ISSN: 2456-1134 www.isjcresm.com
Vol-06 Issue-02 Dec 2021

A Study on the Efficiency of Service Building Maintenance Management with the Application of Power BI and Building Information Modeling

Sanaa AL Mezawyaigh

Building Information Modeling and Management Master Student

Abstract

Maintenance management is primarily responsible for enhancing the efficiency and cleanliness of service facilities. Building information modeling (BIM) was therefore applied to one of the university buildings in this research. The goal was to gather accurate data on the building's components and link maintenance records to those components using the highly effective and flexible Revit software. The results are shown in the You may attain the highest quality service at the lowest cost and improve the accuracy of maintenance operations by adding parameters to the components. As a result, the building's components are used to categorize and model the maintenance data. The next step is to extract, analyze, and examine the data for implicit knowledge using business intelligence approaches. The College of Mechanical and Electrical Engineering's building information modeling (BIM) model was created by conducting a precise description of all architectural features. With an emphasis on both quantitative and qualitative methods, this model details the actual state of architectural maintenance during the last five years (2019–2023) and the maintenance management practices used by the Maintenance Department. Assigning maintenance parameters to the building's architectural components (doors, walls, windows, false ceilings, floors) is the next step in connecting the operational and maintenance data in the model. Then, exporting the tables generated by Revit to Excel and importing them into Power are the final steps. Thanks to Bi, you can examine data, find out what percentage of items have been done and what percentage haven't, figure out why certain things haven't been implemented, and assess how well workshops and experts worked. In addition, we calculated the expected cost of maintaining the doors, estimated the budget for future architectural maintenance, assessed the building elements using technical marks to identify the door element's periodic maintenance items, and planned the materials needed for the next year. We were also successful in creating an optical and spatial connection between the critical issues and the places they arose in the built environment.

Keywords: Maintenance Management; Service buildings; Building information modeling BIM; The university; Business Intelligence BI ….

1.0 Introduction

All of a building's systems need maintenance in order to maintain functioning properly. Building information modeling enhances understanding of the building and its components by recording and storing the data related to the building. Improving maintenance operations, planning them ahead of time, and determining their priorities becomes vital within an information-rich model using business intelligence (BI), a tool of artificial intelligence (AI). This is particularly the case when taking into account the building model's enormous data sets, which will only increase during the investment and operating stages.

ISSN: 2456-1134 www.isjcresm.com
Vol-06 Issue-02 Dec 2021

2.0 Related Work

Maintenance has been defined as (a continual process and permanent activity to maintain buildings and keep equipment in the best condition) and as (the third element after design and implementation that leads to a decrease in the expected life of buildings), according to a number of studies that have examined the concept, types, and costs of maintenance. [11]. We call these operations. Which, in order to keep the structure in good repair, must be put into place throughout its operational life cycle [25]. The whole structure, including all of its architectural, structural, and plumbing systems, must be maintained [8]. There are two main categories for maintenance tasks: scheduled and unexpected [1]. This is beneficial Organizing maintenance tasks according to certain categories at each stage [19]. Over the course of a building's lifetime, a significant amount of money will be spent on maintenance [9]. Inefficient maintenance is the primary cause of unnecessary expenditures, which include [6]. Alterations to the building's function are a leading cause of visible flaws in the facilities [3]. Putting off necessary maintenance [2]. Errors in implementation [4]. The structure is left ignored until it reaches the level of collapse due to shortcomings in administrative legislation that need regular maintenance. When doing maintenance, it is essential to highlight the significance of the object. Steps taken to prevent its recurrence [7]. Maintenance management and efficient utilization during operation also need a scientific approach [14]. Several studies, particularly those involving university buildings, used the balanced performance theory to assess the performance of various types of buildings [24,26]. Another approach is to use a specific model for school buildings to assess the facility's functional, technical, and sanitary aspects, as well as its age, budget, number of maintenance personnel, and building area [10]. One name for building information modeling (BIM) is the life cycle management of building data. [15]. Data from publications in operation and maintenance[26-43-44-45] and the construction sector both highlight the significance of building information modeling (BIM) applications. Although essential, BIM implementation is challenging [23].[25] Theon page 26, Many engineers in the AEC industry have been unable to participate in projects using cutting-edge technology and methods because of this.[37]in the text.the number 33, The benefits of building information modeling (BIM) have been recognized by industrialized nations [28], and it also has the ability to tackle issues that cross disciplines [27-38-35-45-46-47].[28] has several potential uses in many different fields. the number 33, Still, BIM adoption is far lower than anticipated, despite all this [24].As a result, Syrian educational institutions should better invest in training engineers and ensuring that they are able to adapt to new technology [41], Currently, there is a transition happening in Syria's AEC sector from CAD to BIM. The backing of the government, key businesses, and the academic community is vital for this change. In order to acquire the optimal operating model for the building—a repository of data and records for the building throughout its lifetime—this will allow the industry to keep up with the quickly evolving technology environment [34]. The number 22. We identify issues with the conventional method of maintenance work documentation and highlight the value of building information modeling (BIM) for construction-related data and information documentation [16–47]. In order to create a database utilizing BIM for a three-story university building, researchers at an American institution employed the practice of logging maintenance orders for a year. [12]. Creating databases in the BIM&KM environment for the most critical maintenance items in service buildings may greatly assist with decision-making in maintenance, according to studies that have touched on the necessity of integrating knowledge management with BIM [23]. Integrating AI with BIM has become necessary to improve the accuracy and practicality of construction information due to the growth of the AEC construction sector [40-43-44]. [27] The capacity to forecast, organize, categorize, preserve documents, issue reports, and monitor the progress of business implementation is the essence of business intelligence (BI) technology. plus the need to enhance future maintenance by extracting information from historical maintenance data using specialized methodologies [18]. In particular, they brought attention to the fact that Power BI business intelligence enables users to examine, process, and analyze data via the creation of reports that can be connected to REVIT via Excel, all thanks to its interactive interface and the dimensional structure of data. [28] in The number 23.

