A BIM ENABLED AUTOMATED PROCUREMENT MODULE FOR INTELLIGENT FACILITY MANAGEMENT

FINAL YEAR PROJECT UG-2016

By

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This is to certify that the

Final Year Project Titled as

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has been accepted under the requirements for the undergraduate degree in

CIVIL ENGINEERING

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ABSTRACT

Buildings are an incumbent part of any society. They provide the necessary work environment for people. They serve as workplace, center for providing services; carry out daily activities whether government or private, and most importantly it is the quality of work environment inside a building that is directly related to quality of work done. This is where the concept of Facility Management (FM) fits in. The lifecycle of a building comprises two stages: construction and facility management. The construction phase is just a small part of the complete life of the building. The cost that incurs on this phase is much less and same is the case with time. When a building is ready for use then the phase of facility management starts and this is a never ending phase as long as the building is in use. Hitherto, conventional approaches have mostly been used for facility management which take more time and produce more costs. In most of the developed countries, there is a centralized system for facility management process to run efficiently. This system incorporates Building Information Modeling (BIM) augmented with Dynamo and automates the facility management process. This system converges all the stakeholders to a single platform, therefore enhancing the communication among them and improving the overall efficiency. The aim of this project is to develop a BIM based system for facility management by extracting information from BIM using Dynamo and then using QR codes and linking all this information using modern programming techniques.

DEDICATION

We would like to dedicate our work to our parents and our teachers. It is their efforts made us capable of achieving this target. They helped us through every thick and thin and never let their support falter. They are the ones who have helped us fulfill our dreams of finally getting what we always dreamt of.

ACKNOWLEDGMENT

The completion of any project is not just a result of effort of team members. First of all, we are thankful to ALLAH ALMIGHTY. Certainly without the support of ALLAH we would never have been able to accomplish this project.

Secondly, we are grateful for the unfazed support provided by our parents and teachers. It is the prayers of parents that is supporting us in every task we do and make hardships result into fruitful accomplishments. We are grateful for our institute NUST, NICE for giving us the chance of making this accomplishment. We are really thankful to Dr. Muhammad Usman Hassan (Supervisor), Dr. Khurram Iqbal (HOD CEM), Dr. Abdur Rehman Nasir (HOD Research) and Lec Hasnain. It is their support that helped us go through this phase of starting from scratch and ultimately accomplishing the project.

We would also like to pay gratitude to all the people who helped us in any way. It is the moral encouragement of people that also played a very important role in getting this project done. Finally, we are thankful to our friends of computer science who helped us in understanding and implementing modern programming techniques in our project.

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CHAPTER 1

INTRODUCTION

Buildings are a necessary part of any society. They serve as workplace, center for providing services, carry out daily activities on the basis of which a country fare well. Despite the importance of buildings in this aspect, they are also very important to serve the economic needs of a country. They are a symbol of development of any country. To unbundle the complete lifecycle of a building: it typically comprises two major stages i.e. construction and facility management. The phase of facility management starts immediately after the building is put in use and continues until the building is serving the purpose it was intended for. Facility Management is the longest and most crucial part of a building. 'It does not matter how well a building is constructed; it will soon lose its worth if not well maintained.' This means all the heavy budgets, stringent schedules, hard work will be futile if the Facility Management phase is not given ample importance.

In most of the developed countries, the facility management process is a centralized platform through the use of modern techniques. Building Information Modeling (BIM) is intensively being used in automating the facility management process. The BIM is augmented with modern information technology techniques by extracting useful data from BIM model, converging all this information to a single platform and streamlining the whole process. This enables the end users to get real time access to the system and increases the overall efficiency of the system.

The aim of this project is to develop a BIM based automated procurement module using BIM and Dynamo along with a system of QR codes. The aim is to make the intended system easy to use and expediting the whole process. Modern IT tools have been incorporated to bridge the gap between construction and use of modern tools to make the construction sector efficient.

1.1 Problem Statement

The facility management phase is the longest and cost consuming process of the life cycle of a building. Furthermore, it is the most crucial part as the working condition a building strongly depends on it. In most of the countries that are still under the phase of development, the facility management phase is not given due importance. Hitherto, conventional techniques have been used in this phase. There are many problems associated with the lack of modern techniques in this phase.

In conventional methods, more time is consumed in redundant hierarchical steps like manually getting the complaint registered, series of approvals and delayed procurement due to superfluous paper work. This dwindles the working efficiency of employees and ultimately results in longer durations to get the work done. This problem occurs due to lack of automation and a centralized system which will eliminate all these redundancies.

