JIMMA UNIVERSITY
JIMMA INSTITUTE OF TECHNOLOGY
SCHOOL OF GRADUATE STUDIES
FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING
CONSTRUCTION ENGINEERING AND MANAGEMENT CHAIR

A COMPARATIVE ASSESSMENT OF FACILITY MANAGEMENT USING CONVENTIONAL AND BUILDING INFORMATION MODELING APPROACH; THE CASE OF ADDIS ABABA UNIVERSITY SCHOOL OF COMMERCE

A Thesis Submitted to the School of Graduate Studies, Jimma University, Jimma Institute of Technology, Faculty of Civil and Environmental Engineering in Partial Fulfillment of the Requirements for the Degree Master of Science in Construction Engineering and Management

by

Kidist Mamo Desta

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Jimma, Ethiopia

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DECLARATION

I declare that the research entitled "A COMPARATIVE ASSESSMENT OF FACILITY MANAGEMENT USING CONVENTIONAL AND BUILDING INFORMATION MODELING APPROACH (IN THE CASE OF ADDIS ABABA UNIVERSITY SCHOOL OF COMMERCE)" is my original work, and has not been submitted as a requirement for the award of any degree in Jimma university or anywhere else.

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As research Advisor, I hereby certify that I have read and evaluated this thesis paper prepared under my guidance, by Kidist Mamo Desta entitled "A COMPARATIVE ASSESSMENT OF FACILITY MANAGEMENT USING CONVENTIONAL AND BUILDING INFORMATION MODELING APPROACH (IN THE CASE OF ADDIS ABABA UNIVERSITY SCHOOL OF COMMERCE" and recommend and would be accepted as a fulfilling requirement for the Degree Master of Science in Construction Engineering and Management.

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ABSTRACT

Facility management usually is complicated work needs that necessitate multidisciplinary activities and a large amount of data. While some of these requirements are met by some existing system building information modeling. Building information modeling is a method of digitally representing a building's functional and physical qualities and a holistic approach to designing, constructing, operating, and maintaining a building project as a collaborative process utilizing a single coherent digital modeling system.

The objective of this research is to realize the benefits of Building information modeling in facility management by comparing conventional and Building information modeling approaches to facility management. facility management is typically a demanding and time-consuming job to assess, visualize struck, and document the facility's management operations, facility staffs typically use a paper or information system.

This research is based on a comparison of conventional facility management with Building information modeling-based facility management approaches in the case of Addis Ababa University school of commerce. The study uses comparative research designs and both qualitative and quantitative data to explain and examine the findings to arrive at conclusions and recommendations. The descriptive type is used to describe the current Addis Ababa University School of commerce facility management approach and the research has been conducted Building information modeling sample model for the Addis Ababa University School of commerce to illustrate the building information modeling facility management approach.

In the conventional facility management approach, the university facility management staff uses a corrective maintenance strategy and inspects the facility once a year, but they cannot predict the condition of the facility's elements, and the facility management unit lacks a database for facilities management purposes, as well as enough information recorded with different facility element histories such as maintenance history, warranty, replacement cost, lifetime, manufacturer information, job-related to the element, and so on. they also don't have any general building operation and maintenance guides that are specific to sustainability and energy, they don't use any information management system for the facility, and they don't analyze the facility's entire life cycle cost, space, energy efficiency, carbon or anything like that; instead, maintenance is done based on the occurrence of a defect. Whereas the Building information modeling facility management approach uses a preventive maintenance strategy. There is an information management system, database with relevant and important data on the facility element, space management, visualization techniques, energy analysis, LCC analysis, and carbon analysis as well as that can predict the condition of each facility element.

In principle, the BIM FM strategy enables facility managers to make informed decisions regarding all FM operations throughout the lifecycle of the building. As a whole, the building information modeling Approach improves facility management more than the conventional facility management method.

Keywords: - Facility management, Building information management facility management approach, conventional facility management approach.

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ABBREVIATION

2D; 2 DIMENSION

3D; 3 Dimension

AAU; Addis Ababa University

BIM; Building Information Modeling

CAD; computer-aided design

CAFM; Computer-Aided Facility Management

CMMS; Computerized Maintenance Management Software

CO2; Carbon Dioxide

COBie; Construction Operations Building Information Exchange

FCI; Facility Condition Index

FM; facility management

HVAC; Heating, Ventilation, and Air Conditioning

ICT; Information and Communications Technology

IFC; Industry Foundation Classes

ISO; International Organization for Standardization

IWMS; Integrated Workplace Management Systems

KPIs; key performance indicator

Kwh; kilowatt-hour

LCCA; Lifecycle cost analysis

MDI; Mission Dependency Index

NWD; is a computer-aided design (CAD) file developed by Navisworks

O&M; Operation and maintenance

RFID; Radio frequency identification

SPSS; Statistical Package for the Social Sciences

SUI; Space Utilization Index

USD; United States dollar

AAUSC: Addis Ababa university school of commerce

O&M; Operation and Maintenace

LEED; Leadership in Energy and Environmental Design

BREEAM ; Building Research Establishment Environmental Assessment Method

AEC Architectural, Engineering and Construction)

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

The construction sector, which is the second most important sector in the Ethiopian economy in terms of workforce and 20 percent of the GDP in 2019, is crucial in ensuring the successful transformation of the economy. The construction industry makes significant contributions to the socio-economic development process of a country. Its importance emanates largely from the direct and indirect impact it has on all economic activities. It contributes to the national output and stimulates the growth of other sectors through a complex system of linkages. It is noted that about one-tenth of the global economy is dedicated to constructing and operating homes and offices (EEA, 2008)

Consultant firms, being the key stakeholders of the construction design industry, are the primary agents for meeting the design demands made upon the industry. These firms in general, are project-based organizations that are mainly devoted to the production of design and supervising projects. This output of design passes through sequential processes and needs to be managed and controlled. The discipline called design management plays a significant role in handling these processes (Colin Gray & Will , 2001). The facility management, most of the time ignored by consultant firms, and they would not design within facility management concern and they only focus on the design of the construction stage.

Recent studies imply that BIM applications have a great influence on facility management. BIM is a technology, and not a specific program, that offers an integrated platform to improve design, increase the speed of delivery for design and construction, and provide a flow of information without breaks. The use of BIM goes beyond the planning and design phase of the project, being extended throughout the building life cycle, of several infrastructures. The AEC (Architectural, Engineering and Construction) industry is adapting to increased demands for the use of BIM during the design and construction phase of construction projects. Building owners, private and public are increasingly requiring that BIM is used on their projects as the method has proven to have a positive impact on the construction process in many aspects e.g., clash detection, better visualization, facility management, energy.

BIM has transformed architecture, engineering,and construction. However,the great potential of BIM is to provide accurate, timely,and relevant information not just during the design and construction of a single building, but also throughout the lifecycle of an entire portfolio of facilities. The use of BIM technology in the operational phase of a building's lifecycle is just beginning to take hold as building owners look for new ways to improve the effectiveness of their facility operations.

In the year 2010, ECPMI brings the training of trainers to 20 professionals, including ECPMI professionals and other skilled professionals from government office and now ECPMI brings the training 8th round for the industry stakeholders. This may be the beginning of BIM in our country officially nowadays here and there BIM is beginning in private companies which is a good opportunity for BIM implementation in Ethiopia and also it shows there is a driving force in the construction industry. However, the industry's use of BIM is still in its infancy.

1. 2 Problem statement

In our nation, the building of universities is expanding, and once they are complete, facility management is needed. The potential for savings is even greater than in the asset delivery phase because the operation phase (facilities management and maintenance) often has a much higher cost than the construction phase. Additionally, managing facilities is frequently a tough and time-consuming job. As a result, the owner has been forced to pay a high price and has been ineffective, inefficient, and lacking in sustainable practices. Facility staff members often use a paper or information system to evaluate, visualize, track, and document the facility's management operations. When executing facility maintenance, however, facility staff could find it challenging to relate to typical 2D CAD-based information graphics. And also FM staff responsible for the management and maintenance of a facility needs accurate information to make decisions and take action. The performance of the facility management team is significantly influenced by the information's accessibility. Despite the usage of BIM during the design and construction stages, the majority of this information is generated during the planning, design, and building stages of the facility and is typically given at the end of the construction using primarily paper-based methodologies. Although BIM is now being used, it is still not clear how to use it correctly. The questions of what data should be supplied through the model and how to deliver it should be addressed. In order to successfully integrate BIM facilities, interoperability difficulties must be resolved. Therefore, in order to enhance facility management practices by utilizing the BIM approach, it is crucial to research and pinpoint issues with building facility management practices.

1.3 Research questions:

- In a traditional manner, how does building facility management work at a selected building?
- What exactly is a BIM-based facility management system and how does it function?
- Is BIM-based FM management enhanced than conventional facility management?

1.4 Study Objectives

1.4.1 General objectives

The objective of this article is to compare facility management using traditional and building information modeling approaches to determine the benefits of BIM in FM.

1.4.2 Specific objectives

Specific objectives of this study are

- To evaluate the traditional facility management approach.
- To evaluate the building information modeling facility management approach.
- To compare traditional and BIM-based facility management approaches and to realize the benefits of BIM-based facility management.

1.5 Scope and Limitation of the study

1.5.1 Scope of the study

The scope of this thesis is to compare traditional and BIM-based facility management systems in terms of facility management practice on Addis Ababa University's school of commerce campus, with a focus on the building's physical structure management and the hard facility management services.

1.5.2 Limitation of the study

The limitation encountered in this study are as follows:-

The Addis Ababa University School of Commerce facility management unit members who were chosen for the study were intended to interview staff, however the majority of the university's faculty management staff were unaware of the study's objectives and were unable to respond to the study's inquiries. the difficulties in obtaining a paid version of BIM technology software as well as the lack of freely access to BIM technology software that may be utilized to compare BIM technology.

1.6 Significance of the study

Many studies examine the need to enhance BIM's technical and operational performance because it is marketed as the ideal tool for fostering collaboration in the construction sector. This study is important because it recognizes the technical and operational benefits of the BIM FM approach in the construction sector by using components or indicators of construction and operation performance. In order to gain a more comprehensive knowledge of how BIM improves construction and operational facilities lifecycle performance. This study uses data and information from both the traditional FM approach practices and the BIM FM method. The goal of this study's methodology is to offer meaningful data and findings that universities and other organizations of various sizes and scales may take to improve their own facility management's effectiveness, efficiency, sustainability, and cost-effectiveness. These findings could help universities manage facilities more effectively and efficiently.

CHAPTER TWO

LITERATURE REVIEW

2.1 Facility management

Let's start by defining the term "facility." While many people associate the term "facility" with industrial buildings and factories, it can simply be described as "a place where something is done." Schools, hotels, hospitals, offices, and other spaces are examples of facilities.

We will now talk about facilities operations. There are numerous definitions available, including the ones below:

- From the International Facility Management Association (IFMA)**:** "A profession that encompasses multiple disciplines to ensure functionality, comfort, safety, and efficiency of the built environment by integrating people, place, process, and technology."
- From the International Standards Organization (ISO)**: "**An organizational function which integrates people, place, and process within the built environment to improve the quality of life of people and the productivity of the core business."

These definitions are right, but they are a little technical. Facility management (FM) is described in this article as the arrangement of physical workplaces (facilities), people, and support resources to support a company's objectives most cost-effectively.

Why Facility Management is Important

Simply stated, facility management brings value to a company by meeting a variety of short- and long-term requirements. Facility management practices, when performed correctly, minimize maintenance costs, ensure employee safety, and shield the company from liability. Continuity planning aids organizations in preparing for development and developing emergency plans. Finally, facility management helps the company concentrate on its core mission and priorities by creating a positive atmosphere.

Components of facility management

The components of facility management are generally divided into two categories: hard services and soft services, which are discussed in the sections below. Remember that facilities management encompasses a wide variety of roles and events. Each organization's mix of responsibilities is special, and not everyone performs every role.

Hard facilities management systems are related to the building's physical structure and cannot be removed. They have a direct impact on the safety and well-being of workers and are thus mandated by statute. In other words, hard FM services are required; they are non-negotiable. Hard FM services include**:**

- Gas, plumbing, and heating.
- HVAC systems.
- Lighting, electrical, and mechanical.
- Fire safety systems.
- Building maintenance work.

Soft facilities management services, on the other hand, are not mandated by law and can be added or removed as needed. Soft FM facilities are typically used to make a building more convenient and comfortable for its inhabitants.

The following are examples of soft FM services: **Soft facilities services**

- Building security.
- Cleaning.
- Landscaping.
- Office decorating.
- Catering.
- Office moves.

Building Facility Management

According to Barret and Baldry (2003), building facility management is a management system used to operate and maintain the buildings of an institution to create an environment that strongly supports the primary objectives of that institution.

The Aim of Building Facility Management

The general goal of building facility management is to ensure the provision of attractive buildings, with properly functioning components and systems, that are properly operated, and maintained and that provide surroundings and conditions conducive to quality instruction and learning. To fulfill the general goal of the facility management unit (Atkin and Brooks, 2009):

- Identify and correct facility deficiencies and needs through periodic review of existing systems and system components,
- Maintain buildings at a level that ensures facilities that are aesthetically pleasing, clean, sanitary, and safe
- Manage facilities in a manner that minimizes usage conflicts, overcrowding, and retrofit costs.
- Ensure the availability of sufficient funding and other resources to support projected facility maintenance requirements

2.2 Conventional Approach to facility management

The history of a facility includes specific information gathered during the development and operation of the facility in the form of drawings, manuals, repairs, renovations, and alterations. Different employees are involved in the planning, construction, and operation stages of a typical facility's life cycle. Because diverse employees are engaged in the design, building, and operation stages of a typical facility's life cycle, the quality of documentation at each stage has an impact on the facility's performance and management. Repairs, shutdowns, and other maintenance and operations activities can all be planned with the use of facilities documentation. The facilities manager's in-house tool for managing day-to-day operations, planning, budgeting, and objective management decisions is the facilities operation documentation (Clayton, 1996). In many developing nations, higher education institutions evolve from temporary to permanent locations, from improvised to standard constructions, and through the process of purchase and merger, each institution has facilities of varying ages with insufficient records of as-built information. Poor archiving mechanisms, documentation, and information transfer during the transition from one administration or system to another have exacerbated the matter. Creating an authentic facility's history should begin at the development phase and continue throughout the facility's life.

Every operator in each phase of the facility is required to properly document the facility's operations for future reference. The Chicago District Guideline defines as-built drawings as "...an official record of the project at the time of construction completion," which begins the documentation of facilities history. All additions, deletions, and other changes made during construction are shown on the original "as intended" contract drawings and specifications. Accurate as-built drawings are critical for project operation and maintenance, as well as future alterations, especially for hidden plumbing and electrical systems. (Chicago District Guideline, 2014). In practice, any change made during construction has a cascading effect on other parts or service providers.

As a result, information about the intention to change or modifications made should be conveyed in a timely manner so that all parties involved can make the necessary adjustments, and an updated drawing should be generated to direct the contractor accordingly. The final as-built documents made available at commissioning will be authentic and useful for the creation of the facilities' operation documents if these procedures are strictly followed. It is possible to create a near-exact record using either manual or digital approaches in existing buildings or facilities that lack authentic as-built information (Erdener, 2001). It was historically uncommon to commit significant resources to life-cycle operation and maintenance (O&M) problems during the facility design/build phases. However, it is now widely accepted that the most expensive part of owning and operating a building asset is its operations and maintenance. Well-developed, user-friendly O&M manuals are becoming increasingly vital in terms of correctness, usefulness, and timeliness. As a result, thorough, facility-specific O&M manuals are becoming more prevalent before commissioning. The goal is to support the facility's life cycle effectively and efficiently by eliminating unplanned shutdowns and reaping life-cycle cost reductions. (2011, Whole Building Design Guide). System-level O&M information:

- Physical Descriptions
- Functional Descriptions
- Troubleshooting
- Preventive Maintenance (Procedures and Schedules)
- Corrective Maintenance (Repair Requirements)
- Operation-/Maintenance-Significant Drawings
- Equipment-specific O&M information, organized into a vendor/manufacturer data library

Conventional models of CAD are inadequate for efficient maintenance management. Difficulties in the process of transporting documents, tracking, controlling, updating, storing, and identifying the equipment in case of equipment failure and/or exhaustion, quick response to the maintenance activities, and FM (on-site and remote) are critical problems attributed to each of these methods.

When a maintenance operation is required, the typical maintenance strategy focuses on repairing and replacing components. Even though CAD drawings provide basic information, they cannot be easily linked to building amenities for utilization (Su et al. 2011). Current procedures for as-built verification and update entail a lot of time-consuming on-site surveys (Simões, 2013). Another tool for a maintenance company is the maintenance manual, which serves as an information resource (Mendez, 2006). Manual attempts and inspections on paper, on the other hand, are unreliable, ineffective, and time-consuming. According to (Liu et al, 2016). limited access to reliable information on time, a lack of an integrated perspective of different areas for decision support, and a distorted knowledge of lifecycle difficulties are all important causes of productivity hurdles in obtaining equipment specifications. In this approach, more than half of a typical facility's maintenance resources and operations are considered reactive maintenance (Costin et al. 2014). However, such maintenance methods remain the most common technique of delivering inspections around the world.

By changing the perspectives on the maintenance from corrective in the 20th century to preventive in the 21st century, information technology (IT) activities in this area expanded (Hao et al. 2010). In 2017, Rumane stated that the following procedures should be considered in creating an effective O&M program:

1. Ensure that up-to-date operational manuals are available;

2. Obtain up-to-date documentation on all building systems;

3. Implement preventive maintenance programs;

4. Create a well-trained maintenance staff; and

5. Implement a monitoring program that tracks and documents the building system's performance.

In summary, the literature review of this part provides clear evidence that traditional and paper-based inspections potentially result in inefficient maintenance actions. The use of reliable information management infrastructure can significantly improve FM processes.

2.3 BIM Approach to facility management

BIM is a digital representation of a building's functional and physical characteristics. BIM is a collaborative process that involves planning, constructing, running, and maintaining a building project using a single integrated digital modeling system. BIM enables enhanced design visualization, including digital simulations and rehearsals of all stages of the process: design, construction, and operation. As a result of the introduction of BIM, the AEC industry has undergone a paradigm change. Many firms are using it to help them shift to new ways of planning, building, and providing Facility Management services. BIM allows construction professionals to collaborate more effectively by allowing them to organize and access information digitally at any time.

Facility management begins once the building has been finished and handed over. It is a continuous procedure that takes place throughout the life of the building. The most important goal is to make sure the asset and its content are well-managed (equipment, spaces, furnishings, etc.). Because it involves all duties such as business administration, asset management, maintenance, contract management, repair, and refurbishing, facility management is essential for the building to function.

Facility management includes identifying, tracking, controlling, and managing facilities as well as the problems they cause. Furthermore, facility maintenance data must be updated regularly, putting workers who rely on paper and 2D drawings under more strain. A BIM-based facilities management and maintenance system is being developed to address these concerns.

BIM for FM The research in the area of BIM for FM has increased rapidly in the last few years. A recent literature review by Forns-Samso et al (Forns-Samso, 2015) summarizes the potential BIM uses in different functions of facilities management. The area with a stronger focus is in supporting maintenance activities in building operations. Such potential uses include visualization and location of building components with access to real time information concerning attribute data and historical maintenance information. It also facilitates the scheduling of maintenance tasks and the ability to virtually develop a maintenance program without the need of making a site visit. However, all of such uses depend on the accuracy, consistency, and reliability of the data.

The second category that receives more attention is information management. Information management is concerned with enhancing data management across the lifespan, handover information, and the operational phase's as-built/as-maintained approach. Articles in this category look into interoperability, data management methods, and information exchange standards including COBie and IFC. The goal of this study topic is to develop a lifecycle information management approach that captures data from the beginning of a project to its completion. The methods and roles for data capture and data maintenance during the building's lifetime are major challenges with this approach. With a heavy focus on product lifecycle management, supportive principles from industries such as manufacturing, automobiles, and shipping are applied (PLM). In addition, the literature considers emerging requirements for the capture of Building Performance Attribute Data.

The application of BIM for building performance is the third category, which is primarily concerned with tracking and monitoring energy usage, thermal performance, and component performance. Building performance can be measured, according to the literature, by integrating other systems like requirements management, energy simulation tools, and building automation systems. The fourth category is asset management, which is closely tied to maintenance tasks but more closely related to tactical decisions such as determining component service life, maintenance schedules, historical data, and equipment failure and replacement estimates. Australia and the United Kingdom appear to have more publications in the asset management field. The fifth area is space management which is concerned with activities related to real estate functions and cost. Publication numbers in this area are the lowest but it could be because already sophisticated systems such as Computer-Aided Facility Management (CAFM) or Integrated Workplace Management Systems (IWMS) have been widely used in the area of space management and BIM has not found a distinctive application from what already exists. As described BIM for FM has many potential applications.

However, there are only a few studies that show potential uses of BIM for FM and did not found comparative research with the traditional one. With that premise, the current study gives a perspective how BIM can be enhancing FM.

Radiofrequency identification (RFID)

Conventional CAD models are insufficient for effective maintenance management. Difficulties with document transit, tracking, controlling, updating, storing, and identifying equipment in the event of failure and/or exhaustion, timely reaction to maintenance activities, and FM (on-site and remote) are all major issues with each of these approaches.

Radiofrequency identification (RFID) could be an appropriate application technology for managing facility data. It can help with maintenance management by allowing for the quick tracking and retrieval of critical information in the facility without having to carry documents (Shen and Lu 2012). Given the significant investment in constructing facilities, it is critical to have a maintenance system that accurately handles the issues that arise during facility maintenance. (2019, Mohsen Kamelia)

RFID-assisted maintenance management

The findings reveal that despite the numerous benefits of BIM, the staff's ability to efficiently manage maintenance is weakened when information is not instantly available for real-time operation near building facilities. In this regard, Lin et al. (2014) developed a new and practical methodology with application to FM that used an integrated 2D barcode and a BIM approach. RFID is rather similar to bar coding, but removes the human component of physically scanning each barcode. On the other hand, the function of barcode systems is limited due to line-of-sight, durability, and read-range constraints, while passive ultrahigh RFID provides greater read-ranges and works under rugged outdoor and indoor conditions such as temperatures from −40 °C to 200 °C, extreme moisture, and pressure (Vogt and Teizer 2007). Hence, RFID-based systems have so far been used in different applications in construction and maintenance such as component tracking and locating, inventory management, equipment monitoring, progress management, maintenance management, tool tracking, material management, and quality control (Mohsen Kamelia, 2013)

2.3.1 The Benefits of Using BIM for FM

Many researchers, book authors, and even facilities managers have proposed using the data in the building information model to assist with building and operations administration. Advantages for owners and managers are apparent according to (Kensek, 14 August 2015) BIM approach FM can manage space the model can help quickly populate the FM database saving labor time and money, and assets can be effectively managed; the model can be used for building performance simulations and commissioning; operation simulation tools may be able to use data from the model, and as-built information can later be used for retrofits. The model can provide data needed for FM that is useful for maintenance and repair, management of energy, and the commissioning of the building especially if the concerns of FM are articulated at the early stages of design. Other benefits include better visualization of system components, ease of modification, the ability to filter data for staff use, and the advantages of having one coordinated system with integrated BIM and FM. Both authors also described novel uses of the model to assist in planning routes, the former for path optimization for maintenance crews and the latter for smart emergency evacuation. (Kensek, 14 August 2015)

The importance of space planning, accurate quantification of assets such as furniture and equipment, and interoperability incompatibilities between software programs. Accurate space management, efficient population of the FM database, and using BIM data for preventative maintenance are three common reasons for BIM to integrate better with FM; to achieve these owners need to develop BIM guidelines and insist on a record BIM for new construction and retrofits.

2.3.2 Space Management

Spatial BIM has as its primary focus the managing of space rather than building elements or inventory. Space is itself a valuable and manageable asset. It has intrinsic value after the building is completed and is treated as a major tangible asset. It can be rented or re-assigned to other people and is often the key locator for other items like equipment, furniture, voice and data lines, lighting fixtures, people, etc. Detailed knowledge of its size, location, use, and contents is important. This information is relatively easy to insert into a building information model (either typed indirectly or through spreadsheets), can be accessed through schedules within the software, and exported in a commonly used file format for FM use. Owners set requirements based on their needs, and architects provide further insights for the architectural program. The listing of spaces and their attributes should be thorough, systematic, and tailored to the needs of the client and occupants of the building. FM should provide input also as to detailed requirements that can be incorporated into BIM guidelines (Kensek, 14 August 2015)

3.3.3 Using a Building Information Model to populate the Asset Database

The building information model can be used for the efficient population of the FM database and managing assets. A post-processed 3D model can provide spatial data. Equipment (with detailed specifications) can be saved in a spreadsheet format or linked to a 3D model within a FM system. Data fields for each piece of equipment are searchable and modifiable in a CMMS (computerized maintenance management software) system. (Kensek, 14 August 2015)

3.3.4 Preventative Maintenance and Retrofits with BIM Data

Repair and preventive maintenance require a database of what exists and when equipment ought to be fixed, upgraded, or replaced. This is exactly what an accurate and information FM database is. For example, an energy upgrade to a building might entail replacing low efficiency bulbs with LEDs; the location of the bulbs, characteristics of the fixture, and links to manufacturer sites can be in the model. “That said, maintaining a BIM file with regard to facility management information is very similar to maintaining the actual facility. As the components are replaced, repaired, or removed, those changes will need to be reflected in the BIM file”. Of course, the 3D model itself is useful for remodeling, additions, and changes to the building. An accurate as-built model is necessary for FM's future use.