ISSN: 2456-1134 www.isjcresm.com
Vol-06 Issue-02 Dec 2021

3.0 Research problem

The traditional maintenance management systems currently used in university facilities lack an effective approach. We summarize the research problem as follows:

1- Is maintenance information for university buildings archived and stored electronically?

2- How can we benefit from the maintenance information that was performed for future maintenance**?**

4.0 Objective and importance of research

The importance of the research comes from the fact that the maintenance process affects the life span of buildings. The research aims to model the case study using BIM (REVIT) techniques, as it is one of the most important programs that help in creating a building database that can store a huge amount of data, whether through existing parameters. Within the program, or through its flexibility in the ability to add parameters to the elements and components of the building that serve maintenance operations, and analyses the available data about maintenance using business intelligence techniques (POWER BI) with the aim of making the most accurate decisions**.**

5.0 Research methodology

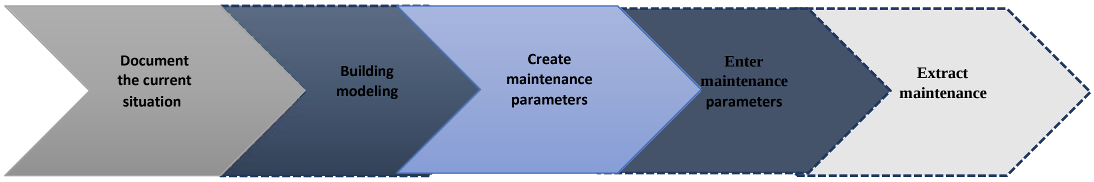
(Descriptive analytical method)

A - In the first stage: modelling the facility on (REVIT), and describing the reality of the building in detail to document the current components of the building elements, taking into account accuracy in determining the technical specifications of the elements from an architectural perspective. It also includes tracking the maintenance work that was carried out over a period of 5 years and working to introduce All maintenance work data to reach a model in the BIM environment that is rich in all maintenance data for the building. Figure (1)

B - In the second stage: it depends on analysing data by exporting reports related to maintenance, and analysing them using business intelligence software, to reach the ability to make decisions Figure (2)

ISSN: 2456-1134 www.isjcresm.com
Vol-06 Issue-02 Dec 2021

.



Scheme of the first stage of obtaining a BIM model)1(Figure

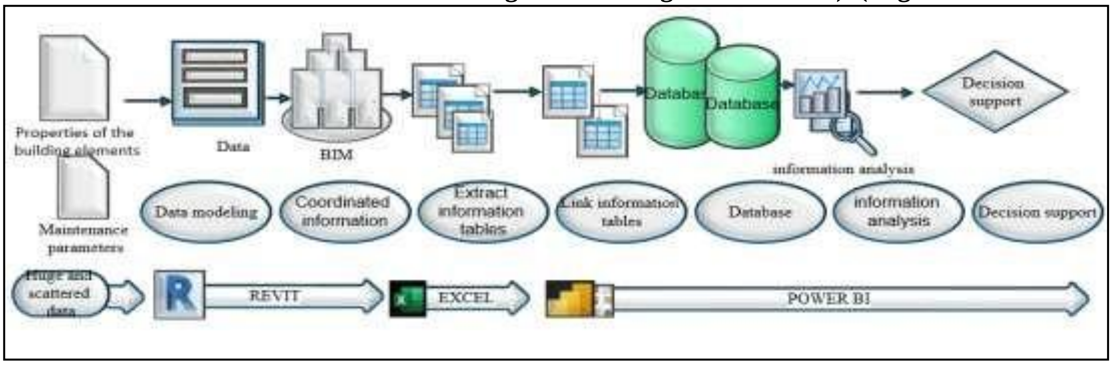


Figure 2: Diagram of the second stage to reach appropriate decisions

6.0 Case study: Creating a maintenance model for the building of the Faculty of Mechanical and Electrical Engineering at Tishreen University using BIM

6.1 Identify the architectural elements of the building

Walls (external walls, interior walls, and bathroom walls), floors ((30*30*3)) Bedrosian marble, ceilings (false ceilings), tiles 60*60, doors (wooden veneers, aluminium veneers), windows (aluminium veneers, aluminium veneers).

6.2 Determine the necessary parameters for maintenance

1. The name of the applicant	2. Date of implemting the request	3. Date of submitting the request	4. The cost of maintenance
5. Request number	6. Site number	7. Place of the element	8. Request status
9. Reasons for non - implementation	10. Maintenance classification	11. Name of the responsible for implementation	12 Description of the problem

6.3. Creating the model for the College of Mechanical and Electrical Engineering building

A model for the college was designed according to Figure (3-4-5) and maintenance parameters were entered into the model by adding maintenance parameters from Add Parameter