Furthermore, there is no proper record maintenance. This is because all the work is done manually on registers. This results in a glut of paper work that makes almost impossible to maintain proper record.

There also exists communication gap among the stakeholders i.e. end users, facility managers, designers, work men. This again happens due to lack of a centralized system.

1.2 Objectives

As mentioned in 1.1, the facility management system in developing countries lacks a centralized system thereby reducing the efficacy of the facility management process. Firstly, the objective of this project is to develop a centralized and automated system that will resolve all the problems mentioned in 1.1. Dissecting it further, this centralized system is aimed to converge all the stakeholders to a single platform that will fix the communication gap, eliminate hierarchical problems and ultimately reduce the overall time consumed in the process i.e. time consumed from generation of complain till the resolving of issue.

The automation will streamline the process and give the end user real time access to the system. This will further reduce the time consumed.

Secondly, we aim to validate our system on a real life example. This means the system developed will be practically implemented on a building or part of a building. This will bolster our project and hence provide a real life example of our project.

1.3 Scope of Project

This project endeavors to develop an environment in which collaboration between different purviews can be achieved. This project encapsulates providing a centralized and automated facility management system which will streamline the processes involved, in real time which is shown in Figure 1 (Brian Haines, 2015).

Figure 1 BIM as a centralized point (Brian Haines, 2015 'FM Systems')

This project encompasses government, commercial and educational buildings. One of the buildings of NUST was selected and it was modeled using Autodesk Revit. The model included all the details about the building i.e. architectural, structural, and electrical and so on. This information was later on manipulated using Dynamo and programming: mainly php. The most important information extracted from the BIM model using dynamo was Element Ids of building components. Each element Id is unique and is associated to a particular element. Later on, this information was incorporated in QR codes. The QR codes can be easily accessed by the end user and all he needs is an internet connection which does not have to be of very high speed. Then complaint will be processed by the concerned staff.

1.4 Areas of Application

This project covers commercial, government and educational institutions. It falls under the category of maintenance of buildings i.e. facility management.

CHAPTER 2

LITERATURE REVIEW

2.1 History of Facility Management

The term facility management started emerging during 1970s, but back then its scope was only limited to maintenance and cleaning. With the passage of time Facility Management grabbed attention and now it has become a multidisciplinary and holistic field. Facility Management is still evolving and hitherto its does not have a universal definition. International Facilities Management Association (IFMA) defines FM as “a profession that incorporates multiple disciplines to ensure functionality of the built environment by integrating people, place, process, and technology”. The British Institute of Facilities Management (BIFM) definition is "Facilities Management is the integration of multi-disciplinary activities within the built environment and the management of their impact upon people and the workplace". This heterogeneity in defining FM is a manifestation of the continuous work being done and changes being incorporated. Facility Management is divided into two parts one is hard services and other is soft services:

Hard Services	Soft Services
• Decoration and Refurbishment	Security
• Electrical, Plumbing and Drainage	Parking
• Air Conditioning System	Recycling
• Energy and Water Management	Waste Disposal
• Building Utilities Maintenance	Cleaning
• HVAC Maintenance	Ground Management
• Safety against Fire	Document Management
• Building Maintenance	Furniture and Equipment

In the past, FM was done manually using 2D drawings and record maintenance was also done manually. This approach was neither cost-effective nor time-effective: one had to rummage through drawings and record keeping registers to get somewhere. At present, this practice is still prevalent since inclination to FM is still in the process of evolution. It remains an unexplored field in most of the countries, especially developing countries. According to International Journal of Facility Management (IJFM) by IFMA, David (2000) shown in Figure 2 the evolution of FM in some countries. The figure shows how, with the passage of time, the inclination towards Facility Management increased. This depicted the realization of importance of facility management vis-à-vis sound condition of buildings and its relation to the working efficiency and also a factor for the development status.