For other clients with numerous buildings in their portfolios, many of them may need to be inspected and evaluated to establish a priority list and timetable for upgrades. In a unique application of spatial BIM used for retrofit planning, the U.S. Coast Guard and U.S. General Services Administration created three indices for upper management to better understand the spatial status of their holdings: Facility Condition Index (FCI), Mission Dependency Index (MDI), and Space Utilization Index (SUI) [6]. Two key attributes (condition and mission criticality) were color-coded (red, yellow, or green). A red/red status indicated a space/building that should be prioritized to be upgraded first; this would be readily apparent to managers examining their building portfolio.

3.3.5 Model for Recording Building Information

Owners should ask for a record building information model, and the FM BIM guidelines partially determine what it should contain. It should be a combination of the best attributes of both the traditional as-built drawings and record drawings, and the record been should be fully populated with data that would make it useful for the continuing operations and maintenance of their building. It should contain a virtual description of the building and associated data: 3D model, 2D drawings, assets (e.g., furniture, furnishings, and equipment), maintenance manuals, specifications, and other information that is usually requested at closeout. “The intent is to include all information that is submitted at closeout linked to a fully functional BIM and highly organized for seamless immediate and future reuse” . Other information can also be included such as training videos or post-processed 3D models (e.g., subsets of models for the energy management system or simplified models for campus maps). However, owners should realize that this is extra work, and additional charges are needed to cover this. (Kensek, 14 August 2015)

BIM guidelines dictate details of what should be in the record-building information model. This BIM data can be used for space management, populating the FM database, anticipating maintenance needs, and providing background information for remodels and retrofits—all pressing needs for the operation of a facility.

2.3.6 IFC and COBie

Spreadsheets are a good way to move data (text and numbers) between software packages because of their inherent simplicity. The information is frequently organized using modified versions of the COBie standard. COBie is a non-proprietary platform allowing facility managers to exchange life cycle data. As new data becomes available, the COBie technique is designed to encourage or demand that it be directly integrated into the building information model or else linked to it.

BIM using IFC data structures contributes to FM as an information source and as a repository to support planning and BM management (Volk, et al., 2014). The IFC standards (which define a collection of open neutral data formats for open BIM that can be shared by other software systems) would help with BIM model interoperability. The IFC data model, which is based on ISO 10303-21 (2002), provides a framework for exporting geometry and material characteristics data from BIM-based applications to a standard format.

2.3.7 Collaborative Processes

This is a significant change in the workflow method of adding data to a 3D model because it will be done during the design and construction phases and inserted directly into Revit models using Google Docs. For operations and maintenance employees, more common parameter features provide more refined data. Design and construction specialists will now be able to communicate with model-based documents thanks to the synchronization of web-based spreadsheets. Because of the feedback loops created by this bi-directional information flow, non-modeling team members can provide direct input information into the contextual framework. This is a significant departure from the coventional method. (Kensek, 14 August 2015)

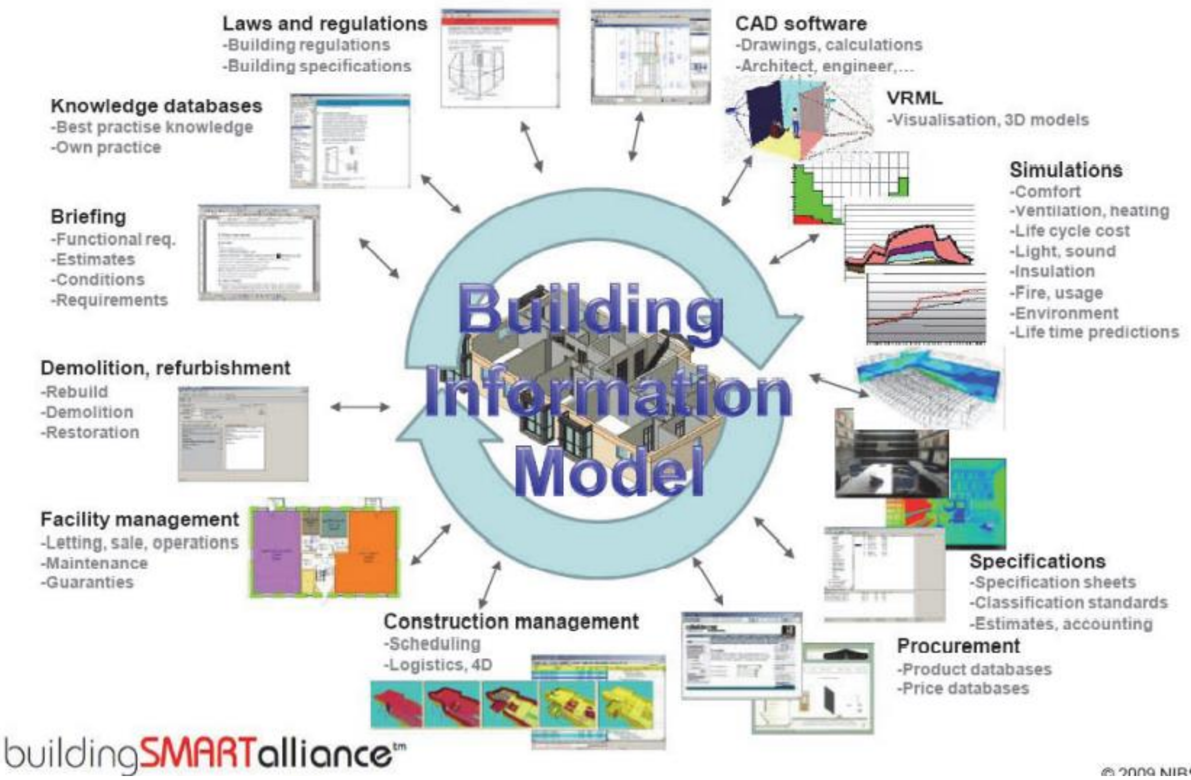

Figure 2-1 Lifecycle Information View (NIBS, 2011)

2.3.8 KPI for Building performance of FM

Energy

Buildings account for 72 percent of electricity use, 39 percent of energy use, and 38 percent of total carbon dioxide (CO2) emissions in the United States (U.S. Green Building Council 2009). Improving the built environment's energy efficiency can make a significant contribution to a sustainable economy (Clarke et al. 2008). Energy management systems, which measure energy usage at a building or zone level over time and occasionally in real-time, are used by FM professionals to control and monitor energy.

For the energy performance of a facility, simulation modeling is commonly utilized. (Augenbroe, 2002)stated simulation modelling is now being more widely applied in post-construction phases such as commissioning and facility management. Simulation has become an important aspect of the entire design, engineering, and operation of buildings. In this research, I used an energy modeling tool to obtain various KPIs linked to energy consumption and CO2 emissions. **Cost**

Lifecycle cost analysis is used to evaluate the economic feasibility based on the calculation of the equivalent values of all the important costs that occur within the life span, with a particular focus on buildings or the major components of buildings. An LCCA is conducted using the following four steps.

(i) The analysis target is identified, which is the first step toward making a cost-effective decision by creating and evaluating the alternatives that can meet the minimum performance standards.

(ii) The basic assumptions are established for the LCCA, including the analysis period and discount rate. In addition, the initial investment cost, operating cost, alteration/replacement cost, and other associated costs are confirmed, and the time of occurrence of each cost is verified. Because these cost items occur at different points in time, it is important to convert each cost to the value at a single point in time.

(iii) The LCC is calculated for each alternative by adding up the costs according to the type of each alternative.

(iv) The related indices are calculated to evaluate the economic feasibility (the LCCA) including the net savings, savings-to-investment ratio, and payback period. In addition, a sensitivity analysis can be implemented to complement the LCCA methodology, which will provide reliability to the LCCA results.

Maintenance

Maintenance is described as work done to bring every facility, i.e., every part of the site or building, back to an acceptable state. A maintenance policy is a tool that maintenance employees can use to plan out their maintenance methods. However, before preparing a maintenance program, maintenance employees and top management must agree on a maintenance strategy, as it necessitates strategic directives as well as resources. The maintenance policy is made up of five basic components, each of which is used to create alternative maintenance methods. Maintenance and operational processes will be disorganized if this policy is not defined. According to Chanter (1996), the five major components) are as follows:

- The length of time for maintaining their present use
- The life requirements of the buildings and their fittings and services.
- The standard to which the building and its services are to be maintained
- The reaction time required between a defect, occurring and a repair being carried out.

- The legal and statutory requirements shall also be considered

Effective facilities maintenance necessitates the management of a huge amount of data as well as a process that includes data collection, storage, and presentation. In response to these conditions, the construction industry has used a variety of information and communication technologies (ICTs) to help with data management, communication, and cooperation, and acquire advanced practices (Lu et al. 2014). The Web is one of the communication services of ICTs. Among various ICTs, BIM is another evolving set of software developed for various purposes which is considered to simulate the planning, design, construction and operation of a facility (Azhar, 2011,2015).

Building managers also use RFID as another ICT tool to track component positions, obtain data on components and materials, and improve management of open-building construction projects (Yagi et al. 2005).

Visualization

Applying analytics to conceptual design has proven difficult because a problem typically has multiple targets and is imprecise with respect to one or more of these objectives (Shaw, 2008) For the procedure to be successful, the interaction of professional competence and computer-based exploration is required. In order to make educated decisions in steering the optimization process, facility managers must be able to analyze overall performance trends as well as variable sensitivities.

The architectural, structural, and HVAC models being separately produced with Autodesk Revit 2021, were combined via Autodesk Navisworks to represent the entire project for visualization, coordination, and other objectives. In this regard, the NWD format of the Navisworks output can simultaneously update the Revit and Navisworks' output. The model is also saved in a format that can handle BIM and IFC descriptions. The IFC 2x3 version is the one used in this research. Building elements, geometric and material aspects of the building product, project costs, timetables, and organizations are all covered by the IFC hierarchy. It is not indeed possible to view all the entities and attributes of the building object at once.

The IFC File Analyzer, on the other hand, does so by constructing a spreadsheet with a single worksheet for each type of IFC entity in the file. As a result, the characteristics of an IFC entity instance may be found in every row of the worksheet. The IFC result can then be imported into databases as an Excel file (Mohsen Kamelia, 2013) BIM visualization provides accurate geometrical data. It enables the analysis of building proposals and the simulation and benchmark of building performance (Atkin and Brooks 2009).

Barriers to BIM implementation in Ethiopia

The difficulties implementing BIM in Ethiopia, as reported in various types of literature are , the use of BIM has been hampered by technological issues such as inadequate ICT infrastructures, expensive BIM technology, and a lengthy adoption process, lack of a BIM-based workflow, a thorough framework and implementation strategy, and a lack of senior management support and attention were organizational impediments to BIM adoption, lack of properly qualified BIM specialists, a lack of client awareness and knowledge of BIM, and unfamiliarity with BIM use are all human- or stakeholder-related hurdles to BIM adoption. lack of BIM National Standards and guidelines, the absence of a legal framework for BIM application, and the absence of standard BIM-based contract papers and contractual ties were considered to be the final standard and policy-related impediments to BIM adoption are barriers to BIM implementation in Ethiopia (Desbalo, October-2020)

CHAPTER THREE

RESEARCH METHODOLOGY

This topic states methodology detailing includes defining way of data collection and types of data collected and methods used for data analysis and evaluation. Primary and secondary data will collect by a qualitative approach.

3.1 Research Area

Addis Ababa University College of Commerce, established in 1943, is Ethiopia's pioneer and foremost business education and training institution. It has built a reputation for producing graduates who have made a difference in all aspects of their business endeavors. This research study location is located in Addis Ababa's Kirkos sub-city, and the university property contains more than ten buildings. The Addis Ababa University School of Commerce is a heritage site in Addis Ababa, located in what is commonly known as Mexico, in Addis Ababa, and has 10 buildings in the university compound. According to the Addis Ababa City Administration Master Plan, the area is called the financial or Bank Zone, and almost all of the major banks in the country have their headquarters in this area. The building selected for this study is located on the site of this business school building. Classrooms, meeting room, cafeteria, lounge, ICT rooms, registrar and other

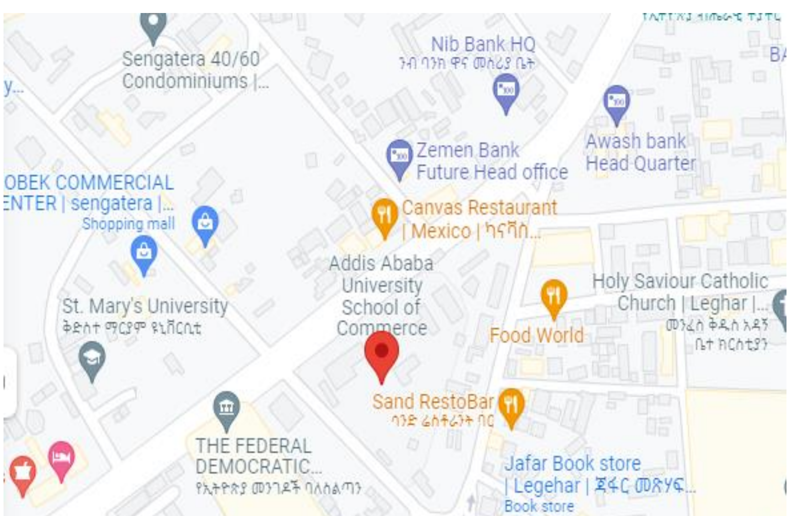

Figure 0-1 Addis Ababa university school of commerce location

offices, bank, services the entire building is B + G + 10 and the exterior is mostly covered with glass and the rest of the building is made of blocks and conventional building materials. All rooms have doors and windows and are designed to provide adequate ventilation.

3.2 Research design

The study uses descriptive and comparative research designs that incorporate both qualitative and quantitative data to explain and examine the findings in order to arrive at conclusions and recommendations. The descriptive type was used to describe the current AAU conventional facility management approach and the comparative type was used to compare both FM approaches. and BIM model was developed for the selected building to evaluate the BIM FM approach by taking samples.

3.3. Study variables

3.3.1 Independent variables

Independent variables of this study are maintenance management, space management, information management, building sustainability management, energy analysis, cost, time, and visualization management systems. These are independent variables that are manipulated by the researcher.

3.3.2 Dependents

The dependent variable of this study is an effective and efficient facility management system.

3.4 Population and Sampling Method

Five facility management specialists and 25 laborers in various professions, including painters, builders, carpenters, electricians, and plumbers, are part of the AAU-commercial school's facilities management section. To achieve the study's goal, only facility management specialists responded to the poll. The rest of the 20 facility management employees were ineligible because they had no experience in facility management and the majority were not professionals. Ten of the 30 facility management employees participated in this study by answering questionnaires and three by giving interviews; the rest were ineligible because they had no experience in facility management and the majority were not professionals.

Purposive sampling was used in the study. Because to focus on specific qualities of a population, such as a facility management employee, who are the best equipped to answer the research questions.

Table 3-1 Target group for survey

The target group for the survey	Total Population size	Selected population sample	Description
Professional facility management staff	5	5	Degree holders and Diploma holders
Facility management employers	25	5	Diploma holders and bellow
Total	30	10	
Building	9	1	Only one has an As-Built drawing.

3.5 Sources of Data and collection procedure

The data collection source for this study was primary data and secondary data. Maintenance manual, energy consumption, frequency of reactive maintenance, preventive tasks, and maintenance plan, as-built drawings were collected. The necessary field visit and data collections were conducted on study area buildings.

Primary data were collected by the questionnaire and also conducted Data by using the KII interview and observation method In terms of functionality, safety, efficiency, effectiveness, and comfort of the facilities component to gather in-depth information, which is in line with the qualitative approach. The respondents in this study were ten AAU facilities management staff, members.

For the questionnaire, the researcher used 3-point Likert scales, which have several advantages and are one of the most widely used survey formats. it was simple to grasp the respondent concept with focusing points and complete for respondents, as well as efficient in obtaining the convention facility management approach practice.It's also a good idea to focus on a specific facility management topic to get a deeper understanding of respondents' thoughts and views.

Secondary data: - Secondary data were collected such as the design documents, maintenance plan manual, and different studies.

3.6 Data presentation and analysis

The survey research approach was used to gather the essential data for this project. The survey research primarily used self-administered questionnaires, which were supplemented with an in-depth personal interview and a survey of the selected building. The most acceptable data gathering devices for the research are a combination of self-administered questionnaires and in-depth personal interviews. This is due to the benefits of both approaches, which include a high response rate, the ability to request clarifications if necessary, and a thorough analysis of the physical asset.

After collecting the relevant data, it was processed and analyzed through the use of a statistical software package called SPSS version 26 and excel. The data from the questionnaire were sorted out and at the same time information was checked for completeness. Then, responses to the questionnaires and interviews were examined to derive a relationship among the variables. After proper editing, data were coded and encoded to the software to make them ready for analysis. Descriptive statistical techniques are adopted for the analysis of data collected from questionnaire respondents. In so doing frequency tables and percentages were used. This helped to thoroughly analyze and interpret the questions in grouped the same facility management functions facility management service, building operation and maintenance, information management, building sustainability and energy, building operation and maintenance cost and time, and visualization in different groups and the remained questions one by one to reach meaningful results. Information collected from interview discussions was also incorporated in the data discussion and interpretation part of the study.

There is also conducted The BIM model to test the value and to illustrate how BIM can enhance value to the FM of existing assets.

- Were conducted analysis for conventional and BIM-based facility management approach based on the collected data.
- A comparison of the conventional and BIM Facility Management approaches was carried out based on the above analysis.
- As a result, a sample BIM model were created to demonstrate the importance of BIM for facility management.

KII, the analysis, comparison and model ware conduct based on five themes: Energy Simulation, Cost Simulation, Time simulation, method of Maintenance and Visualization.

Checklist guiding approach

One structure, AAU's School of Commerce Facility Building B+G + 10 floors, was studied and visually inspected. The condition of facility elements was ranked using a 2-point Nominal Scale Level to indicate the presence of facilities in terms of mentioning if building facility elements are there, in good condition, functional or working well, remark at yes nominal scale. The above-mentioned building facility elements are not existent, are in poor condition, are not functional, or are not operating as expected, is represented by the No nominal scale.

3.7 Software

Excel and SPSS ware used to analyze the collected data and Autodesk Revit software, Auto desk Navisworks ware used to model the sample buildings and will compare both the conventional and the BIM based one.

CHAPTER FOUR

RESULT AND DISCUSSION

This chapter discusses the result of the BIM method based on the model analysis and the desk review results for the BIM FM approach and the conventional facility management approach and discusses the result of the questionnaire checklist and in-depth interview and analysis using SPSS and Excel. Data were collected from the AAU school of commerce and from the AAU main campus main participants, who are the Vice President for Administration or Business and Development, Facility management directorate director Team leader of the facility management team, and facility management, staff. One building block was thoroughly evaluated using checklist guiding, and ten questionnaires were distributed to facility management employers at AAU who are involved in facility management. From the ten questionnaires distributed, ten were filled out and returned.

4.1 Conventional Facility Management Approach

4.1.1 Questioner and KII Analysis Results

The purpose of the primary survey results which are shared in this research was to identify how AAU- commercial school facility building administrators manage and categorize their facilities' assets in a conventional approach. The survey was conducted during September 2021-to 10/30/2021 with ten participants completing the survey. AAU- commercial school has a facility management department at the team level and the team has 5 facility management professionals and 35 laborers in different professions such as a painter, builder, carpenter, electrician, and plumber.

Table 4-1 General profile of the respondent

The General profile of the respondent									
No	**Age of category**	**Gender:**		**Job category**		**Educational status**		**Work Experience**	**Total**
		Male	Female	Facility	Management	Diploma	BSc		
1	40-50	*		*		*		More than 15 years	**4**
2	30-40	*		*		*		11–15 years	1
3	30-40	*		*			*	0–5 years	2
4	Below 30		*	*			*	0–5 years	1
5	40-50	*		*			*	6 –10 years	2
Total		8	2	9	1	5	5	`	10

According to the respondents in the AAU facility building space management survey, 40% answered low, 30% said medium, and 30% stated high. This implies that there are some issues with space waste and management. The university does not have a process for monitoring and managing its physical workplaces. It enables strategic planning to produce cost-effective solutions, as well as optimizing the inventory of space available for employees to perform their work more efficiently. However, they attempt to organize the space that they have and provide space for various functions, although not in an optimal manner. As a result, university space management is at a low management status.

As here described in the Table below the respondents, information management of the AAU facilities management unit during the operation stage is 40% low, 30% medium, and 30 % high, indicating that the university's attention to information of facility management is in the low range. As shown in the graph below, the facility management department at Addis Ababa University has a low rate of information management because they lack facility information such as inspection, equipment property descriptions, space utilization, energy consumption, equipment locations, maintenance manual, maintenance history, warranty, and as-built drawings in 2D, 3D, and model level. They do, however, have some information about the facility, such as the number of buildings in the compound and an FM unit yearly plan, which is all documented and stored in hard and soft copies.

According to the respondents, described in the table below, the AAUSC facilities management unit's attention to Maintenance of equipment inside the building and building systems is 70% medium and 30% high, indicating that the university's attention to Maintenance of equipment inside the building and building systems is in the medium range.

The FM unit's primary responsibility is to maintain building equipment and systems in order to impr ove operating efficiency, save time, and save money. Because of the way the university manages the facility, they maintain the facilities as much as possible within the requests that come up to the FM u nit, and they also make regular check objects for safe operation, but they can't predict what will happ en next or recognize the equipment condition in a recorded manner. because of this the university's Maintenance of equipment inside the building and building systems is under 70% medium range.

All of the respondents rated AAU FM's asset management as a medium, as shown in the figure below. Because the process of planning and controlling the acquisition, operation, maintenance, renewal, and disposal of university assets is not followed properly, information has reached the process of planning and controlling the acquisition, operation, maintenance, renewal, and disposal of university assets.

According to the respondents, the AAU facilities management unit's focus on sustainability during the facility management process in the design and operation stage is rated 50% low, 30% medium, and 20% high, showing that the university is not concerned about sustainability issues. During the design stage of new construction, renovation, and maintenance, the AAU facilities management unit has been given the authority by the FM process to make structural, architectural, and operational adjustments to reduce the negative impact of buildings on their users and the environment. However, they are unconcerned about sustainability difficulties, as respondents said that the university is in the low range. Universities, on the other hand, should take sustainability seriously.

The study of based digital transformation and automation facility management. As indicated in the Figure below, 40% and 60% of respondents at the institutions investigated ranked the rate of digital transformation and automation implementations as low and medium, respectively. The use of integrated technology to automate facilities management operations is known as digital facilities management. Talent is required for digital transformation. Putting together the right team in four domains: technology, data, process people, and organizational transformation capabilities, yet none of this exists at AAU. They attempt to retain information in a computer-assisted manner, but not fully digitally, which is why the majority of respondents rate the university's digital transformation and automation facility management as a medium.

According to the respondents, the attention given to facility management by the AAU facilities management unit during the design stage is 40% low, 50% medium, and 10% high, indicating that the university's attention to facility management is in the medium range. It is important to give greater attention to facility management during the design stage in order to appropriately manage the properties during the operational stage and to reduce maintenance efforts during the facility's operational phase. The Facilities Manager should engage in the design stage, especially through design standards, equipment sizes, and machine rooms, to contribute to good design and equipment selection in terms of maintainability, cost of operations, and safety. As they stated, the AAU does not practice this, so the status is in the middle.

Generally, as you see below in the table the question about how they rank the university's facility management service in terms of Space management, Information management, Maintenance of equipment inside the building and building systems, Asset lifecycle management, Focus on sustainability, Digital transformation, and automation, and the focus on FM at the design stage. Thus, the minimum 40% and the maximum 100% of the respondents stated the facility management services are at low and medium levels respectively.

Table 4-2 Rank of universities facility management service

No	Variable	Response Category	Percentage (%)
1	Space management	High	30
		medium	30
		low	40
2	Information management	High	30
		medium	30
		low	40
3	Maintenance of equipment inside the building and building systems	High	30
		medium	70
		low	None
4	Asset lifecycle management	High	None
		medium	100
		low	None
5	Focus on sustainability	High	20
		medium	30
		low	50
6	Digital transformation and automation	High	None
		medium	60
		low	40
7	Focus on FM at the design stage	High	None
		medium	50
		low	50

The condition and appearance of the building's exterior are evaluated in good, moderate, and high conditions, as shown in the figure below. At AAU, 70 percent of building FM employees said the building's exterior is in good condition, while 30 percent said it is in medium condition. Because the exterior of the building is in good condition in terms of strength, stability, weather resistance, fire resistance, sound insulation, privacy, and safety, the majority of respondents stated the condition and appearance of the building's exterior are in good condition.

The interior of the building is also evaluated in three categories good, moderate, and high, as indicated in the figure below. At AAU, 60% of FM employees stated the building's interior condition and appearance are in good condition, while 40% said it is just in moderate condition.

Because of the AAU facility, the building is well-functioning in terms of how well the space supports the core business, building properties about the needs of the core company, and building properties in terms of technical operations.

The lighting and electrical systems of the AAU facility building were evaluated as per respondant 50 percent good and 50 percent middling , as illustrated. Because the university buildings' lighting and electrical systems are in good working order in terms of Light Distribution and Brightness, Energy Conservation, Space and Luminaires Appearance, Color Appearance, Lighting Control and Flexibility, Lighting of Faces, Light is sufficient to see objects, provide adequate illumination, and Absence of Glare.

Generally, as presented in the figure below, above 60% of the respondents stated the condition of the building is good and 40 % of the respondents stated the condition of the building is in moderate condition.

