Designing a Model for Preparing Reports on the Automatic Earned Value Management Progress by the Integration of Primavera P6, SQL Database, and Power BI: A Case Study of a Six-Storey Concrete Building in Mashhad, Iran

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Abstract—Project planners and controllers are frequently faced with the challenge of inadequate software for the preparation of automatic project progress reports based on actual project information updates. They usually make dashboards in Microsoft Excel, which is local and not applicable online. Another shortcoming is that Microsoft project does not store the data in database, so the data cannot automatically be imported from Microsoft Project into Microsoft Excel. This study aimed to propose a model for the preparation of reports on automatic online project progress based on actual project information updates by the integration of Primavera P6, SQL database, and Power BI (Business Intelligence) for a construction project. The designed model could be applicable to project planners and controller agents by enabling them to prepare project reports automatically and immediately after updating the project schedule using actual information. To develop the model, the data were entered into P6, and the information was stored on the SQL database. The proposed model could prepare a wide range of reports, such as earned value management, Human Resource (HR) reports, and financial, physical, and risk reports automatically on the Power BI application. Furthermore, the reports could be published and shared online.

Keywords—Primavera P6, SQL, Power BI, Earned Value Management, Integration Management.

I. INTRODUCTION

PRIMAVERA P6 is a management tool used for the prioritization, planning, management, and evaluation of projects. It is considered to be a practical tool for project managers in the tracking of the work process, budget maintenance, and workload analysis. Primavera P6 is primarily based on assignments, resource prices, and budget. Depending on the resource allocation to a specific task and work-time estimates, the cost of each program is equal to the calculated speed, which compiles into the working time of the task, followed by multiple summary tasks and the final project [1]. Interactive dashboards are regarded as an effective step toward the direct involvement of the user in the analysis process as they are focused on both visual features and the introduction of functional features, such as point and click interactivity [2]. Power BI Desktop is an integration of the aforementioned methods in the form of a BI development tool. Power BI Desktop enables the user to collect, store, model, and visualize data, while it lacks the feature of content sharing [3].

A project control system establishes guidelines for effective cost and schedule control. Data collection is considered essential to the tracking of the control process [4]. According to the literature, close management could be achieved most effectively through the integration of the time and cost management of construction projects. However, the presence of large quantities of data with complex interrelations has caused challenges in this regard, and the issue could be addressed by developing advanced software [5].

Construction control is an essential management function for the successful delivery and achieving the goals of construction projects. Although extensive research has been focused on project control, there is insufficient data on the visualization of the control process [6]. Recently, novel features of interactive analytical dashboards have emerged for the operational Decision Support System (DSS). Despite their expected value for organizations, data are scarce regarding the efficacy of interactive analytical dashboards in operational DSS or their impact on human cognitive abilities [7].

In the present study, we used Primavera P6 as scheduling software, which was integrated with Power BI to design a model for preparing automatic reports on project progress after the entry of actual data into the scheduling software.

II. METHODOLOGY

Fig. 1 depicts the research methodology. This was a case study of a six-storey concrete building in Mashhad, Iran. The developed model was applied for the preparation of the reports on the automatic process of this building. The designed method generated a framework to be used as an on-premises project management solution and consisted of eight main steps (Fig. 1).

A. SQL Server Installation

To select a database for the storage of the actual data, the SQL express was initially installed to develop the database.

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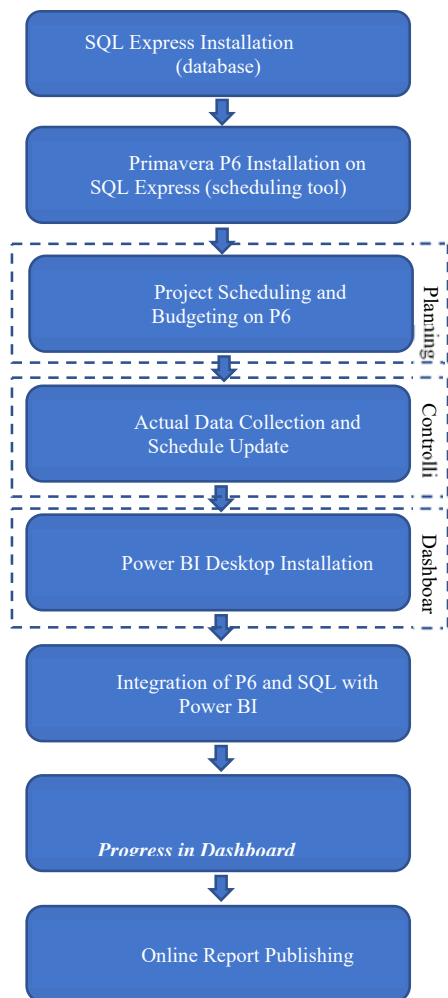
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Fig. 1 Main Steps of Study

B. Primavera P6 and SQL Integration

At this stage, Primavera P6 was employed as the project management software, which was installed and integrated with the SQL database. A key advantage of P6 compared to other project management solutions (e.g., Microsoft Project) is that it is possible to integrate P6 into various databases (e.g., Oracle, SQL Server), which enables the import of stored data to another software (e.g., Power BI) for creating interactive reports and dashboards.

C. Scheduling

Scheduling is an important process for combining time, tasks, resources, and costs in a project. Work schedules are often prepared by listing the main activities involved in the construction, determining the duration of the activities, and assigning their interrelations [1]. At this stage of the current research, project scheduling was carried out using Primavera P6. After determining the duration and interrelations of the tasks, various resource types (labour, non-labour, and material) were assigned to the related tasks. Afterwards, the possibility of tracking the project progression was provided using the Earned Value Management (EVM) (Fig. 2).