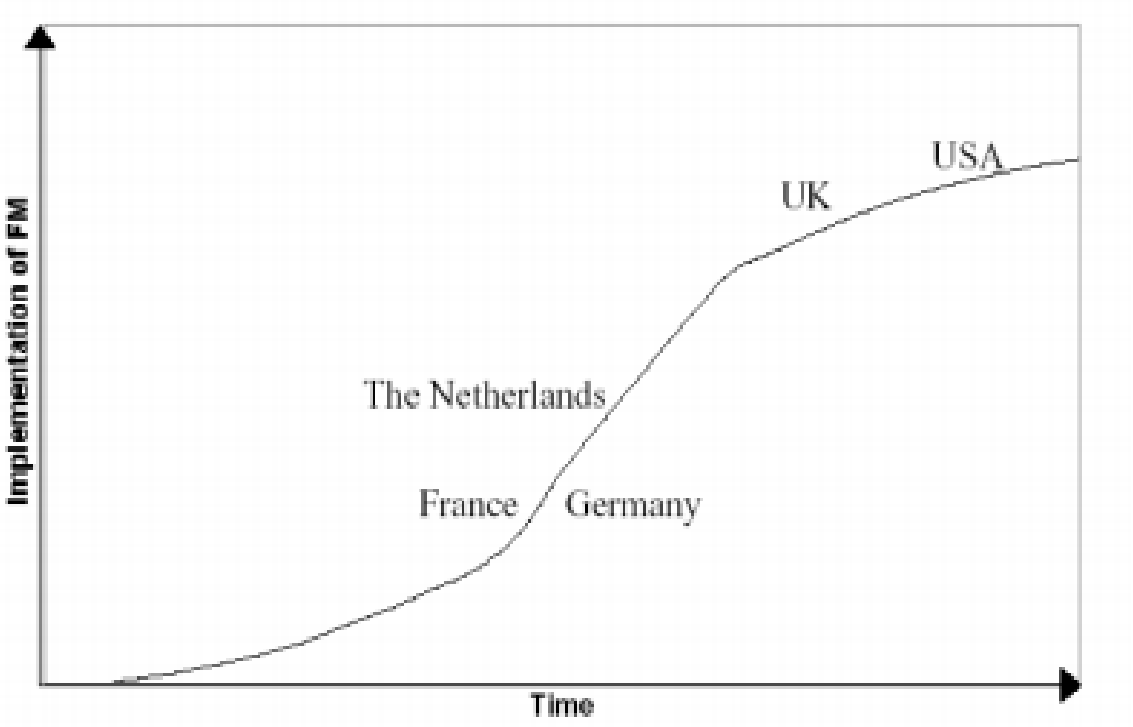


Figure 2 History of Facility Management

2.2 BIM and Facility Management

The integration of BIM in Facility Management can provide a centralized streamlined system for better maintenance. One of the challenges faced in developing a maintenance program is entering the asset and product information which is require for preventive maintenance. It eliminates the effort of months to accurately populate maintenance system by information about building equipment stored in BIM models (Brian Haines, 2016). The BIM models serve as a centralized unit for all the stakeholders with high accessibility and usability. A Potential BIM Lifecycle participant are shown in Figure 3. In Figure 3, it can be seen that the incorporation of Building Information Modeling (BIM) has removed all the redundancies and cleared the communication as well as information gap among the stakeholders. Furthermore, it can also be inferred from the figure that all the concerned people are now converged to a single platform that contains all the pertinent data required to smoothly carry out the process. All the people can now rely on a single source of information. All the updated data can be stored and there is no need to individually communicate the changes to the concerned people. Any update will be automatically stored in the database and the stakeholders will be apprised of the change. This is how BIM bridges all the communication and information gaps.