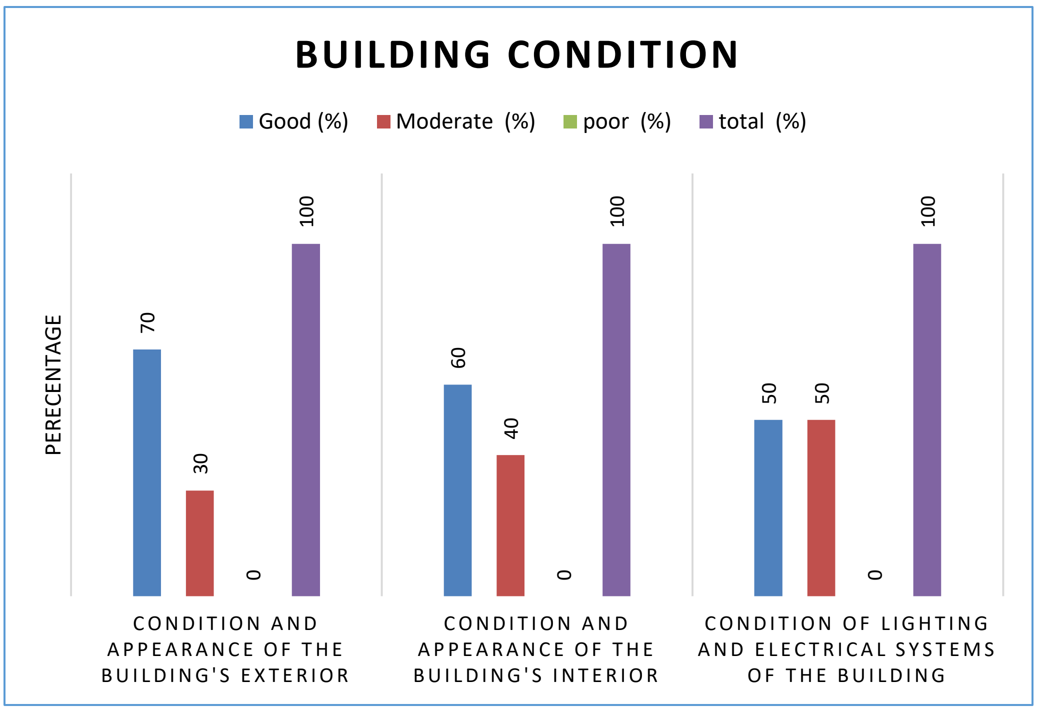

Figure 4-1 The condition of the selected university building

According to the respondents, 80% believe the AAU facilities management unit's organization is in good condition, while 20% said they are unsure. The AAU School of Commerce has a property management unit at the team level that is managed by the vice president of the school and employs 40 people.

As shown figure below all percent of the respondents explained that the university assess the condition of the building annually or semiannually.

As shown below in Figure bellow percent of the respondents explained that yes, we evaluate the structural part safety of the facility, 40 percent of the respondents stated no, we don't evaluate the structural part safety of the facility and 20 percent of the respondents stated don't know. AAU FM unit tray, to evaluate the facility's structural part safety, but not in an appropriate method. When the structural part is examined, both slabs, floors, beams, columns, and shear walls must be analyzed and safety in terms of structural performance must be ensured. When it comes to structural performance, which is the effect of section properties on various materials, they don't employ some laboratory experiments.

In general, the majority (80%) of the respondent said the university's facility management unit are well-organized and 100% of the respondents stated they assess the condition of the building annually in addition to this 40 % of the respondent said they evaluate the structural part of the building for the sake of the safety of the facility as discussed previously.

Table 4-3 university's facility management unit and assessment condition

NO	**Variable**	**Response Category**	**Percentage (%)**
1	Is your university's facility management unit or department well-organized?	Yes	80
		NO	None
		don't know	20
2	Do you assess the condition of the building annually or semiannually?	Yes	100
		NO	None
		don't know	None
3	Do you evaluate the structural part safety of the facility?	Yes	40
		NO	40
		don't know	20

Facility Management information systems are complex and provide high-quality data. As shown in the table below, 60 percent of the respondents stated yes, the university has databases for facility management purposes and 40 percent of the respondents said no the university has no databases for facility management purposes As a result, there is an unclear understanding of the database. Some respondents believe that an FM database is a software similar to Excel, although this is not the case. A database is a logically organized collection of structured FM data stored electronically in a computer system. AAU uses Excel to store information for the FM process, and 60% of respondents identify it as an FM database.

As shown in the table below, 20 percent of the respondents stated yes, the university has detailed records of all university buildings and 40 percent of the respondents said no the university does not have detailed records of all university buildings for facility management purposes and 20 percent of the respondents said I don’t know. AAU Facility management department has some facility management records such as several buildings in the compound, furniture, machinery, electrical equipment, fire protection, sanitary element, and so on.

As per respondent’s 10 percent stated yes, the university has recorded data about all facilities in the universities,50 percent said no the university does not have recorded data about all facilities and 40 percent of the respondents said I don’t Know.

For FM, warranty management is crucial. Managing equipment warranties in a multi-vendor critical facility can be a difficult task in Facility Management, but the university must administer this information. According to the respondents, 30 % said yes, the university has warranty information in the FM record, 20% said no, the university does not have warranty information, and 40% said I don't know.

As shown in the table below, 30 percent of the respondents said yes, the university has the contact person address and manufacturer company information for FM record,20 percent of the respondents said no the university hasn’t 50 percent of the respondents said I don’t know. This information’s are use full in the facility management process to make FM more efficient and effective by communicating with the responsible company and person that help to maintain and manage properly.

In general, the Table below describes the university's information management system in terms of databases used for facility management. The institution uses a database system for facility management, according to 60% of respondents, and they continue to do so. Furthermore, 40 percent of respondents stated that the university facility management department does not use a database for FM purposes and that the university does not have detailed records of all university buildings. Furthermore, a warranty is one of the most important facility management elements that must be recorded and managed, so the university facility management department. 60 % of the respondents said the university use databases for the facility, 50% of respondents supposed I don't know the warranty information for the university facilities, and 50% of respondents stated I don't know about the manufacturer's contact information.

Table 4-4 university information management system

NO	**Variable**	**Response Category**	**Percentage (%)**
1	Does your university use databases for facility management purposes?	Yes	60
		NO	40
		don't know	0
2	Do you have detailed records of all university buildings?	Yes	20
		NO	60
		don't know	20
3	Do you have recorded data about all facilities in your universities?	Yes	10
		NO	50
		don't know	40
4	Do you have warranty information on your FM record?	Yes	30
		NO	20
		don't know	50
5	Do you have the contact person's address and manufacturer company information on your FM record?	Yes	30
		NO	20
		don't know	50

As shown in the table below, 70 percent of the respondents stated No, the university has not recorded data about the facility's energy consumption and carbon Emission and 30 percent of the respondents said don't know. As per respondents, the university doesn't have this data to make energy use more efficient, the university should keep a record of energy use and carbon emissions, which can help to minimize greenhouse gas emissions and other air pollution, address climate change, and preserve our health and the environment. Material selection comparison criteria and techniques are critical for facility managers because of the Environment protection. As indicated in Table 6 below 50 percent of the respondents said yes, the university has material selection comparison criteria and technique 40 percent No and 10 present said I don’t Know. Because the university compares the material cost only but not the material related to energy consumption and carbon emission.

The table below shows that 50% of respondents said yes, the university has a sustainability plan. 40% answered they didn't have it and 10% replied they didn't know. As seen in table 7, 30% of respondents said yes, the university have sustainability standards. 40% answered NO don’t have it and 30% replied they don’t know. 30% of the respondent stated yes, the university have sustainability standards and also 40 % said no doesn’t have sustainability standards and 30 percent said I don’t know. As this implies, and I am convinced that the university facility management department staff has a basic understanding gap of sustainability issues, some of them told me that the yearly operational plan and the sustainability plan were the same things. As a result, the respondents' responses were as stated. All of this indicates that the university administration lacks commitment and does not understand fully the issues of sustainability and energy management.

Table 4-5 The university's degree in sustainability awareness and implementation Management of energy

No	**Variable**	**Response Category**	**Percentage (%)**
1	Do you have recorded data about your facility's energy consumption and carbon Emission?	Yes	0
		NO	70
		don't know	30
2	Do you have material selection comparison criteria and techniques?	Yes	50
		NO	40
		don't know	10
3	As a university, do you have a sustainability plan?	Yes	50
		NO	40
		don't know	10
4	Do you have any sustainability standards?	Yes	30
		NO	40
		don't know	30
5	Do you have the west mineralization technique?	Yes	10
		NO	70
		don't know	20

As indicated Table 8 below defines the university's about how they rank the university building operation and maintenance cost and the time interims of analyzing the Whole life cycle cost of the facility 70% of the respondent stated the university does not analyze the whole life cycle cost of the facility and 20 percent said I don't know and 10 percent said yes. As the respondent said the costs of construction, maintaining, and getting rid of the building are not analyzed in other words, it is the total cost of ownership for a building, minus how the facility or building is maintained.

As shown in the Table below, About the preventive maintenance plan 70% of the respondent said yes, the university has a preventive maintenance plan and 30 % stated No have no preventive maintenance plan the university facility management unit follows the preventive plan in terms of Time-based maintenance manner.

Assessed FM software utilization status in terms of making their job easier and more productive. as shown in the table below. (automation). According to 20% of respondents, the university does have FM software. According to 80 percent of respondents, the university does not have software to make their jobs easier and more productive. As indicated the university FM unit use some software such as excel, word, and office software that software enables organizations to manage their entire repair and maintenance work but those are not FM software program from a web-based dashboard.

As shown below, 40% of respondents stated yes, they study their current energy consumption, 40% said no, they don't analyze, and 20% said they don't know. As previously indicated, the university does not assess energy consumption and hence does not allow users to understand and therefore optimize energy consumption by making production plan adjustments and behavioral changes that improve efficiency.

Performing timely inspection helps in detecting minor defects which will turn into major problems if not addressed early as indicated in table 7, 60 percent of respondents stated yes, they perform timely inspection, and 40 percent said No we don't perform. The university Facility management unit performs visual evaluation systems used to control the facility before creating major problems in the facility.

Table 4-6 Rank of the university building operation and maintenance cost and time performance

No	Variable	Response Category	Percentage (%)
1	Do you analyze the Whole life cycle cost of the facility?	Yes	10
		NO	70
		don't know	20
2	Do you have Put a preventive maintenance plan?	Yes	70
		NO	30
		don't know	None
3	Do you use FM software to make your job easier, and more productive (Automation)?	Yes	20
		NO	80
		don't know	None
4	Do you Analyze your current energy consumption?	Yes	40
		NO	40
		don't know	20
5	Do you perform timely inspection helps in detecting minor defects which will turn into major problems if not addressed early?	Yes	60
		NO	40
		don't know	None

The table below, below defines the university's about how they rank the visualization of the facility management element 90% of the respondent stated the university facility management employers does not visualize every building facility and the components with a 3D model regards to the information of the component (data), 10 percent of respondent said yes, we visualize components with a 3D model As stated by 90% of the respondents, and with related to this 30 percent of respondents said the university has a visual representation of the location of the building components with real-time data, 40, percent stated No we don’t and 30 percent stated We don’t know. The underground results are the same, i.e., the facility management unit does not have any model drawings such as 3D models that help them visualize the components in the building whether in hard copy or soft copy, but they do have as-built drawings in hard copy in a 2D manner.

As shown table below evaluating the university's Visualize Energy Simulation of the Building status 90 percent of respondents said no, they don’t visualize the Energy Simulation of the Building, and 10 percent said yes, we visualize the Energy Simulation. According to their response, the university facility management unit does not use Energy Simulation, which is a computer-based analytical process that assists building owners and designers in evaluating a building's energy performance and making necessary design modifications to make it more energy efficient for new construction.

Table 4-7 Rank of the university visualization of the facility management

NO	**Variable**	**Response Category**	**Percentage (%)**
1	Do you visualize the Energy Simulation of your Building facility?	yes	10
		NO	90
		Don’t know	0
2	Do you visualize the Lifecycle cost Simulation of your Building facility?	yes	10
		NO	90
		Don’t know	0
3	Do you have a visual representation of the location of the building components with real-time data?	yes	30
		NO	40
		Don’t know	30

As shown in the figure below which type of building maintenance is practiced in your university 90 percent of the respondents stated the university Facility management unit performs corrective maintenance, and 10 percent of the respondents said they perform routine maintenance. As they explained Traditional maintenance approach generally focuses on repairing and replacing components when a maintenance operation is demanded.

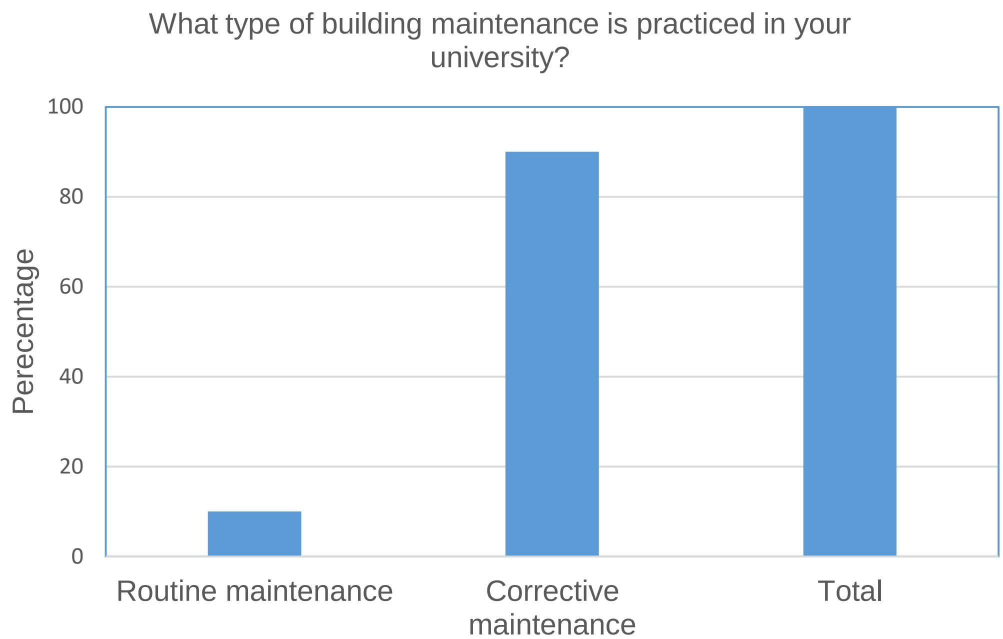

Figure 4-2 Type of building maintenance practiced in the university

As shown in the figure below percent of the respondents said the university data management system is a computerized maintenance management system, 40 percent stated building maintenance control data management system and 20 percent said CAD for the documentation of drawing data system. As they explained the university uses a computerized data system but is not integrated and also, and they use building maintenance control and also the use CAD system for drawing documentation.

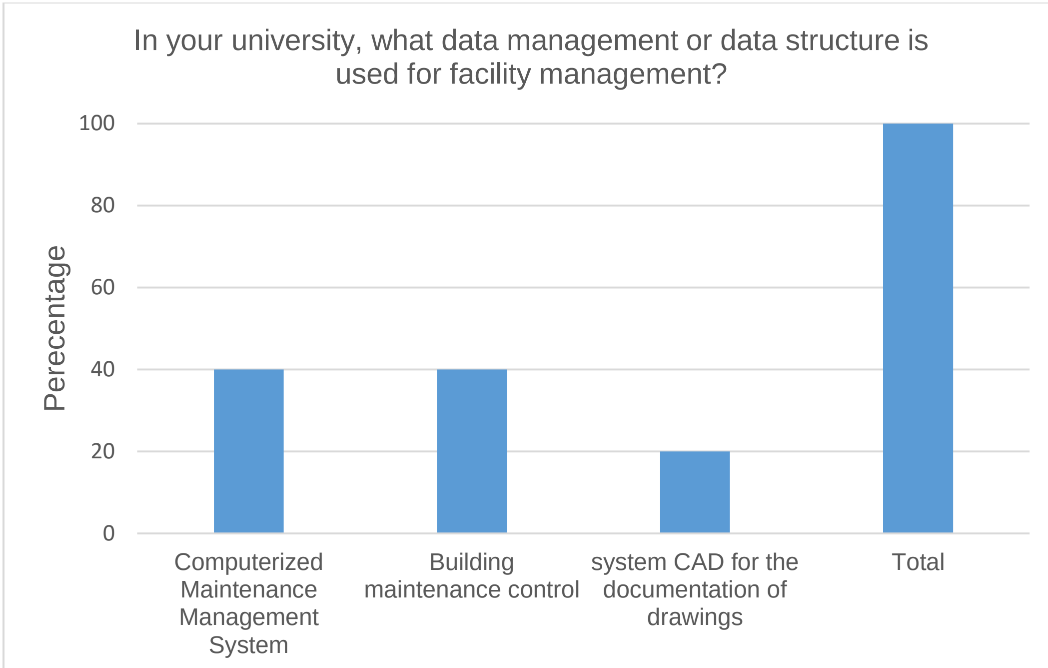

Figure 4-3 Data management or data structure is used for facility management

The figure --below defines whether the university's databases are server-based or cloud base According to the survey, 50 % of the respondents believe the selected university has a server-based database, while the other half believe they do not use any database system the respondents said None of the above. Among the respondents there is confusion half of the respondents confirm the university has a server-based database and the remaining also don’t know about the database.

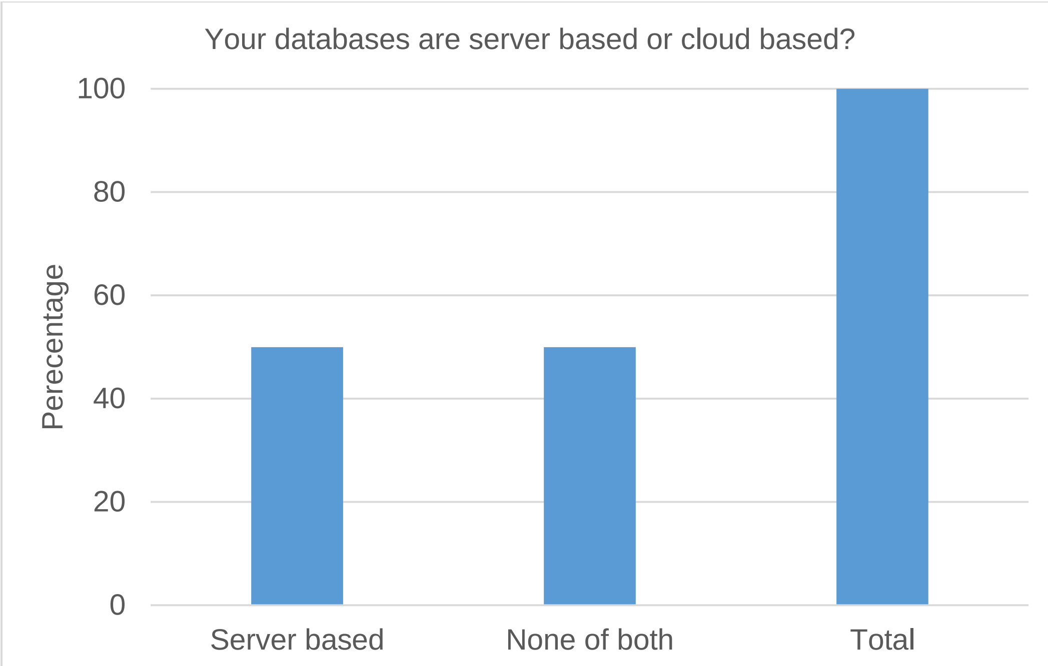

Figure 4-4 The university database system

According to the survey, 40% of respondents believe the selected university uses a Computerized Maintenance Management System and Building Maintenance Control Data Management or Data Structure for facility management. Computer-Aided Facilities Management software provides the facility manager with the administrative tools and the ability to track, manage, report, and plan facilities operations. This function is associated more with an administrative function and not a technical activity. For example, Computer Aided Facilities Management software systems can contain data that identifies departments and staff, identifies and tracks who has space access rights and security level, as well as leased space information including leasing, income, and tenant charge-back information. Even though 40 percent of respondents believed the university data management system performs the Computer Aided Facilities Management system but they don’t as present above level.

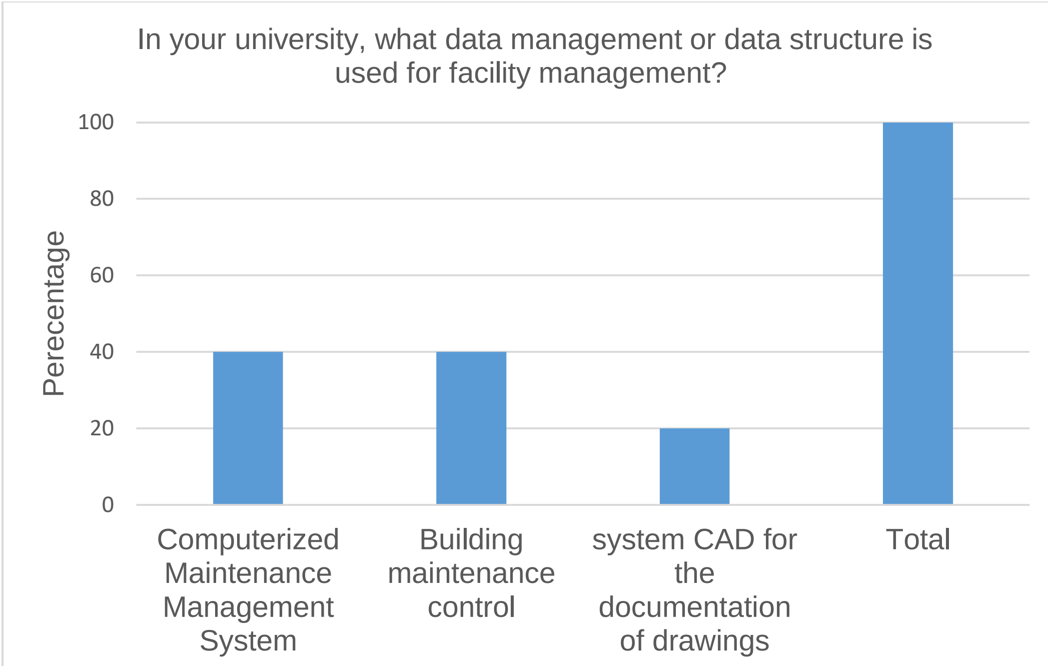

Figure 4-5 The university data management system

About Recorded Facility management documents as presented in figure below, about 40 % of the respondents said the university has as-built drawings, 20 % of the respondents stated the university has Maintenance and operation manually and 20 % of the respondents the university has both as-built drawings and Maintenance and operation manually and 20 percent of the respondents said none of the above options. But Maintenance and operation manuals include not only building facility maintenance rules but also basic methods and technical directions for generating Maintenance Procedure Manuals (step-by-step explanations to develop maintenance procedures) for all types of buildings by this level they don't have maintenance and operation manuals. The university's only has as-built drawings for one building, and there is a significant difference between it and the existing one. The facility management team must get a collection of papers, including as-built drawings, 2D plans, specifications, manuals, and potentially a 3D building model, for facility operation and maintenance in the traditional approach.

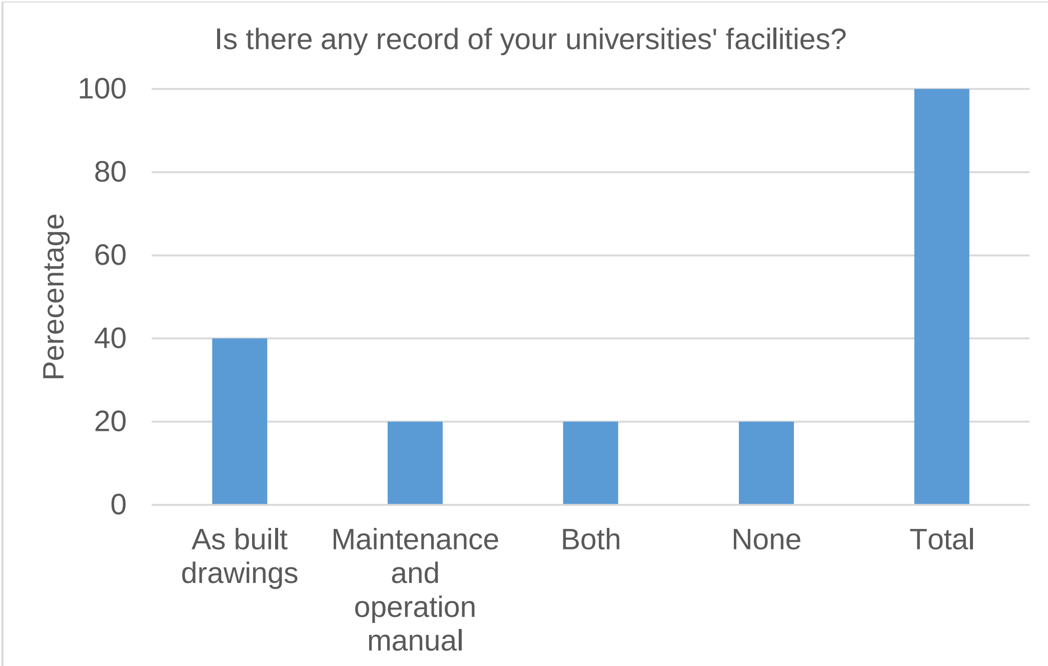

Figure 4-6 The university FM record

4.1.2 Observation analysis

The primary goal of this assessment is to assess the building's condition. The facilities building at Addis Ababa University's School of Commerce was chosen as the condition evaluation site for this study. B+G+10 buildings and mixed-use buildings, which have many floors, are the most common type.

Architectural features that were chosen and assessed include Examples of walls including brick, glass, partition walls, and ceramic walls. Examples of ceiling materials include plywood, gypsum, and plasterboard. Ceramic, tiles, marble, and wooden floors are examples of floor finishes. Wooden, metal, glass, and plastic doors and windows are examples of doors and windows. and Aluminum sills and timber sills, for example, are assessed visually and checked using a checklist. Columns, Beams, and Foundation Slabs are some of the structural features that were chosen and evaluated. Stairs and a Shear Wall Clean water network, dirty water network, floor drain, roof and ground tank, freight elevator, fire protection network, and septic tank were among the mechanical elements chosen and evaluated. Lamps, cable network distribution, sockets, and switches were among the electrical features chosen and evaluated. Outside Paint, Roof, and Lightning Rod are some of the qualities that were appraised visually.

