site 3D view

Similarly the structural and MEP models are prepared in Revit 2017.

3) 4D & 5D BIM Modelling (NavisWorks Models)

4D modeling required the development of a 3D model as well as the schedule. The 3D model was created in Revit Architecture 2017. A simple schedule with several activities generated in MS Project was successfully imported to NavisWorks Manage. Once the linking was complete, a simple 4D model was visualized. The visualization at any given time of the project can be enhanced at Gantt view with the drag of the timeline. This helps a better understanding to prepare for sequencing. Figure No.3 depicts the timeline, activities, and model of the project. BIM produces accurate quantities for the efficient estimation of architectural, structural and services components. These quantities can be extracted at various stages: at concept stage for generating budgets, at the end of design development stage for floating tenders, Good for Construction (GFC) stage for verifying bills.

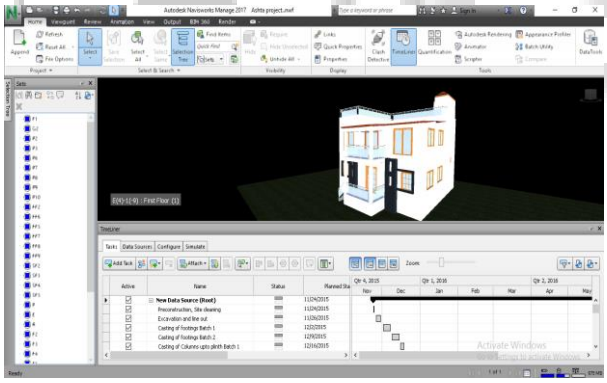

Fig. 3: Timeliner (4D) window for Parthesh Duplex Site.

4) Analysis and results

Clash detection analysis, ROI analysis are done on the model prepared. The principles of IPD are applied to the model prepared and impact of IPD on project where assessed. There are 45 clashes which are of hard type but the status is ok, so we can proceed to construction while considering the clashes in advance. ROI of model prepared is 38%. The impact of IPD implementation is as follows.

IPD principles	% of time and cost saving	Actual time and cost	Impacted cost and time if IPD is implemented
Early Involvement of Key Participants	5 to 6%	18 months Rs. 37,oo,ooo	17 months Rs.35,15,000
Multi-Party Contract	N/A	18 months Rs. 37,oo,ooo	18 months Rs. 37,oo,ooo
Jointly Developed/Validated Targets	3 to 4%	18 months Rs. 37,oo,ooo	17 months 2 week Rs. 35,52,000
Collaborative Decision Making/Control	4 to 6%	18 months Rs. 37,oo,ooo	17 months 3 week Rs. 35,52,000
BIM Execution Plan	10%	18 months Rs. 37,oo,ooo	16 months 1 week 35,00,000

B. Case study 2:- G.G.Patil apartment site nagaow

1) Project Description

The project is an G+2 residential cum commercial apartment. Site is located at village Nagaow in Kolhapur district. Site has land area of 2801.7 square feet and total built up area is 4006 square feet. The site is connected with local water supply, sanitary, and electrical supply. The structure of project is RCC framed structure.

2) 3D, 4D &5D Modeling (Revit & NavisWorks Models)

The 3D, 4D and 5D modeling is done in the same way as the previous case study.

Fig. 4: Fully rendered architectural model of G.G.Patil Apartment site 3D view

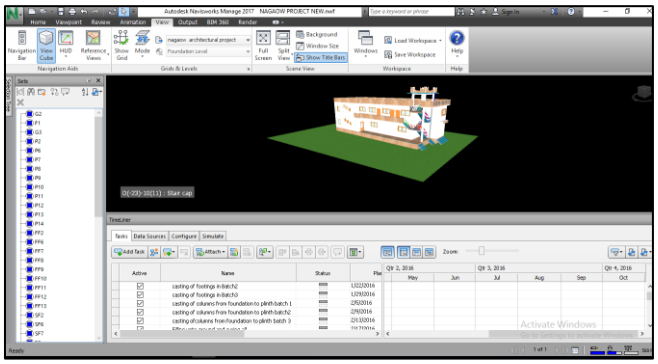

Fig. 5: Timeliner (4D) window G.G.Patil Apartment Nagaow project in NavisWorks.

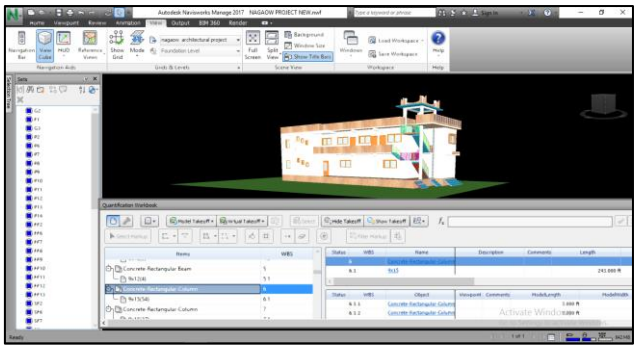

Fig. 6: Quantification (5D) window G.G.Patil Apartment Nagaow project in NavisWorks.

VII. Analysis and Results

Clash detection analysis, ROI analyses are done on the model prepared. The principles of IPD are applied to the model prepared and impact of IPD on project where assessed. There are 63 clashes which are of hard type but the status is ok, so we can proceed to construction while considering the clashes in advance. ROI of model prepared is 50%. The impact of IPD implementation is as follows.

IPD principal	% of time and cost saving	Actual time and cost	Impacted cost and time if IPD is implemented
Early Involvement of Key Participants	5 to 6%	16 months Rs. 57,oo,ooo	15 months Rs.55,15,000
Multi-Party Contract	N/A	16 months Rs. 57,oo,ooo	16 months Rs. 57,oo,ooo
Jointly Developed/Validated Targets	3 to 4%	16 months Rs. 57,oo,ooo	15 months 2 week Rs. 55,52,000
Collaborative Decision Making/Control	4 to 6%	16 months Rs. 57,oo,ooo	15 months 3 week Rs. 55,52,000
BIM Execution Plan	10%	16 months Rs. 57,oo,ooo	14 months 1 week 55,00,000

VIII. 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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