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# Proposed Framework for Intelligent Dashboard that Utilizes Business Intelligence (BI) and Building Information Modeling (BIM) for Better Decision Making

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***Abstract*—The construction sector functions as a vital force which drives national economic expansion, yet it faces enduring obstacles from its intricate multi-stakeholder framework. Construction projects are often constrained by strict timelines and limited resources. It's also characterized by generations of vast amounts of data through project lifecycle. All these factors have made effective management increasingly difficult. The construction industry has adopted Building Information Modelling (BIM) as a revolutionary solution that provides a unified system to handle project information throughout its lifecycle. However, a major challenge exists because stakeholders frequently struggle to extract tailored, real-time insights from BIM models that directly support their decision-making requirements. The development of Business Intelligence (BI) has shown remarkable potential to convert raw data into meaningful insights through its advanced analytical and visualization tools. The research paper proposes a framework to create an intelligent dashboard that integrates Data-rich BIM with the analytical abilities of Business Intelligences. The framework aims to deliver interactive, real-time project insights tailored to diverse stakeholder requirements, resulting in improving decision-making, collaboration and overall project efficiency.**

***Keywords*—Building Information Modeling(BIM), Bussiness Intelegent, Construction Management, Dashbosrd.**

## I. INTRODUCTION

The construction industry functions as a vital economic engine which drives national economic expansion. It represents about 9% of the global gross product according to recent reports [1]. These reports show that worldwide construction sector expenditures reached $11 trillion during 2017, and experts predict they will hit $14 trillion by 2025 [1]. Nevertheless, this industry is known for its low productivity. Complexity stands as a typical construction project characteristic because these projects require handling multiple aspects and disciplines which generate intricate work conditions. The project success depends on how well stakeholders work together through positive collaboration and coordination. Project managers need to handle precise planning along with proper resource distribution while continuously monitoring total project progress. The absence of project phase transparency, effective collaboration, and real-time progress monitoring creates obstacles for project management which usually result in project delay, cost overrun, or in some cases both. Research indicates that 59.46% of construction project complexity stems from inadequate management practices while 16.22% results from poor communication [2]. These obstacles have led construction companies to explore modern solutions.

The construction industry has been undergoing continuous transformation due to technology pushing forward data-driven approaches. Modern techniques have replaced traditional methods because of increased use of data analytics, machine learning, and other cutting-edge technologies. The adoption of dashboard systems combined with intelligent analytical tools have played an important role in this change. Microsoft Power BI stands as a leading example of this technology. Microsoft defines the tool as a business analytics platform which enables users to connect, visualize, and analyze data to turn it into actionable insight and share results within your organization easily [3]. Business enterprises can obtain useful insights from enormous datasets due to Power BI's solid data modelling, analysis, and dashboard-creation capabilities. This process enables stakeholders to make better decisions, enhance construction management, and overall project productivity follow.

### A. Research objectives

- Review the construction industry, investigate its obstacles and discover proper solutions.
- Propose a framework to develop an intelligent dashboard that integrates Data-Rich Building Information Modeling (BIM) with the analytical capabilities of Business Intelligent to enhance decision making for construction management.

### B. Research Roadmap

The process for achieving the research objectives are illustrated below:

- A comprehensive review of (the crucial of construction sector, obstacles facing construction sector, the status of the construction sector in Saudi Arabia, available technological solutions, recent studies related to Business Intelligent in construction.)
- Set an appropriate solution.
- Develop simple guidelines for the implementation of the proper solution.

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## II. LITERATURE REVIEW

### A. The crucial of construction sector

The construction sector is considered one of the most essential sectors, contributing significantly to the economic growth of a nation. It has been found that the construction sector represents 13% of worldwide GDP according to financial statements [4]. Furthermore, the research provides information about the distribution of worldwide construction industry expenditure in spans from 2017 to 2035 with values in trillions of dollars as illustrated in figure1 below.