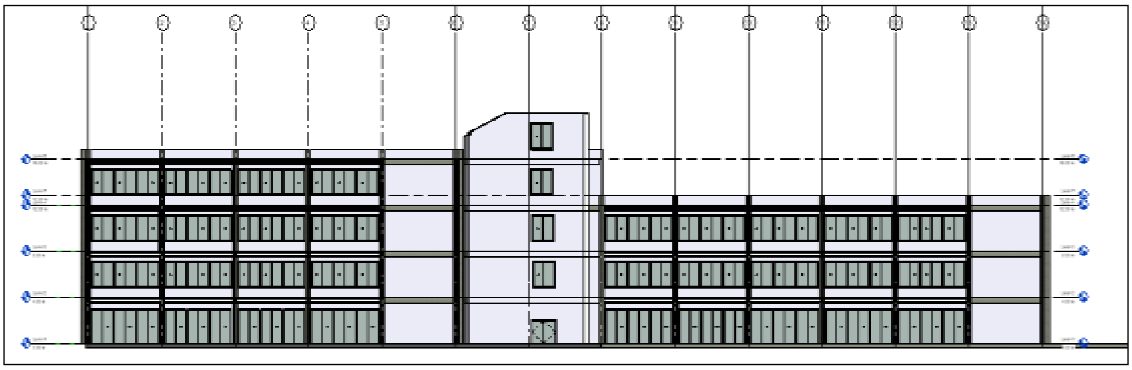


Figure 3: The southern elevation of the building

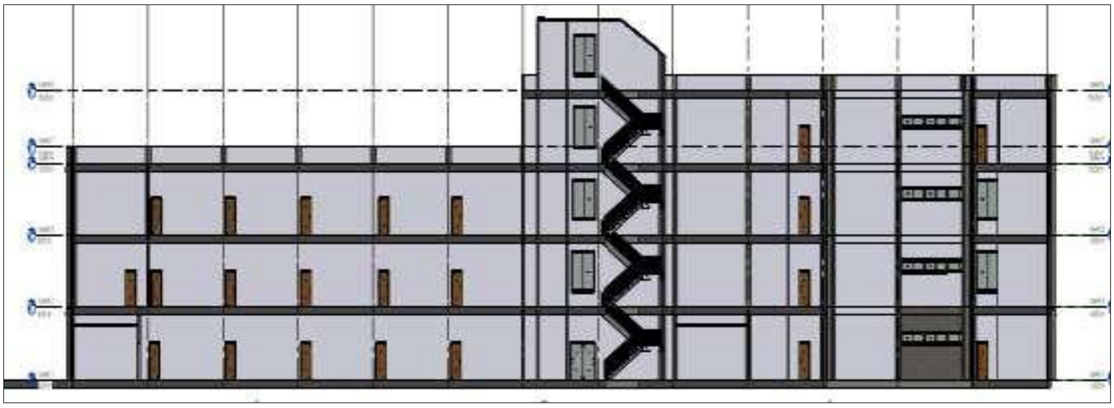


Figure 4: Section A-A

Figure 5: Detailed perspective of the Hamak College building

6.4 Create a database of maintenance items in a business intelligence environment

1) Import maintenance schedules from Excel

Maintenance data is imported (after exporting it from the Revit model to Excel) from the Get data icon, then Excel Workbook, then Connect. We choose the file name Open, and from

ISSN: 2456-1134 www.isjcresm.com
Vol-06 Issue-02 Dec 2021

the Navigator menu, the data tables that were exported from Revit and saved in Excel appear to form a database for building maintenance work.

2) Define truth tables and dimension tables

The main table and the sub-tables are organized using star schemas. The main table **expresses** the characteristics of the operational data of the building elements (Identity Data), which is unique and not duplicated. It is called the truth table (which expresses the data of the elements that already exist in the Revit program and that distinguish the para-objects. Metric) The operational data table includes the following columns (Height-Family and type-family-… Mark-). We note that the Mark column is the unique column in the operational data table. As in Figure (6)