D. Collection of the Actual Data and Schedule Updating

At this stage, a survey was conducted to collect the actual data and update the project schedule regularly. For this purpose, P6 was installed and configured to the SQL database and the raw data stored on the data centre. The SQL database had two advantages as it provided external data storage and allowed the linkage of the database to other data visualization software (e.g., Power BI).
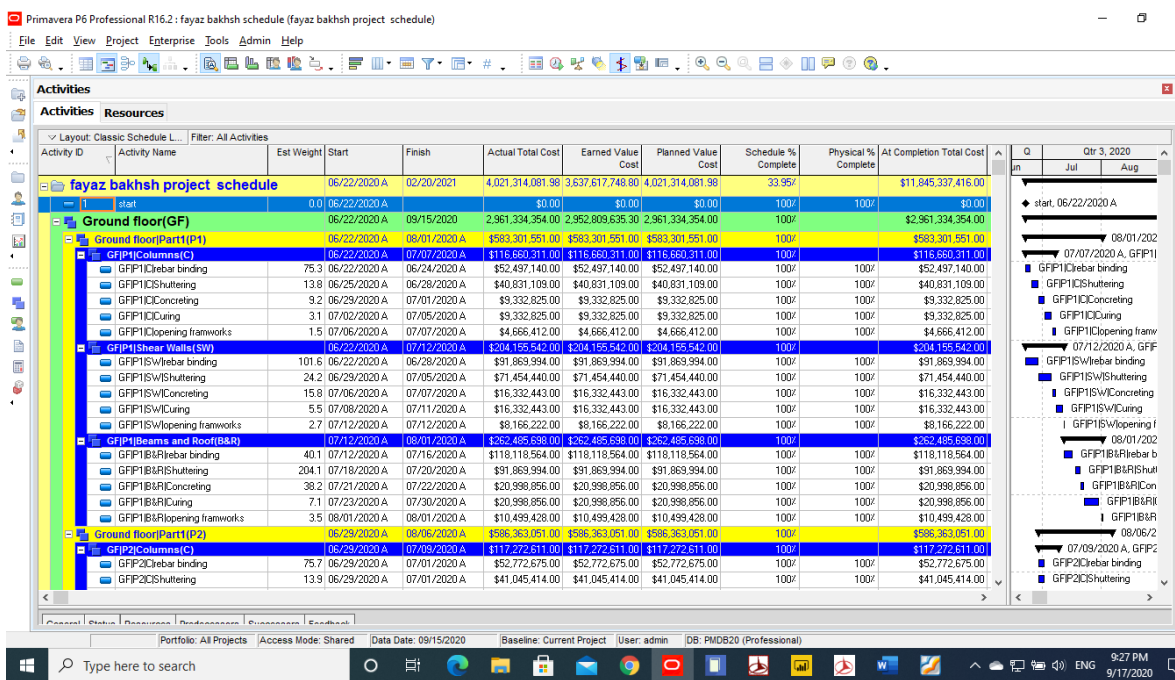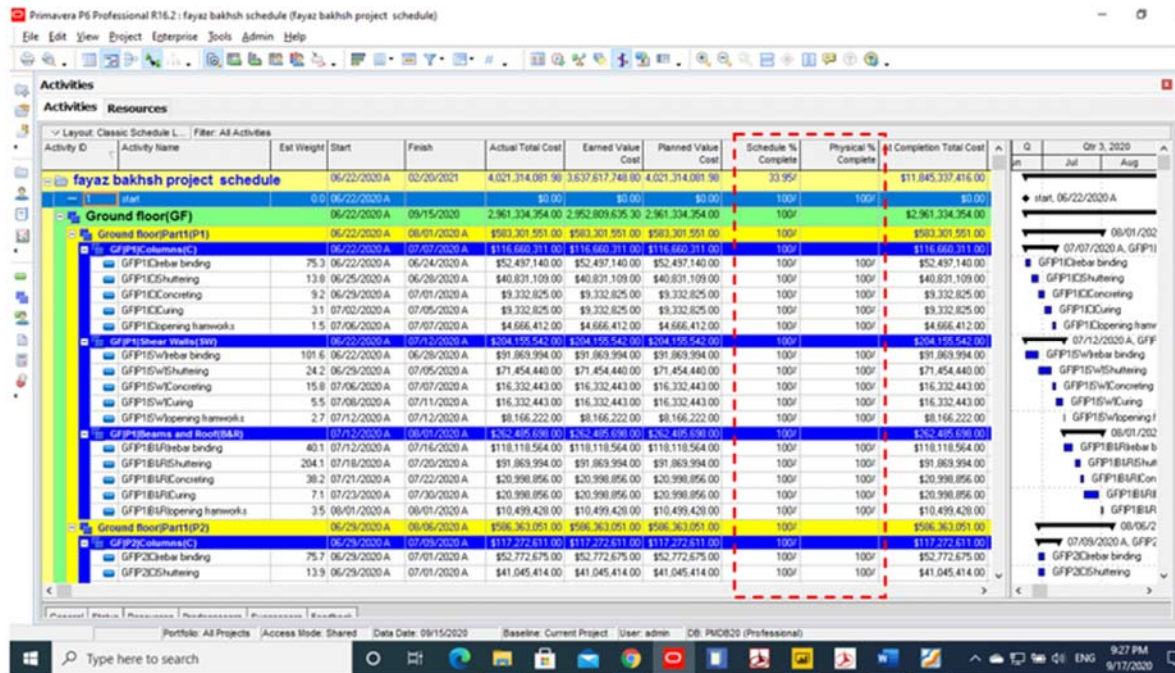

Fig. 2 Schedule of Fayaz Bakhsh Project

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Fig. 3 Schedule Updating with Actual Data