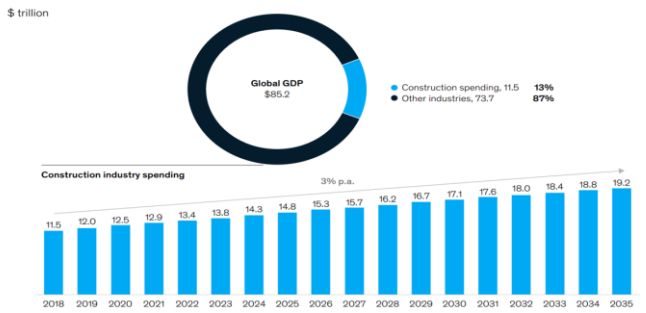


Fig. 1 Global spending in construction sector [4]

The worldwide construction industry spent $11.5 trillion during 2018, and experts predict this number will reach $19.2 trillion by 2035. This tremendous growth in the construction industry will offer significant employment possibilities and lay the groundwork for other businesses such as manufacturing, logistics, and services [5]. That's mean it will create employment opportunities, which will support a wide range of workers, ranging from simple workers to specialists. The economic stability of developing nations depends heavily on this employment sector. Sustainable construction practices together with modern technological methods in developing nations demonstrate success at lowering operational expenses and enhancing energy efficiency which results in Long-lasting economic benefits [6].

Furthermore, the construction sector serves as a key factor in enhancing life quality through building educational institutions, healthcare facilities, roadways, and other essential infrastructure that directly affects public health and overall well-being. A research study took place in Malawi during the year 2024. The research team examined how sustainable construction projects affect the construction industry. The results of this research demonstrate a considerable improvement in overall quality of life along with economic expansion [7]. In 2025 another study conducted in Kuwait. The aim of the research was to study the impact of implementing BIM technologies in construction projects. The results of the research demonstrated a significant improvement in overall efficiency and environmental sustainability practices [8]. Based on the research data, the total construction waste in Kuwait in 2021 was estimated to be 884,248.5 ton and has been reduce to 656,429 ton in 2022 after adopting BIM technologies in construction projects.

### B. Obstacles facing construction sector

Complexity stands as a typical construction project characteristic because these projects require handling multiple aspects and disciplines which generate intricate work conditions such as coordination and collaboration between different stakeholders, managing project tasks during its life cycle, meeting deadlines, and adherence to the requirements and quality standards. Due to its nature companies is always searching for innovative solutions to improve construction management. A research paper has been done in 2018 to investigate the factors that create obstacles for construction management. The results of the research demonstrate that approximately 70% of the project complexity factors are organizational [9]. Another research paper published in 2022 indicates that 59.46% of construction project complexity stems from inadequate management practices, 75.67% from scope complexity, and 16.22% results from poor communication [2]. The complete list of complexity factors from the research appear illustrated in figure2 below.

| Complexity Groups | Frequency of Occurrence |
|---|---|
| Scope complexity | 75.67% |
| Organizational complexity | 59.46% |
| Operational and technological complexity | 56.76% |
| Environment complexity | 40.54% |
| Complexity related to resources on the project | 37.84% |
| Legal and socio political complexity | 27.03% |
| Communication complexity | 16.22% |
| Economic complexity | 18.92% |

Fig. 2 Frequency of the complexity factors [2]

### C. The status of the construction sector in Saudi Arabia

Saudi Arabian construction industry has experienced substantial growth during recent years due to multiple mega projects and extensive infrastructure developments. This expansion is part of the government's plan to strengthen the economy and achieve the objectives outlined in Vision 2030 of the Kingdom. The population of Saudi Arabia grows at 2.5% annually while only 24% of citizens owning their own property [10]. According to plans, the kingdom will need to construct approximately 2.32 million additional houses by 2020 [10]. This will boost the economy while advancing the kingdom's Vision 2030 objectives.

The construction Industry in Saudi Arabia represents 43% of overall investment, with residential buildings accounting for 90% of total projects [11]. The expansion in the construction industry has generated numerous job opportunities for Saudi citizens, decreasing the rates of unemployment, improving workforce capabilities, attracting international investment, and paving the road for a more prosperous future. The construction industry of Saudi Arabia spent around $65.58 billion during 2023, and experts forecast the market will expand by 2.75% to reach $75.12 billion in 2028 [12]. The research study also stated that the construction of buildings across Saudi Arabia expanded by 3.2% throughout 2022. The percentage growth

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supports residential sector expansion as well as fulfill the vision 2030 goal of 70% ownership by 2030.