The research Using the checklist as a guide surveyed to assess the state of the building's facility elements in terms of functionality, existence, and correct operation in terms of interior and exterior building quality, electrical, plumbing, HVAC, and safety. Because the facility is new, nearly all of the building elements are present and functional.

Wall surfaces, Roof, Floors, ceilings, railings, staircases, ramps, bathrooms, showers, toilets, sinks, doors, windows, locks, knobs gutter system, Elevators, Steps, Paint, cables of exterior lights, switches, outlets, electrical connections, Wires, drain pipes, and Fire extinguishers are all in good condition and functional or working properly. However, no ID identification marks are put on every piece of equipment.

As previously stated, many of the building's elements are in good working condition, but the identification of each identifying marker is not functional on all elements and is not digitalized. It severely limits the decision-making process for maintenance and some important repairs by creating a gap in the information that needs to be preserved about each of the building's elements, even while the building's electrical and water supplies are in perfect working order.

4.1.3 Interview analysis

The facility unit team head and deputy dean of the University of AA School of Commerce were interviewed regarding facility management. As they indicated, none of the buildings managed by universities have an as-built drawing. They also inform me that there is no recorded data about the facilities in terms of specifications, equipment lists, product data sheets, warranties, spare part lists, bar codes, maintenance costs, and some of the information, such as the maintained element and requested letter, is kept in a folder in the file cabinets.

Have not calculated the facility's life cycle cost. And the time it takes to complete maintenance requests and maintenance operations is determined by the purchasing department's efforts, which are not measurable.

And also, they perform corrective maintenance if some defect happens, and scheduled corrective maintenance, they scheduled for Maintenance that is needed, but not required to be performed immediately.

Manuals that guide how to operate and maintain the building in instead university the maintenance will be held in the interest of the applicant. However, the facility management needs to provide a proper maintenance strategy and standards. And there is no facility equipment that exceptionally difficult to access

4.1.4 Summary of conventional facility management Approach at AAU

The results of the questionnaire survey and structured interview were contrasted, summarized, and analyzed in this section from the perspective of a literature review on traditional building facility management practice at AA university school of commerce.

The university has an organized facility management section and has annual maintenance plan but doesn't have any guidelines about how to operate and maintain the building. There is also no space management system, information management, asset lifecycle management, or sustainability management, and facility management is given little attention at the design stage.

The condition of the building is generally in good condition because the building is relatively new 6 years old only.

Although the fact that they stated that they use a preventative maintenance strategy, there are no preventative maintenance procedures in place. They use a corrective maintenance strategy and, also inspect the facility once a year, they cannot predict the condition of the facility's elements.

The university facility management unit does have not a database for the facilities management purpose and also doesn’t have any information recorded with different facility element history like maintenance history, warranty, replacement cost, lifetime, manufacturer information, job-related to the element, maintenance manual, and as-built drawing, etc. related to visualization, don’t have a model of the building and its element and cannot visualize facility elements easily but they try to inspect the building within the year at one time but steel they recording the data system is manually in a folder.

The university facility management unit has no general building operation and maintenance guides that are specific to sustainability and energy, and they do not use any information management system for the facility, and neither do not they analyze the facility's entire life cycle cost, energy efficiency, instead, maintenance is performed based on the occurrence of a defect. As a result, university maintenance staff are unable to obtain strategies for developing maintenance programs and standard manuals.

4.2. Building information management (BIM) Facility management approach

General information about the selected Building

Table 4-8 Building information

Building information	
Building name	AAU commercial school facility building
Location	Addis Ababa, kirikos sub - city Local name- Mexico
Hight	B+G+10
Function	Facility building - (classrooms, Library, Cafeteria, registerer, Administration office, Auditorium, lounge,
Building age	Six years old
Total building Area	1442 square meter

Figure 4 -7 BIM model of AAU school of commerce

To understand BIM based FM approach the research has conducted a BIM sample model for AAU school of commerce by connecting the physical facilities with BIM technology, which can monitor energy usage more easily and help save the environment too. 3D modeling drives better space management, allowing you to visually identify underutilized areas and more efficient design workplace layouts

4.2.2 Preventive Maintenance (BIM data)

BIM- Based FM approach is followed by Preventive Maintenance strategy. Repair and preventive maintenance require a database of what exists and when equipment ought to be fixed, upgraded, or replaced. This is exactly what an accurate and informative FM database is.

Many building managers keep track of the following values for building components to assist and track preventive maintenance activities: installation date, expected lifecycle, expected replacement data, estimated replacement cost, and maintenance history. Building managers can schedule planned repair and replacement activities and budget the associated expenditures using these numbers. Building managers can schedule planned repair and replacement activities and budget the associated expenditures using these numbers.

Preventive Maintenance Planning targets smoothing out the course of support and fostering a program by entering the data about the resource, building structure (walls, roofs, floors, and so forth), mechanical, electrical, and plumbing parts. These all mentioned data can be accumulated by BIM. With the assistance of this data, the Facility manager can mastermind the support, fix, and substitution exercises ahead of time contingent upon the guarantee, administration prerequisites, and upkeep manuals. This valuable data about building elements are put away in BIM models and can without much of a stretch decrease a very long time of work to physically populate upkeep records of every component

4.2.3 Space Management

Space Management and Tracking is allocating, managing, and tracking spaces and related resources within a facility. Data collection, analysis, forecasting, and strategizing are all part of the space management process. In practice, this entails developing a space management system that tracks floor layouts. This approach is simplified by space management software or BIM tools, which makes it easier to scale for effective space planning.

Typically, space planners keep track of information on a room-by-room basis. Room area, room volume, maximum occupancy, if a room is assignable, which department it is allocated to, the names of the inhabitants, the present use, the materials (floor, wall, ceiling) in that room, key codes, and so on are some of the values that can be tracked. The Revit platform allows adding new parameters to the project model as defined and updated, allowing to serve the space planning and facilities management needs of the building managers.

BIM- Based FM approach by acquiring a reasonable comprehension of resources, floor plan, space prerequisite, and so forth, office experts can attempt to decrease the wastage of room prompting an uncommon decrease in land costs. The data inferred by BIM about floor region and rooms is the premise of how space is overseen. BIM ends up being helpful in this cycle as it gives a far-reaching comprehension of existing space use of the structure. The office expert can utilize the data to design, track, dissect, and control the space by using it ideally. This in outcome guarantees the presentation of the structure is productive at the most extreme. The usage of a 3D model for space planning and tracking furniture and office equipment within a building can be beneficial. And the location of building components with access to real-time. In space management in BIM Identifying parameters for tracing space utilization is mandatory in the BIM approach. As shown below figure Space planning in Revit helps by identifying the assignable and non-assignable areas/rooms. And also we can display facility management information's on the floor plan or other plan views using graphical data by using color fill legend like graphically the space assigned whether not assigned Utilizing this BIM approach technique, can make the graphical view and summed up facility management data in a simple manner whether people groups understand.

According to a study conducted at the Addis Ababa School of Commerce, more than 20 % of the space on the ground, first, and second floors is wasted or not assigned for functional service, but BIM facility management can assist in effective space management.

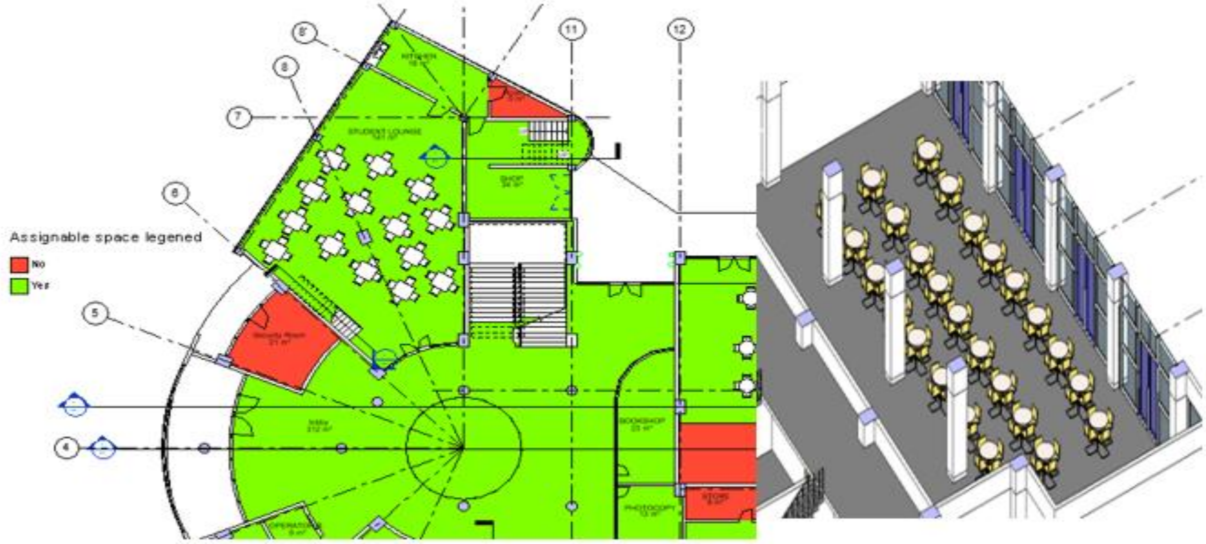

Figure 4-8 Result from AASC building BIM model

Creating schedules for reporting and quickly entering parameter values as we see below simply make space utilization summary schedule with detailed information about the rooms like room name, level, area volume, floor finish assignable room, and non-assignable rooms with the specific area and the total floor and Building area. And also, can display facility management information on floor plans or other plan views using graphical data by using color fill legend like graphically the space assigned whether not assigned. Utilizing this BIM approach technique, we can make a graphical view and summed up facility management data in a simple manner whether people groups understand.

<Space utilization summary>

A	B	C	D	E	F	G	H	I
Level	Name	Area	Volume	Floor Finish	Assignable	Assignable Area	Assignable Area	Net to gross
Ground floor								
Ground floor	TO.	2 m^2	5.13 m^3	ceramic	☑	2 m^2	1.60%	1.60%
Ground floor	TO.	2 m^2	5.13 m^3	ceramic	☑	2 m^2	1.60%	1.60%
Ground floor	WC	2 m^2	4.34 m^3	ceramic	☑	2 m^2	1.35%	1.35%
Ground floor	WC	2 m^2	4.74 m^3	ceramic	☑	2 m^2	1.48%	1.48%
Ground floor	WC	2 m^2	4.74 m^3	ceramic	☑	2 m^2	1.48%	1.48%
Ground floor	WC	2 m^2	4.74 m^3	ceramic	☑	2 m^2	1.48%	1.48%
Ground floor	WC	2 m^2	4.74 m^3	ceramic	☑	2 m^2	1.48%	1.48%
Ground floor	PHOTOCOPY	13 m^2	49.95 m^3	PVC	☑	13 m^2	10.01%	10.01%
Ground floor	KITCHEN	18 m^2	43.74 m^3	ceramic	☑	18 m^2	13.56%	13.56%
Ground floor	Security Room	21 m^2	50.14 m^3	PVC	☑	21 m^2	15.59%	15.59%
Ground floor	BOOKSHOP	23 m^2	113.23 m^3	granite	☑	23 m^2	17.29%	17.29%
Ground floor	SHOP	34 m^2	104.66 m^3	PVC	☑	34 m^2	25.67%	25.67%
Ground floor	SHOP	40 m^2	145.09 m^3	PVC	☑	40 m^2	29.62%	29.62%
Ground floor	SHOP	40 m^2	146.56 m^3	PVC	☑	40 m^2	29.66%	29.66%
Ground floor	SHOP	41 m^2	151.31 m^3	PVC	☑	41 m^2	30.61%	30.61%
Ground floor	SHOP	41 m^2	151.31 m^3	PVC	☑	41 m^2	30.61%	30.61%
Ground floor	SHOP	41 m^2	151.34 m^3	PVC	☑	41 m^2	30.61%	30.61%
Ground floor	SHOP	62 m^2	215.67 m^3	PVC	☑	62 m^2	46.23%	46.23%
Ground floor	STUDENT LOUNGE	141 m^2	422.73 m^3	PVC	☑	141 m^2	105.06%	105.06%
Ground floor	KITCHEN	149 m^2	694.60 m^3	ceramic	☑	149 m^2	111.12%	111.12%
Ground floor	lobby	312 m^2	1551.19 m^3	granite	☑	312 m^2	233.27%	233.27%
Ground floor	STUDENT CAFTERIA	333 m^2	1533.33 m^3	granite	☑	333 m^2	248.40%	248.40%
42		1442 m^2				1442 m^2	1076.25%	1076.25%
Mezzanin Floor								
Mezzanin Floor	STUDENT LOUNGE	7 m^2	17.31 m^3		☑			5.38%
Mezzanin Floor	Room	221 m^2	0.00 m^3		☑			165.20%
2		229 m^2				0 m^2	0.00%	170.58%
First floor								
First floor	STAFF LAOUNGE	Not Enclosed	Not Enclosed		☑			
First floor	WC	1 m^2	5.06 m^3		☑			1.10%
First floor	Room	1 m^2	4.97 m^3		☑			1.07%
First floor	WC	1 m^2	4.97 m^3		☑			1.07%
First floor	Room	1 m^2	5.02 m^3		☑			1.09%

Figure 4-9 Result from AAUSC building BIM model space utilization summary

4.2.4 Information management

BIM facility management models are not simply graphical data but it has all information about each building element or each facility found on the building. and the data server may be on a computer-based or cloud base. BIM could bring more integration and act as one source of the truth with all information accessible 24/7 on a range of devices. The true advantage of BIM for facilities management may be its capacity to store all of a building's information in one location.

The information shared in the source are graphical and non-graphical data graphical such as 3D models, floor plans, elevations, sections, etc., and non-graphical data such as Quantities, Materials, Elements, Spaces, Rooms information, specification, and maintenance cost. The good thing is here this information is Extracted from BIM FM models, and all data are reached within Warranty, Maintenance, budget, Inspection, and User data. As far as FM operators and providers are concerned, there is this huge amount of data, how you compile an accurate asset database is a huge challenge energies data.

Every individual or object has its own set of data. For illustration, an HVAC system at a facility contains information such as the product's manufacturing year, price, check cycle, and specifications, which is known as UNIT SPEC, and storing them in BIM space allows for integrated management without the need for separate papers during maintenance. Each UNIT or area may require a particular SPEC, such as work or materials information, company or historical information. Lists required during maintenance must be organized, and information appropriate for each UNIT must be entered, to save unnecessary labor between models and avoid confusion.

And those motioned data are ensured accuracy, consistency, and reliability of the data and it improves data management during the lifecycle, handover information, as-built/ as the maintained model used for the operational phase. BIM-based facility management approach information exchange standards such COBie, IFC, and lifecycle information management approach by capturing information from initial phases of the project through demolition. RFID may be a proper application technology applied to manage the facility's information.

COBIE collects O&M data as a part of BIM and the goal of COBie is the improvement of the information capturing method during the design and construction phase to use for operations, maintenance, and asset management purposes. One of the facility's life cycle data formats is the construction operation building information exchange (COBie). COBie is an international standard that governs the management of assets such as space and equipment. It's intimately linked to BIM (building information modeling) approaches to design, construction, and asset management. This data aids in the correct tracking of facility components, the identification of inefficiencies in building operations, and the prompt response to client requirements. Each facility component or asset has a cost associated with its installation, replacement, and routine maintenance in the COBie data. For budgeting repair/replacement and maintenance expenditures, a precise equipment inventory is important. The COBie information is related to the facility's floor, space, type, component, system, assembly, connection, spare resource, job, impact, document, attribute, issues, and document information in COBie or other data transfer formats.

And this all information can be linked with the database if it is necessary by using Revit DB Link which lets you export Revit model data to a database, update it, and then re-import it back into the model. Autodesk Revit DB Link can be accessed. Facility management personal's can connect to an existing database or establish a new one with Revit DB Link. The database and Revit can then be linked. Revit DB Link establishes a connection between a Revit project and a Microsoft Access or Microsoft Excel database. Revit DB Link allows facility management experts to export Revit project data to a database, edit it, and then import it back into the project. Before importing, the database presents Revit project information in a table view that you can change.

You can also use this table view to build Revit Shared Parameters, which adds additional fields to the linked tables for those parameters. Any changes to these additional fields in the database are reflected in Revit Shared Parameters on subsequent imports.

<Room Schedule>

A	B	C	D	E
Level	Name	Area	Volume	Floor Finish
Ground floor	STORE	8 m^2	18.01 m^3	PVC
Ground floor	G.T.1	9 m^2	21.96 m^3	ceramic
Ground floor	OPERATOR R.	9 m^2	20.61 m^3	PVC
Ground floor	CHANGING ROOM	11 m^2	27.05 m^3	PVC
Ground floor	STORE	12 m^2	28.21 m^3	PVC
Ground floor	PHOTOCOPY	13 m^2	49.95 m^3	PVC
Ground floor	KITCHEN	18 m^2	43.74 m^3	ceramic
Ground floor	Security Room	21 m^2	50.14 m^3	PVC
Ground floor	BOOKSHOP	23 m^2	113.23 m^3	granite
Ground floor	SHOP	34 m^2	104.66 m^3	PVC
Ground floor	SHOP	40 m^2	145.09 m^3	PVC
Ground floor	SHOP	40 m^2	146.56 m^3	PVC
Ground floor	SHOP	41 m^2	151.31 m^3	PVC
Ground floor	SHOP	41 m^2	151.31 m^3	PVC
Ground floor	SHOP	41 m^2	151.34 m^3	PVC
Ground floor	SHOP	62 m^2	215.67 m^3	PVC
Ground floor	STUDENT CAFTERI	124 m^2	495.13 m^3	PVC
Ground floor	STUDENT LOUNGE	141 m^2	422.73 m^3	PVC
Ground floor	KITCHEN	149 m^2	694.60 m^3	ceramic
Ground floor	STUDENT CAFTERI	209 m^2	962.97 m^3	granite
Ground floor	lobby	312 m^2	1549.57 m^3	granite
44				

Figure 4-10 Result from AAUSC building BIM model ground floor Room schedule

<Door Schedule>

A	B	C	D	E	F	G	H
Name	Type	Level	Width	Mark	Phase Created	QR code	Warranty
D1-170cm							
	D1-170cm	Basment floor	180	356	New Construction		
D1-170cm: 1							
D2-160cm							
	D2-160cm	Basment floor	180	354	New Construction		
	D2-160cm	Basment floor	180	357	New Construction		
D2-160cm: 2							
D4-85-cm							
	D4-85-cm	Ground floor	85	1	New Construction		
	D4-85-cm	Ground floor	85	2	New Construction		
	D4-85-cm	Ground floor	85	3	New Construction		
	D4-85-cm	Ground floor	85	4	New Construction		

<DOOR REPLACMENT SCHEDULE>

A	B	C	D	E	F	G
Level	Mark	Type	InstallationDate	ExpectedLife	ReplacementCost	Replacement year
Ground floor	1	D4-85-cm				
Ground floor	2	D4-85-cm				
Ground floor	3	D4-85-cm				
Ground floor	4	D4-85-cm				
Ground floor	5	D4-85-cm				
Ground floor	6	D5-65-cm				

Figure 4-11 Result from AAUSC building BIM model Door and door replacement schedule

And also, many tools enhance the facility management process in the BIM approach such as YouBIM. YouBIM is a web-based 2D/3D-BIM interface that extends the usefulness of BIM [Building Information Modeling] throughout the lifecycle of a building by providing owners with an integrated database and fast access to location and asset information. Within the online Building Information Model (BIM) collection, YouBIM links rich data and documents [PDFs, JPGs, Excels, and so on] too smart objects. YouBIM also features "light" Work Orders and Preventive Maintenance capabilities, as well as seamless integration with CMMS and CAFM systems like IBM Maximo, Planon Software, ArchiBUS, Infor, and others. YouBIM can also link with BAS/BMS, allowing for the presentation of real-time performance statistics within the YouBIM environment. The YouBIM User Interface sets itself apart from other industry solutions by focusing on the Owner and facility employees while building the User Experience. YouBIM is similar to "Google Maps for Facilities." Generally, these life Cycle data management ways such as Db link, you BIM and data formats COBie, window, and door schedules, and replacement schedules can improve productivity and efficiency in the construction sector throughout the O&M phase, which is the most costly period of the facility's lifecycle.

4.2.7 Building sustainability and Energy

As seen in the pie chart below, the BIM FM technique aids in the analysis of carbon, which is embodied carbon per material. The following materials were used in the construction of the AAU School of Commerce facility. masonry = 1325.52tco2 miscellaneous= 1068.41tco2 concrete = 1714.35tco2 metal = 1663.13tco2 The carbon embodied in the hole structure is 7749.79 tCO2.

We may supply different factors for carbon life analysis according to the BIM Approach, such as material type, production condition, transportation, construction, and design life. By altering the material when optimizing carbon emissions, we may change the waste factor, particular value, component life span, and asset reference period, and compare the project with other project options.

4.2.8 Carbon analysis

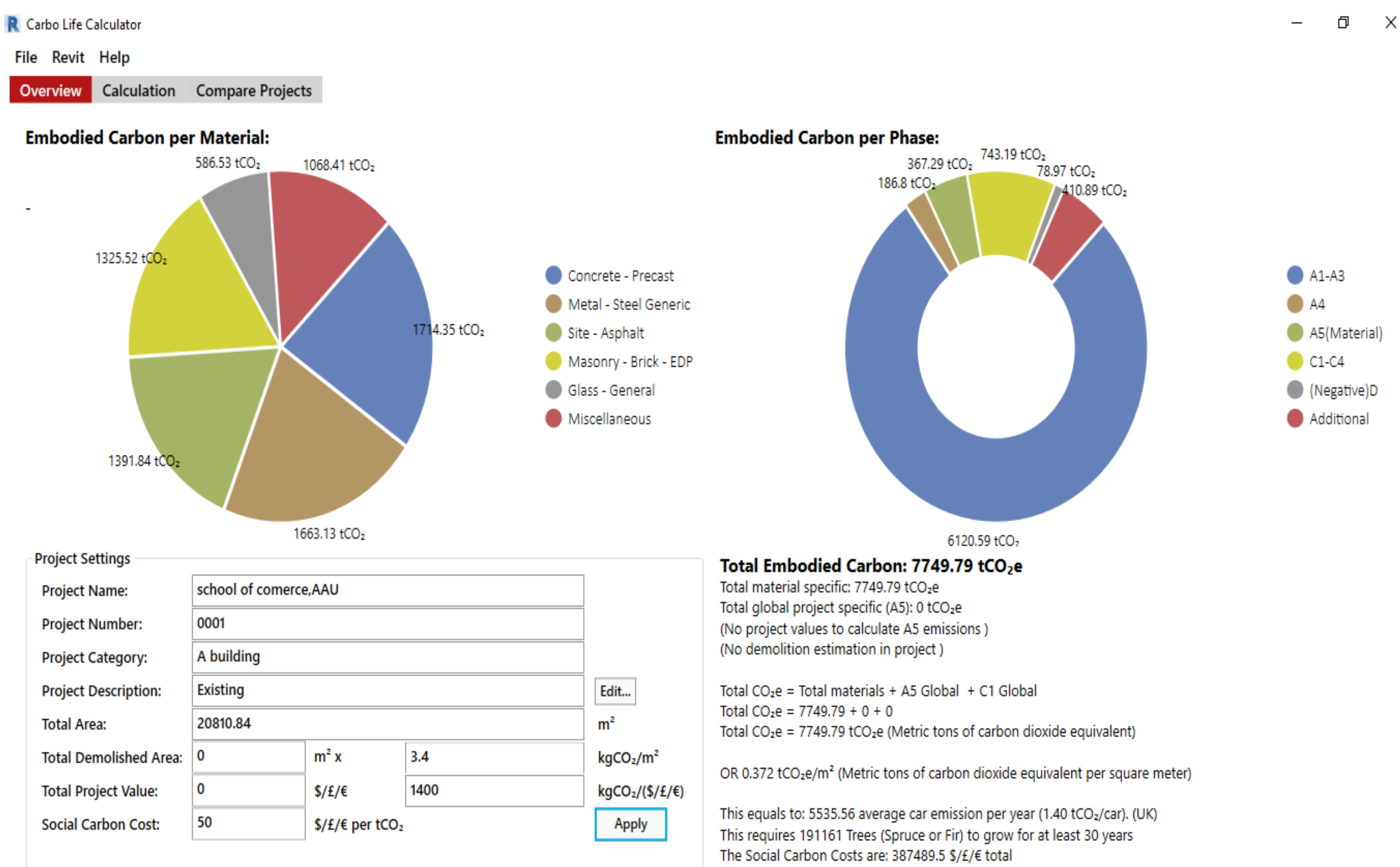

Figure 4-12 Result from AAUSC building BIM model Carbon analysis

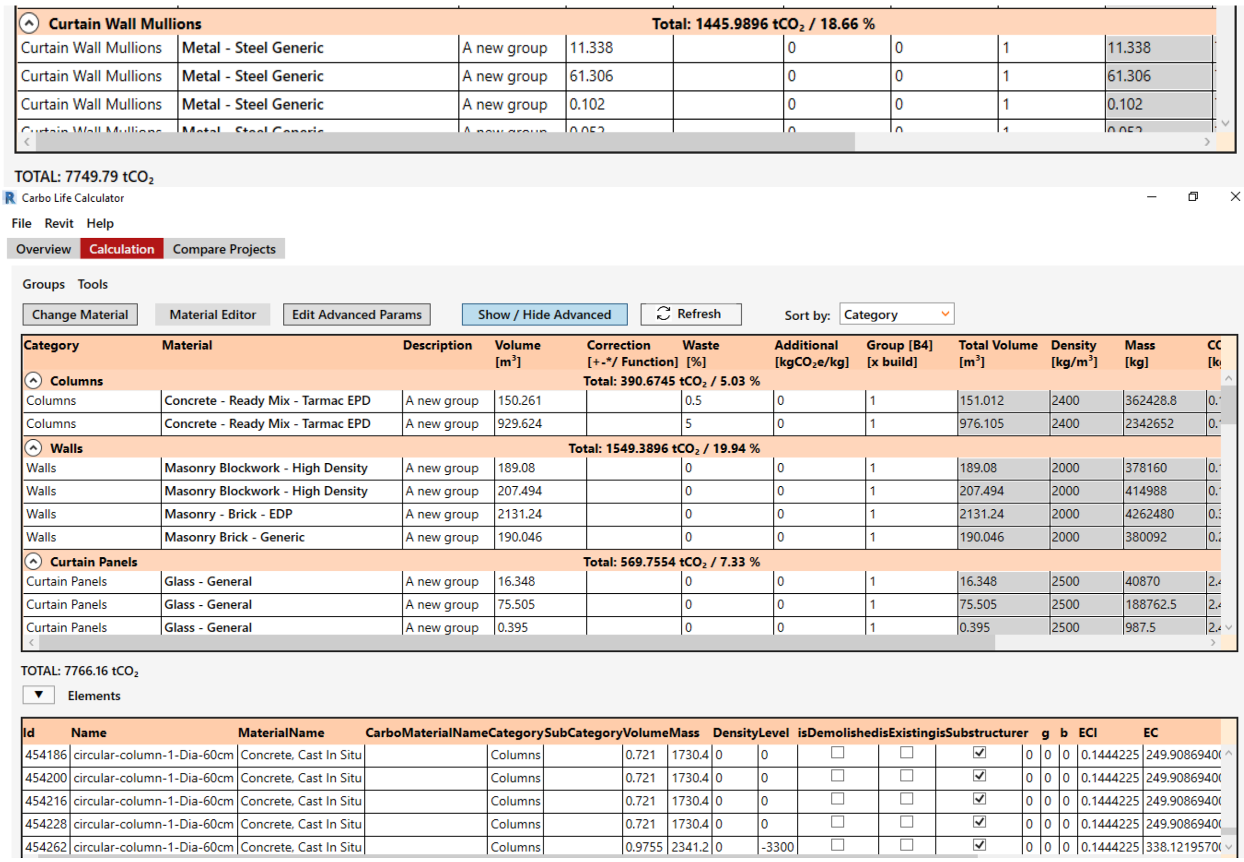

Figure 4-13 Result from AAUSC building BIM model Carbon analysis with a specific element

4.2.9 Efficient use of energy

An energy upgrade to a building might entail replacing low-efficiency bulbs with LEDs(light-emitting diode) the location of the bulbs, characteristics of the fixture, and links to manufacturer sites can be in the model. The model can provide data needed for FM that is useful for maintenance and repair, management of energy, and the commissioning of the building especially if the concerns of FM are articulated at the early stages of design

The efficient use of energy has a direct environmental impact and huge operating costs. Proficiently utilize the energy in a structure. BIM helps by helping the facility manager and the proprietor with the essential data that can be utilized to examine the expense and contrast different choices with diminishing the expense of energy by embracing the most possible and climate cordial alternative. This as well as keeps a persistent track of the presentation over the existence of the structure and different variables like solace, water utilization, power utilization, and so on so that substitute recommendations whenever required can be set in motion.