E. Power BI Desktop Installation

A brief review of the basic BI process is depicted in Fig. 2, which shows the development and management of data using the Enterprise Resource Planning (ERP) systems, accounting systems, and HR systems and their integration into a specific environment to draw insights into the entire organization. The mentioned process is completed through five main steps (Fig. 2).
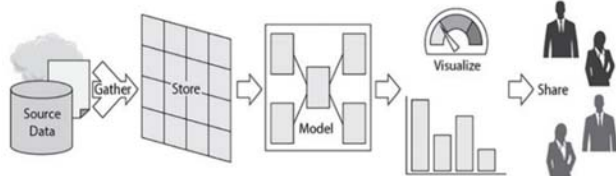
Fig. 4 BI Process

Power BI could be solely used as a visualization tool via two approaches; the first approach is in BI environments, where the server of Microsoft SQL Server analysis services is hosting one or more tabular data models. The second approach is in an environment where one or more Power BI data models have been published to the Power BI service for the user. In both cases, a feature known as 'live connection' is employed to interact with the existing data model (Fig. 3), while no data are stored in the Power BI file. Notably, the data are queried from the data model each time visualization should be rendered, which is the reason the feature is referred to as live connection [3].

In the present study, Power BI Desktop was selected as the visualization tool and installed.

F. Integration of P6 and SQL with Power BI

Following the installation of the Power BI Desktop application, the data were stored on the SQL Server. As depicted in Fig. 5, the direct query was used in the next stage of the study to connect Power BI to the data storage and link the data warehouse to Power BI. Fig. 6 shows the selected SQL Server from the data tool located in the Home tab of Power BI.

After entering the name of the server and database (Fig. 7), the related database tables that had been generated by Primavera P6 in the SQL Server could be seen in the pop-up navigation page (Fig. 8).

G. Progress in the Dashboard Template Based on the EVM

An optimal method had to be selected to prepare the project reports and determine the possibility to evaluate the project performance from various aspects (e.g., cost, schedule, budget, and scope). In addition, the concept of EVM was considered in the design of the project progress dashboard template based on the key performance indicators (KPIs) of the EVM (e.g., EV, PV, AC, SPI, and CPI).

1. Earned Value Concept

Earned value (EV) is a measure of the performed task expressed in terms of the budget authorized for the task. EV is the budget associated with the authorized task that has been completed. The measurement of EV should be related to the performance measurement baseline, and the measured EV cannot be greater than the authorized planned value (PV) budget for a specific component. EV is often used to calculate the completion percentage of a project. Progress measurement criteria should be established for each component of the work breakdown structure to measure the work in progress. Project managers should monitor EV incrementally to determine the

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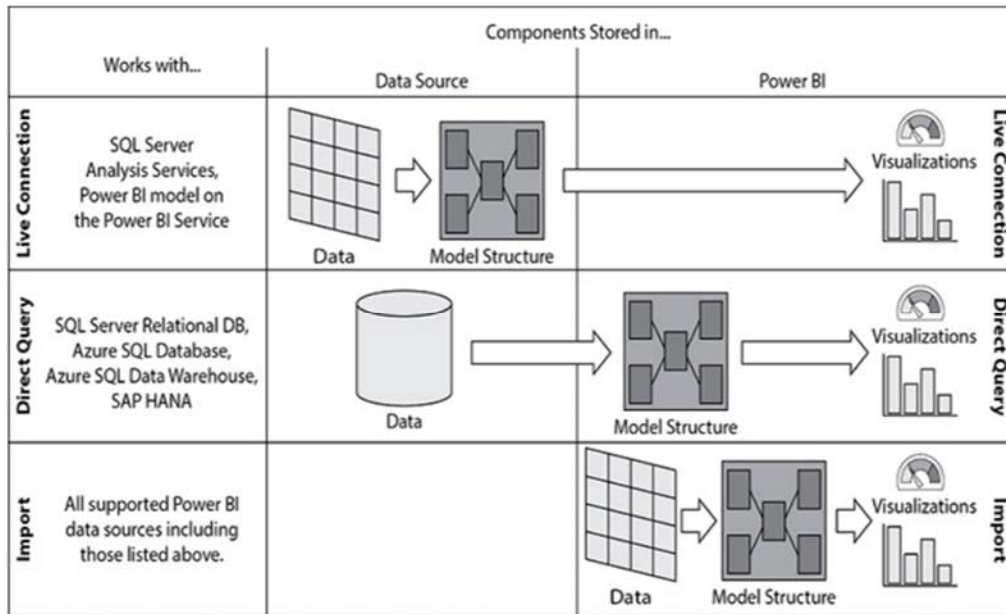current status and cumulatively to determine the long-term performance trends [8].