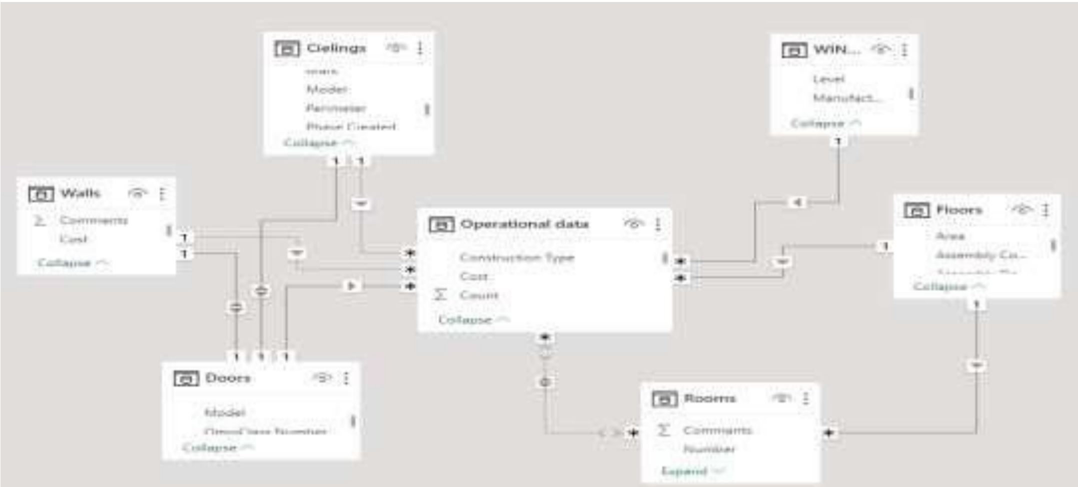


Figure 6: Linking the truth table with the dimension table

7.0 Analyse maintenance data in a business intelligence environment

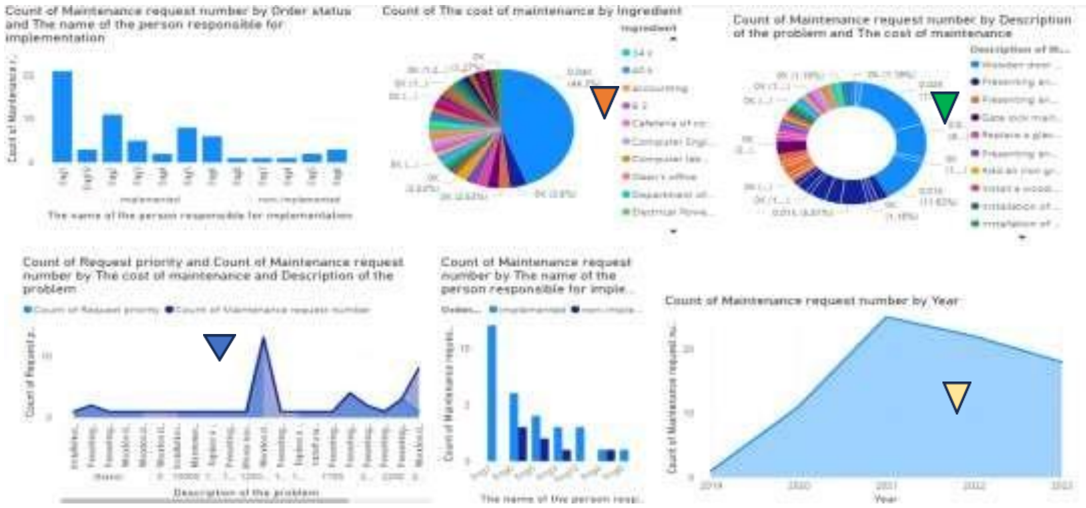
7.1 At the level of building elements:

Figure (7) shows an interactive interface in Power Bi for doors through which we notice that the number of maintenance requests ranges between 18-22 requests per year due to the lack of opening

ISSN: 2456-1134 www.isjcresm.com
Vol-06 Issue-02 Dec 2021

new specializations, while we notice that in 2019 the percentage of requests was 5-20 requests due to the transfer of the Engineering Institute to the Hamak building. The most important problems that make doors need maintenance, the most important of which is the maintenance of bathroom doors, which constitute 36% of the number of requests, due to problems with plumbing installations, frequent use, and lack of continuous care, in addition to the type of materials used in painting the doors, which do not achieve good insulation. We also note that the problem of locks constitutes 20%. From the number of maintenance requests, the locks used are of the cylinder type. The cost of maintaining wooden doors constitutes the highest cost at 50.3% of the maintenance cost of doors. The installation of iron doors constitutes 24%, and they are placed for security reasons and to preserve assets. We note that the number of maintenance requests is concentrated in the bathroom area at a rate of 35.38% due to problems with sanitary installations, frequent use by students, and lack of continuous maintenance, followed by student affairs at a rate of 21.68% due to the opening of new rooms affiliated with student affairs and due to the increasing number of students, followed by the Engineering Institute Department at a rate 9% due to the increasing need for investment

ISSN: 2456-1134 www.isjcresm.com
Vol-06 Issue-02 Dec 2021



.

Figure 7: Interactive interface for doors

Table 1: Maintenance data at the element level

Element	Number of maintenance requests	The percentage of maintenance cost	The percentage of the problem according to repetition	The percentage of the problem by cost	The percentage of the problem according to the void	The void according to the number of requests
the doors	86	34%	36%	50.30%	35%	bathroom
Walls	48	26%	50%	58.30%	58.30%	bathroom
Windows	23	12.49%	43%	32%	43%	B m
Bishop	15	16.72%	31%	44%	24%	Dean's office
Floors	3	5.45%	100%	41%	100%	bathroom

In the same steps, the rest of the data for other elements: walls, floors, false ceilings, and windows are analyzed in Table (1).

7.2 Analyze maintenance data in a business intelligence environment at a building-level

ISSN: 2456-1134 www.isjcresm.com
Vol-06 Issue-02 Dec 2021

Implementation cost:

We note that the cost of maintaining doors constitutes 34.35% of the maintenance cost, then walls at 26%,then windows at 17.4%, then false ceilings at 16.72%, and the cost of maintaining floors at 5.4% Figure (9)

.

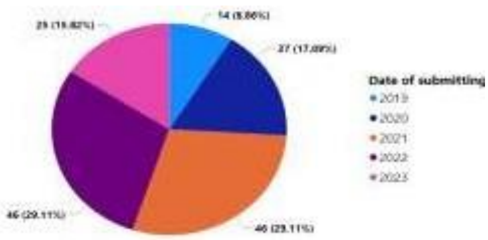


Figure 9: Distribution of maintenance costs among the various elements of thebuilding

Excution percentage:

The percentage of completed works reached 88.5% of the total requests, and the percentage of unimplemented requestsreached 11.4% for financial reasons (lack of budget) or technical reasons (lack of workshops) Figure

.)8(

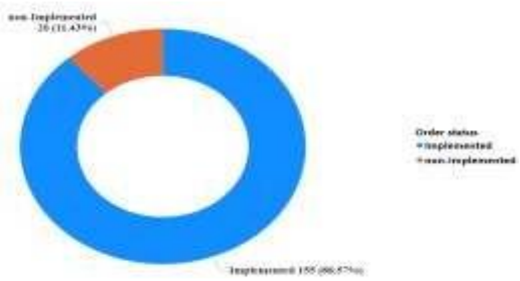


Figure 8: Ratio of emplement to non-emplemented works

7.3 Identify the most frequent maintenance problems

The Pareto principle (20/80) suggests that a small number of issues account for a disproportionately large amount of damage or losses in factories. By analyzing the frequency of these issues, we may identify the most significant maintenance concerns. Reducing or eliminating these few but significant factors will have a positive effect on manufacturing quality and cost. Figure ten: Frequency table of maintenance issues

The plan allows us to identify the most critical maintenance issues, which are: repairing a ceramic wall, supplying and installing a lock, painting a wall, putting up a fake ceiling, replacing a glass panel, supplying and installing an iron door, and maintaining a wooden door.

