Enhancing facility management for buildings using BIM (case study: model of a medical building)

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Abstract

Facilities management is one of the main challenges in the maintenance and operation of buildings. The use of BIM in facility management is an effective tool that helps to provide information, identify maintenance needs, plan a budget and direct efforts to improve the long-term performance of the facility. This study aims to find the best ways to apply BIM in facilities management and facilitate access to any information needed at the stage of operation and maintenance to deal with it and improve the maintenance of the building. The Autodesk Revit program was used, which provides many tools and features that help in the process of effective facility management. A practical model of a medical building with various clinics, consisting of two floors and a glazed additional floor, was applied. The Autodesk BIM Interoperability Tools interoperability tool was activated to obtain the full model information and then the fire sprinkler maintenance information was filtered using the COBie Extension for Autodesk Revit standard. The data and information from the building model were exported to an Excel file to illustrate the results in a unified format. Research has shown that the use of BIM improves facility management by providing accurate and comprehensive information about maintenance and operation and facilitates the detection, prediction, treatment, handling and management of maintenance problems more efficiently compared to traditional methods of Facility Management, which are considered more complex. The research concluded that the use of BIM in facility management can achieve efficiency, save time and cost, extend the life of facilities, reduce the field of error, fraud and theft. It is recommended to study BIM accreditation in facilities management, especially for large projects, and learn more about other BIM tools and programs for future studies.

Keywords: Facility Management; Building Information Modelling (BIM); Operation and Maintenance; Autodesk BIM Interoperability Tools; Construction Operation Building Information Exchange (COBie).

1.Introduction

The architecture, engineering and construction (AEC) industry has recently been considered the most influential contributor to development worldwide. However, the AEC industry faces countless challenges due to the huge development in the field of construction [1,2,3,4,5,6]. This starts with the client's early conception, going through the pre-design, design, construction, operation and maintenance (O&M) stages until the demolition of the building [3]. The urgent need for innovative, sophisticated and complex architectural, engineering and construction (AEC) industry projects with in-depth details makes traditional methods unsuitable for completing projects with the required efficiency, performance and productivity [4].

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"Although building information modeling (BIM) has been widely adopted worldwide, it is still considered a new approach in Syria" [7]. There are a lot of important results achieved by BIM at the design and construction stages, however, the use of BIM in facilities management is relatively new and has not yet reached the required level and full and expected use. Even the concept of facilities management is not common in Syria yet, as facilities management staff face major problems during the operation and maintenance phase where the data required for facilities management is either incomplete or insufficient, the researcher believes that most workers in the construction sector do not realize the importance of the BIM system and do not have the knowledge and skill to apply it at present. Although it is carried out by some consulting offices. However, the level of BIM adoption is still much lower than expected [5,6,7].

The use of BIM in facilities management can add great value through documentation, quality control, maintenance, warranty data, service information management, energy, space, evaluation, monitoring, etc., and the presence of a digital database of building information to make better and faster maintenance decisions and provide more efficient performance. The database contains building information and supports the optimal use, modification and modernization of the building throughout the life cycle as required by each stage. "BIM applications are interactive and dynamic compared to two-dimensional plans and traditional study methods." [8]

BIM has a big role in facilities management, but this role is not widely activated, and this can be for several reasons, perhaps as a result of the lack of Arab research studies in this field and the lack of experts in it and its programs, or the inability to accept the idea of switching to modern technology and delving into it, because the majority of engineers are used to working in the traditional way and the usual programs, or because they do not know enough about the benefits of BIM application, or because of the lack of available capabilities and manpower, or the lack of a budget allocated to work with this technology.

This research paper aimed to highlight the development of BIM and its application in facilities management and develop awareness of its benefits, highlight the importance of information required by facilities management during the operation and maintenance process, as well as identify the best practices for exchanging facility data in Revit through a practical study, and finally identify the challenges facing the BIM application in facilities management and submit proposals for its successful application. The research questions that the research aims to answer are:

1. What are the most prominent BIM tools in Revit that enhance the facilities management and maintenance process and what are their benefits?
2. How is the data exported from Revit to an Excel file?
3. What are the most important challenges of using BIM technology in facilities management and how to overcome them?

The operational stage of the building is the main contributor to the cost of the life cycle of the building. It is estimated that the life cycle cost is five to seven times higher than the initial investment costs [9] and three times the construction cost.as a result, there is now a significant economic and environmental need to manage new and existing facilities in an efficient manner. Governments around the world have recognized the shortcomings affecting the construction industry in general, and have recommended or mandated the use of building information modeling (BIM) as a strategy to address low productivity.

1.1. FM concepts:

According to the ISO vocabulary FM is: "the organizational function that integrates people, place and process within the built environment with the aim of improving people's quality of life and core business productivity" [10]

According to IFMA: "FM is a profession dedicated to supporting people. It ensures functionality, comfort, safety, sustainability and efficiency of the built environment - the buildings in which we live and work and the surrounding infrastructure" [11]

1.2. BIM concepts:

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The American Institute of Architects (AIA) defined BIM systems as building information management as follows: "the process that provides the benefits that are evident through the electronic form, includes the centralization of information, visual communication of construction elements, sustainability, effective integration of various disciplines, quality control, site organization and more accurate operational schemes".[12]

The General Union of contractors of the USA has defined BIM as follows: "it is the development and use of a computer software model to simulate the original construction and operation, and the resulting model, the construction information model, is a dual-purpose, intelligent and parametric rich asset digital representation with which scenes and data suitable for different needs of users can be extracted and analyzed, to generate information that can be used for decision-making and optimize the delivery of the asset.[13]

2. Literature Review:

Previous research papers have pointed out the motives and constraints of using BIM in facilities management, and emphasized the need for more applied research, although it was agreed that the most common problem facing facility managers is access to information. Some studies have covered the difficult aspects of developing and providing such information in the context of real-world projects with owner-specific information requirements.

On the other hand, a review of the literature showed that the BIM application at the operational stage is still weak and has not reached the expected level due to poor awareness of its importance, lack of inclusion from the early stages of projects and the need for a lot of resources and funding for its application. "There is still a limited understanding of how BIM effectively supports facilities management activities and how it affects current design and construction processes in practice, necessitating clarification of information requirements from the very beginning of the project, "he said. [14]

2.1 BIM challenges in FM applications

The FM domain relies heavily on getting usable data from BIM to do anything meaningful with it. Many times, these data are not really there or are inaccurate, as the model has not been updated with any design changes made after the design phase and is therefore not an accurate model of the facility as it was built, " he said .[15] the cultural approach to the adoption of new processes and technologies in the facilities management industry is also a major challenge. The facilities management industry is very strict in its approach to new technology, and unless the benefits of BIM for facilities management are clearly demonstrated, its uptake in the facilities management industry will remain low. [16]

The lack of customer awareness is exacerbated by the lack of BIM skills and understanding of facilities management professionals [17]so these two factors together create a vicious circle that prevents the adoption of BIM in FM applications. In fact, this is a very harmful challenge since BIM for FM uses requires constant maintenance to remain valuable for the building itself and its owners. [16]

A summary of some non-engineering requirements has been outlined in recent studies. [16] this challenge is best summarized by him [18] who considers that "building information models that are delivered when a project is completed is a rich source of information for facilities management, but not all information is valuable on a daily basis within the broad scope of management management practice, where data retrieval, change management, cost tracking and work activity are critical. Facility managers will need to detail and prioritize their information requirements. Therefore, it is proposed to carry out the process of searching for basic information requirements within the industry.