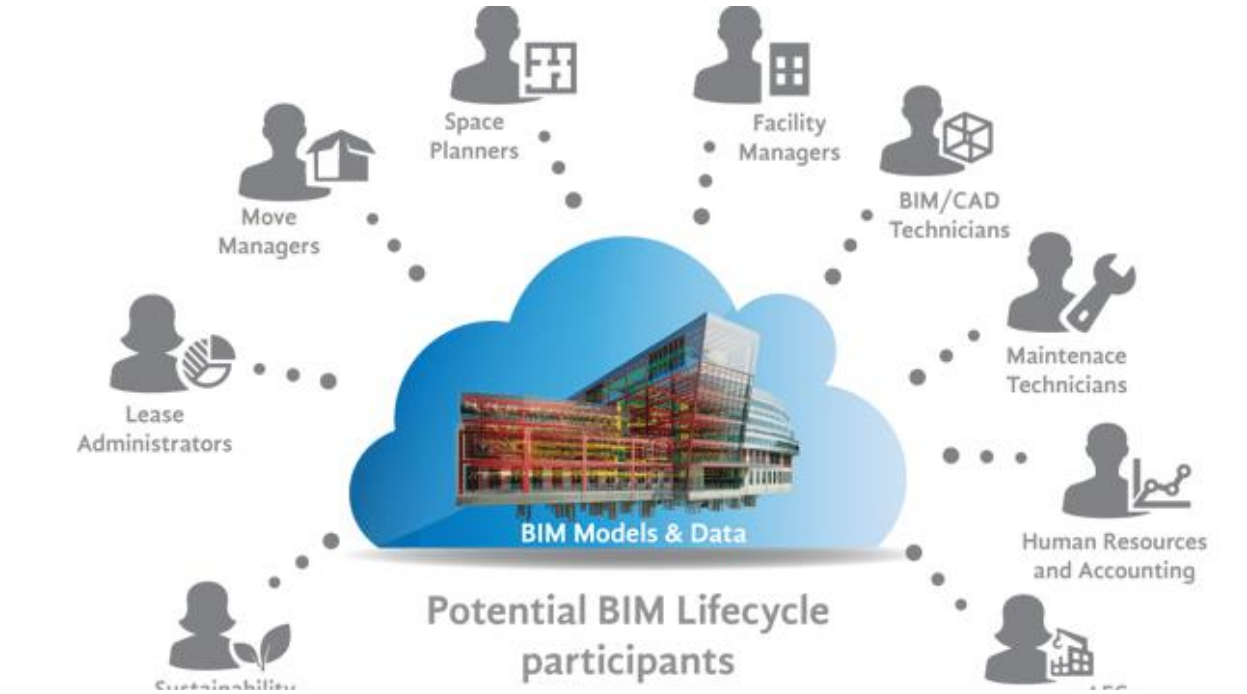


Figure 3 Potential BIM Lifecycle (Brian Hines 2015 'FM Systems')

BIM converging all the stakeholders to a single source of data and information

The use of BIM in FM reduces the time for updating FM database by 98% (Ding et al.2009).

Computerized Maintenance Management System (CMMS) is being used in most of the facility management operations. This system stores glut of data on hard and soft services or simply data about facilities and components of a building. The issue lies in the integration of this data with Facility Management operation. In order to provide this linkage several approaches have been developed namely YouBIM Software and Construction Operations Building Information Exchange

YouBIM is a prototype which is based on BIM approach and used in facility management that integrates databases. One can easily get access to asset location and information through its navigable and user-friendly interface.

As YouBIM is a cloud-based software which means that one can get access from any web browser. Staff can view and edit information on the system by using any device or web browser.

YouBIM convert large amount of data and documents from building model to various formats such as Excel etc.it also attach data and documents from pdf and other file formats with the help of Building information model (BIM). YouBIM also have function of light work orders and preventive maintenance and it integrates with CMMS and CAFM systems.

Construction Operations Building Information Exchange (CoBie) is a non-proprietary data format which is a part of building information modeling (BIM) which transfers asset data apart from geometric information. Cobie incorporates BIM models and provides asset related data to stakeholders. The CoBie helps in decision making by providing assets location and data location which is required for building repair and maintenance purpose. For example, Cobie can help a facility manager to know the location of equipment by using BIM model, the expiry date of equipment, installation date, model number and manufacturer.

2.2.1 Benefits of BIM for Facility Management

The British Institute for Facility Management (BIFM) conducted a survey in 2017 to know what stakeholders think about integration of BIM into FM: enhanced benefits of BIM. The result concluded from the survey is:

- 83% of respondents trust BIM will help bolster the conveyance of offices the executives, with a similar number showing it is as of now having an effect, or will do as such, not far off.
- 81% firmly concur that BIM may offer organizations that receive and use it a preferred position over those that don't.
- 83% concur that BIM can possibly convey critical increased the value of FM.
- 72% state the FM business isn't yet clear what BIM is and 67% differ or unequivocally differ that the FM business is solid and steady to manage BIM ventures, demonstrating more work should be never really individuals are better educated about and increasingly arranged for BIM ventures.
- This line up with the 91.3% of respondents who concur or unequivocally concur that office directors would profit by more acquaintance with BIM to have the option to characterize the yields in the BIM procedure.

2.3 Traditional and Automated facility Management Research

The importance of facility management is recognized by every organization. There are various businesses which organize themselves in such a way that is conducive to productivity and competence. Organizations are using traditional facility management due to which they are faced with increasing problems which remains in front of their operations, balancing everything from changing industry practices to equipment and building maintenance schedules. With traditional facility management we are not able to provide readily available and crucial information on time

Software advice started research on different organization to determine what they want in new facility management software and what they were using. For that purpose, they collected a random data from different organization whose responses are shown in Figure 4. After this research it was found that a large number of facility managers were using ineffective and time-consuming methods. Only 9 percent facility managers were using latest software's and methods for facility management purposes. This shows the lack of cognizance related to the use of innovation.