Despite the enormous advances made in the construction industry, Saudi Arabia's construction industry continues to face several critical obstacles that impede its development, execution, and efficiency. One of the common obstacles are project delays and cost overruns. Studies show that the delays in essential material delivery, subcontractor work and unplanned inflation impact are major factors leading to project delays and cost overruns [13]. Furthermore, ineffective project management techniques has been considered one of the major challenges in the construction industry in the Kingdom. According to recent research papers there are several factors contributing to this issue including inadequate project planning, lack of experienced project managers, poor communication and collaboration between different stakeholders [14]. The research also state that the lack of skilled workers as well as modern equipment is considered one of the major obstacles facing the construction industry in the Kingdom. A construction project's implementation depends heavily on having sufficient skilled workers along with appropriate modern equipment. The absence of any of these components will create both project delivery delays and quality issues. Moreover, it has been identified that one of the issues impeding the efficiency of the Saudi construction sector is organizational and cultural resistance to change. The reluctance to implement new technologies and methodologies including lean construction and Building Information Modeling (BIM) stems from deep dependence on conventional methods [15]. This resistance to change will have a negative influence on the construction industry's ability to increase productivity and efficiency. The construction sector's ongoing development requires organizations to adopt innovative technologies along with methodologies to maintain their market competitiveness.

Research studies have been conducted to overcome these problems by analyzing current conditions and develop multiple recommendation to improve Saudi Arabia construction industry. Research studies recommend the adoption of BIM as a method to enhance project outcomes, reduce design errors, and foster greater collaboration. BIM implementation has proven to decrease claims by up to 90% in certain cases [16]. Furthermore, a research study conducted in 2024 has recommended the implementation of Industry 4.0 technologies such as Artificial Intelligence and Internet of Things systems which has proven to be promising solutions to enhance construction management [17]. Additionally, overcoming the obstacles that Kingdom of Saudi Arabia faces requires addressing organizational reluctance to change. This can be achieved by offering incentives for implementing new technologies and involving stakeholders through educational and training initiatives [15].

D. Available technological solutions for construction challenges

The construction sector has made significant technological progress during the last few years which helped solve multiple construction challenges. Building Information Modeling (BIM) and Business Intelligence are an example of these technical solutions. These technologies has proven their effectiveness in enhancing productivity and efficiency of construction projects. Building Information Modeling (BIM) defined as a digital representation of the construction process which facilitate interoperability and exchange of information in digital format [18]. BIM has facilitated coordination and collaboration between different stakeholders through offering a single model which grants access to all authorized participants to view and update information. The Building Information Modeling (BIM) functions through ten stages as illustrated in figure3 below.

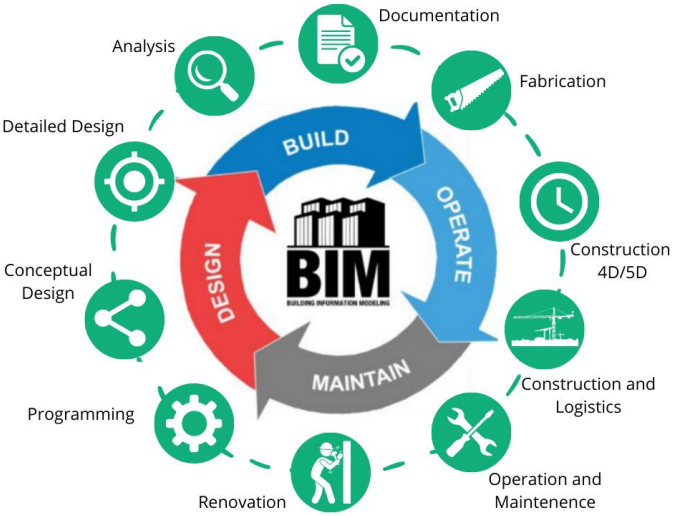


Fig. 3 Building Information Modeling (BIM) stages [24]

Business intelligence (BI) represents a technology-based system which processes data to generate information that assists executives and managers in making well informed decisions [19]. Project managers can use BI tools to monitor project performance efficiency. In today's era, precise and prompt reporting is critical for the success of any project. Power BI emerged as a sophisticated data visualization and analysis tool that enables project managers to track project KPIs, monitor real time project progress, and predict potential issues. Power BI defined as a business analytical platform developed by Microsoft that delivers business analytical capabilities, Intelligence reports, and data visualization [20]. The platform allows users to link their raw data from multiple sources to analyze and create interactive dashboards as well as sharing insights with project stakeholders.