BIM provides the necessary information and assists in determining the most efficient energy use method at the lowest possible cost. Set the location of the AAU commercial college for this study. Because, as illustrated in the diagram below, weather conditions have a significant impact on energy analysis and analysis settings. Building element material attributes (physical and thermal), project phase, room area, volume, building type, and HVAC system are all needed for BIM energy analysis. as well as determining the unit and union rates of electricity per kilowatt-hour and gas per cubic meter. Below is an example of a BIM model setting.

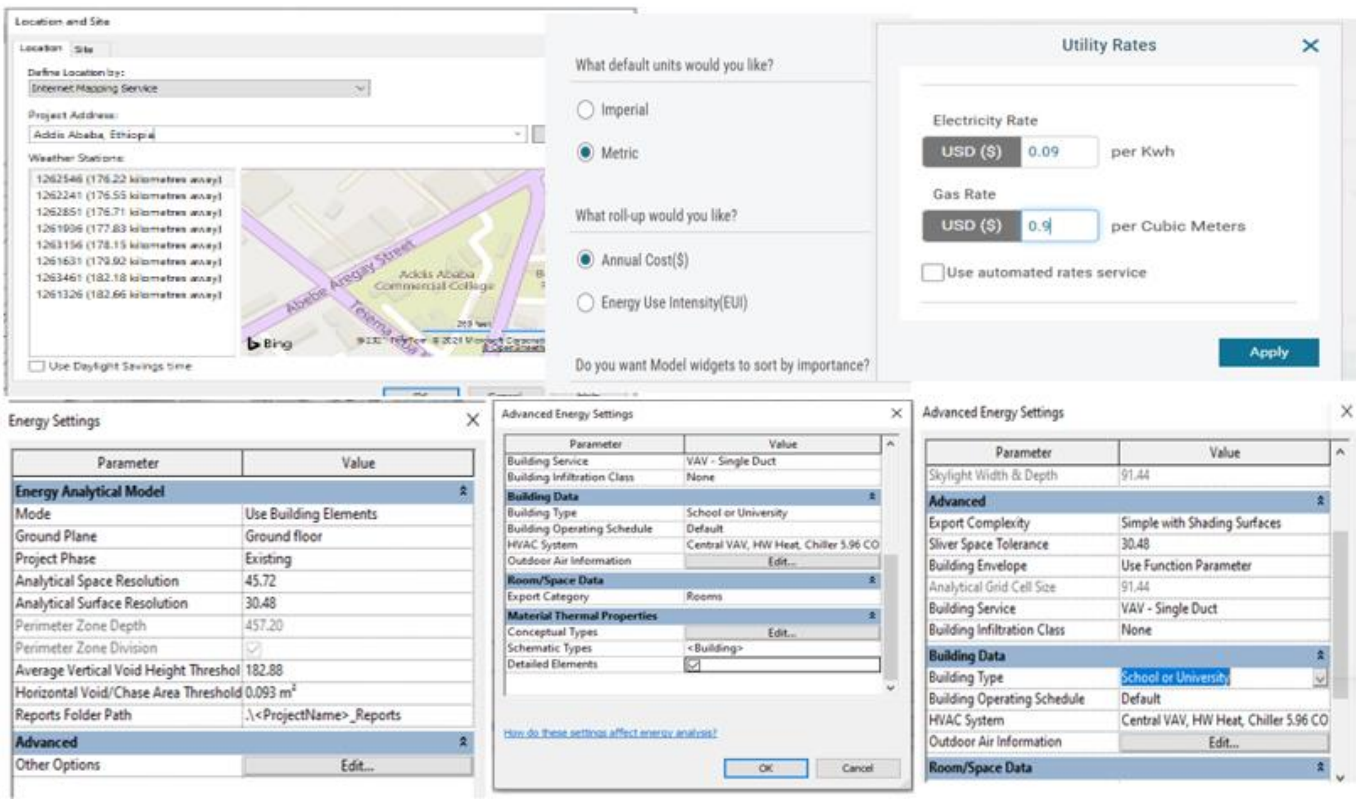

Figure 4-14 Result from AAUSC building BIM model Energy setting requirements

The AUTODESK INSIGHT is a powerful guide to Better Building Energy. and Environmental Performance. According to the study sample BIM model of the AAU commercial school building total cost of energy is cost max 48.7 USD/m2/yr, is cost mean of 16.8 USD/m2/yr, and is cost min 3.5 USD/m2/yr. This information enables the understanding of the optimum operating parameters for energy assets. It also enables management to act immediately in response to events, such as operational malfunctions. It provides ongoing visibility to energy efficiency over time, reducing energy waste. On the other hand, some main factors are affecting the energy analysis such as Project or Building location and Scenarios samples like net-zero target and international architectural 2030 goal.

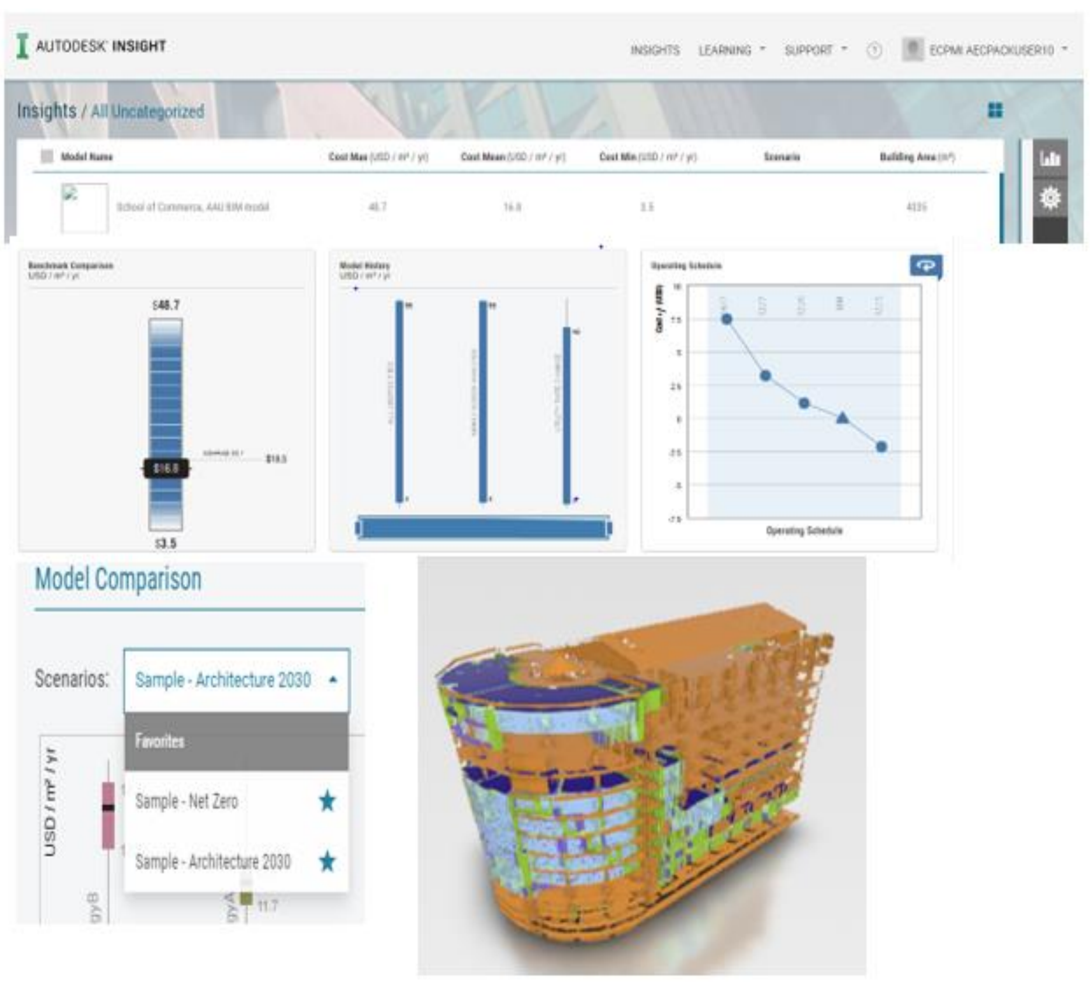

Figure 4-15 Result from AAUSC building BIM model energy analysis

The energy optimization technique allows us to adjust the efficiency and cost; if we increase efficiency, the cost will rise, allowing us to modify and optimize as shown below: the first image shows the lighting efficiency is equal to BIM energy and the energy cost mean is equal to 15.0 m2/yr; the first image shows the lighting efficiency is 20.45w/m2 and the energy cost means is equal to 16.8 m2/yr, and the second image shows the lighting efficiency is equal to BIM energy and the energy cost

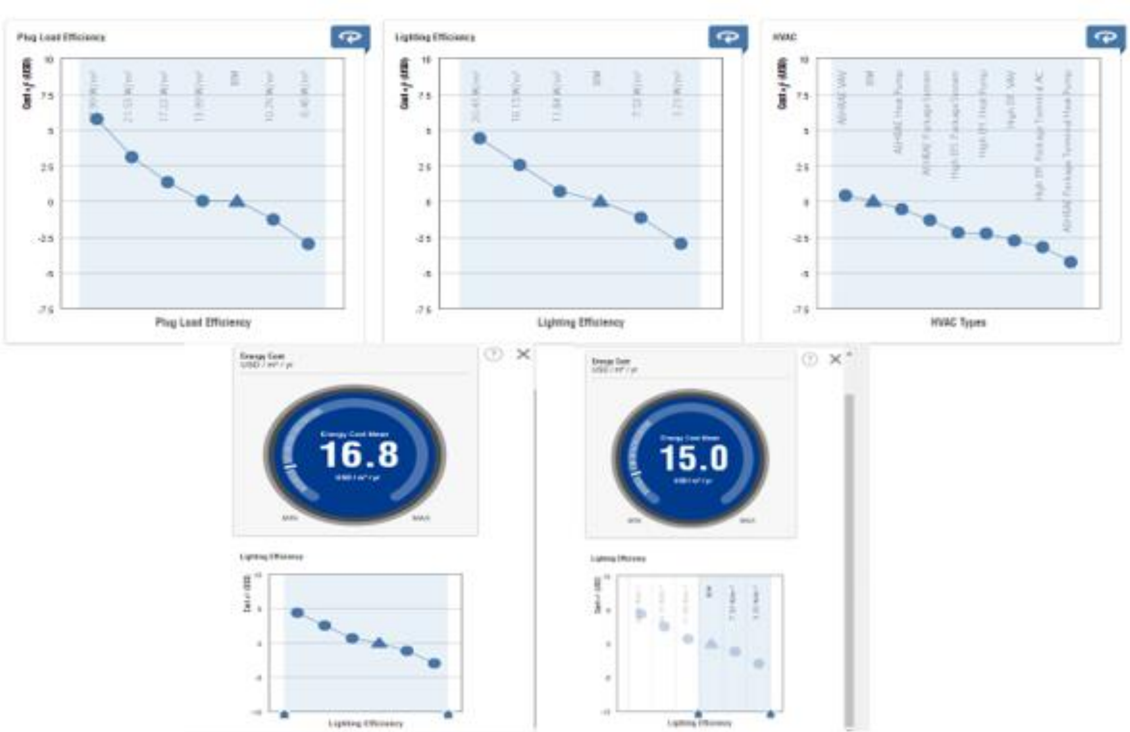

Figure 4-16 Result from AAUSC building BIM model energy optimization technique

4.2.10 Cost and Time

The BIM-based FM approach model can help quickly populate the FM database saving labor time and money, and assets can be effectively managed. The process of gathering crucial information when it comes to maintaining any defect of the facility encountered in the building life cycle process is expensive, as well as the physical activity in the building. As a result, the BIM facility management approach can easily access information needed for decision-making and maintenance, while performing maintenance tasks in a shorter work order, and also reduces the number of facility management staff, which can be costly. This is not only a minimizing advantage but also more reliable information compared to the conventional system, which in turn reduces the risk, which in turn reduces the annual cost of property inventory as organizations are organized and consolidated. In addition, can reduce expenses from energy analytics by reducing the cost of electricity, gas, transportation, Waste, and other related expenses. The information we receive during the BIM Facility Management approach will give us a business process perspective, increase productivity

The cost of a building's life cycle is referred to as its life cycle cost (LCC). During the design phase of a building, using a lower beginning cost index to choose one alternative among others with equivalent performance may not result in the most cost-effective option during the life cycle. The LCC of a building takes into account its initial cost, repair and maintenance costs, running costs, and salvage value at the end of its usable life, among other things.

BIM FM approach give us to calculate life cycle cost during the design and operational stages and the software is add-ins in Revit and we have to set the options like help to establish clear terminology and a common methodology for life-cycle costing to enable the application of LCC techniques and methodology for a wide range of procurement methods, help to improve decision making and evaluation processes at relevant stages of any project, address concerns over uncertainties and risks and improve the confidence in LCC forecasting, make the LCC and the underlying assumptions more transparent and healthy, provide the framework for consistent LCC predictions and performance assessment, which facilitates more robust levels of comparative analysis and cost benchmarking.

And to calculate life cycle cost we have to adjust currency and exchange rate, local construction labor rate, local cost index, discount factor (capital cost) inflation, Energy consumption rate, water consumption, fuel conception (unit cost and quantity) and for all item quantity, unit cost and service life. We can use the result to improve our design and earn valuable certification credits, including LEED, BREEAM, and money others. All calculations within the software are standard-based and follow a strict protocol. What used to take weeks is now possible is now in less than an hour with BIM software which is one click LCA.

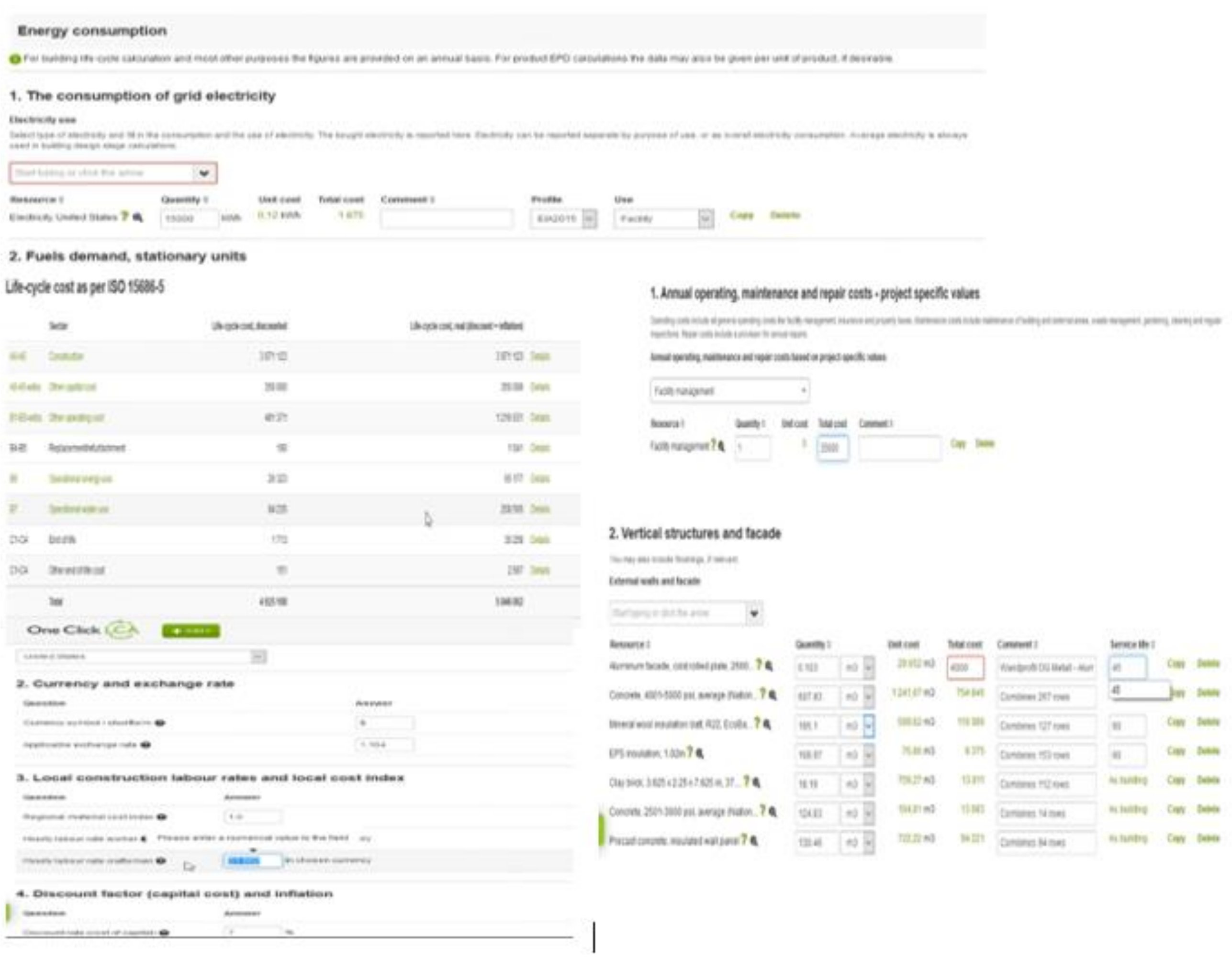

Figure 4-17 BIM life cycle cost analysis setting

Time simulation

Export BIM to 4D simulator Navisworks is used for adding the time to the 3D BIM model for 4D simulations. In this step, components' conditions over time are visualized. The 4D simulation is based on the updated work order data from the CMMS. IFC and NWC are the formats used to export the 3D model from Revit to Navisworks. Autodesk Navisworks NWC file exporter is an external plug-in to export the Revit file in NWC format to Navisworks.

4.2.11 Visualization

BIM approach automates the visualization in 2D, 3D, engineering data, Area, and site plan, Large scale digitalization, and Auto material takeoff

The architectural, structural, and MEP models being separately produced with Autodesk Revit in different versions were combined via Autodesk Navisworks to represent the entire project for visualization, BIM visualization provides accurate geometrical data. It enables the analysis of building proposals and the simulation and benchmark of building performance.

As seen below, we may obtain a get- valve and WC elements from the seventh floor of the AAU BIM model, allowing us to visualize every single element in 3D with its related attributes.BIM facility management approach visualization of the informational model that provides the ability to create building areas sections, access technical facilities information and associate it which the specific location. When a technical receives a message about an issue facility manager can enter a vertical space, and detect it.

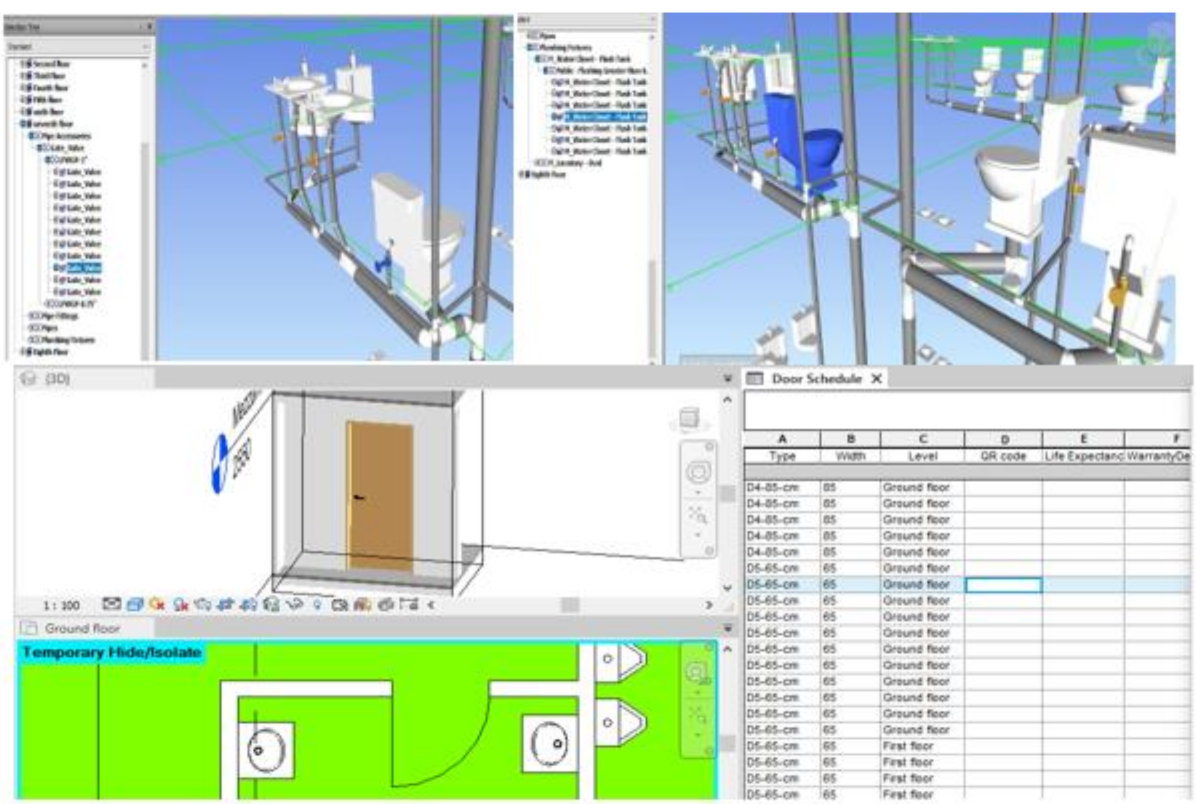

Figure 4-18 Result from AAUSC building BIM model building element with different views and details

Each equipment element has its ID for faster search. Once the technician arrives in a place, he can scan the QR code on the room door with a tablet for virtual room observation. The gyroscope provides the accurate conformity between real and virtual viewing angles. Through the building model, a technician can navigate in space and locate all the MEP equipment by hiding ceilings, walls, or floors. This way failure can be fixed immediately in the meantime, a technician colleague receives the system or component data directly in FM prepared information model.

The BIM-based FM approach help maintenance engineer can use a 3D model to check access to damaged components without having to perform an initial inspection. Every time someone visits it costs several thousand Birr for the security access and radiation checks BIM–based FM approach but how complex is an office building we can take off a couple of ceiling tiles and have a look. Can adds that service contractors are likely to be reluctant to provide a quote for a repair based on information collected from a 3D model. we can produce a price based on a model that might be accurate. But the cost may be affected by price escalation. unless someone was giving you a warranty.

