Achieving the Benefits and Requirements of Integrated Project Delivery Method Using BIM

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Abstract. Through the last decade, Integrated Project Delivery (IPD) methodology considers one of the new contractual relations that are also on the way to further integrate the process of combining design and instruction. On the other hand, Building Information Modeling (BIM) made significant advancements in coordinating the planning and construction processes. It is being used more often in conjunction with traditional delivery methods. In this paper, the researcher will present the achievement of IPD methodology by using BIM through applying on the design of the financial commission building in Mayssan Oil Company in Iraq. The building has not been constructed yet and it was designed by using 2D CAD drawings. The researcher will redesign the project by using BIM to eliciting the abilities that are consistent with the requirements and benefits of integrated project delivery (IPD). The results show that BIM is an appropriate technology that can be used with the IPD method because it has achieved most of the requirements and benefits of IPD.

Keywords: Building information modeling (BIM), integrated project delivery (IPD).

1. Introduction
Integrated Project Delivery (IPD) is a new approach, its main requirements is the involvement of the major project participants from initial phases of the project, and that can be achieved by using BIM. BIM is a tool that recently adopted by architecture, engineering, and construction industries in the world. BIM technology provides a precise digital virtual model of building without conflicts or clashes. It promotes design during all its phases, enabling better control and analysis when the model completed, it become a curate digital model contains all data that support the construction and other phases of the project. Using the IPD method with BIM relatively is a new approach to the design and construction phases of the project [1].

2. IPD Definitions and Characteristics
Many literatures define what IPD is about. Although they have some differences in some parts of the definition, however, there are more similarities. The most common definition is presented by American Institute of Architect California Council, which is "IPD as a project delivery approach that integrates people, organizations, business structures and exercises into a process that collaboratively harnesses the talents and insights of all project participants to optimize the results, increase value to the owner, reduce waste, and maximize efficiency through all stages of design, manufacturing and building"[2]. This detention point to the development of an integrated team which guided by the principles that shown in Fig. 1.

These principles of IPD can be a chance to be used under a variety of contractual exercises to accomplish in cooperation. This will initiate starting from the early phase of design and continue
through to deliver the project [4]. The main emphasis in delivering the integrated project is the final value that has been formed for the structure and the owner, instead of focusing each participant exclusively on their share of the building without considering the implications of the entire project process. This IPD system will bring the whole participants together early with cooperative incentives to maximize the value of the project to the customer. This integrated system will allow participants to make decisions in early project designing so they can prepare most of the costs. Close teamwork can get clear of a large waste trade in the scheme, and permit data to be shared simultaneously between the planning and construction team, which removes a large obstacles to increasing project productivity [4].

Figure 1. Principals of IPD [2, 3].

3. Building Information Modeling (BIM)

The US National Building Information Model Project committee has a great starting point in illustrating BIM. Although there are many definitions, they defined BIM as "Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition. Another definition describes BIM as "A basic premise of BIM is collaboration by different stakeholders at different phases of the life cycle of a facility to insert, extract, update or modify information in the BIM to support and reflect the roles of that stakeholder" [6].

As a practical substance, the committee also notes that the BIM represents the management of information, this means data added to and shared by all project members. The right data to the right individual at the right time. Also, BIM represents a project delivery interoperable process - determining how individual teams work and how many teams work together to design-build and operate the facility. As well as BIM represents integrated technology solutions for design, encourages creativity, provides more feedback, and team empowerment. So BIM is a software tool that the project team uses to virtually design and build the building over the Internet by integrating model simulations, such as service constructability and service configurations that can be simulated during construction [7].

4. Relationships Between BIM and IPD

AIA and AIA California Council Guide reflect the interrelationship between BIM and IPD as "It is understood that integrated project delivery and building information modeling (BIM) are different concepts – the first is a process and the second a tool. Certainly, integrated projects are done without BIM and BIM is used in non-integrated processes. However, the full potential benefits of IPD and BIM are achieved only when they are used together" [2]. Moreover, IPD and BIM match each other by improving project management by increasing data exchange and collaboration between stakeholders, this leading to less risk of defects and rectification; less materials waste and less disputes during construction.
IPD is the catalyst that allows parties to easily exchange ideas, information, and intellectual property, and this along with BIM, creates efficiencies throughout the project life. This methodology also removes the "us vs them" attitude because participants must share protected intellectual property in another way to achieve project outcomes.