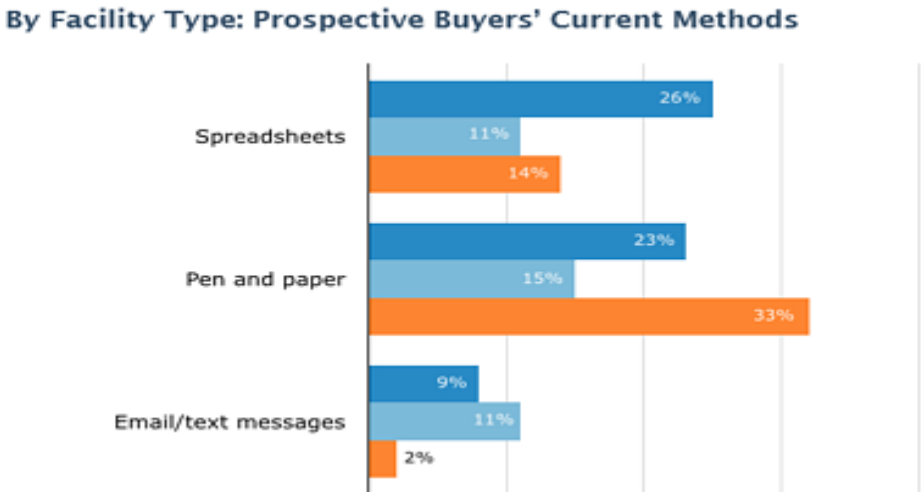


Figure 4 Prospective Buyer's Current Methods

Using traditional facility management organization are not able to provide accurate, comprehensive and predictive information which is very important for understanding trends and making smart decisions. Traditional facility management is not capable of handling the large amount of data which lost in many cases and record cannot be handled in an efficient way. These methods have failed in providing high level of informational quality. They are becoming outworn which are not able to fulfill the evolving industry needs.

In order to get easy access to data and to make this complicated system easy to use there is only one solution of this problem which is automated facility management. Organizations need this modern method to solve their daily life issues and to make the whole process fast and efficient which is a need of today's evolving industry.

2.4 Automated Facility Management

Automated facility management uses advanced software's and approach to solve the facility management issues. For this purpose, BIM approach and web-based technology is used to enhance the maintenance progress and effectiveness in facility management. In facility management most critical tasks are to identify, tracking, controlling and managing facility management assets. The study of Automated facility management helps in understanding the

BIM approach and make easy use of this approach by staff and facility managers and enhance the facility information tracking and sharing efficiency. Notably modern FM approach uses 3D model and BIM to track facility assets in graphic form. The mapping of facility assets and 3D model illustration is done by using BIM. The main benefit of using this approach is it keeps facility information in digital format and easy updating and transfer of information in 3D model. The Project participants can easily obtain overview of previous and current facility asset in a given facility by using the 3D cad model. The facility staff can also check the recent changes or maintenance done in the building by easy access to data stored in their servers. In web-based tool all the maintenance information will be updated regularly which can be access any time.

Automated facility management uses new technologies and advanced software's to improve the efficiency and time of existing process. Use of advanced software's in facility management system brought better and precise delivery of service. For instant data and information transfer between various units and mobilization of resources there was a need to automate the entire system.

The main purpose of facility management is to improve the process of building maintenance and make life easier of those who are a part of this intelligent building network. Latest technology, advanced software's and approach like BIM is used as a source to make easier life of people who are part of this sector. It should be used in such a way so that it will meet the demands and needs of facility to bring about 100 percent process improvements. Since facility management is a continuous process which will be improving more with time and one will get maximum output from service.

The automated facility management deals with onsite and offsite management and it combine all services into a cohesive network which means:

- It creates a database which stores all the information and monitor a database for all service.
- It creates a work schedules and maintenance of equipment's on periodic basis.
- It creates a report on errors and defects,
- resourcing expenditures
- it creates a schedule for periodic inspections and quality control checking.
- Record maintained
- Report sending
- Detail of all costs
- maintaining documentation

The differences between BIM imported mode and traditional mode as shown in Figure 5.