Most contract forms still require the delivery of paper documents containing equipment lists, product data sheets, warranties, spare parts lists, preventive maintenance schedules, and other information. This often leads to incomplete and inaccurate information that is difficult to access and use for the purpose of increasing financial management efficiencies. [19]

2.2 The value of BIM in FM applications

Most contracts today require the delivery of paper documents containing equipment lists, product data sheets, warranties, spare parts lists, preventive maintenance schedules, etc. This information is necessary to support the management of facilities by the owner and facility managers. The current process of delivering information to the FM stage is generally done manually. The information provided is often incomplete and inaccurate. [20]

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Optimization of deliveries is among the main motives for using BIM in FM .[21] despite the current interoperability challenges, BIM data and information collected during the building life cycle will reduce the cost and time required to collect and build FM systems [18] for example, data on spaces, systems, finishes, etc .can be captured in digital format within BIM and do not need to be recreated in finished FM systems.[22] the ability to capture manufacturers ' information within three-dimensional parametric objects reduces the need to duplicate asset information .[23] BIM is considered as an enabler to improve data quality and reliability which will result In turn, it will increase the efficiency of the workforce [18] and data quality will improve as more people get used to working in a BIM environment.

There are also suggestions that the adoption of BIM in financial management will facilitate the future participation of facility managers at a very early design stage, in order to convey their input and influence on the design and construction of the building .[24] the adoption of BIM in facilities management is also expected to provide ways to manage knowledge about the construction process that can be used in future designs .[17]

For renovation projects, building information modeling (BIM) and associated technologies such as laser scanning are expected to reduce the cost of producing built information and the accuracy and reliability of information .[25]

3.Research methodology and tools

The descriptive approach was followed in preparing the theoretical basis for this research by reviewing previous books, references and research articles, but in practice, the case study method was used and the BIM interoperability tool was applied to a medical building containing operational information for facility management and maintenance by using Revit Autodesk, which is one of the famous programs in the field of Building Information Modeling, and it also has a great role in facilitating the facilities management process by providing many tools and features that help maintain the building effectively. The BIM Interoperability Tools interoperability tool has been applied to the medical building. this tool is considered as a powerful add-on for Revit and must be installed separately from the Revit installation.it is available for free and provides options for exporting Revit files in IFC format and allows collaboration between various disciplines. The results were demonstrated by the COBie Extension for Autodesk Revit standard provided by interoperability tools, the importance of which comes from the huge amount of stored information in the role of organizing this data in the form of Excel tables in a unified global format.

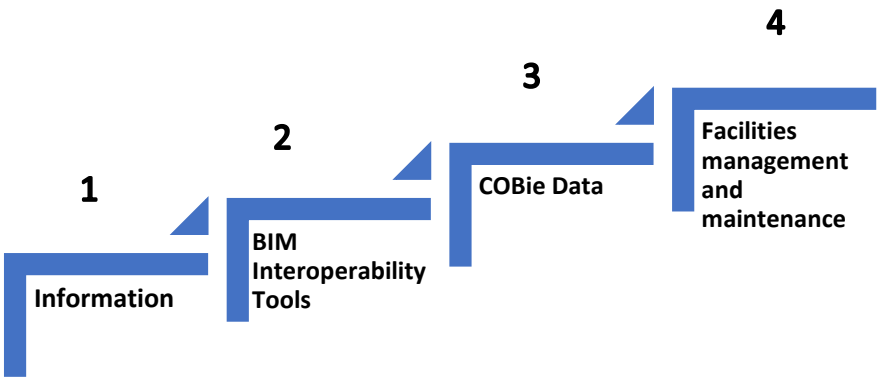

Figure 1: Summary of the sequence of main research ideas

4.Case study:

Project description: it is a two-storey medical building with a glass roof to illuminate the building naturally, it contains various clinics, the advantage of this building is that it contains operational information that benefits the owner/maintenance company in the management of facilities during the operation and maintenance phase.

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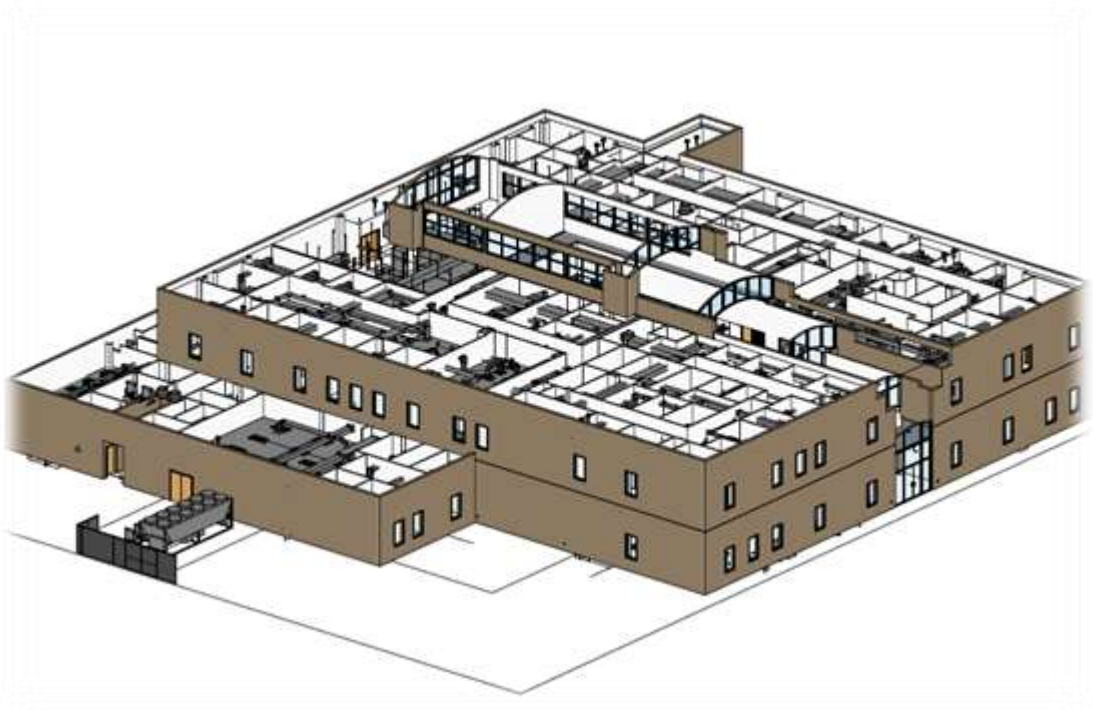

Figure 2: The medical building that was worked on and the results were extracted in 3D

Autodesk Revit software and the COBie Extension for Autodesk Revit standard were used by activating the BIM interoperability tool: Autodesk BIM Interoperability Tools. Note that there are many BIM interoperability tools that can be used, but Autodesk COBie Extension for Revit was chosen because it relates to the delivery phase (Deliver) and operation and maintenance:

Figure 3: Types of Revit program additions (Autodesk BIM Interoperability Tools for Revit | New Features for Version 8). [33]

The working method will be displayed on the COBie Extension for Revit located under the Autodesk BIM Interoperability Tools tool:

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Figure 4: Interoperability tool toolbar and steps to implement it (Setup Project General, Space)

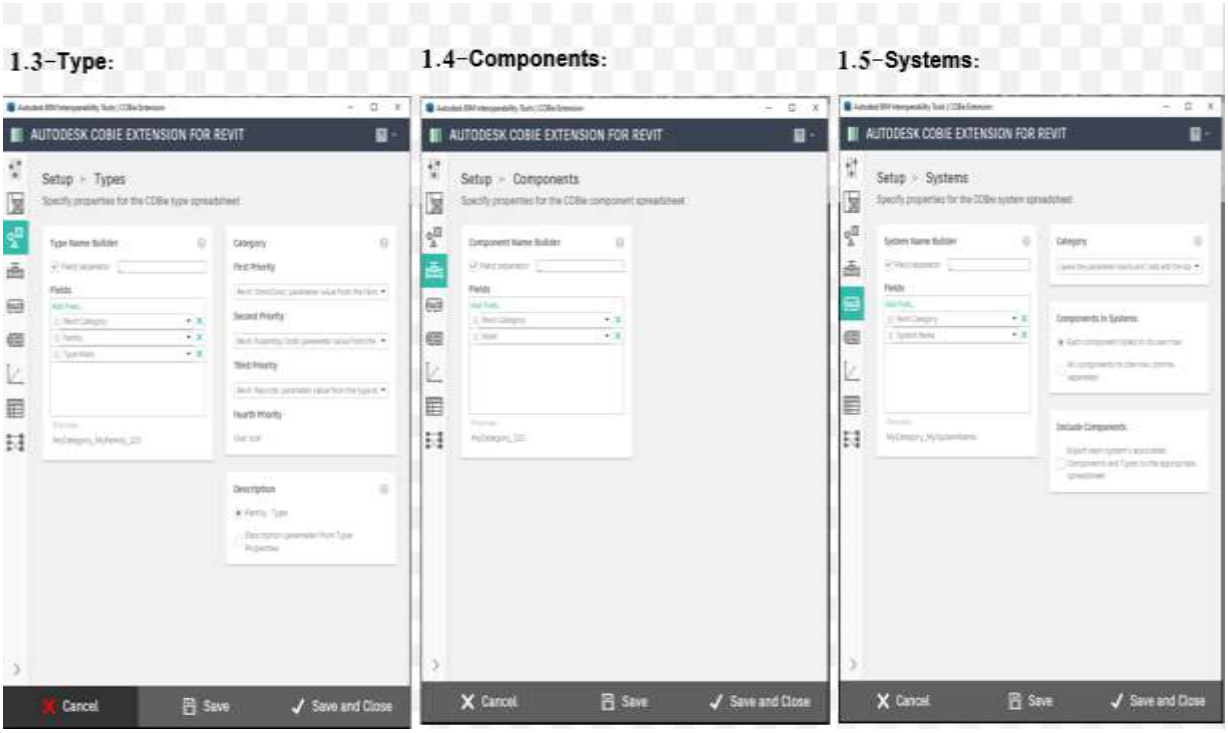

Figure 5: Apply the three steps (Type, Components, Systems)

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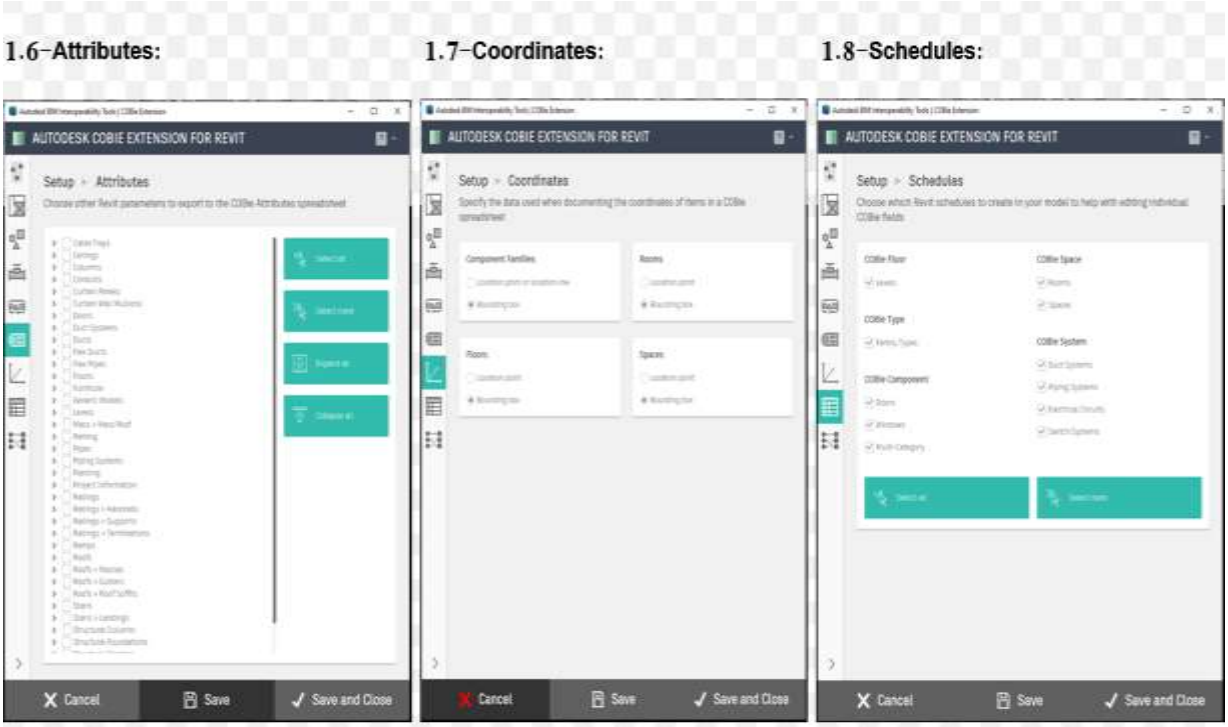

Figure 6: Apply the three steps (Attributes, Coordinates, Schedules)