5. Application of IPD-BIM Integration
To examine the achievement of IPD-BIM integration, a construction project will be used as a case study. The project locates in the campus of Mayssan Oil Company in the center of Al-Amarah city/Mayssan province in Iraq. The area of the project 2240 m². The building includes three stories, the ground story consist of sixteen office rooms, two holes, two rooms for manager of commission, fortified room to store the money, and a room for electricity adapters. The first floor also consists of the same described facilities except one hole was divided into two rooms and set an office room instead of the protected room, while the second floor was the same with the ground floor. The building scheme also consisted of one elevator, two water cycles for each story, and two emergency exits.

The building design involves all the items in the structural design in which the concrete was used for foundation, columns, ceiling, and walls that make up the protected room, as well as the brick for the walls of the other rooms of the building. While the architectural interfaces were designed in a way that to be compatible with nearby buildings interfaces. Fig. 2 shows the architectural drawings for the ground floor.

Figure 2. Architectural drawing for the ground floor of the financial commission building.

6. Current Design Workflow
In this case study, the workflow of design consists of several steps that usually adopted in the Iraqi government firms when implementing the work using traditional ways such as direct implementation or Design-Bid-Building. After obtaining the approval of the establishment of the project, the design department begins to form the schematic design using 2D CAD according to the building requirements stated by the requesting commission for the building, and then presented this conceptual design to the same body to make notes on the plan. After amendment on the plan according to the notes, the design department begins to prepare a detailed design for the architectural, structural, electrical, and mechanical designs separately using 2D. They use to description of the plumbing works illustrated in the bill of quantities only without being represented in the drawings, depending on the implementation on the site by the engineers at the construction phase. The bill of quantities were performed by each division according to the specialist, and then combined in one bill and estimate the cost for the project.
and obtain the approval for the budget to prepare the contract documents for bidding. Fig. 3 summarized the current workflow of the designing phase in the department of design.

In general, there is no single model that combines all the components of the building design to detect conflicts that cause delays in the construction phase. Also, the steps followed in the design stage suffer from fragmentation and were not characterized by cooperation where each division design their part and prepare the related bill of quantities without reference to other components of the building design. This may cause many inconsistencies and errors during the construction phase that result in a delay in the implementation time and increasing the construction cost of the project due to rework. Also, the majority of these activities in the design phase were made by correspondence between departments and between designers while the face-to-face communication may be nonexistent.

Figure 3. the current design flow chart for the case study during the design phase.
7. Application of BIM

7.1. Design Requirements

The Design of the financial commission building was performed according to the requirements that were stated during the meeting between the Director of the financial commission, the Director of the projects commission, the department's Directors of the financial commitment and the designers, which were as following:

- A building that accommodates a staff of six departments with all divisions.
- Design the floors and rooms according to the relation between the departments so that each two departments have more communication will locate on one floor.
- Specify the ground floor to the departments related to the payment of salaries of employees and financial dues to facilitate the delivery of dues through the external windows of the building.
- Adopting the halls system for the employees to facilitate the communication between them and allocate one hall for training.
- Placing emergency exits with fire alarm system in the building for safety requirements.
- Installing external roofs around the building on windows where salaries are delivered to prevent the arrival of sunlight as well as the rains when salaries are delivered to employees.
- Identify the money storage room on the ground floor as it is intended to pay salaries and dues.

The main goal was to fulfill these requirements so that they construct one building collecting all the departments of the financial commitment to facilitate the communication between them and decrease the time consumed to perform the transaction. Meeting with most of the stakeholders of the project to identify the requirements of the building before starting the design process, means involve the participation of all parties concerned from the early stages of the project. This step will achieve one of the most important principles of the IPD method (Early Involvement of Key Participants), which enhances the ability to define the project goals (Early Goal Definition). Thus, creating a long list of requirements are achieved, and then shorten this list to the requirements only to being creating a schematic design and produce it to the owner or the requesting body for approval. Then starting the 2D architectural plan. To redesign the building using BIM methodology, the architectural model will be allocated after conversion from 2D to 3D as a central file to be imported to create local files to complete the other components of the building (Structural and MEP design). The design in each local file will be synchronized to the central file to show all the updates in the central file and show the work of each other local files in this local file and vice versa. The researcher will apply the flowchart diagram that illustrated in Fig. 4 to redesign the building using BIM methodology.
BIM coordinator