	BIM Imported Mode	Traditional Mode	
		Management Information System	Paper Works
Information Presenting	• 3D visual model • External related information files	• Screen display • 2D CAD-based • Related information files	• 2D figures • Related paper report
Information Recording	• BIM-based model to save information • Save in external related information files	• E-System to save information	• Paper works to save information
Information Searching	• Searching by combination functions of model and software • Linking to external related information files • Searching by standard report which was exported by BIM model and software	• Searching the information in the system	• Searching the information on paper reports

Figure 5 Automated vs Traditional FM

In order to address the needs of facility managers facility management programs are built from ground up. In true facility management program, there are extra ordinary features. Facility managers surprised to see these features. They have all of the features needed to:

- Optimize space
- Improve efficiency
- Collect and report on historical data
- Ensure easy access to records
- Improve accuracy of records
- Gain insight without going through stacks of files
- More information to help negotiate better prices

2.5 Procurement

Procurement is the process of finding and agreeing to terms, and acquiring goods, services, or works from an external source.

Overview:

Procurement activities are often unbundled into two distinct categories, direct and indirect spend.

a) Direct Spend:

Direct spend means the production-related procurement which covers all items that are part of finished products, such as raw material, components and parts.

b) Indirect Spend:

On the other hand, indirect procurement is related to acquisition that is not product related; acquiring "operating resources" which a company purchases to enable and continue its operations. Indirect procurement encapsulates a diverse variety of goods and services, ranging from standardized items like office supplies and machine related menial material to complex and cost demanding products and services like heavy equipment. This project majorly falls under the category of indirect spend.

2.5.1 Conventional Procurement:

This is a conventional method that has been commonly used in the construction sector. In this method, all the procurement related work is done manually i.e. on registers or at the best in excel files. In this conventional approach, redundant hierarchical steps are followed which are just a waste of time. For instance, if an employee wants to get his desk fixed, he will first have to write a letter to the concerned authority for approval. This list of approvals ascends as the work progresses. After that, the procurement office is ordered to make the procurement. In this conventional system, there is lack of a centralized system and also lack of a streamlined process that will give real time access to the users.

Disadvantages of Traditional Procurement are

- Communication gap among stakeholders.
- Time wasted in redundant approvals and checks.
- No centralized system: all the data related to maintenance procurement is scattered and people involved in it are also not on a single page.
- There is no proper record maintenance.
- More cost is incurred due to sheer lack of transparency.

2.5.2 Innovative Procurement Method:

The use of BIM enabled e-procurement platforms results in a reduction of more than 3% of public expenditures without reduction in outputs. (L.V. Tavares, 2010)

Certainly, this is possible because of improved transparency, integrated environment and reduction in complexity of the process.

This is an innovative approach to e-procurement in construction, which uses building information modeling (BIM) to shoulder the construction procurement process. The concept behind the proposed framework is that BIM-based solutions may reduce the negative effects of the fragmentation of the construction project lifecycle through the integration and integrity of

information across the procurement processes in a project's life-cycle. This will imply new strategic approaches to the procurement cycle and support more accurate decisions. The result is an integrated instrument connected to a rich knowledge base capable of advanced operations and able to strengthen transaction relationships and collaboration throughout the supply chain.

Advantages are

- An integrated system where everyone can easily communicate with each other, therefore plummeting the discrepancies among the stakeholders.
- Provision of a single point of access where all the information is stored. This reduces the chance of any sort of data related issues.
- Enhanced transparency that reduces costs.
- Reduced time due to automation.

This in the methodology of one of the techniques that have been implemented for the process of BIM based e-procurement.

This technique for BIM based e-procurement compromises a step which involves modeling of BIM model using modeling software like Rivet. From this modeling, unique code for each element is identified and IFC file also generated. Server stores the IFC files automatically and user has accessed to approach these files and can change IFC files or can update model. On the other hand, there was a schedule, scheduled by primavera. Each component of IFC file is linked with primavera. Primavera send information to the server automatically for update and server approaches that IFC file and resulting BIM model is viewed using BIM viewer. BIM viewer is also used to select manual files and these files are sent to the procurement platform for proper action. Suppliers login to their account to get notification about the things for which procurement is needed. Supplier will view BIM model will estimate the amount of material which is required and will evaluate the request according to requirement. This whole procedure is summed up in following flow chart shown in Figure 6. The figure explicitly explains how various kinds of innovative techniques have been put into use while incorporating BIM. It can be seen that all these technological innovations are revolving around Building Information Modeling (BIM) to make the process more streamlined. BIM is basically the core and the innovative techniques are more of a source of extracting data in more efficient ways from the BIM database and to exploit in a more effective way.