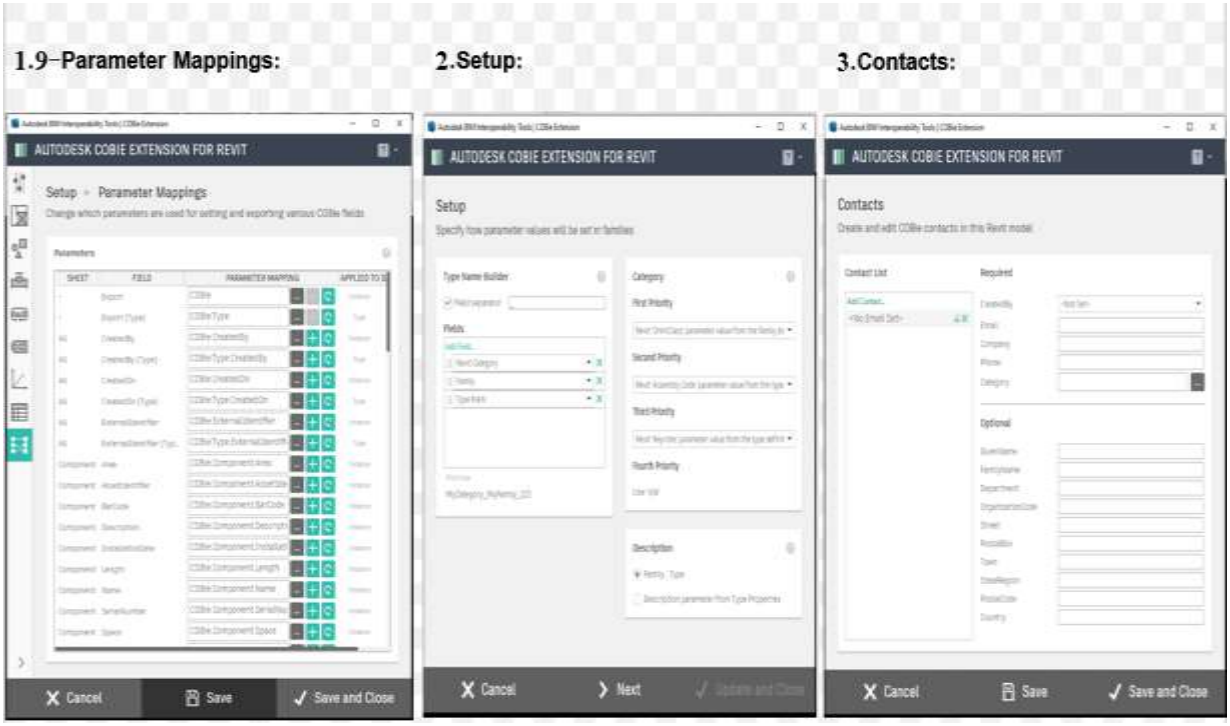

Figure 7: Apply the three steps (Parameter Mappings, Setup, Contacts)

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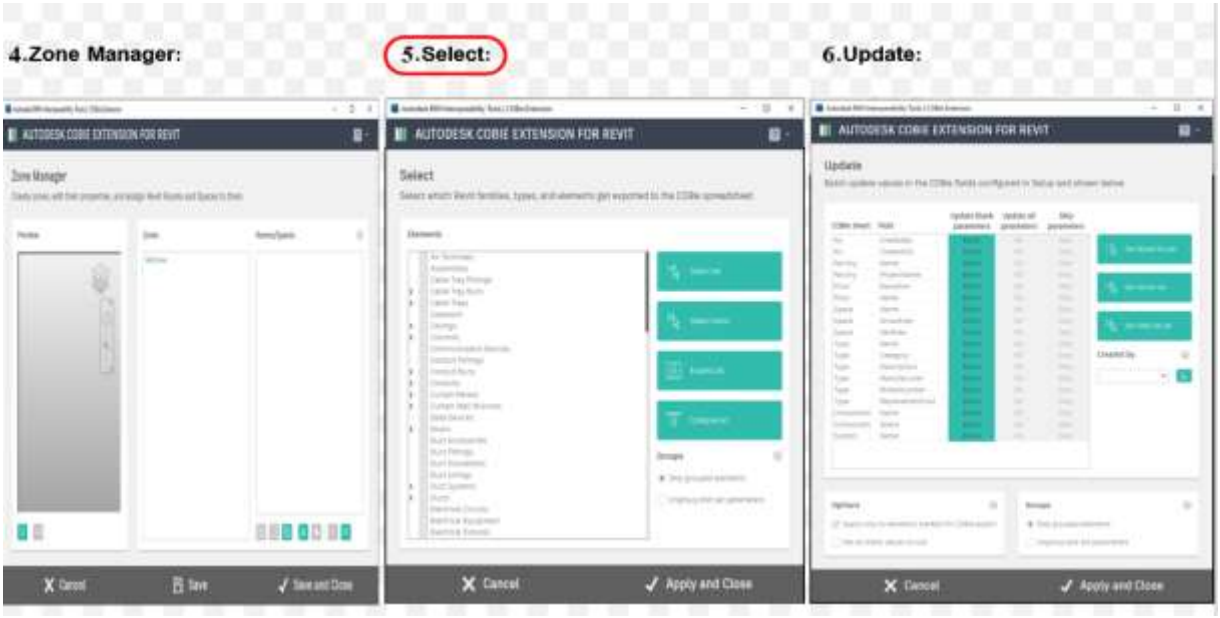

Figure 8: Apply the three steps (Zone Manager, Select, Update)

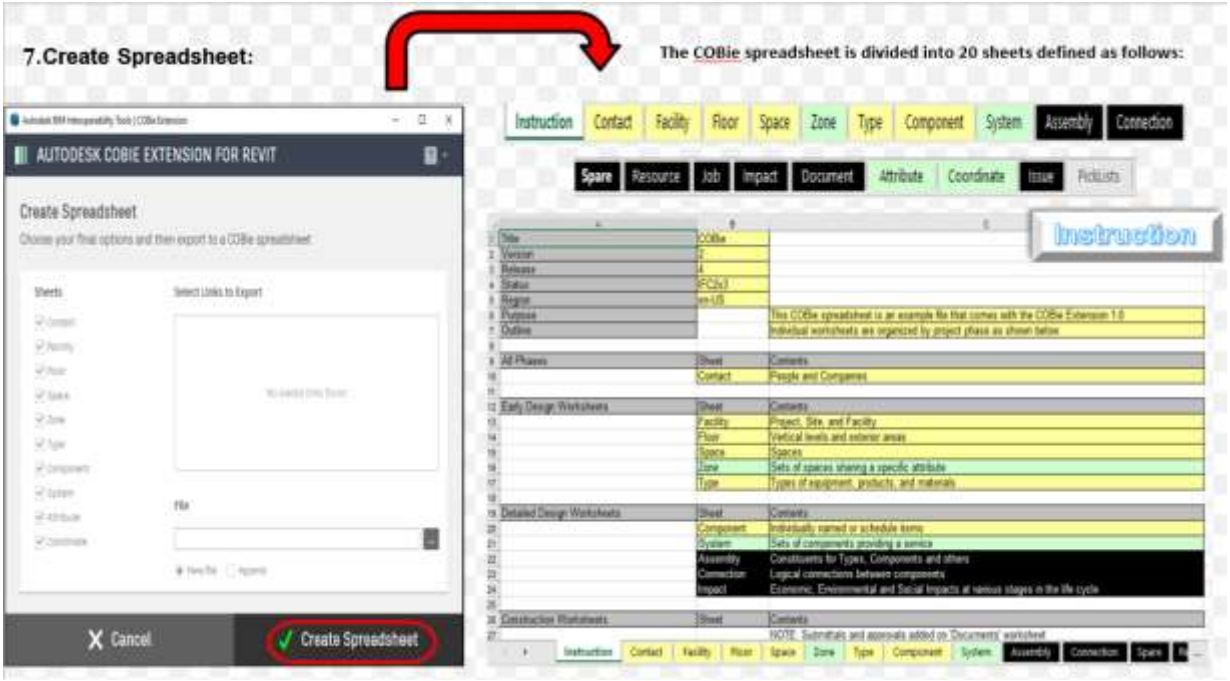

Figure 9: The final step in applying the tool is to create an Excel table and an Excel file interface