Convert the 3D Model to central file
(Server)

Designer 1 (Local file)
Work set A
Work set B
Work set C

Designer 2 (Local file)
Work set A
Work set B
Work set C

Designer 3 (Local file)
Work set A
Work set B
Work set C

Designer 4 (Local file)
Work set A
Work set B
Work set C

Borrower

Synchronize each local file

Figure 4. The flowchart diagram of BIM implementation.

7.2. Architectural model
The researcher used Revit 2019 to create a 3D architectural model and integrate all other components of the case study. The start was by import the 2D plan for each story of the building from cad to Revit. Based on the description of some items such as interface's items, the finishing of walls, the location of columns in the 2D drawings, location, and dimensions of the windows and doors. The architectural model was built to become the original model for all other discipline designers, which later will be imported to complete the design details of other components of the building. Fig. 5 shows the 3D architectural model.

Figure 5. The 3D architectural model.

7.3. Structural Form
After the architectural design was completed, the model was imported to create a local file related to the structural design. The structural design began by applying the live and dead loads using the structural analysis programs to determine the dimensions of the foundations, columns, beams, and the slab based on carry out the required calculations, as well as calculating the required reinforcements. Then establishing the elements cross-sections of building to cover all structural details that will be needed in the construction phase of the project. The structural model was synchronized to the central
file to merge the structural and architectural design in one model. Fig. 6 shows the structural model for the building.

![Structural Model](image)

**Figure 6.** The structural model and section of beam B4.

### 7.4. Mechanical, Electrical & Plumbing (MEP) Design

The case study does not contain any mechanical works, therefore the researcher will focusing on the electrical and plumping designs in this domain.

### 7.5. Electrical Design

A local file was created related to electrical design and subdivided into four work sets represent the lighting, power, telephone, and fire alarm system to be synchronized to the central file. All the electrical drawings were presented in a 3D model based on 2D CAD and the description of electrical items in the bill of quantities. The interior ceiling light fixture and wall lighting were represented in the 3D model for each floor. All these lighting fixtures and other electrical fixtures such as fans and power sockets 13A, 32A, 45A, were linked to the electrical secondary panel for lighting and power. Fig. 7 shows the distribution of ceiling light and its wiring system.

![Electrical Design](image)

**Figure 7.** The ceiling light fixture and wiring system.
The fire alarm system was also represented in the 3D model based on the 2D CAD and the items description in the bill of quantity. Smoke detectors have represented in the ceiling for each story and linking them to the 4-zone panel of fire alarm. The electrical and telephone cables will be represented by draw conduits and marking each conduit to represent a specific cable. The cables included in the building consist of the cables from the main boards to the sub-panels on each floor, in addition to the interconnecting cables between the mainboards, as well as the interconnecting cables between the main boards and the main feeders of the building. The specification of each cable was fixed in the properties as shown in Fig. 8.

![Figure 8. Telephone and Electrical cables and panels.](image)

### 7.6. Plumping Design

In the same manner, a local file will be created from the center file to complete the plumping design. The plumping components are not included in the 2D CAD drawings because they used to perform the plumping works based on the description of the item in the bill of quantities only, while the electrical drawings made in 2D CAD as in architectural and structural aspects. Therefore, the researcher represented the plumping items in the drawings based on the requirements of the requesting body and the description of this item in the bill of quantity. The roots of the sewage drains, cold and hot water pipes were identified in all stories of the building, as well as the plumbing fixtures, which consist of western and eastern toilets, heaters, water tanks in above the building, pipefittings and manholes. Then after complete the plumping design, the model was synchronized to the central file to show all the architectural, structural, plumping design in one model. Fig. 9 shows the design of the plumping works in the 3D model.