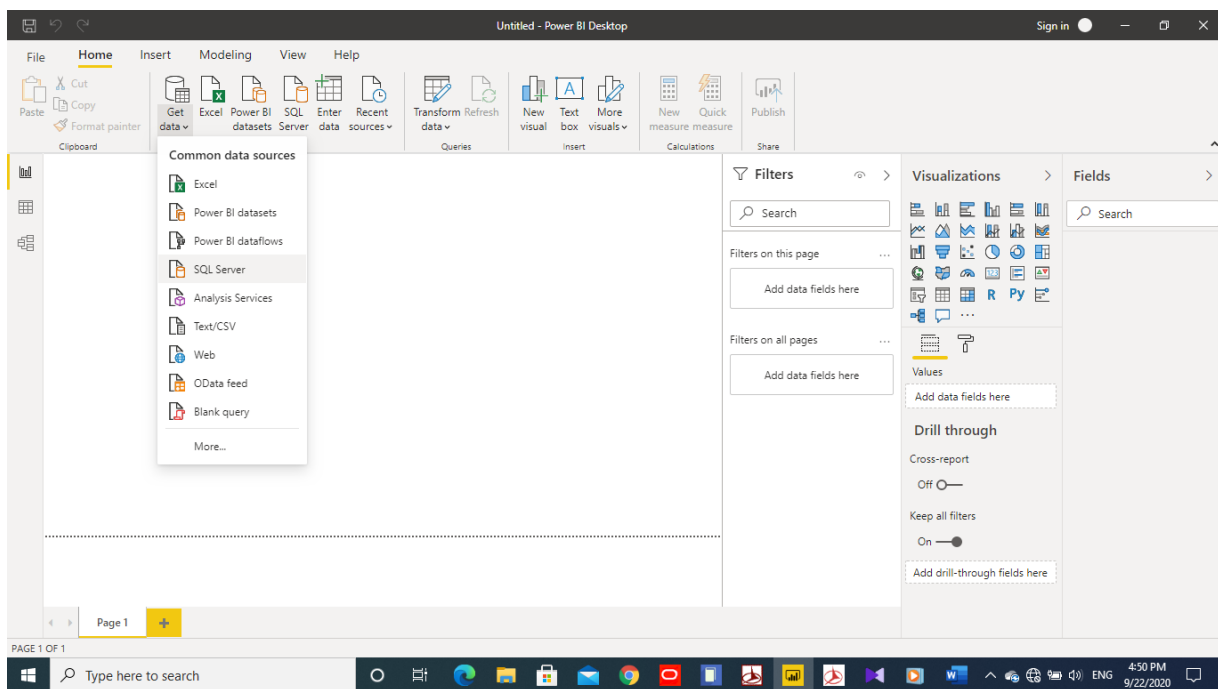Fig. 5 Power BI Connection Types

Fig. 6 Connection between Power BI and SQL Server

2. EV in Construction Management

The importance of project control tools in the construction industry is undeniable. It is quite natural that projects may run out of budget and fall behind the schedule, so there is a need to provide some controlling indicators which could indicate issues in the project control system. EVM is a project control technology that provides a quantitative measure of work performance and is regarded as the most advanced technology for the integration of schedule and cost [9]. The concise reports derived from the EVM in a project enable the project manager to access the exact information on the project details. The importance of the matter lies in the following facts:

- The early warning of a deteriorated situation provides the opportunity to take timely measures.
- Accurate predictions allow for better decision-making regarding the course of the project.
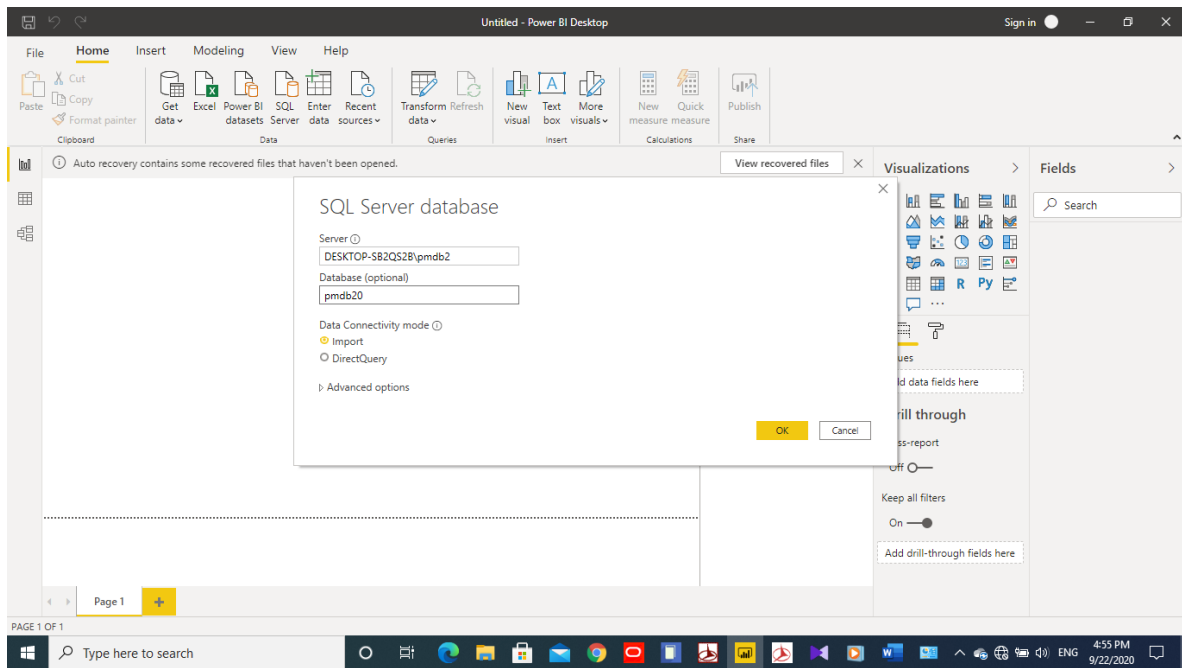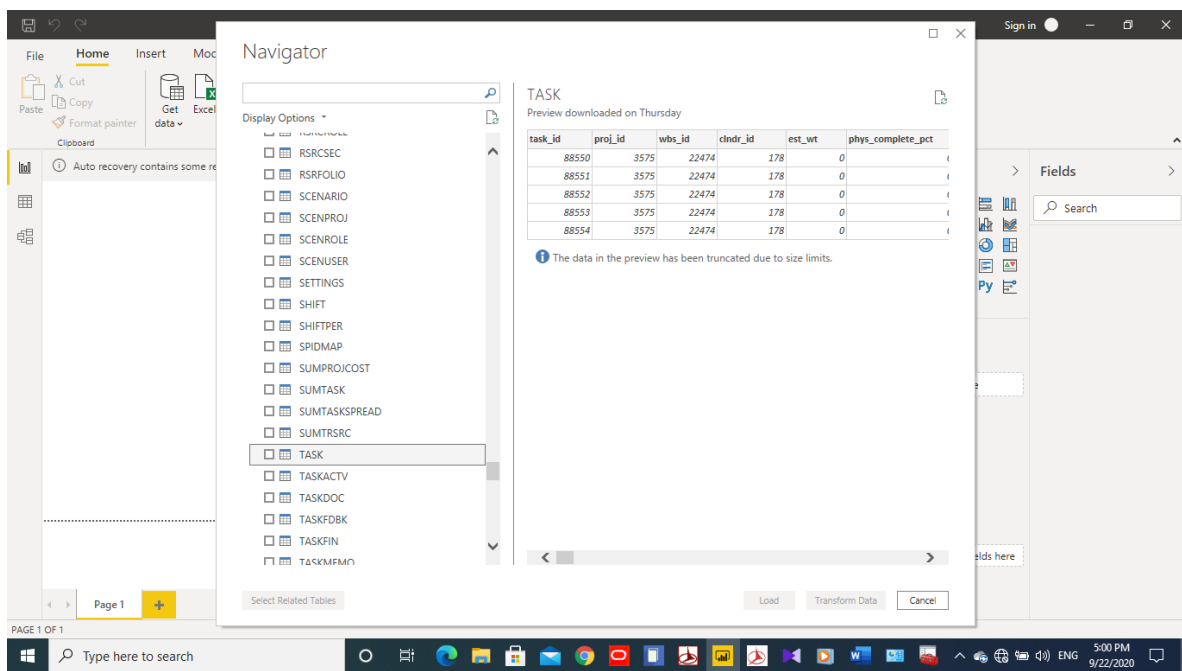
Fig. 7 Access to SQL Server Database