Power BI offers multiple advantages for users such as data connectivity which let users link to a variety of data sources including third-party services like Google Analytics, cloud-based databases like Azure SQL, and Microsoft Excel spreadsheets. Power BI provide cost saving for users since it's free to use. It also provides a wide range of customization which help users build customized dashboards that match their specific project requirements. Additionally, the platform enables project stakeholders to collaborate and share reports securely though its cloud platform [21]. Figure4 below illustrates a sample of Power BI dashboard.

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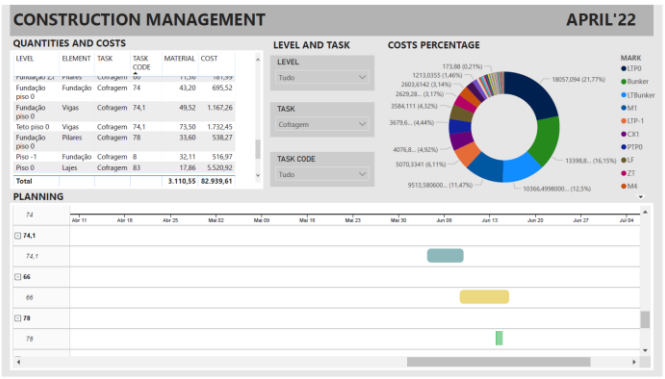


Fig. 4 Power BI dashboard [22]

E. Key studies in Business Intelligent in construction sector

Construction projects have been known by their nature to generate vast amounts of data during their life cycle. A research paper was conducted on the 7th of April 2022 to help overcome this issue. The aim of the study was to examines the connection between visualization and construction projects. During the project life cycle construction projects produce massive amounts of data. Thus, immediate access to project data is critical for project stakeholders to analyze and make well informed decisions. To help visualize the data and study its impact on the construction project, the research suggested using Business Intelligent technologies. The research methodology is conducted by extracting data from models and exporting it to Excel spreadsheets then importing it into Power BI platform to visualize the data [22]. The research demonstrated that this approach has helped enhance decision-making reliability, ensuring project delivery on time, and promoting sustainability practices by reducing energy consumption [22]. However, there was some limitation on the research such as 3D models have not been exported to the platform. The model data couldn't be exported directly to Power BI platform, instead it has been exported first to Excell sheets then imported to Power BI.

Another research took place on 09 September 2020. The primary goal of that research is conducting a systematic literature review to examines business intelligence and analytical tools in construction management. The research examined data from 1407 articles which originated from various database sources. Most software solutions were created for special cases due to the distinctive characteristics of each project. The research team applied specific selection standards which resulted in the elimination of certain studies. One of the selection cratirea is that the paper needed to directly focus on business intelligence applications in construction rather than just mention it on the context. From the total of 1407 study paper, only 93 were selected for further analysis. The analysis of the research data shows that there were 35 records of using data mining which represent 37.63% of the total pool, 33 recods of using data warehouse approximetally 35.48% of the total pool, while the use of intelegent dashbords has been sponted only in 4 records which represent nearlly 4.30% of the total pool [23]. This gives us an indication that more reseach papers should be done in the field of utlizing intelligent dashboard in construction management to highlight its advantages and abilites to facilitate the construng management process.