![Figure 9. The plumping works.](image)

This teamwork in the design phase was done through the work-sharing feature in Revit 2019 that allowed all team members to communicate and collaborate by exchanging information and
synchronizing each work to the central model. Therefore, the communication was open between all parties and mutual trust in addition to mutual understanding and a high degree of coordination between them that led to the completion of the design of the building in all its domains. This means that several IPD requirements have been achieved, which are (Collaboration during all phases of the project, Mutual understanding concerning each other’s objectives, Open communication among parties, Mutual trust among the parties).

7.7. Clash Detection
One of the most important features of the BIM methodology is identified of all clashes in the design phase, where a conflict is identified between any two items in the design phase that can lead to project delay or increases the cost during the construction. Clash detection leads to preventing rework during construction, which saves large amounts of money in addition to reducing the schedule and preventing many problems in the construction phase. Revit provides this feature but the researcher has chosen the (Autodesk Navisworks Manage 2019) to implement the clash detective as it has better features than Revit in the detection of clashes, it provides a detailed photo-enhanced report for each conflict.

After the coordination of all domains of the building in one 3D model, the researcher starts to export the model to Autodesk Navisworks through (Add-Ins) tab and save the file in the computer as (nwc) then open Autodesk Naviswork and open the saved file. The clashes were initially identified between the plumping and beams, as well as the clashes between the conduits and structural framing, and the electrical work with architectural and structural design, so that there were no clashes between them as shown in Fig. 10. Regarding the clashes between the pipes with walls and between the structural framing with walls, the results showed that there are 45 and 29 clashes, respectively. The most of the pipes and walls clashes are considered acceptable, as most pipes works pass through walls, and this is what is implemented in projects, so all the clashes were approved except three of them that were resolved because the pipes were outside the boundaries of the wall as shown in Fig. 11. While all the clashes between the structural framing and walls were approved because they overlap simply so as not to cause delay or rework, where most of them overlap with upturned bridges.

Figure 10. Results of clash detection for some items.
Using BIM methodology in the design phase has immediate and clear benefits. This methodology requires the collaboration to obtain the benefits of this technique for all participants, which enhances mutual trust, exchanging of information and open communication. Therefore, most of the requirements and principles of IPD method have been achieved, so BIM technology can be considered as the appropriate technology because it catalyzes the processes of the IPD method, and thus fulfills one of the principles and requirements of IPD method (appropriate technology).

7.8. Achievement of IPD Benefits
BIM is the only tool that can facilitate the work of more than one participant in the same project model and can make all members of the project teamwork on the same model. This helps to enhance cooperation between all participants, enable them to arrange meetings based on this model, prevent duplication of information, and complete the work faster as well as prevent any collision in the building design. This means obtaining high-quality building, which leads to reducing project costs and waste, as well as improving contract documents to exclude the use of the requests for information (RFIs) and change orders then the cost of the building and the scheduling can be accurately estimated. These gained benefits from using BIM are fully agreed with the benefits of the IPD method that is (Arrange collaborative meetings based on a shared model and a virtual reality application, get better quality of design, with less waste, shorter timelines, decrease the construction costs, interference and collision detection, improved contract documentation to eliminate using RFIs and Change Orders, improved preconstruction estimating, procurement, expediting and scheduling, faster and more effective processes through sharing and reusing information).

8. Conclusions and Recommendations
The construction industry needs to adopt new technology and delivery systems that differ from traditional methods if they want to overcome all obstacles in traditional systems to reduce costs, time, and waste and thus increase productivity. IPD method provides a collaborative environment not provided by the traditional approaches of delivery by involving all the main parties from the early stages of the project and cooperation during all stages and open communication and mutual trust between the parties in addition to effective coordination. BIM is a suitable technical tool that needs a collaborative environment to obtain the highest benefits. Therefore, it has achieved many requirements and benefits of IPD when used together. Also, the benefits of IPD have been achieved when using BIM methodology so BIM is the appropriate technology to be used with the IPD method to improve
the performance of construction projects. Adopting the use of IPD method in the public sector (as a philosophy), which means adopting this method through its principles because of the difficulty of creating a contract among all parties, will help in providing better and faster building in the future. As well as encourage using the IPD method with BIM to obtain the greatest benefit for BIM and helps to providing faster and excellent buildings.

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