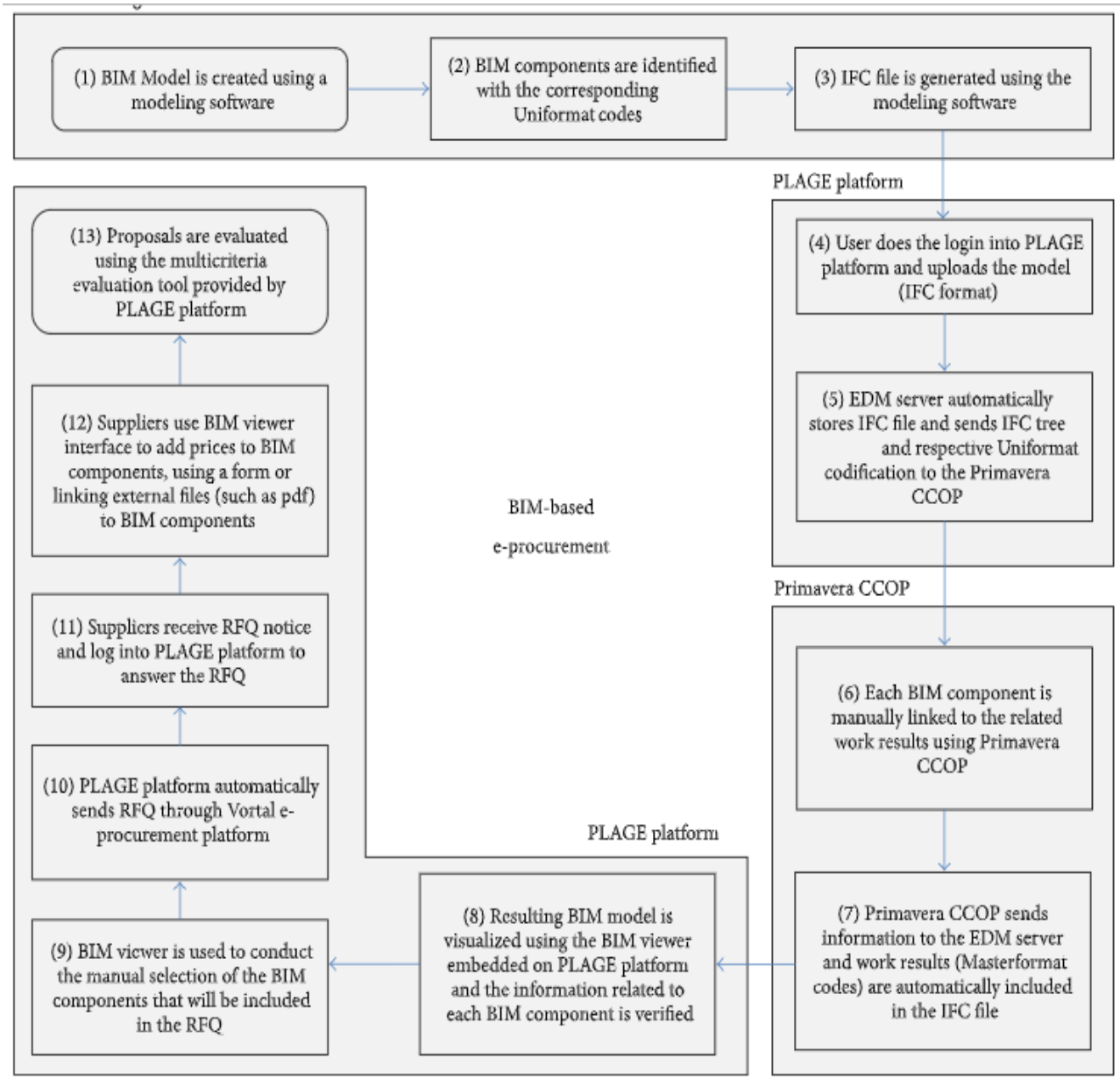


Figure 6 BIM based e-procurement (António Aguiar Cost, 2015 'BIM based e-procurement)

2.6 Revit

Revit is a building information modeling software by Autodesk. It has been widely used for architectural, structural, plumbing, electrical modeling in facility management related projects. The 3D model created in Revit consists of all the details about the building components. Every component in Revit can be viewed in detail and all the information can be updated on a regular basis. Revit has been extensively used in many Facility Management projects. Autodesk Revit is the most popular BIM tool used in the US AEC sector. (*Anoop Sattenini, Salman Azhar*, and Joseph Thuston)*

Revit assigns a unique element Id to each component in a 3D model. This helps in identifying any component that is required for facility management purpose.