BIM facility management for building condition assessment to assess the complete state of a building. This concept is based on cause-and-effect linkages between unknown elements that influence building conditions. Building elements and systems were rated as high, medium, or low in terms of their condition. The word "high condition," for example, refers to a piece of equipment that is in good operating order and can be used to its full extent for its intended purpose. The figure below shows the BIM model for assessing building conditions. All of the general civil and architectural features, as well as MEP (mechanical, electrical, and plumbing) systems, may be depicted in hierarchical tiers in the model.

This mechanism is used mainly for visualizing construction tasks in 4D. However, in this research, this concept is used for visualizing the components' deterioration conditions over time. Therefore, deterioration condition data is linked to the components. As all the components are interrelated to their corresponding data in the 4D simulator for temporal analysis, the values of the attributes should be unique. For this matter, the year of inspection is added to the condition value. A condition assessment system is primarily used to rank all aspects of an asset according to the amount of repair that is required, as found during an inspection and to produce consistent, relevant, and helpful data.

As shown below BIM FM approach can support the facility management system by identifying the objects with different colors according to their ages and condition within the maintenance history.

Visualization configuration is defined in the Revit BIM tool to visualize the results of the queries. “Colored 3D components” are used as the visualization method in this case. The components with good, fair, or bad conditions can define to become green, yellow, or red, respectively.

A data model is used to link BIM with the building condition risk assessment model. Furthermore, the proposed system architecture streamlines the data transfer process. The system architecture provides a user-friendly decision-making tool, and dealing with uncertainty in building situations may be done using the probabilistic technique, as well as a BIM visualization for building condition and causality analysis.

<Floor Replacement plan>

A	B	C	D	E	F	G	H	I	J	K
Level	Name	Volume	Floor Finish	Area	Floor cost per m2	Floor instalation year	Floor lifecycle	Floor Replacement Year	Floor Replacement Cost	Element condition
Ground floor	STORE	18.01 m³	PVC	8 m²	2500.00	2006	20	2026	$18755.2	Fair
Ground floor	G.T.1	21.96 m³	ceramic	9 m²	2500.00	2006	20	2026	$22873.6	Fair
Ground floor	OPERATOR R	20.61 m³	PVC	9 m²	3000.00	2006	17	2023	$25741.8	Fair
Ground floor	CHANGING R	27.05 m³	PVC	11 m²	3000.00	2006	17	2023	$33816.0	Fair
Ground floor	STORE	28.21 m³	PVC	12 m²	3000.00	2006	17	2023	$35260.2	Fair
Ground floor	PHOTOCOPY	49.95 m³	PVC	13 m²	3000.00	2006	17	2023	$40217.6	Fair
Ground floor	KITCHEN	43.74 m³	ceramic	18 m²	3000.00	2006	17	2023	$54501.1	Bad
Ground floor	Security Roo	50.14 m³	PVC	21 m²	3000.00	2006	17	2023	$62674.6	Bad
Ground floor	BOOKSHOP	113.23 m³	granite	23 m²	3000.00	2006	17	2023	$69484.3	Fair
Ground floor	SHOP	104.66 m³	PVC	34 m²	3000.00	2006	15	2021	$103148.1	Bad
Ground floor	SHOP	145.09 m³	PVC	40 m²	3000.00	2006	15	2021	$119027.9	Bad
Ground floor	SHOP	146.56 m³	PVC	40 m²	3000.00	2006	15	2021	$119186.2	Bad
Ground floor	SHOP	151.31 m³	PVC	41 m²	3000.00	2006	15	2021	$123015.5	Bad
Ground floor	SHOP	151.31 m³	PVC	41 m²	3000.00	2006	15	2021	$123015.5	Bad
Ground floor	SHOP	151.34 m³	PVC	41 m²	2500.00	2006	20	2026	$102514.8	Good
Ground floor	SHOP	215.67 m³	PVC	62 m²	2500.00	2006	20	2026	$154838.9	Good
Ground floor	STUDENT CA	495.13 m³	PVC	124 m²	2500.00	2006	20	2026	$309457.2	Good
Ground floor	STUDENT LO	422.73 m³	PVC	141 m²	2500.00	2006	20	2026	$351871.0	Good
Ground floor	KITCHEN	694.60 m³	ceramic	149 m²	2000.00	2006	20	2026	$297731.4	Good
Ground floor	STUDENT CA	962.97 m³	granite	209 m²	2500.00	2006	15	2021	$522480.3	Bad
Ground floor	lobby	1549.57 m³	granite	312 m²	2500.00	2006	15	2021	$780428.5	Bad
44										

Figure 4-19 Result from AAUSC building BIM model Floor replacement plan

4.2.11 flowcharts of the BIM FM approach

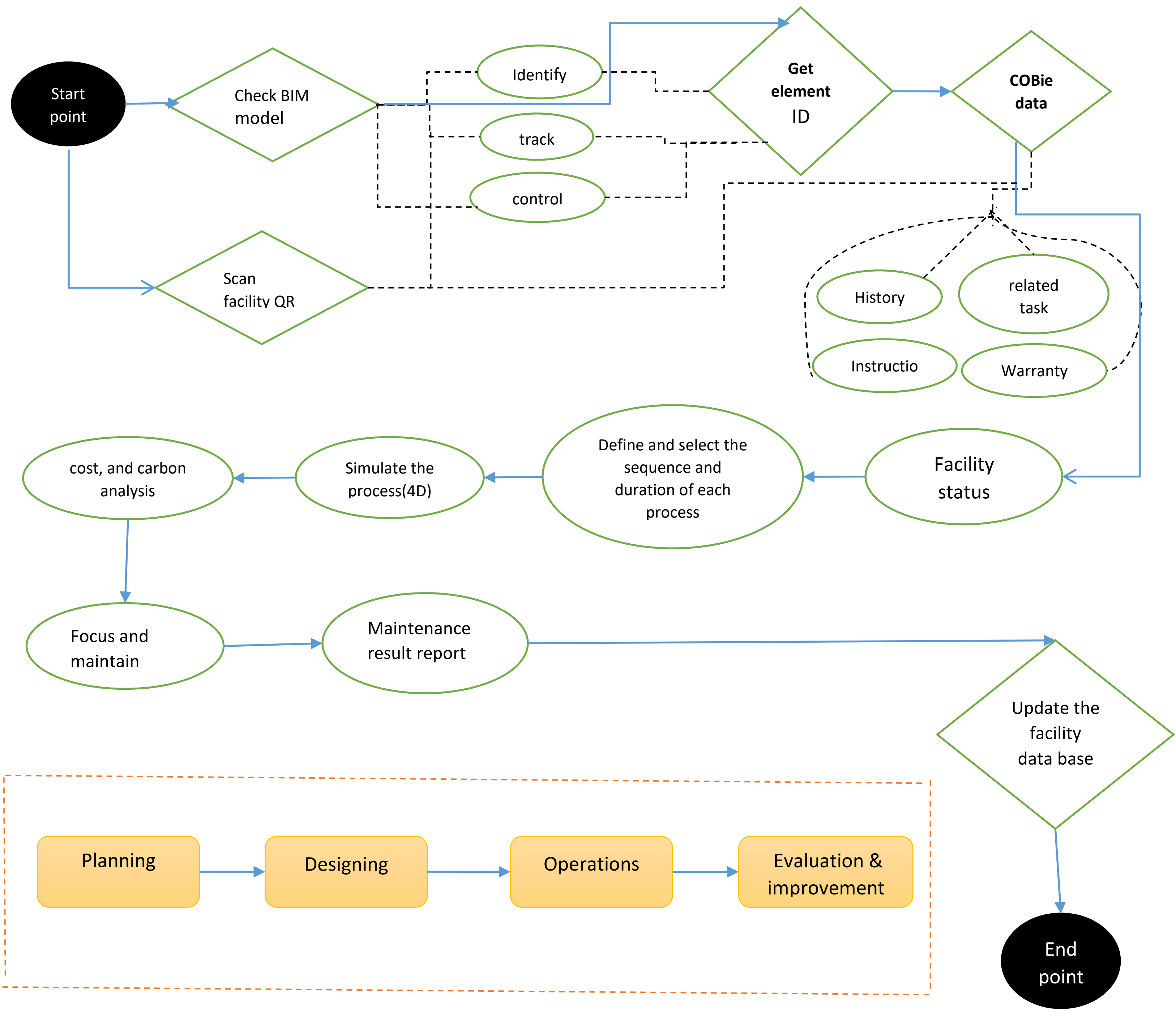

Figure 4-20 BIM -Based Facility management work flow

BIM -Based Facility management workflow chart

The BIM FM Approach process flow chart for facility management is developed in this study. And it illustrates how employees may improve the effectiveness of facility information tracking and sharing. The 3D model, as well as the BIM approach for tracking and managing assets graphically, is essential for facility assets, as it helps maximize information value while minimizing information loss. Project participants can get an overview of prior and present facility assets at a given facility and manage facilities by using the 3D facility asset. Moreover, during the maintenance phase, facility employees can track and obtain the most recent information for any basic information, conditions, or maintenance. The web-based 3D environment allows maintenance information to be updated quickly and made public.

The flow chart that can be used to demonstrate the BIM-based facility management process is presented in this study, which shows the process from start to finish. The first step is to look for, identify, and control the part you are looking for, and then begin to examine the information associated with the process by identifying the element identification number: Then, once we have a clear idea about the element, we will list the tasks that need to be done. We focus on getting the repairs done. After the repair is done, will use the repair report to update the elemental information, which will allow the next repair process to make sustainable and also make the repair process more efficient and data-based. As a result, they generally offer the following benefits.

- Identifying, tracking, controlling, and managing facility assets should be made easier.
- Easily answer the "Where" (Location) and "What" (attributes, history, specs, warranty details...) of Facility components (Assets, Systems, Spaces), augmented with real-time performance data from Work Orders.
- The facility personnel may immediately discover the location of facilities, monitor the state of facility maintenance, and analyze the relevant files of a facility using the BIM imported mode. As a result, when facility managers need to take action or make a decision, the BIM imported mode can be more useful than the traditional model.
- The facility staff may increase the effectiveness of facility maintenance and management work by integrating the BIM model with associated information on facility maintenance.

- By providing owners with an integrated database and rapid access to location and asset information through an easy-to-navigate web-based 2D/3D-BIM interface, it extends the value of BIM [Building Information Modeling] throughout the Buildings Lifecycle.
- It can be used as BIM for FM middleware, bridging the gap between design and construction and operations/facilities management. Building Information Modeling, Building Automation Systems, and Work Management data from CMMS software are all combined into a single platform.
- Some services, such as creating reports and accessing BIM models on the web, might be useful in managing facilities. When the facilities models have been saved with maintenance information and updated automatically, the "Build Report" function can create a report of facilities management information.
- The facility personnel may immediately discover the location of facilities, monitor the state of facility maintenance, and analyze the relevant files of a facility using the BIM imported mode. As a result, when facility managers need to take action or make a decision, the BIM imported mode can be more useful than the traditional model.
- Facilities management planning can help facility managers understand task schedules, task times, and task maintenance, staff. The BIM imported mode improved facility management efficiency and convenience while also reducing schedule management issues caused by human factors.

4.3. Comparation between BIM-based FM and Traditional FM Approach

The research was undertaken based on the case study of a selected building to evaluate the conventional FM approach and BIM-based FM Approach according to the evaluation result the research got some comparison results related to the previously selected variables

Information management (data)

BIM-based FM data information is a fully digital system but the traditional FM has a paperwork format and some excel files. The data sharing and exchanging in BIM-based FM is in degital form each instance in the BIM model was identified and the available information and one source of the truth which is Get up-to-date documentation on all building systems; while it is traditional FM it is paper-based.

In the BIM FM approach, basic information and associated data are linked with the graphical and non-graphical data graphical data such as geometric BIM model in 3D,2D, and non-graphical data COBie data and also these data are Well-structured, standard, and detailed and accurate data but in the conventional FM approach providing basic information via CAD drawings in this approach, they cannot be easily linked to building facilities and as-built verification and updating procedures largely involve time-consuming on-site surveys. The use of reliable information management infrastructure can significantly improve FM processes. And Information transfer Handy by conventional and Search for information in documents and Web-based database and search the database with one click in BIM-based FM approach.

By using the BIM model to undertake real-time monitoring of the equipment's operating parameters, the user may determine if the equipment is running smoothly based on the associated information. After accumulating long-term data, an operation organization can create an equipment maintenance database to increase management levels, improve building safety performance, and limit the occurrence of emergencies during the facility's operation stage.

In terms of information presentation, the BIM FM approach uses a 3D visual model with external related information files such as user manuals, warranties, work orders, and preventive maintenance manuals, whereas the traditional approach uses 2D drawings with related files stored in file cabinets in paper form. It is time-consuming to search for information on paper reports.

The BIM import option not only makes facility information transparent, but it also improves it. Furthermore, BIM integrates 3D model-based building design by adding external aspects such as facility location, facility descriptions, and facility conditions into a database that serves as the single integrated source for all facility-related data. The BIM model of a facility can link the associated files of the facility with the help of an external program, allowing users to gain a more comprehensive grasp of the facility information and successfully enhancing the integrity of BIM in FM. After the maintenance task is completed, the related information for facilities maintenance is updated to the facility model using this method.

BIM FM approach follows QR code mapping to manage the building elements by using mapped with bar code but the conventional FM approach demands manual efforts and paper-based inspections and which is unreliable, ineffective, and time-consuming, and poor access to accurate information on time, lacks an integrated view of multiple areas for decision support, and distorted understanding of lifecycle problems

Space management

FM personnel must maintain a representation of facilities with the attributes of each space, such as space numbers, descriptions, boundaries, areas (gross, assignable, and no assignable), volume, intended use, and actual status, to efficiently manage space during the occupancy stage, forecast space requirements, assign space, and streamline the move process. Traditionally, CAD files have been used to manage space, with identifiers being used to retrieve and show space attributes. The traditional approach has two major flaws inconsistent name conventions and time-consuming attribute modifications. Building information modeling can help identify underutilized areas, estimate space requirements, simulate space analysis, manage the move process, and compare actual and projected space utilization by visualizing space and hosting space properties for fast access. This data could be utilized for a variety of purposes, including the effective compilation and management of office schedules, the precise identification of spaces' varied uses, and the optimal assignment and control of spaces and assets for events. In addition, BIM allows facility managers to visualize and track assets throughout time as they move from one location to another.

Effective space management improves not just the physical usage of spaces and related assets, but also the productivity of the people who work in those areas. Using a BIM model for space management, the facilities team may review current space consumption, consider prospective adjustments, and efficiently prepare for future demands. Having accurate and detailed space information is highly beneficial when planning renovation projects because some building segments may stay occupied and change over the construction process.

Operation and Maintenance

BIM-based FM Implement preventive maintenance programs which are Preventive Maintenance Approach Scheduling aims at streamlining the process of maintenance and develop a program by entering the information about the asset, and building structure and arranging the maintenance, repair, and replacement activities in advance depending on the warranty, service requirements, and maintenance manuals, implement a monitoring program that tracks and documents building systems performance. while the conventional approach follows the corrective maintenance approach, manually populated maintenance records of each element and depending on the defect. In this way, more than half the maintenance resources and activities of a typical facility are respected as reactive maintenance and traditional and paper-based inspections potentially result in inefficient maintenance actions. Effective facilities maintenance requires managing a large amount of information along with a process that includes gathering, storing, and presenting data. BIM Approach Ensure that up-to-date operational manuals are available.

Visualization

BIM FM approach Gating a fair understanding of assets, floor plan, space requirement, etc., facility professionals can try and reduce the wastage of space leading to an extraordinary reduction in real estate expenses. BIM tools are capable of simulating and predicting different parameters that can be utilized by FM professionals.FM requires a robust database linked to the visualization environment for identifying the items within facilities. presented an approach to 3D visualization of BIM models in a conventional Web browser.

BIM models can provide data-rich 2D and 3D floor plan views, as well as visual filters that can be used to track patterns and problem areas in facilities. The condition of the facility element is connected to the work order system to track FM data in the facility and tie it to rooms and spaces in the building but in the traditional fashion of 3D and 2D drawings with no related information and data. but the traditional facility management approach have lack interoperability and visualization capabilities and fails to support FM needs.

Time visualization

BIM can provide 3D modeling for a virtual simulation of the building lifecycle in an integrated process. checked the time factor models, and used various colors to distinguish four types of maintenance conditions in the BIM model as follows: maintenance on schedule, completed maintenance, delayed maintenance, and no need for maintenance but not applicable in the conventional FM approach. The possibility of inspection in the conventional FM approach is Time-consuming but in The BIM approach, it is Fast.

Technology

In the conventional FM, Limited use of advanced technologies but in the BIM FM approach Widespread use of advanced technologies such as Networking Systems, Software, Hardware, and BIM models can be viewed on a tablet/mobile device during future inspections or other site visits and Fully digitalized.

Sustainability and Energy

BIM can improve the measurement of energy use and waste. Then BIM can assist facility managers in analyzing and comparing various energy alternatives to reduce environmental impacts and operating expenses. An approach based on BIM and FM The BIM model aids in the completion of energy and sustainability assessments. Building Energy Facility electrical/gas/oil/water bulling evaluation and reporting energy-efficient efficient project planning and Building information modeling could also be used to track historical energy usage for each room/zone/occupant, as well as to associate historical data with visual objects in BIM, allowing energy consumption behavior to be analyzed and predicted, as well as energy-related budgeting and conservation activities to be supported.

To wrap up all comparison studies Instead of using the traditional FM approach, BIM models incorporate building design data, as well as life expectancy and replacement costs. The BIM FM approach helps the facility manager or owner in evaluating the benefits of investing in materials and technologies that may have a one-time cost but have a long-term effect that provides better payback over the building's lifecycle. BIM-based FM software aims to support building inspection operations, make them more efficient thanks to its extensive database, and allow the user to identify anomalies in construction components directly within the BIM model, and associate them with probable causes, recommended solutions, and repair methods, as well as related photographs. Visualization A BIM model also aids owners in visualizing the building's spatial organization as well as understanding the sequence of construction activities and project length. Information management In the BIM facility management approach all building components, including architectural, structural, mechanical, electrical, plumbing, and fire prevention systems, as well as a site plan with safety accesses, are accurately modeled as-built. BIM is more helpful than the conventional FM approach in the BIM FM process since it provides a thorough insight into the building's current space utilization. Constructing mechanical equipment information included in BIM models can be useful in building a database for continuous preventive maintenance. Reconstruction & Renovation As-built BIM model of the building provides a reference and basis for future planning of retrofits or renovation or refurbishment. Organizations can manage space like the area available to lease, regulate rental income, minimize vacancy, and achieve large reductions in real estate expenses by integrating building data with BIM. In response to these statuses, various information and communication technologies have been introduced to the building industry to address information management issues, enhance communication and collaboration, and acquire advanced practices.

4.3.2 Enhancing factors BIM facility management

❖ Enhance Lifecycle Management

The lifecycle data of the building element is very crucial as it is required to forecast when it needs to be replaced and how much capital of improvement will cost. Building design data and their life expectancy and replacement cost are embedded in BIM models rather than the conventional FM approach one. BIM FM approach helps the facility manager or the owner to analyze the benefits of investing in materials and systems that may have a one-time cost but it has a long-lasting effect that gives better payback over the lifecycle of the building. Contractors and owners are well informed about the replacement cost, and the life expectancy of the materials that they will be investing in which helps them to make a well-informed decision and avoid any futile overhead expenses.

BIM-based software aims to support building inspection operations, make them more efficient thanks to its extensive database, and allow the user to identify anomalies in construction components directly within the BIM model, and associate them with probable causes, recommended solutions, and repair methods, as well as related photographs.

Visualization

A BIM model also aids owners in visualizing the building's spatial organization as well as understanding the sequence of construction activities and project length (Joannides et al. 2012). Motamedi et al. (2014) used BIM visualization capabilities to give FM technicians the tools they needed to solve problems using their cognitive and perceptual reasoning.

Information management

In the BIM facility management approach all building components, including architectural, structural, mechanical, electrical, plumbing, and fire prevention systems, as well as a site plan with safety accesses, are accurately modeled as-built. and have accurate as-built models for main utility lines to buildings, accurate telecommunication representations, including proper placement and annotation of outlets, labeled, annotated, and colored spaces under FM guidelines, which should include standards for space type, description, and usage, among other things, accurate clearance requirements for mechanical, electrical, and plumbing (MEP) equipment to ensure maintainability based on technical specifications and logical object tree organization to manage the many components inside the model. This information helps the facility management process to be more efficient. Generaly ensure an integrated digital process that provides coordinated, reliable, and shareable data at all stages of the project.

And also, facility managers can aim to reduce space wastage by getting a thorough grasp of the asset, floor design, and space requirement, among other things, resulting in a significant reduction in real estate expenses. BIM's information regarding floor area and rooms is the foundation for how space is managed. BIM is more helpful than the conventional FM approach in the BIM FM process since it provides a thorough insight into the building's current space utilization. The facility manager can use the data to optimize the space by planning, tracking, analyzing, and controlling it. As a result, the building's performance is as efficient as possible. Constructing mechanical equipment information included in BIM models can be useful in building a database for continuous preventive maintenance.

Operation and maintenance

BIM promotes Preventative Maintenance in a term that refers to the process of By entering information about the asset, building structure (walls, roofs, floors, etc.), mechanical, electrical, and plumbing components, scheduling seeks to streamline the maintenance process and generate a program. BIM can be used to collect this data. Facility managers can plan maintenance, repair, and replacement actions ahead of time using this information, based on warranty, service needs, and maintenance manuals. This valuable information about building equipment is kept in BIM models, which can save months by automating the creation of maintenance records for each unit.

Efficient use of energy

Energy efficiency has a direct influence on the environment as well as a high lifetime cost. It is critical to use energy as efficiently as possible in a structure. BIM supports facility managers and owners by giving critical information for analyzing and comparing various options to save energy expenditures by selecting the most feasible and environmentally friendly option. Not only that, but they can also track the building's performance over time, as well as other factors like comfort, water use, and electricity consumption. so that, if necessary, alternate proposals can be implemented BIM provides the necessary data and aids in the formulation of the most cost-effective energy consumption strategy.

Reconstruction & Renovation

As-built BIM model of the building provides a reference and basis for future planning of retrofits or renovation or refurbishment. BIM helps the Facility manager and owners to settle on a superior educated choice as they are very much aware of the current state of the structure. This simplifies the interaction and limits cost impacts. BIM comprises of data on each component of the structure exhaustively. It diminishes the expense of the intricacy of building remodel and retrofits projects by giving such itemized and exact information. This just kills the chance of any interdisciplinary MEP (Mechanical, Electrical, Plumbing) conflict that typically happens to bring about weighty harm and cost to the structure.

Generally Improving the data collection procedure to take preventive maintenance measures. It employs BIM as a data store, aggregating and presenting maintenance-related data in the event of failures or problems. Using energy performance to locate difficulties within a facility. Obtaining relevant information about a given location to determine the source of poor performance. Investigating the impact of occupant activities on building systems and allowing for such considerations when locating system issues. And Organizations can manage space like the area available to lease, regulate rental income, minimize vacancy, and achieve large reductions in real estate expenses by integrating building data with BIM.

In response to these statuses, various information and communication technologies (ICTs) have been introduced to the building industry to address information management issues, enhance communication and collaboration, and acquire advanced practices

In general, BIM allows facility managers to make informed decisions about space utilization, floor layout, equipment and asset maintenance, energy consumption, and cost reductions throughout the facility's lifecycle. so that the BIM Approach enhances the facility management more than the conventional facility management approach.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This chapter wraps up the research by summarizing the most important findings concerning the research goals and questions, as well as their worth and significance. It will also examine the study's limitations and make recommendations for future research.

The traditional facility management approach was evaluated so that the conventional way has key failings: inconsistent name conventions, a time-consuming and expensive approach, and a strategy that generally follows the Corrective Maintenance strategy. Furthermore, conventional FM approaches have shortcomings in terms of visualization of building elements, information management systems, operation and maintenance, energy efficiency, and reconstruction and renovation.

The BIM FM facilities management strategy ensures that inaccuracy and incomplete data are reduced. When it comes to entering data into FM tools, it also saves manpower, money, and time. BIM ensures that the building and its facilities can be maintained. This promotes energy efficiency, low lifecycle costs, and long-term reliability. In facility management, BIM helps in predicting various maintenance and operating requirements. Managers can get a clear picture of ongoing maintenance costs and see when equipment has to be serviced. In the age of BIM, the as-built documentation received at handover is one of the most powerful tools for facility management. BIM Facility Management ensures that the building works smoothly in general. Facility Management or Operation Management ensures the building's performance. The operational phase of the building is predicted to be the most costly of the entire life cycle. As a result, making an informed decision to decrease costs is crucial. BIM is particularly useful since it helps managers to maintain control over the information and documents related to the building.

BIM FM approach uses a 3D visual model with external related information files such as user manuals, warranties, work orders, and preventive maintenance manuals with one click in and BIM integrates 3D model-based building design by adding external aspects such as facility location, facility descriptions, and facility conditions into a database that serves as the single integrated source for all facility-related data. By visualizing space and hosting space attributes for quick access, building information modeling can help identify underutilized regions, estimate space requirements, simulate space analyses, manage the move process, and compare actual and predicted space utilization. Effective space management increases not only the actual use of areas but also the efficiency of those places. and related assets, as well as the productivity of employees who work in those fields. FM using BIM Implement a preventative maintenance strategy to make facility management more efficient.

The study's other goals include comparing both FM approaches and demonstrating how the BIM FM approach improves FM activities so the BIM FM approach and the conventional FM approach were evaluated in this study as a result. BIM FM approach has superior Lifecycle data management, which makes facility management decisions more accurate and appropriate since they are based on accurate data, and it creates an efficient operation and maintenance system.