The Pareto principle (20/80) suggests that a small number of issues account for a disproportionately large amount of damage or losses in factories. By analyzing the frequency of these issues, we may identify the most significant maintenance concerns. Reducing or eliminating these few but significant factors will have a positive effect on manufacturing quality and cost. Figure ten: Frequency table of maintenance issues

The plan allows us to identify the most critical maintenance issues, which are: doing upkeep on ceramic walls - preserving a wooden door - hanging a fake ceiling, painting a wall, and supplying and installing a lock

- putting in an iron door - removing and replacing a glass panel.

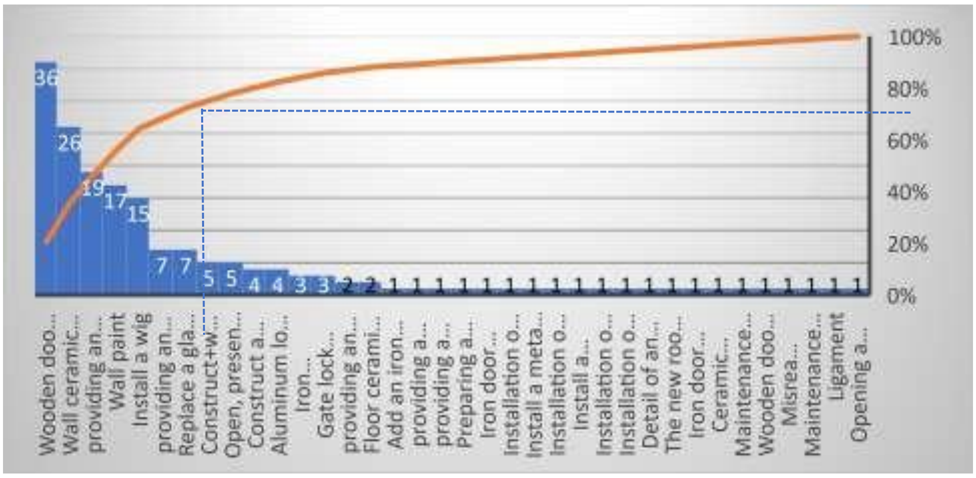


Figure 10: Maintenance problems frequency chart

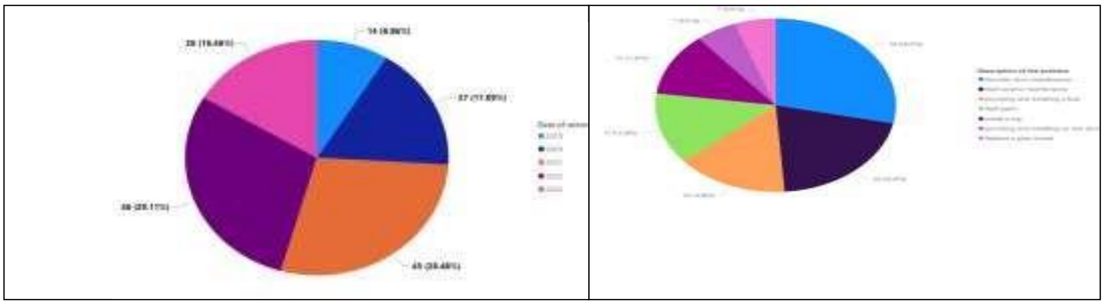
7.4 Statistical analysis of the implementation time of maintenance items

Request execution time T(x) = request execution time t1 – request submission time t0
Duration of carrying out wooden door maintenance: We calculate the total time periods for the wooden door maintenance item and divide by their number $T(x) = \sum_{n=1}^{n}(t_1 - t_0)$ There is a delay in implementing requests in general, especially the carpentry and blacksmith workshops, and therefore the performance of the workshops must be improved (Table 2).

Replacement of glass panel	Providing and installing an iron door	Installing a false ceiling	Wall paint	Provide and install a lock	Wall ceramic maintenance	Wooden door maintenance	the problem
80 Day	Day 175	Day 265	Day 115	Day 57	107 Day	114Day	Duration of implementation

7.5 Statistical analysis of the cost of maintenance items:

Maintenance costs for the most important maintenance items, where the percentage of maintenance costs for wooden doors is 27.85% of the total costs, then the cost of installing false ceilings is 26.5%, then maintaining wall ceramics is 24.5%, then installing iron doors is 13.5%, painting walls is 4%, then replacing glass panels is 2%. % Figure (11). Given the heterogeneity of costs due to price differences and their constant change as a result of economic conditions during the five years, it was necessary to determine the cost of maintenance work for each year according to the following**:**



Maintenance costs during the five years from 2019-2023, indicating that the costs for the year 2023 until the end of May, Figure (12).