Fig. 8 Primavera P6 Related Database Tables

- Accurate predictions allow for better decision-making regarding the matters outside the project, which may be influenced by the progress of the project.
- An open and verifiable view of progress improves the sponsor's confidence. In addition, the manager would be able to mitigate risky decisions in the critical stages of the project given the availability of an early warning tool for project control. As a result, the project could be completed within a short period [10].

H. Selection of the Database Tables

After the installation of Primavera P6 and its setup with the SQL database, numerous tables were generated for the database that was located on the server to thoroughly store the data created by Primavera P6. Some of these tables were named TASK, PROJECT, PROJCOST, OBS, NOTE, PHASE, and PROJRISK (Fig. 9-P1). Moreover, each table contained the name data; for instance, the project risks data were stored in the PROJRISK table, which contained various columns (Fig. 9-P2).

An important matter to consider was the type of the reports

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that should be prepared. In addition, the tables that were relevant to the objectives of the current research had to be selected accordingly, while the shared features of these tables had to be clarified as well. To prepare the EVM reports, we selected the three database tables of PROJCOST (cost data), PROJECT (project), and TASK (project activities) (Fig. 10).
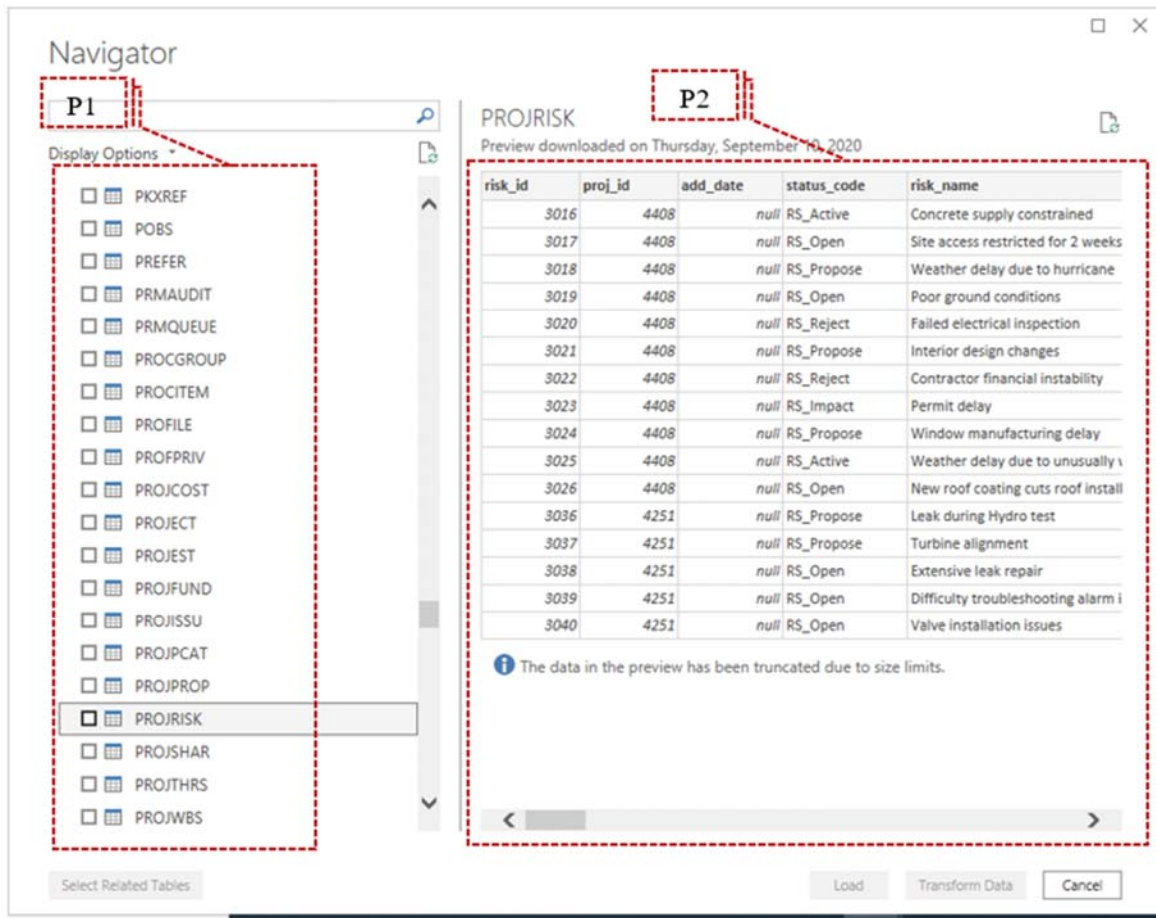
Fig. 9 Selection of Relevant Tables Based on Reports