BIM FM approach is more efficient when it comes to space planning. The difference is that a BIM model is required for constantly updated dataset libraries. The value of BIM is proportional to the quality of model upkeep. Virtual reality and the BIM database can be combined to create a single all-in-one tool. This can help FM with visual space planning and data storage for operations and maintenance. In terms of visualization, the BIM FM approach uses additional approaches and can view every building part along with its associated data. In the BIM FM approach, the information management system is also excellent. And the BIM FM approach to energy efficiency gives the essential data and assists in the creation of the most cost-effective energy consumption strategy. Throughout the lifecycle of a facility, BIM allows facility managers to make informed decisions about space usage, floor layout, equipment and asset maintenance, energy consumption, and cost reductions. as a result of this, the BIM Approach improves facility management more than the traditional facility management approach.

The BIM FM approach was discovered to be better and more efficient than the conventional FM approach in this study. According to other research, the cost of operation in the construction sector is much more than the cost of construction, and it is apparent that our country, Ethiopia, is creating and maintaining a vast number of buildings in our universities. As a result, it will be extremely profitable for us to implement the BMI FM approach, which is important for our country, at various universities, so further research is needed on how to adopt and implement the BIM-based FM approach in the future.

Recommendation

Based on the findings and conclusion presented, the following recommendations are suggested:-

- The crucial step an AAU school of commerce facility management unit can do it is to consider digital transformation. The advantages of digitizing facility data have been demonstrated. Every facility management data should be organized in a computerized system at Addis Ababa University's School of Commerce.
- The benefits of space management have been presented in the study, and it is also the best optimization technique, thus the Addis Ababa University School of commerce facility management unit should use space management techniques following the BIM FM approach.
- According to the study, carbon emissions have a huge impact on the global atmosphere, and the BIM facility management strategy is working to tackle this problem. Addis Ababa University School of commerce facility management unit should reduce its carbon footprint by applying the BIM facility approach.
- The BIM facility management approach helps in the implementation of a preventative maintenance strategy. Data on sanitary systems, electrical networks, heating and ventilation systems, structural strength, roof coverage, lifts, doors, and windows is collected through building condition evaluations. It shows which repairs need to be done straight away to avoid harmful situations (such as repairing bad electrical connections or faulty fixtures or replacing broken windows). Although the AAU FM unit assessing the building's status once a year is a good practice, it does not help with proper preventative maintenance implementation. By entering data into a database and identifying and monitoring the state and status of each asset, the AAU FM unit should improve this technique to the BIM facility management approach to effectively perform preventative maintenance.
- The energy analysis and optimization technique of the BIM FM approach should be implemented by the Addis Ababa university school of commerce Facility Management unit as one of the key elements of the BIM facility management outlined in this study.
- During the construction and operational phases of the building, the Addis Ababa university school of commerce facility management unit shall organize lifetime information on the

architectural, structural, sanitary, electrical, and mechanical components of the building. This data is entered into a computer system, and as this study has shown, all of this data is required for facility management.

- In general, as stated in the conclusion section of this study, conventional facility management approaches have numerous issues with regard to information management, space management, carbon and energy analysis, visualization, and preventive maintenance strategy, so the Addis Ababa University School of Commerce facility management unit should implement BIM facility management approach to address these issues.
- Even though BIM in facilities management has numerous benefits, as demonstrated in this study, this researcher recommends that Addis Ababa University School of Commerce conduct more research on BIM facility management adoption and implementation, as well as BIM facility management adoption barriers.

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APPENDIX

Appendix A Questionnaires

JIMMA UNIVERSITY:- Institute of Technology

Research topic

THE STUDY OF A COMPARATIVE ASSESSMENT OF FACILITY MANAGEMENT USING CONVENTIONAL AND BUILDING INFORMATION MODELING APPROACH

Questionnaire

Dear /Sir

Dear Participant, I am a graduate student at Jimma University and currently I am conducting a research for the completion of my masters in Construction Engineering and Management sincerely request your involvement and assistance in the STUDY OF A COMPARATIVE ASSESSMENT OF FACILITY MANAGEMENT USING CONVENTIONAL AND BUILDING INFORMATION MODELING APPROACH by responding to the questionnaire. Any information you could provide would be really useful.

General information

The main objective of this research is to compare facility management using traditional and building information modeling approaches in order to determine the benefits of BIM in FM.

The intention of the survey

The purpose of this survey is to obtain necessary data for the consumption of research paper in JIMMA UNIVERSITY INSTITUTE OF TECHNOLOGY DEPARTMENT OF CIVIL ENGINEERING MSc. IN CONSTRUCTION ENGINEERING AND MANAGEMENT. All data's find from the survey will be kept, and only used for academic purpose.

The attached questionnaires are derived based on literature review. You can tick, write in words or rank when it is required on the space provided at you convince to the questionnaire.

The responders' identities will be kept anonymous. I'd want to express my gratitude for your assistance in filling out the questionnaire and for taking the time to do so.

If you have any questions regarding this research study, you may contact me at E-mail: zkid.mamo12@gmail.com Tel 0911684503 **Thank you so much for your cooperation**

Section1. General Profile of the Respondent

1. Age of category

   a. Below 30 ☐ b. 30-40 ☐ c. 40-50 ☐ d. above 50 ☐

2. Sex: a. Male ☐ b. Female ☐
3. Job Category

   a. Vice President for Administration and Student Services ☐ b. Facility ☐

   c. Management ☐ d. Director Technician ☐ e. Facility Management Expert ☐

4. Educational status

   a. Diploma/TVET b. BA/BSc c. MA/MSc d. Others; specify

5. Work Experience

   a. 0–5 years b. 6 –10 years c. 11–15 years d. More than 15 year

Section 2 Questions about Conventional facility management approach

2.1 How would you rank your university's facility management [FM]?

NO	FM services	Level of Implementation		
		Low	Medium	High
1	Space management			
2	Information management			
3	Maintenance of equipment inside the building and building systems			
4	Asset lifecycle management			
5	Focus on sustainability			
6	Digital transformation and automation			
7	Focus on FM at design stage			
	FM services	**Level of condition**		
		Good	**Moderate**	**poor**
1	Condition and appearance of the building's exterior			
2	Condition and appearance of the building's interior			

3	Condition of lighting and electrical systems of the building			

2.2 General question about your facility management [FM]?

No	Questions	Yes	No	I do not know
Questions about Building operation and maintenance				
1	Is your university's facility management unit or department well-organized?			
2	Do you assess the condition of the building annually or semiannually?			
2	Do you evaluate structural part safety of the facility?			
Questions about information management				
1	Does your university use data bases for facility management purpose?			
2	Do you have detail records of all university buildings?			
3	Do you have detail records of all university buildings?			
4	Do you have recorded data about all facilities in your universities?			
5	Do you have warranty information on your FM record?			
6	Do you have contact person address and manufacturer company information on your FM record?			
Questions about Building sustainability Energy				
1	Do you have recorded data about your facility Energy consumption and carbon Emission?			
2	Do you have material selection comparation criteria and technique?			
3	As a university, do you have a sustainability plan?			
4	Do you have any sustainability standards?			
5	Do you have west mineralization technique?			
Questions about Building operation and maintenance cost and time.				
1	Do you analyze the Whole life cycle cost of the facility?			
2	Do you have Put a preventive maintenance plan?			

3	Do you use FM software to make your job easier, and more productive (Automation)?			
4	Do you have energy efficiency as an investment strategy?			
5	Do you Analyze your current energy consumption?			
6	Do you perform timely inspection helps in detecting minor defects which will turn into major problems if not addressed early?			
Questions about Building visualization				
1	Do you visualize every building facility and the components with a 3D model regards to the information of the component (data)?			
2	Do you visualize Energy Simulation of your Building facility?			
3	Do you visualize Lifecycle cost Simulation of your Building facility?			
4	Do you have a visual representation of the location of the building components with real-time data?			

What type of building maintenance is practiced in your university?

Preventive maintenance ☐ Routine maintenance ☐ Corrective maintenance ☐

IF any Other

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In your university, what data management or data structure is used for facility management?

Computerized Maintenance Management System ☐ b. Building maintenance control ☐

c. system CAD for the documentation of drawings ☐ d. BIM- COBie Facility management ☐

IF any Other

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Your databases are server based or cloud based?

Server based ☐ b. Cloud based ☐

IF any Other

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Is there any record of your universities' facilities?

As built drawings ☐ b. Maintenance and operation manual ☐ c. Both ☐ d. None ☐

IF any Other

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Which types of maintenance do you perform?

Preventive maintenance ☐ b. Scheduled maintenance ☐ c. Corrective maintenance ☐ d. condition-based maintenance ☐ e. emergency/unforeseen maintenance ☐ f. predictive maintenance ☐ g. deferred maintenance ☐ on-site/off-site maintenance ☐

IF any Other

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What are the maintenance procedures followed by your university?

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Please mention if there are any problems and challenges present in facility management practices of your university

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Please share any additional comments, information, or contacts you have about building facility management in your universities.

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Appendix B Observation check list

Section one :- General information

Type of building: - Office ☐ class room ☐ Cafeteria ☐ library ☐ dormitory ☐

Number of floors --------------

Age of the building :- Old (above 40 Years) ☐ New (Bellow 3 years) ☐

Section Two :- observation

Interior Building Quality Observation					
No	**Observation**	**Yes**	**No**	**N/A**	**Remark**
1	Are Walls, Floors and ceilings are in good condition				
2	Are railings, staircases, and ramps are in good condition				
3	Are there leaks or water damage in bathrooms and ceilings				
4	Are there wall surfaces for cracks, water stains, and water leaks				
5	all locks and knobs work properly				
6	Doors and windows are in good condition				
7	Elevators are working properly				
Exterior Building Quality Observation					
No	**Observation**	**Yes**	**No**	**N/A**	**Remark**
1	Roof and gutter system are clear of debris; no pooling or leaking				
2	Ramps, Steps and railings are in good condition				
3	Paint and siding are in good condition				
4	Exterior signage is accurate and easily readable				
5	Fencing is intact and in good condition				

6	condition of sidewalks and parking lots for potholes				
7	surface deterioration on the exterior wall surfaces				
8	all drains and vents are working properly and have no clogs				
9	any metal corrosion				
Electrical Quality Observation					
No	**Observation**	**Yes**	**No**	**N/A**	**Remark**
1	cables of exterior lights and other hardware are in good condition				
2	all lighting is properly installed and functioning				
3	Clean and re-torque electrical connections				
4	Wires properly installed secured, supported and protected properly				
5	automatic and manual switches are operating properly				
6	Are outlets properly operate				
Plumbing Quality Observation					
No	**Observation**	**Yes**	**No**	**N/A**	**Remark**
1	Toilets, sinks, and showers are properly functional				
2	The safety and valves function properly				
3	all drains pipes work properly				
4	Is there any leaks or unusual noises				
HAVC Quality Observation					
No	**Observation**	**Yes**	**No**	**N/A**	**Remark**
1	The facilities are receive proper air flow from the units				
2	Wires, capacitors, and thermostats are all in good operating condition				

3	safety controls and equipment are working properly				
4	operation of interior and exterior units				
Safety Quality Observation					
No̲	**Observation**	**Yes**	**No**	**N/A**	**Remark**
1	Fire extinguishers are present where required				
2	Fire escapes and stairs are free of obstructions				
3	Chemical products are sealed, clearly labeled, and stored				
4	Fire alarm system work properly				
5	Check smoke and carbon monoxide detectors				
Equipment Quality Observation					
No̲	**Observation**	**Yes**	**No**	**N/A**	**Remark**
1	Are all equipment's have their identification mark, ID,				
2	Are they properly Functionality				
3	Condition of the equipment's are good				

Appendix C In-Depth Interview Guide

Interview questions

1. How many building facilities does your university have, and how many buildings have as built drawing from those?

2. Do you have recorded data like as-built drawings, and useful for the continuing operations and maintenance of their building. (virtual description of the building and associated data: 3D model, 2D drawings, assets (e.g., furniture, furnishings, and equipment), maintenance manuals, specifications, equipment lists, product data sheets, warranties, spare part lists, preventive maintenance schedules, etc and other information that is usually requested at closeout) purchase price, installation date, commissioning data, asset location, serial number, barcode number, expected useful life (EUL), warranty terms, equipment preventive maintenance plans, startup and shutdown procedures, guaranty information, and spare and

consumable parts information

3. Do you calculate the life cycle cost (LCC) of the Facility? If yes, How?

4. How much time take to maintain something in the facility please tell me minimum and maximum time taken?

5. Is there any facility equipment that is exceptionally difficult to access? If yes, please specify: and why it difficult to access?

6. Where do you keep the inspection logs, maintenance manual and other reference information for the facility?

7. Are there any warranty case claims resulting from losses?

8. What kinds of complaints do you receive from users regarding the FM?

9. How do you plan your facility management? And do you calculate the cost and time to facility management activities?

Appendix D SPSS analysis out put

Age of category

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Below 30	1	10.0	10.0	10.0
	30-40	4	40.0	40.0	50.0
	40-50	5	50.0	50.0	100.0
	Total	10	100.0	100.0	

Sex:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	8	80.0	80.0	80.0
	Female	2	20.0	20.0	100.0
	Total	10	100.0	100.0	

Job category

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Facility	9	90.0	90.0	90.0
	Management	1	10.0	10.0	100.0
	Total	10	100.0	100.0	

Educational status

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Diploma/TVET	5	50.0	50.0	50.0
	BA/BSc	5	50.0	50.0	100.0
	Total	10	100.0	100.0	

Work Experience

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0–5 years	2	20.0	20.0	20.0
	6 –10 years	3	30.0	30.0	50.0
	11–15 years	1	10.0	10.0	60.0
	More than 15 years	4	40.0	40.0	100.0
	Total	10	100.0	100.0	

Space management

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Low	4	40.0	40.0	40.0
	Medium	3	30.0	30.0	70.0
	High	3	30.0	30.0	100.0
	Total	10	100.0	100.0	

Space management

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Low	4	40.0	40.0	40.0
	Medium	3	30.0	30.0	70.0
	High	3	30.0	30.0	100.0
	Total	10	100.0	100.0	

Information management

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Low	4	40.0	40.0	40.0
	Medium	3	30.0	30.0	70.0
	High	3	30.0	30.0	100.0
	Total	10	100.0	100.0	

Maintenance of equipment inside the building and building systems

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Medium	7	70.0	70.0	70.0
	High	3	30.0	30.0	100.0
	Total	10	100.0	100.0	

Asset lifecycle management

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Medium	10	100.0	100.0	100.0

Focus on sustainability

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Low	5	50.0	50.0	50.0
	Medium	3	30.0	30.0	80.0
	High	2	20.0	20.0	100.0
	Total	10	100.0	100.0	

Digital transformation and automation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Low	4	40.0	40.0	40.0
	Medium	6	60.0	60.0	100.0
	Total	10	100.0	100.0	

Focus on FM at design stage

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Low	4	40.0	40.0	40.0
	Medium	5	50.0	50.0	90.0
	High	1	10.0	10.0	100.0
	Total	10	100.0	100.0	

Condition and appearance of the building's exterior

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Good	7	70.0	70.0	70.0
	Moderate	3	30.0	30.0	100.0
	Total	10	100.0	100.0	

Condition and appearance of the building's interior

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Good	6	60.0	60.0	60.0
	Moderate	4	40.0	40.0	100.0
	Total	10	100.0	100.0	

Condition of lighting and electrical systems of the building

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Good	5	50.0	50.0	50.0
	Moderate	5	50.0	50.0	100.0
	Total	10	100.0	100.0	

Is your university's facility management unit or department well-organized?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	8	80.0	80.0	80.0
	I do notknow	2	20.0	20.0	100.0
	Total	10	100.0	100.0	

Do you assess the condition of the building annually or semiannually?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	10	100.0	100.0	100.0

Do you evaluate structural part safety of the facility?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	4	40.0	40.0	40.0
	No	4	40.0	40.0	80.0
	I do notknow	2	20.0	20.0	100.0
	Total	10	100.0	100.0	

Does your university use data bases for facility management purpose?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	6	60.0	60.0	60.0
	No	4	40.0	40.0	100.0
	Total	10	100.0	100.0	

Do you have detail records of all university buildings?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	2	20.0	20.0	20.0
	No	4	40.0	40.0	60.0
	I do notknow	4	40.0	40.0	100.0
	Total	10	100.0	100.0	

Do you have detail records of all university buildings?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	2	20.0	20.0	20.0
	No	6	60.0	60.0	80.0
	I do notknow	2	20.0	20.0	100.0
	Total	10	100.0	100.0	

Do you have recorded data about all facilities in your universities?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	1	10.0	10.0	10.0
	No	5	50.0	50.0	60.0
	I do notknow	4	40.0	40.0	100.0
	Total	10	100.0	100.0	

Do you have warranty information on your FM record?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	3	30.0	30.0	30.0
	No	2	20.0	20.0	50.0
	I do notknow	5	50.0	50.0	100.0
	Total	10	100.0	100.0	

Do you have contact person address and manufacturer company information on your FM record?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	3	30.0	30.0	30.0
	No	2	20.0	20.0	50.0
	I do notknow	5	50.0	50.0	100.0
	Total	10	100.0	100.0	

Do you have recorded data about your facility Energy consumption and carbon Emission?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	7	70.0	70.0	70.0
	I do notknow	3	30.0	30.0	100.0
	Total	10	100.0	100.0	

Do you have material selection comparation criteria and technique?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	5	50.0	50.0	50.0
	No	4	40.0	40.0	90.0
	I do notknow	1	10.0	10.0	100.0
	Total	10	100.0	100.0	

As a university, do you have a sustainability plan?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	5	50.0	50.0	50.0
	No	4	40.0	40.0	90.0
	I do notknow	1	10.0	10.0	100.0
	Total	10	100.0	100.0	

Do you have any sustainability standards?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	3	30.0	30.0	30.0
	No	4	40.0	40.0	70.0
	I do notknow	3	30.0	30.0	100.0
	Total	10	100.0	100.0	

Do you have west mineralization technique?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	1	10.0	10.0	10.0
	No	7	70.0	70.0	80.0
	I do notknow	2	20.0	20.0	100.0
	Total	10	100.0	100.0	

Do you analyze the Whole life cycle cost of the facility?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	1	10.0	10.0	10.0
	No	7	70.0	70.0	80.0
	I do notknow	2	20.0	20.0	100.0
	Total	10	100.0	100.0	

Do you have Put a preventive maintenance plan?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	7	70.0	70.0	70.0
	No	3	30.0	30.0	100.0
	Total	10	100.0	100.0	

Do you use FM software to make your job easier, and more productive (Automation)?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	2	20.0	20.0	20.0
	No	8	80.0	80.0	100.0
	Total	10	100.0	100.0	

Do you have energy efficiency as an investment strategy?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	1	10.0	10.0	10.0
	No	9	90.0	90.0	100.0
	Total	10	100.0	100.0	

Do you Analyze your current energy consumption?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	4	40.0	40.0	40.0
	No	4	40.0	40.0	80.0
	I do notknow	2	20.0	20.0	100.0
	Total	10	100.0	100.0	

Do you perform timely inspection helps in detecting minor defects which will turn into major problems if not addressed early?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	6	60.0	60.0	60.0
	No	4	40.0	40.0	100.0
	Total	10	100.0	100.0	

Do you visualize every building facility and the components with a 3D model regards to the information of the component (data)?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	1	10.0	10.0	10.0
	No	9	90.0	90.0	100.0
	Total	10	100.0	100.0	

Do you visualize Energy Simulation of your Building facility?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	1	10.0	10.0	10.0
	No	9	90.0	90.0	100.0
	Total	10	100.0	100.0	

Do you visualize Lifecycle cost Simulation of your Building facility?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	1	10.0	10.0	10.0
	No	7	70.0	70.0	80.0
	I do notknow	2	20.0	20.0	100.0
	Total	10	100.0	100.0	

Do you have a visual representation of the location of the building components with real-time data?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	3	30.0	30.0	30.0
	No	4	40.0	40.0	70.0
	I do notknow	3	30.0	30.0	100.0
	Total	10	100.0	100.0	

What type of building maintenance is practiced in your university?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Routine maintenance	1	10.0	10.0	10.0
	Corrective maintenance	9	90.0	90.0	100.0
	Total	10	100.0	100.0	

In your university, what data management or data structure is used for facility management?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Computerized Maintenance Management System	4	40.0	40.0	40.0
	Building maintenance control	4	40.0	40.0	80.0
	system CAD for the documentation of drawings	2	20.0	20.0	100.0
	Total	10	100.0	100.0	

Your databases are server based or cloud based?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Server based	5	50.0	50.0	50.0
	None of both	5	50.0	50.0	100.0
	Total	10	100.0	100.0	

Is there any record of your universities' facilities?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	As built drawings	4	40.0	40.0	40.0
	Maintenance and operation manual	2	20.0	20.0	60.0
	Both	2	20.0	20.0	80.0
	None	2	20.0	20.0	100.0
	Total	10	100.0	100.0	

Which types of maintenance do you perform?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Preventive maintenance	2	20.0	20.0	20.0
	Corrective maintenance	6	60.0	60.0	80.0
	condition-based maintenance	2	20.0	20.0	100.0
	Total	10	100.0	100.0	

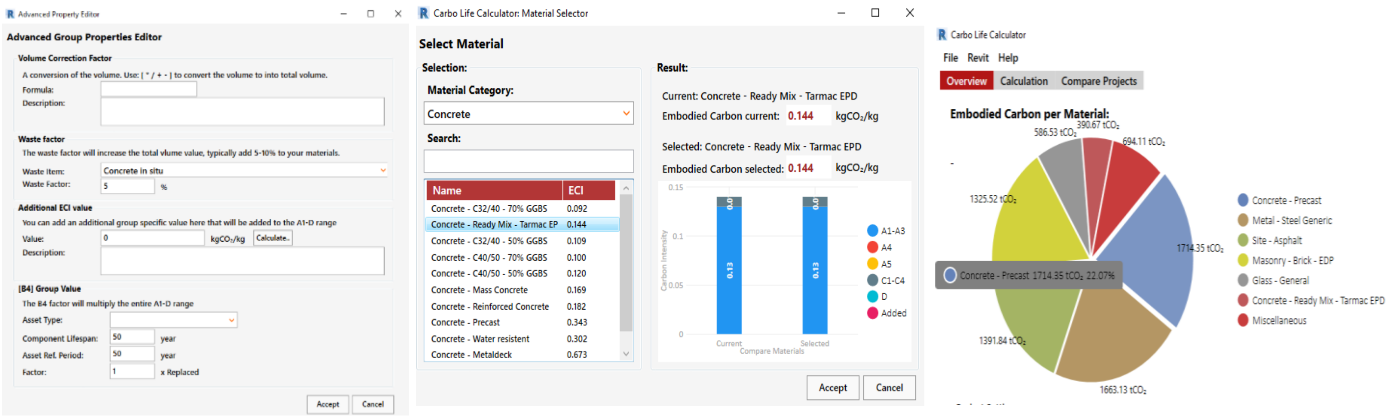
Case Summaries

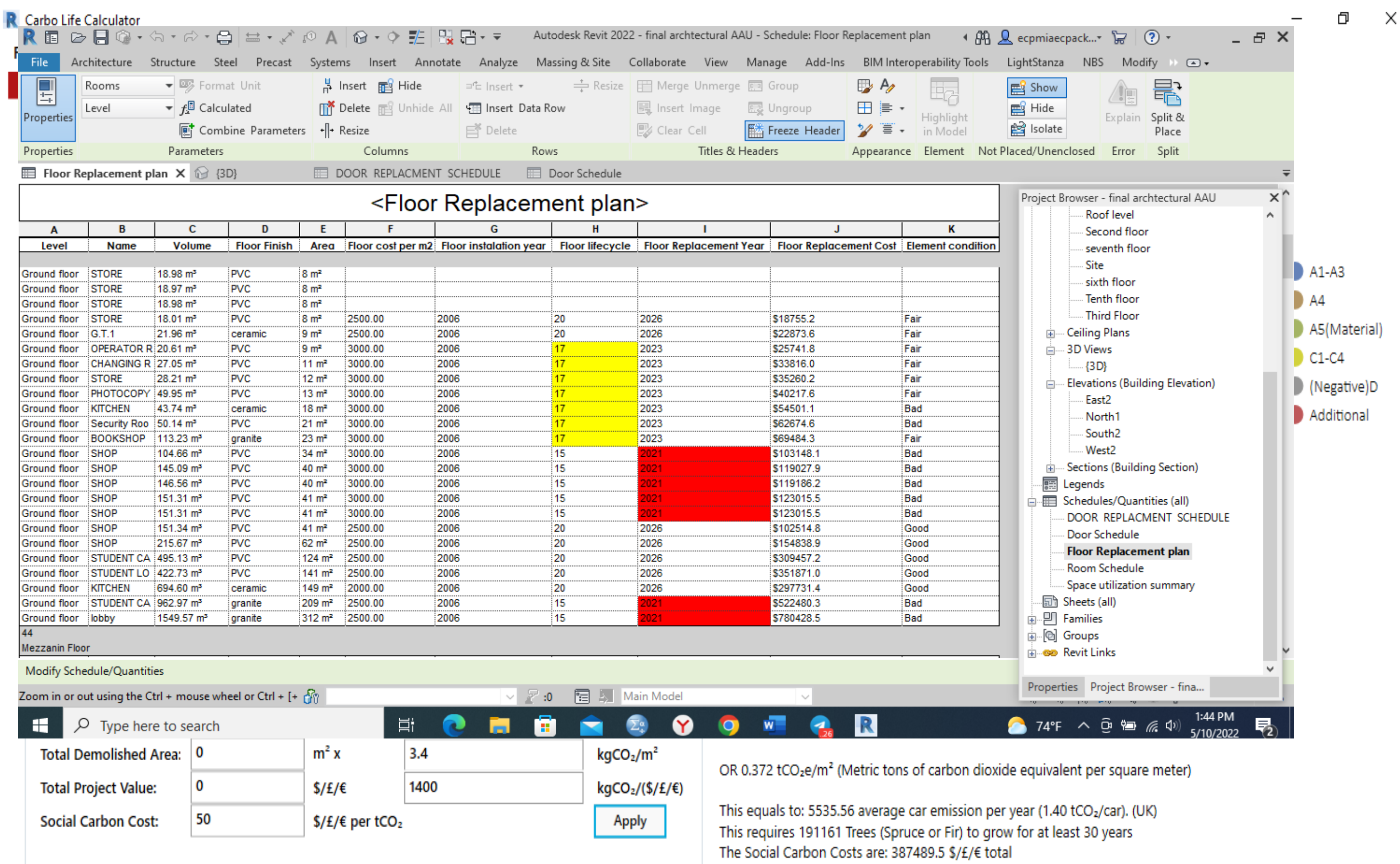
Case Number	Space management	Information management	Maintenance of equipment inside the building and building systems	Asset lifecycle management	Focus on sustainability	Digital transformation and automation	Focus on FM at design stage
1	High	Medium	Medium	Medium	High	Low	Low
2	Medium	High	High	Medium	Low	Medium	Medium
3	Medium	Medium	Medium	Medium	Medium	Medium	Medium
4	High	High	High	Medium	High	Medium	High
5	Low	Low	Medium	Medium	Medium	Medium	Medium
6	Low	Low	Medium	Medium	Low	Low	Low
7	Low	Low	Medium	Medium	Low	Low	Low
8	High	Medium	Medium	Medium	Low	Low	Low
9	Medium	High	High	Medium	Low	Medium	Medium
10	Low	Low	Medium	Medium	Medium	Medium	Medium
Total despondent	10	10	10	10	10	10	10