ISSN: 2456-1134 www.isjcresm.com
Vol-06 Issue-02 Dec 2021

7.6 Approximate budget forecast:

It is also possible, through the Power BI program, to use the relationship between the cost of maintenance in the college and the number of college students in the same year to predict the approximate budget needed to maintain a college with a specific number of students, as the correlation coefficient between the cost and the number of students was strong (0.93), and Figure (13) shows the relationship between the cost of college maintenance and the number of its students

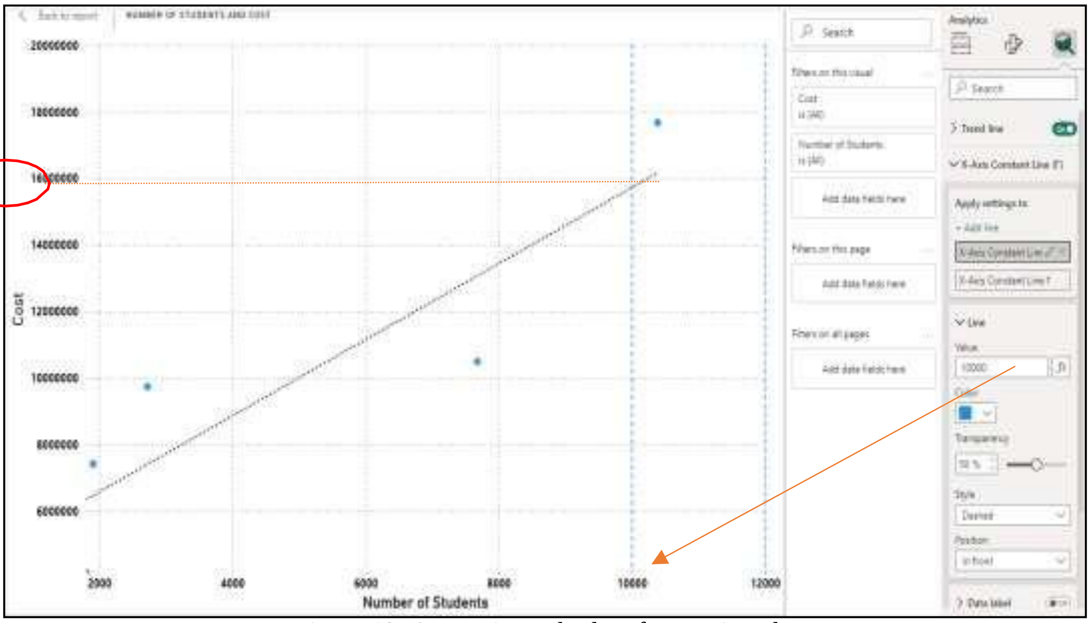


Figure 13: Approximate budget forecasting chart

If the number of students in the next academic year is 10,000 students, the approximate expected budget is about 16,000,000 SYP, which must be multiplied by the inflation factor corresponding to the year of calculating the budget as follows: Inflation factor in the year x= (exchange rate of the dollar in the year x /1800), where /1800/ is average. The dollar exchange rate in 2019, the year of data collection, and assuming the inflation factor for the year 2024 (12600/1800 = 7), the approximate budget for the maintenance of Al-Hamak College in 2024 = 16,000,000*7 = 112,000,000 SYP

7.7 Conduct door element evaluation

Determining the technical signs of the severity of the condition of the door element, the specific condition standard for evaluating the condition of the elements (Choka, 2012

Table 3: evaluation of doors

	Cost of maintenance	Evaluate and describe the problem			

	Replacement and installation of internal	Replacement and	Painting with scratching and kneading x3	Replacement grip x2	Replacement lock x1	Quality of clothing	Quality material	Paint quality	Quality of grips	Quality locks			
$X_1+X_2+X_3+X_4$	0	X_4	X_3	X_2	X_1	0	0	0	0	1	1	16	replacing
$X_1+X_2+X_3$	0	0	X_3	X_2	X_1	0	0	0	1	1	2	22	Maintenance is critical
X_1+X_2	0	0	0	X_2	X_1	0	0	1	1	1	3	30	Periodic maintenance
X_1	0	0	0	0	X_1	0	1	1	1	1	4	27	Minor maintenance

Through the following equation, we can predict the budget required to maintain the door component for the coming year, Table (3)

$$\textbf{budget} = \sum \boldsymbol{n_1} * (\boldsymbol{X_1} + \boldsymbol{X_2} + \boldsymbol{X_3} + \boldsymbol{X_4}) + \boldsymbol{n_2} * (\boldsymbol{X_1} + \boldsymbol{X_2} + \boldsymbol{X_3}) + \boldsymbol{n_3} * (\boldsymbol{X_1} + \boldsymbol{X_2}) + \boldsymbol{n_4} * (\boldsymbol{X_1})$$

X_3= The cost of painting Door frame	n_3=Number of doors with a rating of 3	X_1= The cost of providing and installing a lock	n_1=Number of doors with a rating of 1
X_4= The cost of providing and installing wood	n_4=Number of doors with a rating of 4	X_2= The cost of providing and installing a grab	n_2=Number of doors with a rating of 2

8.0 Results

As a first step toward modeling the other faculties of Tishreen University that share the same architectural components, a building information modeling (BIM) model was built for the building of the Faculty of Mechanical and Electrical Engineering using the REVIT application. In addition to entering data for architectural maintenance (walls, doors, windows, false ceilings, floors), parameters were also set for maintenance items for the building parts.