Fig. 10 Selected Tables

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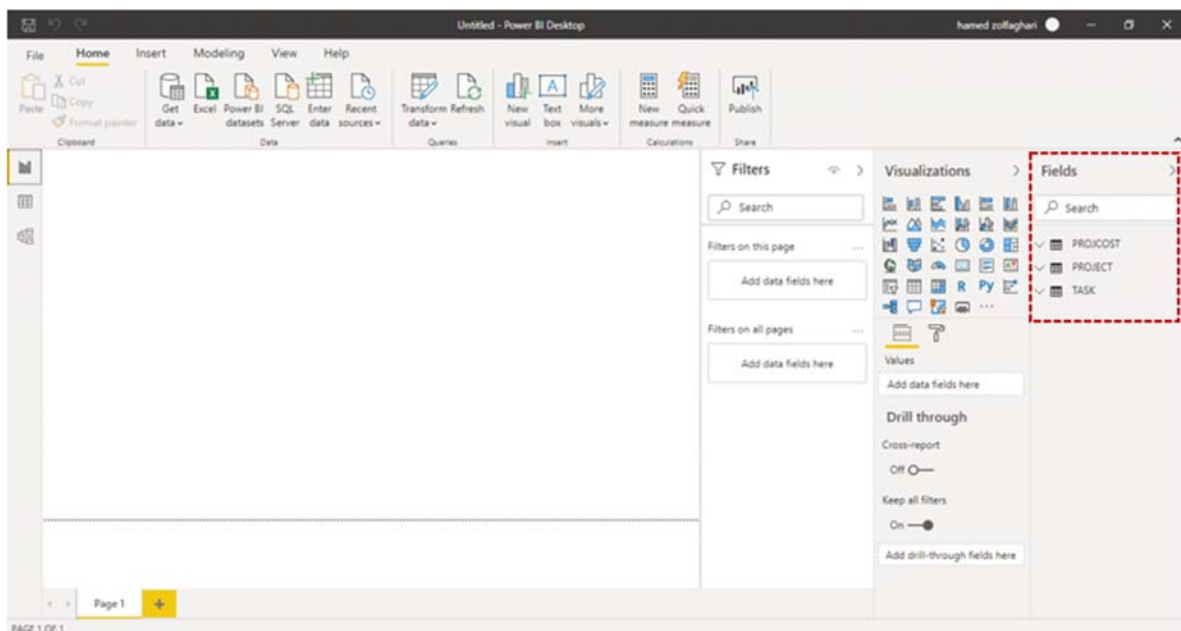
1. Connections between Tables

After the selection of the tables (Fig. 4), data modelling was performed. At this stage, logical relations were automatically established by Power BI. For instance, proj_id was a column repeated in three of the selected tables (Fig. 11), and Power BI connected these tables accordingly (Fig. 12).

2. Data Visualization

Data visualization was carried out at the final phase of data management. Fig. 13 depicts the final EVM dashboard designed in Microsoft Power BI.

I. Online Report Publishing

The final stage involved the online publishing of the prepared report (Fig. 14).
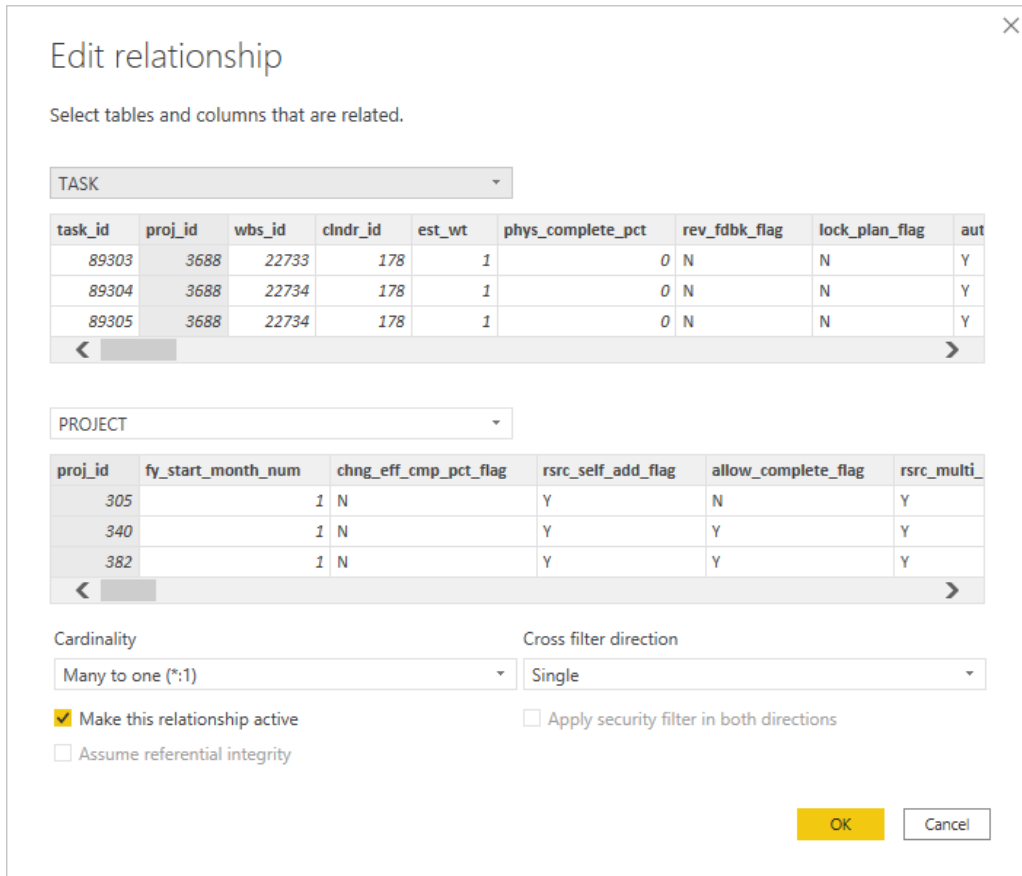
Fig. 11 Connections between Tables