F. Literatsure summary

Around 13% of the global gross domestic product is generated by the construction sector, creating a significant impact on national economies [4]. However, this industry is characterise by its low productivty due to its natsure that require handling multiple aspects and disciplines as well as managing project data generated through its life cycle. Many research papers has been conducted to study the factors effecting the construction management. Based on the stucdies most of the construction challenges around 70% are organizational [9]. The reseach studies have also suggeted using advance technologies to overcome these challenges and enhance project managemnt [16] [17]. Fortunately, the new advancement in technologies has given promising solutions to improve the construction industry. Power BI dashboard stands out as one of the technologies that provides extensive data analysis and visualization that enable project managers to enhance control and monitoring of construction project. Unfortunately, only few research papers talking about intelligent dashboards. Based on Lopes literature summary about the using of Business Intelligent in construction sector he found only 4 out of 93 records were talking about the using of intelligent dashboards in construction industry [23]. Even those research papers had some limitation than hurdle the full utilization of Business Intelligent capabilities such as they could not export the 3D models to Business Intelligent tools for further analysis, also they could not directly export the data from the models, where they had to export it Excell sheets first then import it to Business Intelligent tools. All these factors has motivated me to write this reseach paper. The paper will suggente a propsal framework to creat Intelgent Dashboard that combines the rich data of BIM with the analytical cababilites of Bussiness Intelgent to enhance decetion making in construction project. The proposed framework of this paper will overcome the limitation of previous reseach and it will contribute to increase knowledge and benefits of implemeting Bussiness Intelegent tools in construction sector.

## III. METHODOLOGY

The proposed framework for creating an intelligent dashboard that utilizes the Data-Rich BIM and analytical capabilities of Business Intelligent to enhance decision making is illustrated in figure5. The framework consists of three stages. The first stage is input which represents the data sources. In this stage we connect our different data sources to Power BI. These data includes the structural, architectural, mechanical, electrical, and pluming 3D models from the Revit software. These data gives visuals and geometric details.

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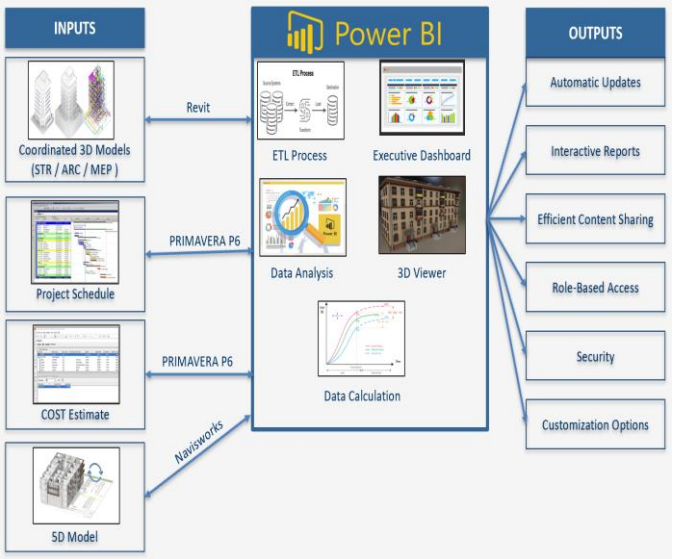


Fig. 5 Research framework

Project schedule along with project cost estimate has also been linked to Power BI through Primavera P6 in this phase. Project schedule will provide the construction schedule, activities, and timelines details while cost estimate will provide budgeted and actual cost of data linked to the assigned project activities. Finally, the 5D model will also be linked to Power BI through Navisworks. Once all data sources have been linked, the second stage begins. The second stages represent Power BI integration where data process and analysis occur. The first step in this phase is ETL process which represents data extraction from previously linked project management tools, transform it into a consistent format, and load it back into Power BI. The main important action in Power BI process phase is data analysis and calculation. Power BI inbuilt and added tools help in analyzing project progress, expenditures, delays, risks, and utilization of the resources. Furthermore, the advanced calculation abilities such as the calculation of Earned Value Management (EVM) curves and forecasting help in discovering insights and support planning and decision-making process. Power BI enables users to create interactive and visually appealing dashboards that allow stakeholders to quickly interpret project data. Moreover, the dashboard will be powered by the 3D models imported in the first stage to enhance the intelligence and interactivity of the dashboard experience. The last stage is output which represents the results and benefits of Power BI dashboard. There are several benefits associated of using this approach such as automatic updates of data, interactive reports, efficient content sharing across project stakeholders, role-based access to data, security of data, and customization options where dashboards and reports can be tailored to project or stakeholder needs. To help achieve this framework a detailed process has been developed as illustrated in figure6 below.