- Ascertain the percentage of completed vs unfinished tasks, and note that the implementation was prompted by two factors: a shortage of funds and ineffective workshop facilities. Estimates for the price of repairs (to doors, walls, windows, and false ceilings) were also derived from the data.
- Using the Pareto principle, we were able to identify the most critical maintenance issues with a wooden door within 5 years, allowing us to devote our future maintenance resources to resolving those issues. Wall paint lock installation and maintenance for ceramic walls - setting up a cover for the ceiling - securing a new iron door - repairing a broken glass panel
- The Power BI tool was used to forecast the following year's budget and provide an anticipated budget for the doors element's maintenance based on the link between the college's maintenance costs and the number of students in the same year.

ISSN: 2456-1134 www.isjcresm.com
Vol-06 Issue-02 Dec 2021

10.0 References

Building Maintenance by Seely, I.H. 1987, London, Second Edition, 470 pages. [2] Zaki Hawass. Diseases that affect buildings.the year 1992. First edition, 54 pages, Egypt, World of Books. The version in Arabic
[3] Sharif Abu Al-Majd. (1993). Methods for treating concrete constructions that have cracked. Published by the Egyptian Universities Publishing House - Al-Wafaa Library in Egypt, this book was 143 pages long. The version in Arabic

(1996), Muhammad Suleiman Menoun. Household building upkeep. Egypt, 150 pages, master's thesis. The version in Arabic

This is according to Saladin, Wael (1997). Method for enhancing hotel maintenance efficiency by measuring post-occupancy performance. Science and Technology University of Egypt.20

in the Arabic text

Source: [6] Al-Khatam, J. (2003). Cost of Building Maintenance (66P), King Fahd University of Petroleum and Minerals, Master's Thesis.

Repfat, R., Gero, J., and Peng, W. (2004). Making Use of Data Mining for Building Life Cycle Maintenance. Australia: University of Tasmania, 91–97.

Generic Process Model for the Management of School Building Maintenance [8] Bin Akasha

A 92-page book published by Malaysia University

Building Maintenance Management, Second Edition, Blackwell Publishing, USA, 313 pages [9] Chanter and Swallow.

Building maintenance in Malaysia (Abdulateef, 2008, pp. 207–214).

Mandar Abdel Sabour. You are Abdul Hadi Hosni. Ahmad Issawi wrote this. Ibrahim Naseer. in the year 2009, Keep residential amenities in the Egyptian Arab Republic running well, despite setbacks and optimism. M.Phil. dissertation defended at Ain Shams University. Volume 4, number 4,72 pages.

In 2010, Akcamete and Akinci published a study. Possible Application of BIM in Planning and Maintenance Tasks. Seven points, Carnegie Mellon University, USA.

in [13]Author: Abdul Aziz Al-Nadawi (2011). When it comes to creating administrative procedures for businesses, business intelligence is a cutting-edge technique. Vol. 2, Issue 2, 26 pages, Journal of Financial and Commercial Studies. The version in Arabic

[14] In their 2011 master's thesis, Hadad and Hassan examine the elements that impact hospital maintenance expenditures; the work spans 115 pages and was completed at Tishreen University. The version in Arabic

In 2011, Eastman, Teicholz, Sacks, and Liston published a study. Building Information Modeling (BIM) Handbook: A Resource for Everyone Involved in the Process The publishing house John Wiley & Sons15

In 2011, Wang and Chen published a study. A Three-Dimensional Visualized Method for Facility Management and Maintenance. Pages 468–4751 in the journal Information and Computational Technology.

[17] Choka, D.G. (2012); A Case Study of Public Universities in Kenya Examining the Effects of Management Systems on the Buildings' Maintenance Conditions.June 17, page 76

[18] inAbdul Rahman, Hisham. Abdul Karim Eid and Muhammad Eid (2013) Methods for the planned upkeep of Egypt's most fundamental public structures. "Journal of Engineering Sciences at Assiut University," Volume 41, Issue 1, January 257-289. Translation into Arabic

The source is Lopes (2016). Case Study 268–273: Requirements Specification for an Automated Maintenance Management System.

A 133-page master's thesis published in 2016 by Tishreen University by Basil Al-Hassan and Fayez Jarad titled "Improving maintenance management for government buildings using building information modeling (BIM) techniques"

[21](Reham Ibrahim and Muhammad Arja) (2017). The creation of a performance-based framework for the administration of school facility maintenance. 164 pages, Arabic translation, Master's thesis, Tishreen University

The Way to Building Information Modeling (BIM), a 151-page guide published by Dar Al-Kutub Al-Ilmiyyah for Publishing and Distribution in 2018 by Ahmed and Saleem, is cited as [22]. (Portuguese variant).

In 2018, Shaban and Elhendawi published a study. Challenges and Needs for the Implementation of Building Information Modeling in Syria. Publishes research in the field of building information modeling and engineering science.

In 2018, Yusof, Ishak, and Doheim published a study. An Inquiry on the Level of Development of BIM in the Construction Sector. Volume 1, Issue 1, pages 6-19, International Journal of Building Information Modeling and Engineering Science.

Elhendawi, A.I.N. (2018) [25]. The BIM Implementation Methodology in the KSA AEC Sector. Edinburgh Napier University, United Kingdom (MSc in Construction Project Management).

In 2019, Elhendawi, Omar, Elbeltagi, and Smith published a study. (1926). An actionable strategy for encouraging those who aren't already using BIM to start using it. "International Journal of Building Information Modeling and Engineering Science," volume 2, issue 2, pages 1–22.

Banawi, Aljobaly, and Ahiable (2019) were cited in reference 27. Building information modeling frameworks compared and reviewed. Volume 2, Issue 2, pages 23–48, International Journal of Building Information Modeling and Engineering Science.