III. RESULTS

Project progress could be determined by various approaches in Primavera P6 with different types of %complete, such as work%complete, physical%complete, and duration%complete. In general, these approaches could be classified as plan%complete and actual%complete. The former is calculated by the schedule update in Primavera P6, and the latter must be entered manually. In our study, physical%complete was in the TASK table (Fig. 15), while plan%complete had to be calculated in Power BI by DAX using (1):

$$Duration\%complete = \frac{(target\_drtn\_hr\_cnt - remain\_drtn\_hr\_cnt)}{target\_drtn\_hr\_cnt} * 100 \quad (1)$$

In order to calculate EV% and PV%, three other formulas were developed in the present study.

$$w.f = \frac{cost\_per\_qty}{target\_cost} \quad (2)$$

$$PV\% = Plan\%complete = Duration\%complete * w.f \quad (3)$$

$$EV\% = Actual\%complete = phys\_complete\_pct * w.f \quad (4)$$

Since the objective of the research was using the EVM, the EVM KPI formulas had to be generated based on data analysis expressions (DAX), as well as an extra formula to identify the key performance indicators (Table I).

IV. DISCUSSION

BI is a remarkable solution for a wide range of problems ranging from data storage to data analysis, modelling, and visualization. In the present study, Power BI was utilized as a

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project management solution, along with the SQL database to store all types of data generated by Primavera P6. To initiate the model, Primavera P6 was integrated with the SQL Server, which preserved the P6 data in numerous data tables. According

to our findings, the use of Power BI and its ability to extract data from external data storages (e.g., SQL) was the key advantage for the current research to proceed.
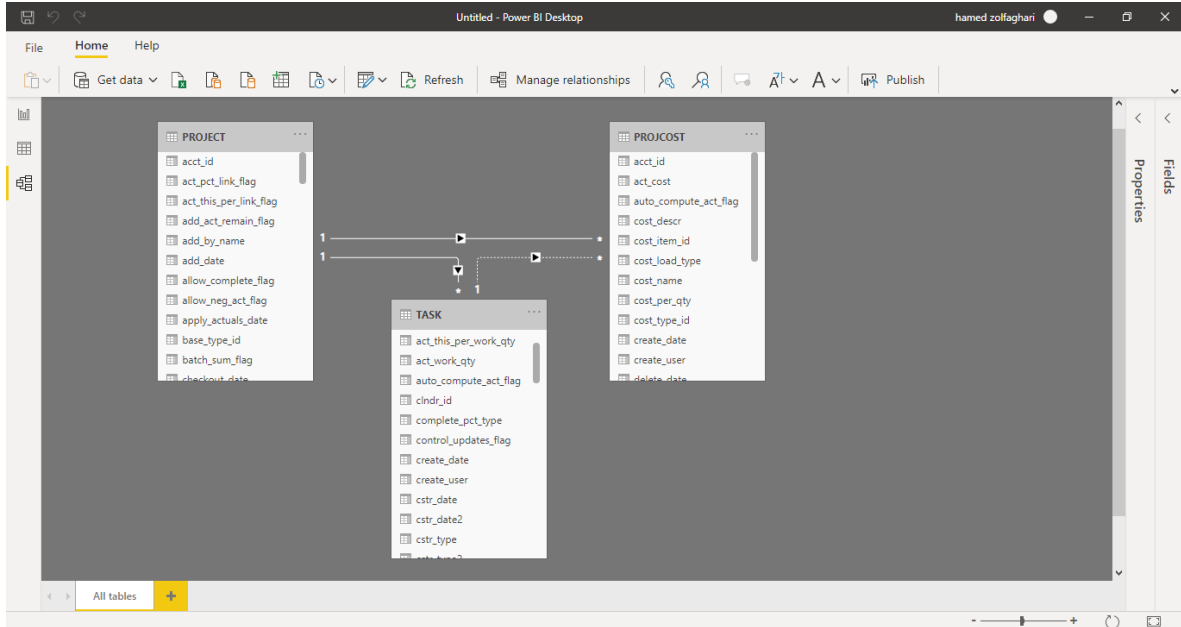
Fig. 12 Connections between Tables