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After exporting this information to an Excel file, COBie data appeared within 20 specific sheets as follows:

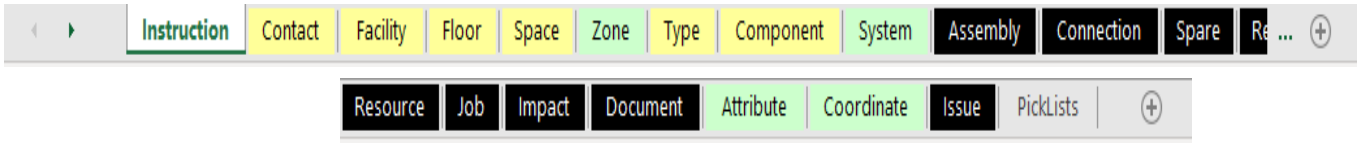

Figure 10: All sheet that come in the Excel file

1.Instruction:
The instruction sheet is a useful page that provides an overview of the type of data, the stages of the project, the papers that belong to each stage, and also contains an explanation of the colors of the data columns. They are used to clarify the data formatting and input rules required for the project.

2.Contact:

A contact sheet is simply a table of each person or company that participated in the lifecycle of the facility and entered any COBie data into the project. They include: email, created by, created in (timed), category, Company, phone, external system, external object, external identifier, Department, organization code, given name, last name, street, mailbox, town, state region, postal code, country.

Figure 11: Contact, facility, floor sheet and their contents

3. Facility:

The facility sheet indicates a specific operational or geographical origin, usually it is a building or a section of infrastructure in addition to details about the building (location, Project, facility). most projects will contain only one row in this sheet, but in the case of a larger multi-facility project, each building will be listed in its own row. Includes: name of the enterprise, created by, created at (timed), category, project name, site name, linear units, area units, volume units, currency unit, area measurement, external system, external project object, external site object, external site ID, external facility object, external facility id, description, project description, Site description, stage.

4. Floor:
The floor sheet is a row for each floor separately, as well as some basic information about it and the location to get any assets located in those areas. Includes: floor name, created by, created in (timed),

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class, external system, external object, external identifier, vertical/vertical height from sea level, vertical/vertical height from land surface.

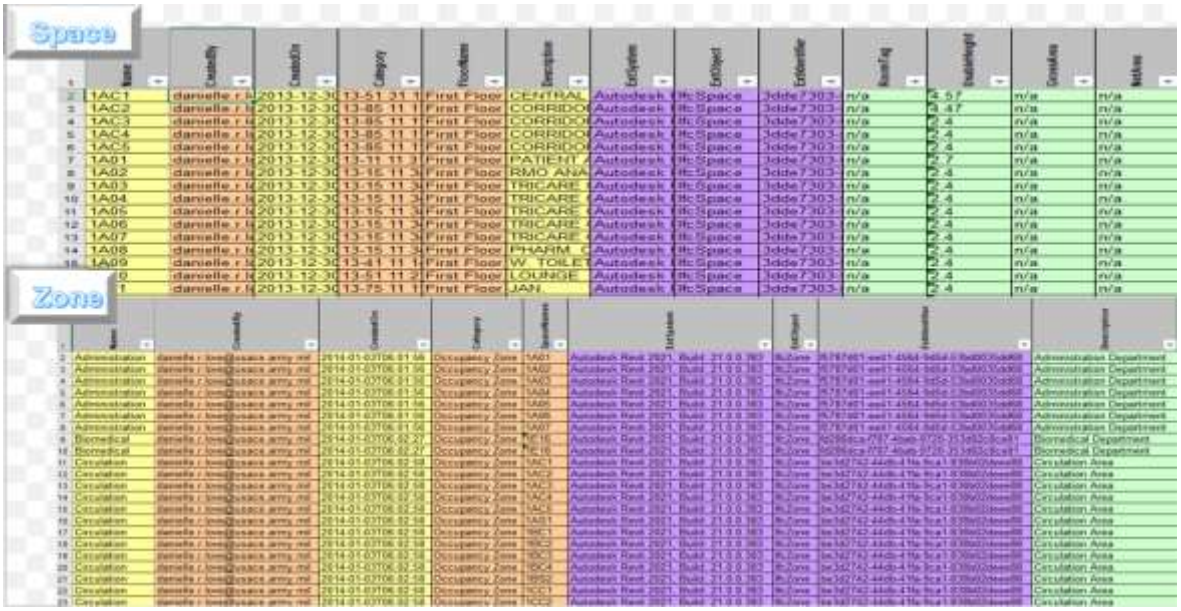

Figure 12: Space, zone sheet and their contents

5. Space:

It is an area sheet that details the basic information related to each space/room in the building.we note here that the floor name column is in Orange, it should be a reference for the row/floor of the floor worksheet. Used to assign the required maintenance to each space including unoccupied or uninhabitable spaces. Includes: space name, created by, created in (timed), category, floor name, description, external system, external object, external identifier, room tag, usable height, total area, Net area.

6. Zone:

The area sheet is completely green, which means that it is required only if requested by the owner, and they are groups of spaces that share specific features. Used to classify spaces and floors into specific areas based on common requirements/uses. Includes: partition name, created by, created in (timed), class, space name, external system, external object, external identifier, description.

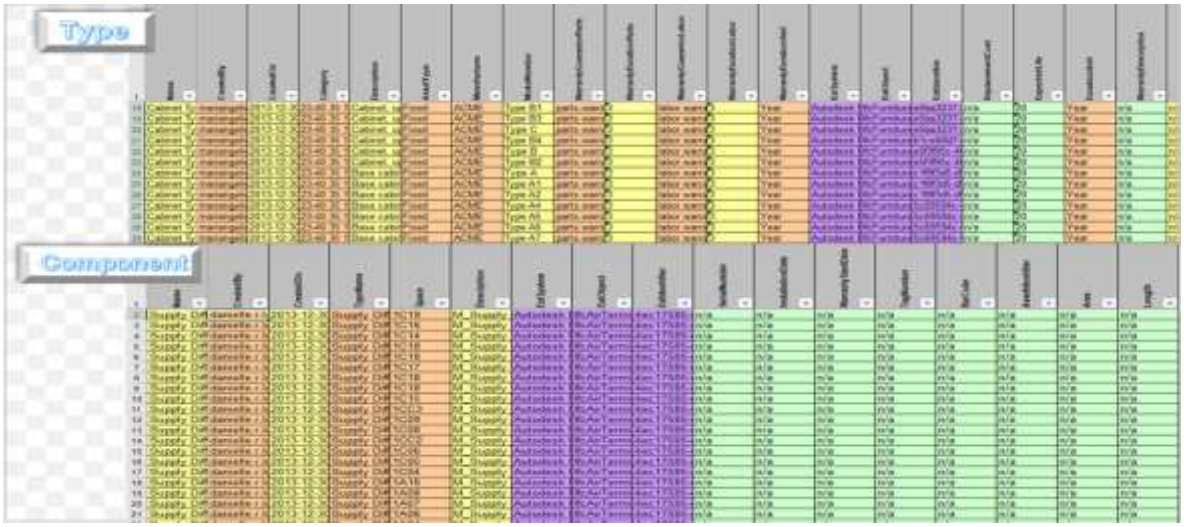

Figure 13: Type, Component sheet and their contents

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7. Type:

The type sheet contains information about a specific type of asset that will be applied to every single parameter of this asset such as manufacturer or warranty information and concerns the types of equipment, products and materials. They include: parameter name, created in, category, description, asset type, manufacturer, model number, warranty parts, warranty term parts, work warranty period, work warranty period, warranty period unit, external system, external object, external identifier, replacement cost, expected life period unit, warranty description, nominal length, nominal width, nominal height, model reference, shape, color, size, finish, grade, material, attributes, accessibility performance, code performance, sustainability performance, area, length.

8. Component:
The component sheet contains all the data related to the different assets in the project and detailed information about each part in the building including systems and equipment, and is used to determine the maintenance schedules of each part. They include: component name, created in (timed), category, description, name type, area, description, external system, external object, external identifier, secret number, installation date, warranty start date, tag number, Barcode asset ID, logic, length.

9. System:

The system sheet is a functional set of components that provide a service, as it contains the grouping of some individual assets from the component sheet according to the systems that make up this tab, such as the region tab, it may be formatted in this way with each component in its own row with the inclusion of each component in the component name cell. It also contains information about the various systems in the project, such as air conditioning, cooling, heating and electricity systems. Used for planning maintenance schedules. Includes: System name, created by, created in (timed), class, component names, external system, external object, external identifier, description.

- Note: There are /8/ papers whose color is black at the bottom (unused and not required) and they are entered manually. Their contents will be explained in general:

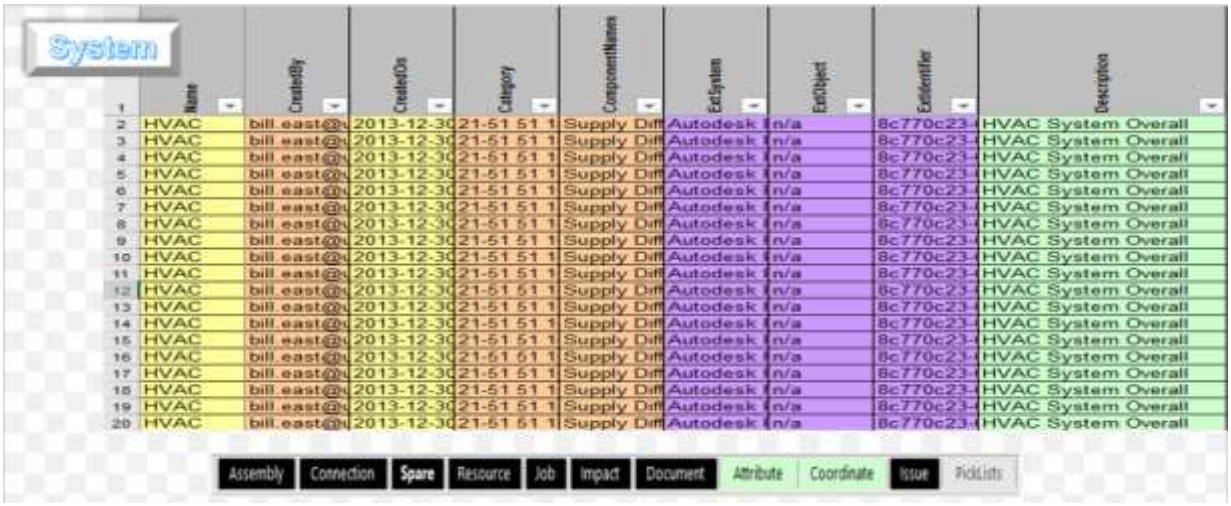

Figure 14: System sheet and their contents

10. Assembly:

The assembly sheet contains information about the different assemblies in the project such as the components that make up a single assembly. Includes: Assembly name, created by, created in (timed), sheet name, Assembly type, external system, external object, external identifier, description.

11. Connection:

A contact sheet is a named logical relationship between two components and contains information about the connection between the various components and the relationship of their interconnection in the project. Such as: connection name, created by, created in (timed), connection type, sheet name, row name1, row name2, port name1, port name2, external system, external object, external identifier, description.

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12. Spare:

The spare/spare parts sheet contains information about the spare parts available for the components in the project. Such as: segment name, created by, created in (timed), category, name type, suppliers, external system, external object, external identifier, description, group number, segment number.

13. Resource:

The resource sheet contains information about the resources available to the components of the project. Such as: labor, equipment, consumables. They include: resource name, created by, created in (timed), class, external system, external object, external identifier, description.

14. Job:

The worksheet/task contains information about the functions and tasks associated with the project, as well as information about the specific maintenance work to be performed, including expected dates and implementation status. They include: task name, created by, created in (timed), category, status, name type, description, duration, duration unit, Start, Task start unit, frequency, frequency unit, external system, external object, external identifier, description, task number, resource names.

Note: The Three Sheets (Spare, Resource, Job) are related to the operation and maintenance phase as shown in sheet Instruction.

15. Impact:

The impact sheet contains information about the potential impacts of events/ changes to the project such as economic (cost), environmental (carbon dioxide emissions) and social impacts at different stages of the project life cycle. Includes: Effect name, created by, created at (timed), effect type, effect stage, sheet name, row name, value, effect unit, timeout duration, external system, external object, external identifier, description.

16. Document:

The document sheet contains information in the form of a list of documents related to the project and all applicable documents. It also contains maintenance-related documents such as maintenance instructions, lists and reports. Include: document name, created by, created in (timed), category, approval by, stage, sheet name, class name, directory, file, external system, external object, external identifier, description, reference.

17. Issue:

The problem sheet may be a lack of information or risk and contains information about the problems/ defects in the building and inquiries related to the project, and is used to guide maintenance schedules to correct problems. They include: problem name, created by, created at (timing), category, type, risk, opportunity, impact, sheet name1, row name1, sheet name2, row name2, description, owner, problem mitigation method, external system, external object, external identifier.