In 2019, Elhendawi, Smith, and Elbeltagi published a study. Saudi Arabia's approach to building information modeling (4D). Publication: International Journal of Building Information Modeling and Engineering Science, Volume 2, Issue 1, Pages 1–21.

Basil Al-Hassan, Jamal Omran, Jarad Fayez, and others (29). (2019), PhD thesis, Tishreen University, 171 pages (Arabic version): Creating a system to back up maintenance choices in service buildings using an integrated approach between knowledge management and BIM.

[30] inFayez Jarad and Sanaa Al-Mazawi. In 2019, Mia and Rana were both mentioned. Presenting a framework for tracking and assessing the real effectiveness of public university building repair management in line with balanced performance theory (using Tishreen University as an example) Engineering Sciences, Tishreen University Journal, Vol. 41, No. 4, pp. 317–339. The version in Arabic

In 2019, Morais and Casado published a study. Administration of Building Maintenance in a Public Organization. October 85–103, University of Pernambuco, Brazil.

[32]Fayez Jarad and Sanaa Al-Mazawi. Randa Mia. (2020). Evaluating real performance to improve maintenance management efficiency at public institutions. thesis for a master's degree,

Two hundred and eighty pages, published by Tishreen University

This information is sourced from Hamma-adama, Kouider, and Salman (2020, 33). Examining the factors that encourage or discourage the use of building information modeling methods. Volume 3, Issue 1, pages 18–41, published in the International Journal of Building Information Modeling and Engineering Statistics.

Salamah et al. (2014) published an article in the International Journal of Building Information Modeling and Engineering Science titled "Improving AEC Project Performance in Syria Through the Integration of Earned Value Management System and Building Information Modelling: A Case Study." The article can be found on page 75 of the volume 5, issue 1.

For example, see Safour, Ahmed, and Zaarour (2021) [35]. BIM Adoption throughout the World. Pages 49–63 of the International Journal of Building Information Modeling and Engineering Science, volume 4, issue 2, published in 2016.

Zaarour and Maihoub (2021) cite this material as [36]. How different needle diameters affect the electrospun PVDF nanofibers' size. Volume 26, Issue 3, of the International Journal of Building Information Modeling and Engineering Science, pages 26-40.

Salami and Alothman (2022) [37]. Why Building Information Modelling Requires Engineering Education. Pages 41–60 of the International Journal of Building Information Modeling and Engineering Science, volume 5, issue 1,

Roumieh and Ahmed (2022) [38]. The International Journal of Building Information Modeling and Engineering Science, Volume 5, Issue 1, pages 61–72, discusses the use of professional risk management methodologies as a means to save Syria’s cultural heritage sites.

Saada and Aslan (2022) cite this work as [39]. Improving the precision of quantity estimates for post-war public facility repair projects in Syria via the use of building information modeling,

Publication: International Journal of Building Information Modeling and Engineering Science, Volume 5, Issue 2, Text Number: 08-18

[40] Mashalali and El Tantawi did it again in 2022. Smart construction megaprojects (SCMPs) rely on building information modeling (BIM) for stakeholder information exchange (IE) throughout the planning stage. Publication: International Journal of Building Information Modeling and Engineering Science, Volume 5, Issue 1, Pages 18–19.

Dalloul and Saod Lama (2023) [41]. A case study of the Faculty of Civil Engineering at Tishreen University demonstrates the need for a framework to introduce the idea of engineering digitalization in the context of curriculum development. Volume 6, Issue 1, Pages 34–51, 2023, International Journal of Building Information Modeling and Engineering Science (IJBES).

In 2023, [42] Al Mezawy, S., Jrad, F., and Maya, R.Process for Using Business Intelligence to Streamline Service Building Maintenance Management Performance.The Engineering Sciences Journal of Damascus University, volume 12, issue 12.

Referenced in [43] Saleh, F. H., Elhendawi, A. Darwish.In 2024, A.S. and P. Farell published. To achieve smart, sustainable cities, an information and communication technology (ICT) framework is required for innovative BIM and lean practice integration. International Journal of Building Information Modeling and Engineering Science, 2(2), pages 68–75, published by Al-Rashid International Private University.

With the help of Abdul Salam Darwish, Peter Farrell, Ashraf Elhendawi, and Fawaz Saleh (2024). Smart Sustainable Cities: A Framework for Harnessing the Power of AI, BIM, and the Internet of Things. “Journal of Intelligent Systems and the Internet of Things,” volume 11, issue 2, pages 75–84 This article has the DOI: 10.54216/JISIoT.110207.

In 2020, a group of researchers including Evans, Farrell, Elbeltagi, Mashali, and Elhendawi published a study. Stakeholder behavior in construction mega-projects as a result of partnership agreements linked to building information modeling (BIM) adoption. Published in the International Journal of Building Information Modeling and Engineering Science, volume 3, issue 1, pages 1–20.

In 2021, Elgendi, Elhendawi, Youssef, and Darwish co-authored the following work: [46]. A Look at the Construction Ergonomics' Exposure to COVID-19 and How It Could Affect Efforts to Fight the Virus. Publication: International Journal of Building Information Modeling and Engineering Science, Volume 4, Issue 1, Pages1-29.

Ahmad, S., Dlask, P., Selim, O., and Elhendawi, A. (2018) published a study in 2018. Framework for Building Information Modeling Performance Improvement in Syrian AEC Firms. Publication: International Journal of Building Information Modeling and Engineering Science, Volume 1, Issue 1, Pages 21–41 (2012)