The initial phase of the process involves creating the design model. In this phase we began developing detailed structural, architectural, and mechanical models through Revit software. Revit functions as an authoring tool which enables users to create 3D models from conventional 2D plans. The first step to create detailed models requires users to export grid lines and elevation details from the AutoCAD plans. Secondary, you need to start developing the structural model though using the structural templet of Revit. You will have to do the same for architectural and mechanical models. When developing the architectural model, you will choose the architectural layout and mechanical layout for the mechanical model. Completing the first phase will result in having three detailed models ready to be tested and reviewed in the second phase.

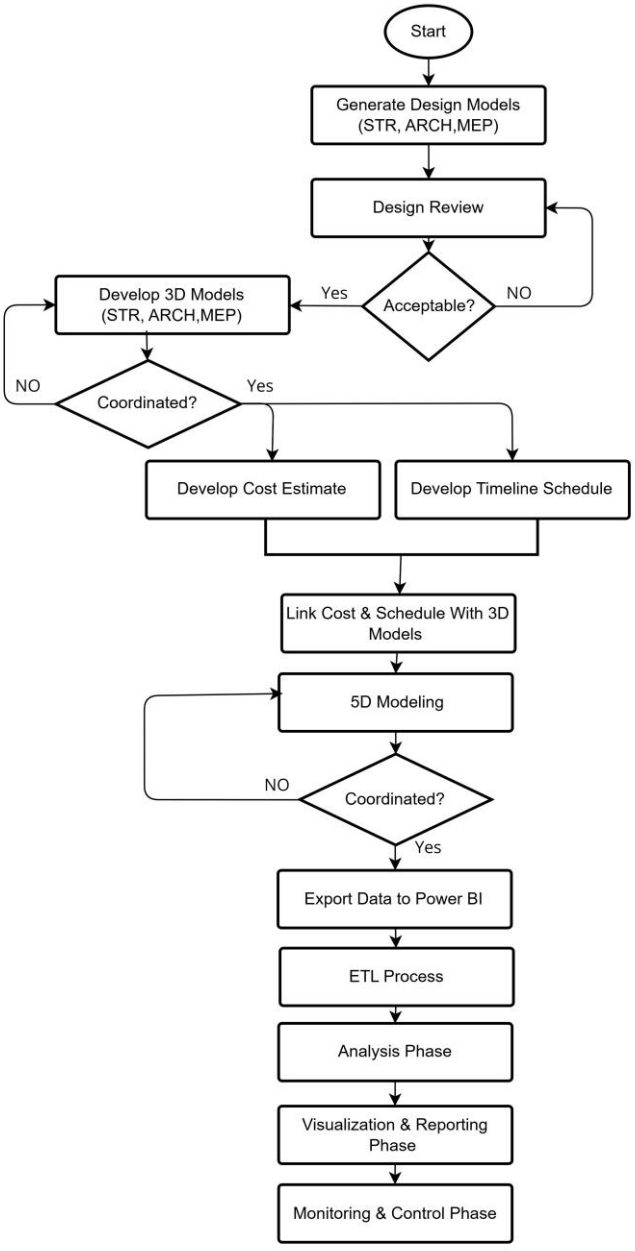


Fig. 6 Research process

The design review phase begins through integrating the developed models in the previous phase into a single model to identify initial errors or clashes. The designers will receive a list of identified clashes which needs to be addressed in the model. The model will undergo adjustments based on changes received. The third phase begins by developing 3D model from the reviewed model in the previous phase. In this stage we use Clash detection technologies to identify interference between systems. This stage significantly decreases design errors during

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construction by simulating actual system deployment. Once the coordinated 3D model is running without errors we start the quantity takeoff process for all systems through Revit software. Revit is one of the best software for quantity takeoff due to its accuracy and efficiency when dealing with data models. All collected quantities will serve as fundamental data for the subsequent phase which involves project scheduling and cost estimation.