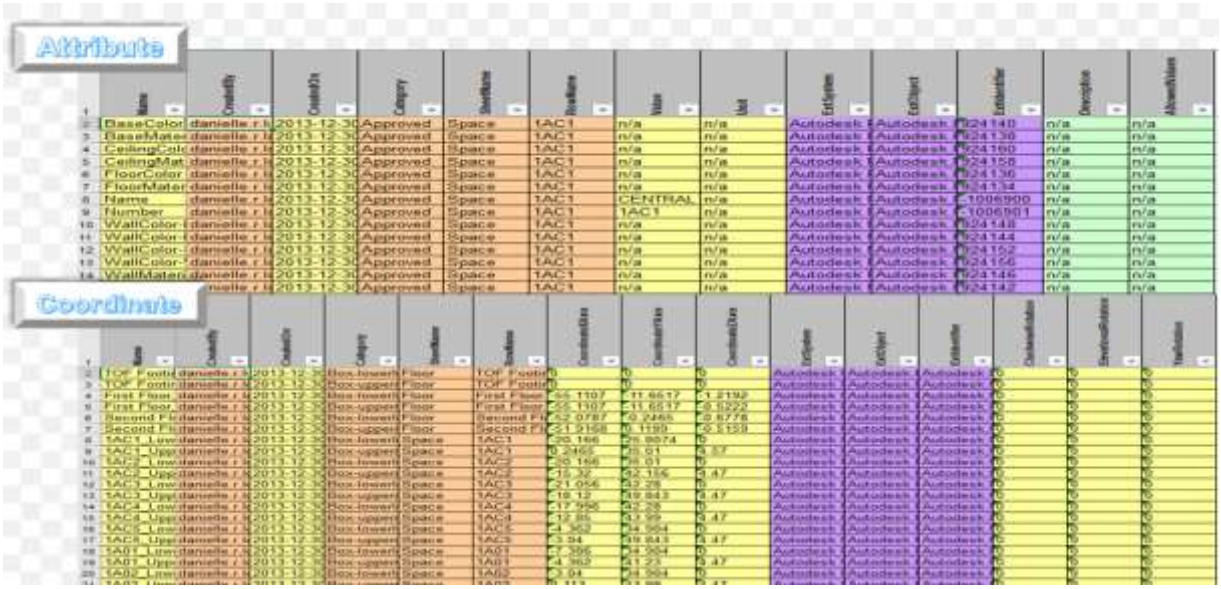

Figure 15: Attribute, Coordinate sheet and their contents

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18. Attribute:
The attribute sheet includes the indicated project properties and contains information about the various attributes that can be assigned to the components in the project, and also provides additional information related to maintenance and operation. Includes: attribute name, created by, created in (timed), class, sheet name, class name, value, external module system, external system, external object, external identifier, description, allowed values.

19. Coordinate:
The coordinates sheet contains information about the spatial coordinates of the components in the project, such as a reference system and triangular coordinates (length, width, height). Includes: coordinate name, created by, created in (timed), category, sheet name, row Name, co-ordinatexaxis, co-ordinateaxis, co-ordinatezaxis, external system, external object, external identifier, clockwise rotation, height rotation.

20. PickList:

The selection lists sheet contains the selection lists used in various aspects of the project. They include: Grouping type, category connection, category format, document category, Category item, facility category, floor category, impact category, problem category, task category, product category, Resource category, Role category, Space category, spare category, Category area, document approval by, impact stage, issue-opportunity, problem impact, problem risk, functional status, sheet name, sheet name-grouping, sheet name format, stage, type-asset type, units-area, units-currency, units-duration, impact units, linear units, volume units, object grouping, object attribute, object attribute type, object component, object connection, object contact, object coordinate, object document, facility Object, Object floor, object effect, object problem, object task, object project, object resources, object location, object space, object spare parts, object system, object type, object guarantee, object area.

Note: this paper contains a huge amount of information, as some of its columns occupy approximately /6899/ lines in the Category-Product column and/55/ column.

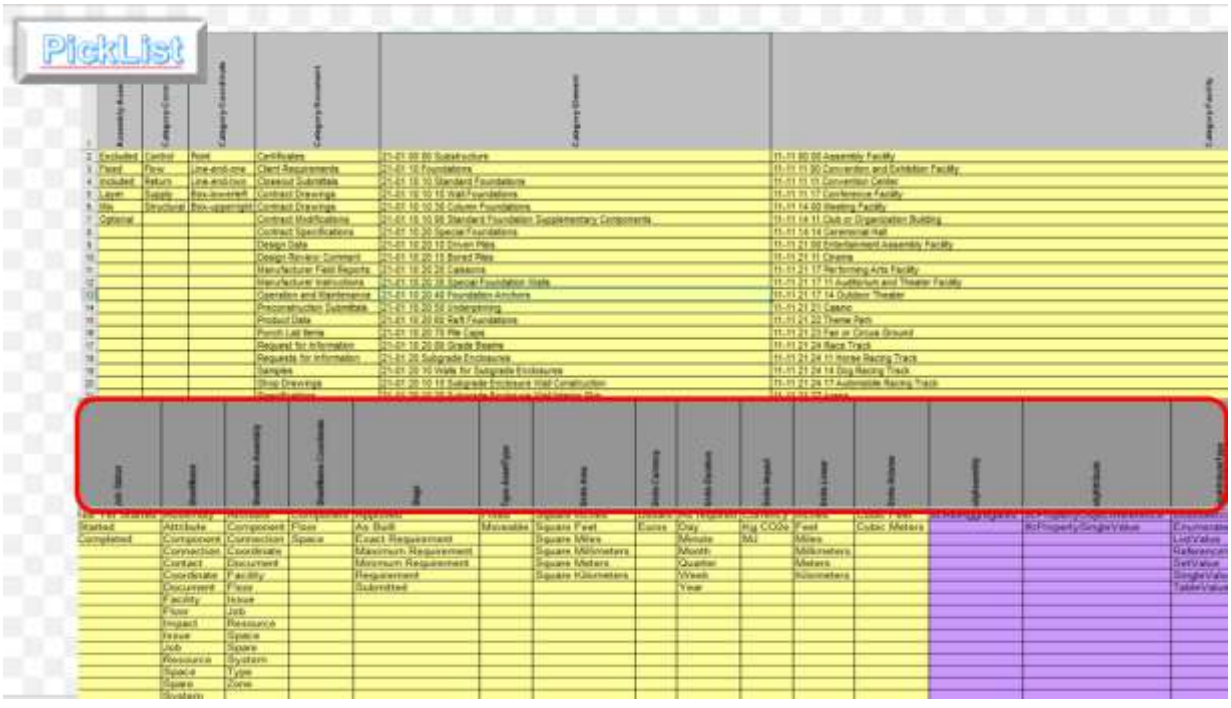

Figure 16: PickList sheet and their contents

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4.1. Application Example

To clarify, the researcher selected one of the maintenance elements, the fire Sprinkler, in this model by selecting/selecting it in the Revit program and then exporting its information to the Excel file, the results appeared as follows:

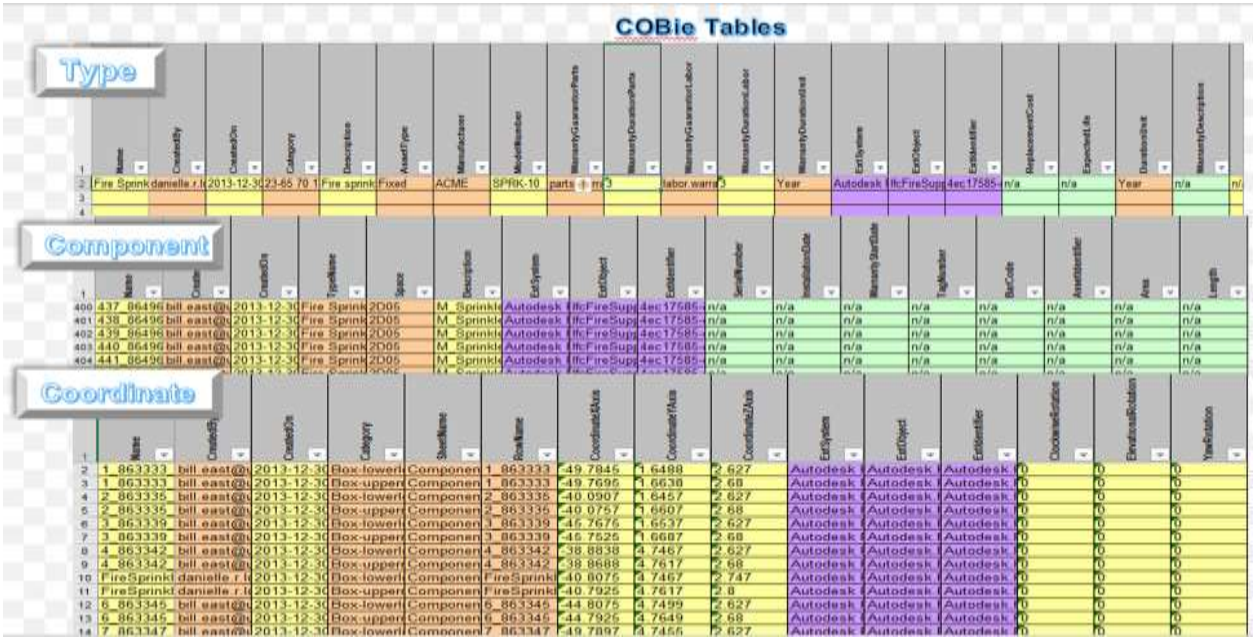

Figure 17: Type, Component, coordinate sheet and their contents

5.Results

These sheets contain information that varies depending on the information on the Model . In the sheet **Type:** item name/parameter, date of its creation, category, description, asset type, manufacturer, model number, warranty parts, warranty term parts, work warranty period, work warranty period, warranty period unit, external system, external object, external identifier, replacement cost, expected life period unit, warranty description, nominal length, nominal width, nominal height, model reference, shape, color, size, finish, grade, material, attributes, accessibility performance, code performance, sustainability performance, area, length.
And in the sheet **Component:** component name, created in (timing), category, description, type name, area, description, external system, external object, external identifier, secret number, installation date, warranty start date, tag number, Barcode asset ID, logic, length.
And in the sheet **coordinate**: created by, created in (timing), category, sheet name, row Name, co-ordinatexaxis, co-ordinateexaxis, co-ordinatezaxis, external system, external object, external identifier, clockwise rotation, height rotation.
This research concludes that it is easy to access maintenance data and be able to manage it, operate the building efficiently and with high quality, and maintain facilities and facilities thanks to the application of BIM technology and its tools, which in turn saves a lot of effort, time and significant cost in maintenance work. Based on the results obtained at the end of this research, the importance of using this tool was concluded because of its great benefits:

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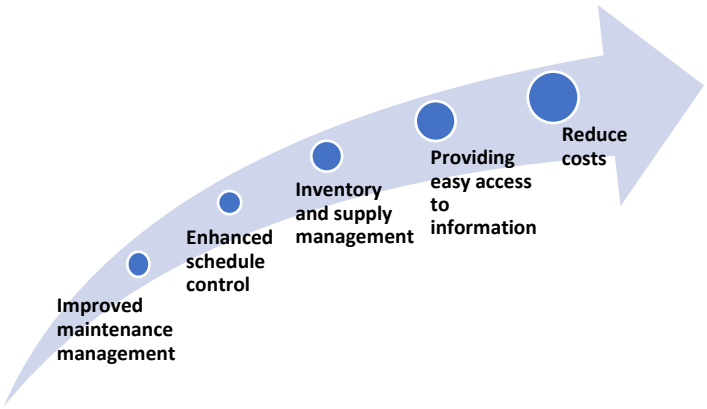

Figure 18: The most important benefits of interoperability tools

7. Recommendations

- ✓ Due to the benefits revealed, it is recommended to study the adoption of BIM in facilities management in large and complex projects and learn about more BIM tools in Revit and other BIM programs for future study and expansion in order to better understand and improve the efficiency of building operation.
- ✓ Raising awareness of Facilities Management in educational institutions through lectures and seminars and encouraging institutions to activate their roles and applications in the life cycle of existing buildings. "Adopting the digital transformation of practical decisions and linking new technologies according to BIM with the reality of engineering work". [29]
- ✓ Increased awareness of the concept of BIM, its integration with facilities management, and the capabilities offered by Revit. According to the applied study, "In the field of operations, there is a need for a better understanding of delivery methods." [30]
- ✓ Finding effective plans to increase owners ' confidence in BIM investment through more applied research and providing encouraging results in terms of efficiency, saving time, cost, effort, information security and extending the life span of facilities and facilities.
- ✓ Developing strategic plans to activate the role of digitization at all stages of construction and the gradual transition towards the adoption of the BIM model, providing materials, government, trade union and all necessary facilities to advance engineering work. [31]
- ✓ "It is necessary to raise the awareness of institutions and companies in Syria about the importance of BIM, through conferences, seminars, and practical examples of countries that have applied this technology." [32]

8. Conclusion

"Information plays an important role in the management of construction projects." [26]. Information is the key that plays an important role in the management of facilities through BIM, information is handled with full efficiency. This study pointed out the benefits of the BIM application in facilities management: improved planning and organization of maintenance and facilities management operations, providing quick and easy access to information, reducing errors and conflicts and improving the accuracy of data and information, providing detailed information on previous maintenance and maintenance dates, improving asset traceability and facilities lifecycle management, enabling informed decision-making, improving collaboration and communication between different work teams, and finally improving resource efficiency and achieving cost savings. The idea of using interoperability tools and the COBie standard was also highlighted, which is considered one of the main uses of COBie data necessary for effective facility management and maintenance, which provides many benefits, including: simplifying the operational process of the facility, improving data tracking and documentation, improving customer satisfaction, standardizing codes and the way information is presented at the level of companies and organizations.

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Finally, the most important obstacle facing facilities management that the research found is the difficulty of accessing information that serves facilities management and how to deal with it. "The information in the BIM model is often missing or is added only at later stages of the project"[27]. The second concerns the lack of awareness and experience in FM-BIM applications and the lack of the possibility of high analytical ability to deal with BIM technology and its data,"the most important recommendations indicate the need to enhance awareness of BIM culture and its applications"[28]. With the owner's noted concerns about data privacy, cybersecurity considerations and all the limitations of BIM's adoption of the FM stage. Therefore, it is proposed to provide appropriate training for BIM employees, encourage adoption, support from senior management, performance evaluation and continuous improvement of the application BIM.

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