Fig. 13 Final EVM Dashboard

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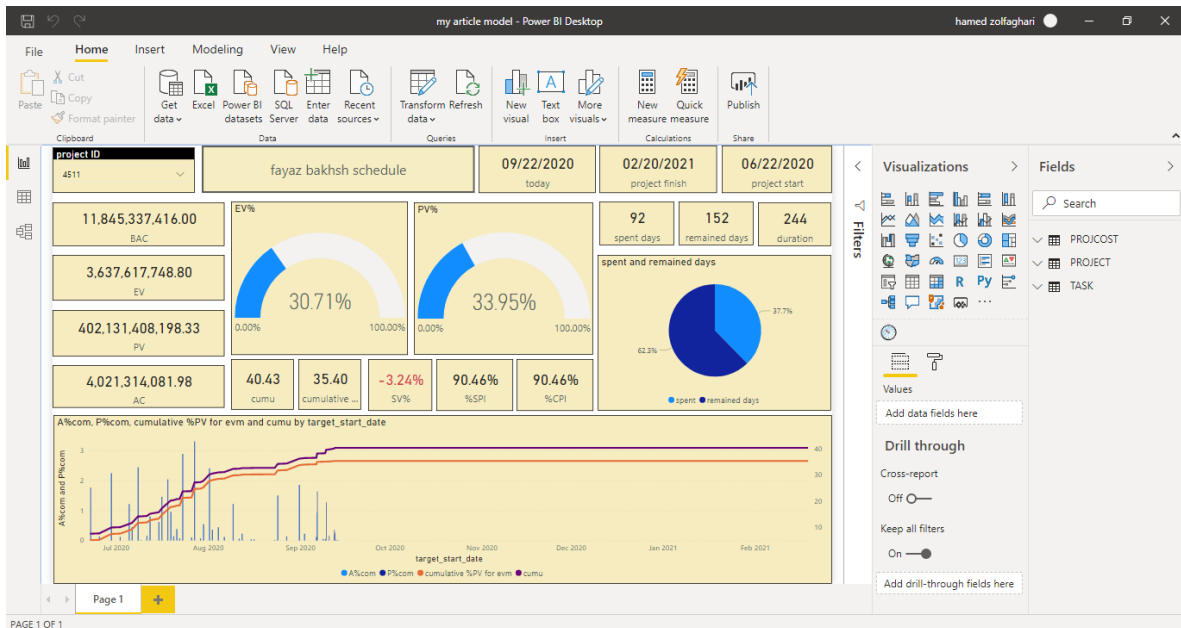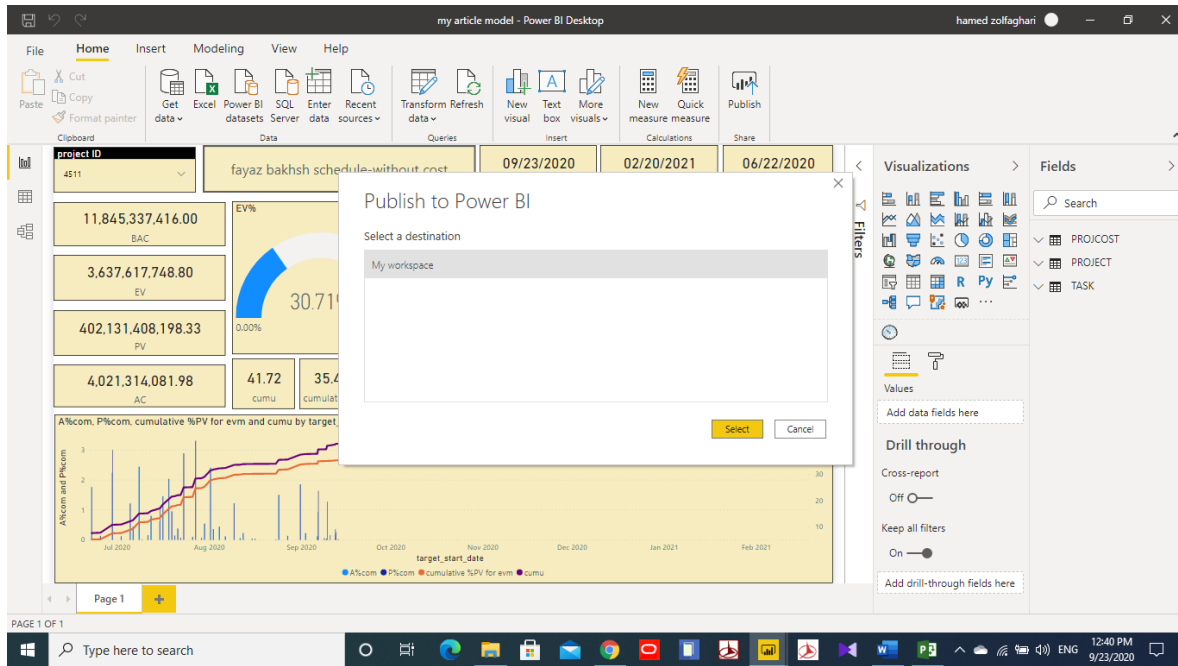
Fig. 14 Published Report Online

Fig. 15 Physical % complete

In the current research, project progress reports were also presented based on the EVM, while our model could also prepare other types of reports. Considering the extensive data that could be entered in P6 (e.g., risks, issues, resources, costs, documents, and changes), these reports could contain all the aspects of project areas in the future in order to prepare a wide array of reports. Notably, the Microsoft Power BI enabled us to design and develop an efficient model for the direct query, which lays the groundwork for further investigations regarding project management solutions.

V. CONCLUSION

The preparation of construction project reports is a time-consuming project, and time errors are inevitable most of the time. Project managers look forward to receiving timely and error-free reports, while in some cases, the lack of experience of project controllers may lead to their dissatisfaction. On the

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other hand, project controllers often have difficulty making project progress dashboards and reports after updating the project schedule. One reason is that the project schedule may not be relevant to the reports, and the reports must be updated manually. Another reason for this problem is that errors may occasionally appear in the presented reports.

TABLE I
USING DAX TO GENERATE EVM KPIS

KPI	Definition	Related Tables	Related Column	DAX
BAC	Budget at Completion	PROJCOST	Target_cost	Sum
EV	Earned Value	PROJCOST& TASK	Target_cost Phys_complete_pct	Target_cost* Phys_complete_pct
PV	Planned Value	PROJCOST& Formula 1	Target_cost Duration%complete	Target_cost* Duration%complete
AC	Actual Cost	PROJCOST	Act_cost	Sum

We have proposed an eight-step process to integrate project schedules with EV reports as an efficient approach to updating projects and project reports. Moreover, our survey aimed to automatize the process of EVM in projects and reports and facilitate the presentation of these reports through online publishing. In the suggested model, the SQL Server, Primavera P6, and Microsoft Power BI were integrated to design an automated process for the preparation of EV reports for a six-story concrete building in Mashhad (Iran), and the obtained results could successfully achieve the objective of the research.

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