Case Summaries

Case Number	Space management	Information management	Maintenance of equipment inside the building and building systems	Asset lifecycle management	Focus on sustainability	Digital transformation and automation	Focus on FM at design stage
1	High	Medium	Medium	Medium	High	Low	Low
2	Medium	High	High	Medium	Low	Medium	Medium
3	Medium	Medium	Medium	Medium	Medium	Medium	Medium
4	High	High	High	Medium	High	Medium	High
5	Low	Low	Medium	Medium	Medium	Medium	Medium
6	Low	Low	Medium	Medium	Low	Low	Low
7	Low	Low	Medium	Medium	Low	Low	Low
8	High	Medium	Medium	Medium	Low	Low	Low
9	Medium	High	High	Medium	Low	Medium	Medium
10	Low	Low	Medium	Medium	Medium	Medium	Medium
N	10	10	10	10	10	10	
Sum	19.00	19.00	23.00	20.00	17.00	6.00	

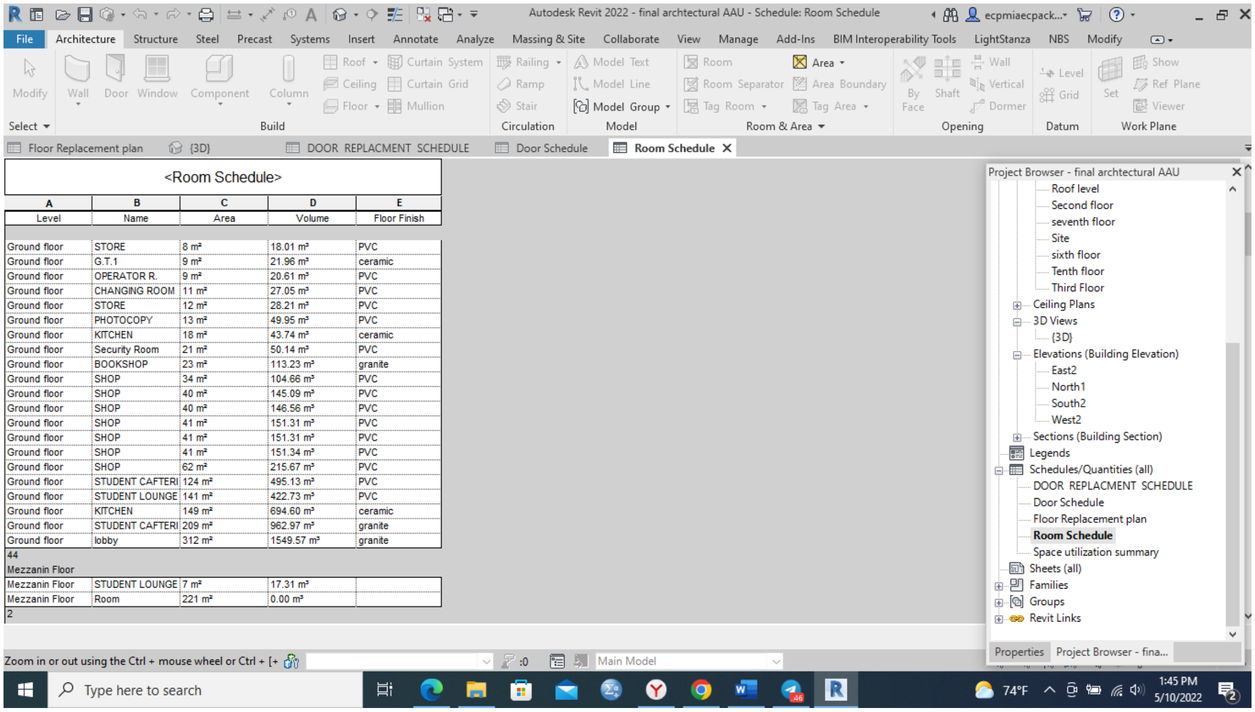
Appendix E Some results from BIM model analysis out put



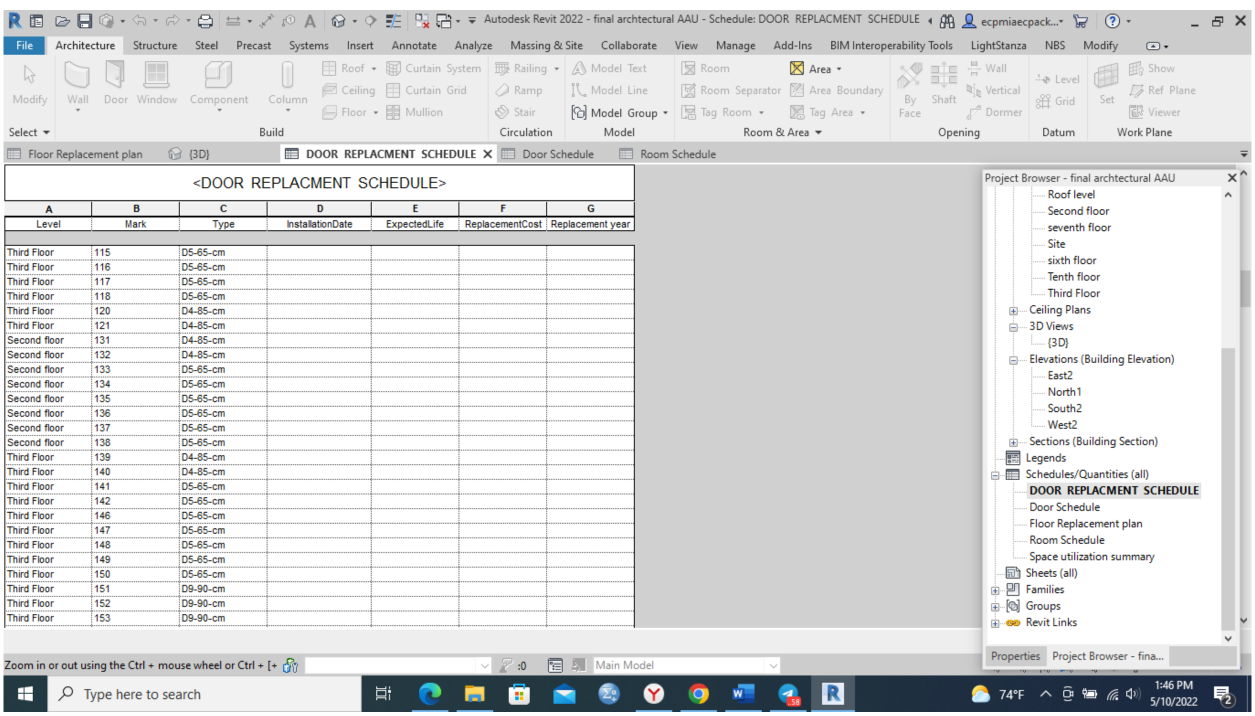


<Floor Replacement plan>

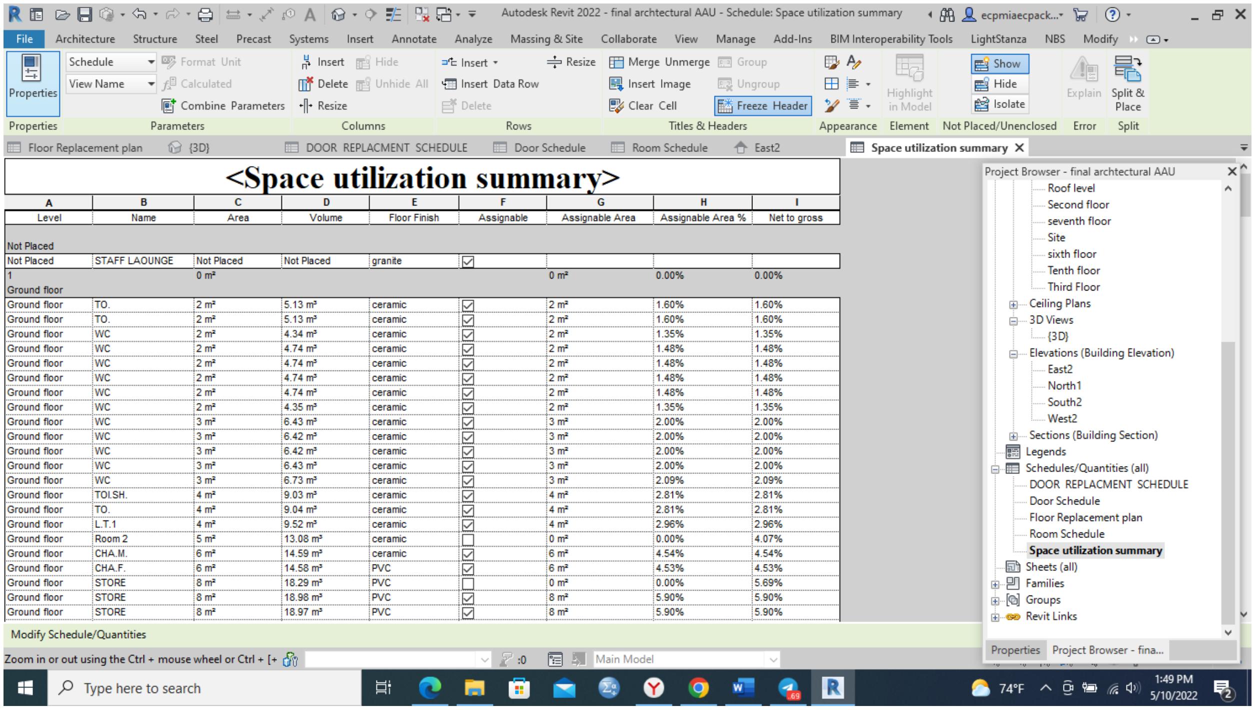
Level	Name	Volume	Floor Finish	Area	Floor cost per m2	Floor instalation year	Floor lifecycle	Floor Replacement Year	Floor Replacement Cost	Element condition
Ground floor	STORE	18.98 m³	PVC	8 m²						
Ground floor	STORE	18.97 m³	PVC	8 m²						
Ground floor	STORE	18.98 m³	PVC	8 m²						
Ground floor	STORE	18.01 m³	PVC	8 m²	2500.00	2006	20	2026	$18755.2	Fair
Ground floor	G.T.1	21.96 m³	ceramic	9 m²	2500.00	2006	20	2026	$22873.6	Fair
Ground floor	OPERATOR R	20.61 m³	PVC	9 m²	3000.00	2006	17	2023	$25741.8	Fair
Ground floor	CHANGING R	27.05 m³	PVC	11 m²	3000.00	2006	17	2023	$33816.0	Fair
Ground floor	STORE	28.21 m³	PVC	12 m²	3000.00	2006	17	2023	$35260.2	Fair
Ground floor	PHOTOCOPY	49.95 m³	PVC	13 m²	3000.00	2006	17	2023	$40217.6	Fair
Ground floor	KITCHEN	43.74 m³	ceramic	18 m²	3000.00	2006	17	2023	$54501.1	Bad
Ground floor	Security Roo	50.14 m³	PVC	21 m²	3000.00	2006	17	2023	$62674.6	Bad
Ground floor	BOOKSHOP	113.23 m³	granite	23 m²	3000.00	2006	17	2023	$69484.3	Fair
Ground floor	SHOP	104.66 m³	PVC	34 m²	3000.00	2006	15	2021	$103148.1	Bad
Ground floor	SHOP	145.09 m³	PVC	40 m²	3000.00	2006	15	2021	$119027.9	Bad
Ground floor	SHOP	146.56 m³	PVC	40 m²	3000.00	2006	15	2021	$119186.2	Bad
Ground floor	SHOP	151.31 m³	PVC	41 m²	3000.00	2006	15	2021	$123015.5	Bad
Ground floor	SHOP	151.31 m³	PVC	41 m²	3000.00	2006	15	2021	$123015.5	Bad
Ground floor	SHOP	151.34 m³	PVC	41 m²	2500.00	2006	20	2026	$102514.8	Good
Ground floor	SHOP	215.67 m³	PVC	62 m²	2500.00	2006	20	2026	$154838.9	Good
Ground floor	STUDENT CA	495.13 m³	PVC	124 m²	2500.00	2006	20	2026	$309457.2	Good
Ground floor	STUDENT LO	422.73 m³	PVC	141 m²	2500.00	2006	20	2026	$351871.0	Good
Ground floor	KITCHEN	694.60 m³	ceramic	149 m²	2000.00	2006	20	2026	$297731.4	Good
Ground floor	STUDENT CA	962.97 m³	granite	209 m²	2500.00	2006	15	2021	$522480.3	Bad
Ground floor	lobby	1549.57 m³	granite	312 m²	2500.00	2006	15	2021	$780428.5	Bad
44										
Mezzanin Floor										



Level	Name	Area	Volume	Floor Finish
Ground floor	STORE	8 m²	18.01 m³	PVC
Ground floor	G.T.1	9 m²	21.96 m³	ceramic
Ground floor	OPERATOR R.	9 m²	20.61 m³	PVC
Ground floor	CHANGING ROOM	11 m²	27.05 m³	PVC
Ground floor	STORE	12 m²	28.21 m³	PVC
Ground floor	PHOTOCOPY	13 m²	49.95 m³	PVC
Ground floor	KITCHEN	18 m²	43.74 m³	ceramic
Ground floor	Security Room	21 m²	50.14 m³	PVC
Ground floor	BOOKSHOP	23 m²	113.23 m³	granite
Ground floor	SHOP	34 m²	104.66 m³	PVC
Ground floor	SHOP	40 m²	145.09 m³	PVC
Ground floor	SHOP	40 m²	146.56 m³	PVC
Ground floor	SHOP	41 m²	151.31 m³	PVC
Ground floor	SHOP	41 m²	151.31 m³	PVC
Ground floor	SHOP	41 m²	151.34 m³	PVC
Ground floor	SHOP	62 m²	215.67 m³	PVC
Ground floor	STUDENT CAFTERI	124 m²	495.13 m³	PVC
Ground floor	STUDENT LOUNGE	141 m²	422.73 m³	PVC
Ground floor	KITCHEN	149 m²	694.60 m³	ceramic
Ground floor	STUDENT CAFTERI	209 m²	962.97 m³	granite
Ground floor	lobby	312 m²	1549.57 m³	granite
44				
Mezzanin Floor				
Mezzanin Floor	STUDENT LOUNGE	7 m²	17.31 m³	
Mezzanin Floor	Room	221 m²	0.00 m³	
2				

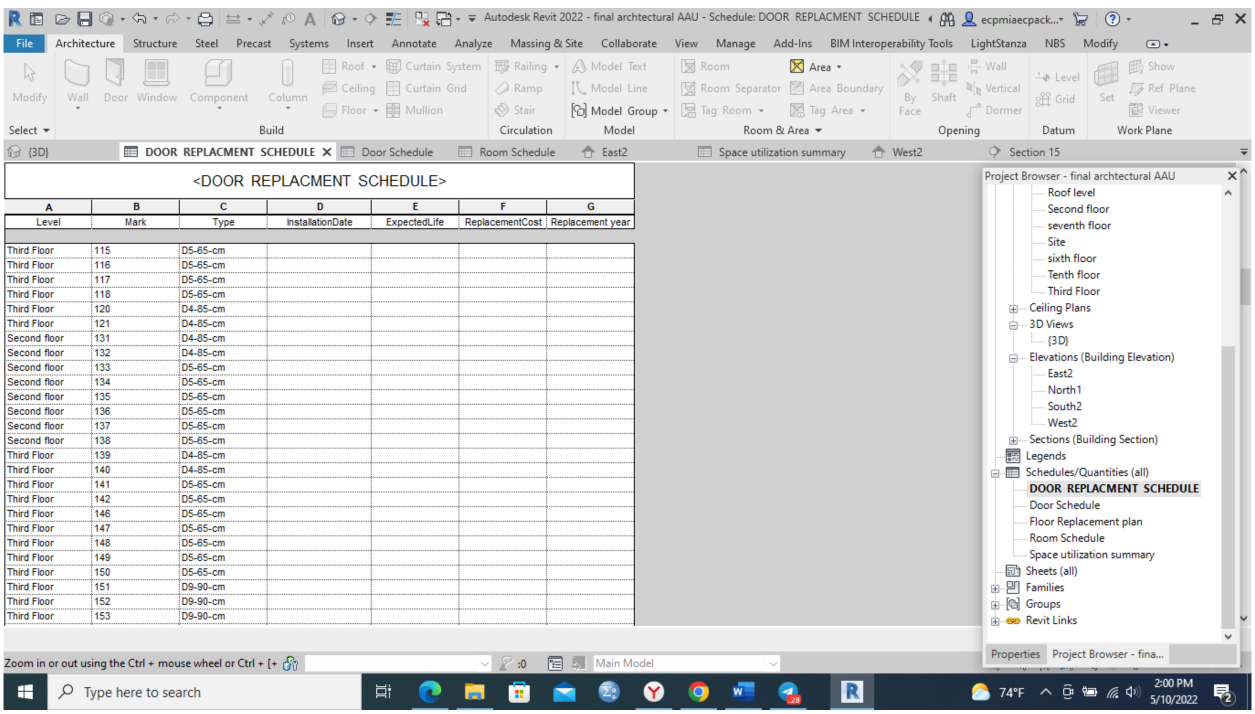


Level	Mark	Type	InstallationDate	ExpectedLife	ReplacementCost	Replacement year
Third Floor	115	D5-65-cm				
Third Floor	116	D5-65-cm				
Third Floor	117	D5-65-cm				
Third Floor	118	D5-65-cm				
Third Floor	120	D4-85-cm				
Third Floor	121	D4-85-cm				
Second floor	131	D4-85-cm				
Second floor	132	D4-85-cm				
Second floor	133	D5-65-cm				
Second floor	134	D5-65-cm				
Second floor	135	D5-65-cm				
Second floor	136	D5-65-cm				
Second floor	137	D5-65-cm				
Second floor	138	D5-65-cm				
Third Floor	139	D4-85-cm				
Third Floor	140	D4-85-cm				
Third Floor	141	D5-65-cm				
Third Floor	142	D5-65-cm				
Third Floor	146	D5-65-cm				
Third Floor	147	D5-65-cm				
Third Floor	148	D5-65-cm				
Third Floor	149	D5-65-cm				
Third Floor	150	D5-65-cm				
Third Floor	151	D9-90-cm				
Third Floor	152	D9-90-cm				
Third Floor	153	D9-90-cm				



<Space utilization summary>

Level	Name	Area	Volume	Floor Finish	Assignable	Assignable Area	Assignable Area %	Net to gross
Not Placed								
Not Placed	STAFF LAOUNGE	Not Placed	Not Placed	granite	☑			
1		0 m²				0 m²	0.00%	0.00%
Ground floor								
Ground floor	TO.	2 m²	5.13 m³	ceramic	☑	2 m²	1.60%	1.60%
Ground floor	TO.	2 m²	5.13 m³	ceramic	☑	2 m²	1.60%	1.60%
Ground floor	WC	2 m²	4.34 m³	ceramic	☑	2 m²	1.35%	1.35%
Ground floor	WC	2 m²	4.74 m³	ceramic	☑	2 m²	1.48%	1.48%
Ground floor	WC	2 m²	4.74 m³	ceramic	☑	2 m²	1.48%	1.48%
Ground floor	WC	2 m²	4.74 m³	ceramic	☑	2 m²	1.48%	1.48%
Ground floor	WC	2 m²	4.74 m³	ceramic	☑	2 m²	1.48%	1.48%
Ground floor	WC	2 m²	4.35 m³	ceramic	☑	2 m²	1.35%	1.35%
Ground floor	WC	3 m²	6.43 m³	ceramic	☑	3 m²	2.00%	2.00%
Ground floor	WC	3 m²	6.42 m³	ceramic	☑	3 m²	2.00%	2.00%
Ground floor	WC	3 m²	6.42 m³	ceramic	☑	3 m²	2.00%	2.00%
Ground floor	WC	3 m²	6.43 m³	ceramic	☑	3 m²	2.00%	2.00%
Ground floor	WC	3 m²	6.73 m³	ceramic	☑	3 m²	2.09%	2.09%
Ground floor	TOI.SH.	4 m²	9.03 m³	ceramic	☑	4 m²	2.81%	2.81%
Ground floor	TO.	4 m²	9.04 m³	ceramic	☑	4 m²	2.81%	2.81%
Ground floor	L.T.1	4 m²	9.52 m³	ceramic	☑	4 m²	2.96%	2.96%
Ground floor	Room 2	5 m²	13.08 m³	ceramic	☐	0 m²	0.00%	4.07%
Ground floor	CHA.M.	6 m²	14.59 m³	ceramic	☑	6 m²	4.54%	4.54%
Ground floor	CHA.F.	6 m²	14.58 m³	PVC	☑	6 m²	4.53%	4.53%
Ground floor	STORE	8 m²	18.29 m³	PVC	☐	0 m²	0.00%	5.69%
Ground floor	STORE	8 m²	18.98 m³	PVC	☑	8 m²	5.90%	5.90%
Ground floor	STORE	8 m²	18.97 m³	PVC	☑	8 m²	5.90%	5.90%



<DOOR REPLACMENT SCHEDULE>

Level	Mark	Type	InstallationDate	ExpectedLife	ReplacementCost	Replacement year
Third Floor	115	D5-65-cm				
Third Floor	116	D5-65-cm				
Third Floor	117	D5-65-cm				
Third Floor	118	D5-65-cm				
Third Floor	120	D4-85-cm				
Third Floor	121	D4-85-cm				
Second floor	131	D4-85-cm				
Second floor	132	D4-85-cm				
Second floor	133	D5-65-cm				
Second floor	134	D5-65-cm				
Second floor	135	D5-65-cm				
Second floor	136	D5-65-cm				
Second floor	137	D5-65-cm				
Second floor	138	D5-65-cm				
Third Floor	139	D4-85-cm				
Third Floor	140	D4-85-cm				
Third Floor	141	D5-65-cm				
Third Floor	142	D5-65-cm				
Third Floor	146	D5-65-cm				
Third Floor	147	D5-65-cm				
Third Floor	148	D5-65-cm				
Third Floor	149	D5-65-cm				
Third Floor	150	D5-65-cm				
Third Floor	151	D9-90-cm				
Third Floor	152	D9-90-cm				
Third Floor	153	D9-90-cm				

Appendix F Letter of support

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በኢ.ፌ.ዲ.ሪ የከተማ ልማትና ኮንስትራክሽን ሚንስቴር
የኢትዮጵያ ኮንስትራክሽን ፕሮጀክት ማኔጅመንት ኢንስቲትዩት
FDRE MINISTRY OF URBAN DEVELOPMENT AND CONSTRUCTION
ETHIOPIAN CONSTRUCTION PROJECT MANAGEMENT INSTITUTE

ቁጥር: 1/4/33
Ref. No.
ቀን: 16/09/2013
Date:

ለአዲስ አበባ ዩኒቨርስቲ ዋናው ግቢ

<u>አዲስ አበባ</u>

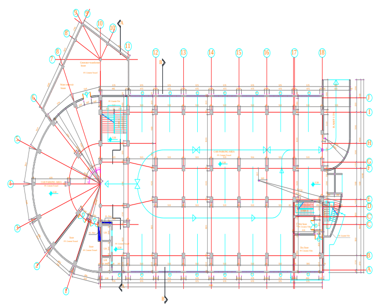
ጉዳዩ፡- <u>ትብብር እንዲደረግላቸው ስለመጠየቅ፤</u>

የኢትዮጵያ ኮንስትራክሽን ፕሮጀክት ማኔጅመንት ኢንስቲትዩት ሠራተኛ የሆኑት ወ/ሮ ቅድስት ማሞ በኢንስቲትዩቱ ስፖንሰርነት የሁለተኛ ድግሪያቸውን እየተማሩ እና ጥናታዊ ጽሁፍ እያዘጋጁ ስለሆነ አስፈላጊውን የዲዛይን ዶክመንቶች እና መረጃዎችን በመስጠት ትብብር እንድታደርጉላቸው እንጠይቃለን፡፡

ከሰላምታ ጋር

ስልክ /0115575627/0118276910 ፖ.ሣ.ቁ. 23650/100 ፋክስ 0115575643 ድረገጽ/web.sitWWW.ecpmi Gov.et

Appendix G CAD Files of AAU school of commerce FM building



BASEMENT FLOOR PLAN sc=1/100