The fourth phase will take place in Primavera P6. Primavera stands as one of the leading planning software in the industry. Experts consider it the best due to its widespread use. This software has been used to create project schedules as well as estimating the project cost. To create a project schedule, we need to divide the project into smaller components using Work Breakdown Structure (WPS) then calculate the duration for each activity. The duration is calculated by dividing quantity over productivity. Luckly, we already calculated all the quantities in the previous step. The project cost will be estimated according to the resources required for each project activity. Once finished it will be exported and linked to our developed model. The 5D simulation will take place in Navisworks software. 5D modeling has been widely used in the construction industry to improve collaboration, reduce errors, increase efficiency, and minimize delays and cost overruns. It gives us the ability to simulate construction processes, evaluate different scenarios, identify potential issues early on, and make well informed decisions before construction begins. Once everything is coordinated the model will be exported to Power BI.

The ETL process stands as extract, transform, and load data. Data extraction refers to the process of connecting your data into Power BI. One of the most important features of Power BI is data connectivity which let users connect to a variety of data sources including third-party services like Google Analytics, cloud-based databases like Azure SQL, and Microsoft Excel spreadsheets. When connecting data there are three modes whether its direct query, import mode, or composite mode. The import mode functions by transferring data from the original source directly into Power BI's memory space which enables rapid interactive analysis. In direct query mode Power BI maintains an active connection to the data source for real time querying instead of transferring data. This type is particularly important when handling huge quantities of data.

Data transformation take place in power query editor. It's a built-in tool that facilitates data transformation and preparation through a scripting language known as M. Data transformation takes places in two steps data cleaning and transforming. These two steps occurs before loading data into the model for analysis. The cleaning process involves eliminating null values/errors, substituting values, and either removing or retaining specific rows or columns. The transforming process involves changing data types, splitting/merging columns, pivoting/unpivoting data, grouping/summarizing data, and adding conditional columns. After transformation, the data can be loaded into the data model, which consists of tables organized with relationships and business logic. In loading stage, we define the relationships between our data models. The model distinguishes three sorts of relationships: one-to-many (the most prevalent), many-to-many, and many-to-one. Data analysis can be done through Data Analysis Expressions (DAX) tool. DAX provides users with the ability to create complex calculations and aggregation functions, which enables the extraction of significant insights from the information. A measure represents a DAX formula employed to dynamically compute values within your data model according to the filters placed and context of the visual being utilized. Data analysis is the key for the visualization and reporting stage.

Power BI provides users with diverse data visualization options, including data tables, maps, graphs, charts, matrix diagrams, and time series representation. These visualizations are interconnected, meaning when adjustments made to one visual's parameters triggers corresponding changes in all other visuals within the report, facilitating effective project management practices. For example, when you choose specific calendar month, the dashboard will automatically update to show only the activities related to that month along with other details related to budgeted cost, actual cost, responsible engineers, progress of the project, as well as with other important data based on your customized dashboard. Having all this information in a single dashboard that updates in real time and interact with user interaction will help enhance project management and decision making.

## IV. CONCLUSION

Although Business Intelligence (BI) tools are commonly used in many industries, the construction management field has been slow to adopt them. There were only few research papers talking about the integration of Business Intelligence in the construction industry. Moreover, there well some limitations on those published papers hinder the full utilization of Business Intelligence tools. This paper introduced a framework to overcome the limitation of previous studies and create an Intelligent Dashboard that utilizes the analytical capabilities of Business Intelligence and rich data of Building Information Modeling (BIM). The proposed solution can improve real-time monitoring, enhance decision making, facilitate collaboration and coordination between stakeholders and improve overall project control. By integrating the rich data of BIM with the analytical capabilities of BI the dashboard will overcome the gaps in the traditional project management techniques by offering dynamic and interactive visualizations of crucial project KPIs and convenient platform for stakeholder’s communication and collaboration. This platform can be easily accessed through laptop, browser, or even smartphone. It’s also highly secure where the level data can be accessed is based on the rank and authority of the stakeholders. Finally, the proposed framework developed in this paper can be extended through selecting a case study for analysis. This will open a greater opportunity to discover and highlight the capabilities of integrating BI into construction industry.

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