Information from the BIM that was determined to be useful for facility management included room numbers, element ids and room names shown in Figure 7. This information helps in identifying the location of a particular element in a room. (*BIM for Facility Managers*)

Element ID	Room Number	Area	Department	Name
#79462	'100'	1416.96	'CIRCULATION'	'CORRIDOR'
#79190	'100A'	111.40	'COMMON SPACE'	'VEST'
#79311	'100B'	98.42	'COMMON SPACE'	'VEST'
#81146	'100C'	341.30	'CIRCULATION'	'CORRIDOR'
#78879	'100D'	368.78	'CIRCULATION'	'CORRIDOR'
#79914	'101'	498.46	'MISC.'	'LOUNGE'
#277	'102'	1164.16	'MISC.'	'MULTI-PURPOSE'

Figure 7 An extract from 'BIM for Facility Managers' (Courtesy SDS Architects, Inc.)

2.7 Dynamo

Dynamo is a visual programming tool that works with Revit and visual programming is done in dynamo for many purposes including data extraction from BIM model. Dynamo extends the working power of Revit by providing access to Revit API (Application programming interface. In Dynamo there is no need to type a code. One can create programs by selecting graphic elements from dynamo library and then connect it. It reduces the effort of typing codes and makes programming easier and saves time. It is one of the best approaches to programming and easier to understand the visual programming for engineers, designers and architects.

In Dynamo there are different nodes and each node performs a specific task. At one side one put inputs by connecting to other node and from other side it gets outputs. The output of one node will be connected to input of another node with the help of wires. The program will start from

left end of node through network of wires and will give final result on right side of node and also by clicking on result.

One main benefit of visual programming in dynamo is access to library of nodes from where one can select node and connect it with the help of wires.it saves time and effort of writing a code. In library there is an option where one can search the node he needs shown in Figure 8.

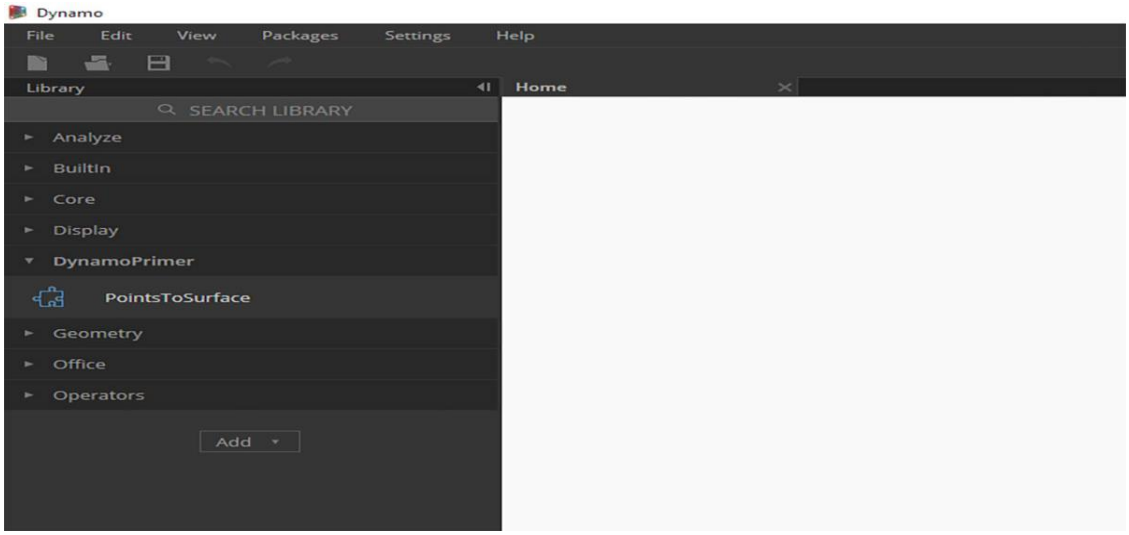


Figure 8 Library of Dynamo

There are few benefits of dynamo given below.

2.7.1 Automate repetitive tasks

There are some tasks which one have to do again and again which is time consuming. In order to avoid this repetitive process dynamo used node system in which there is already a node made for specific task. One has to select the node and connect it.

For example, there is a node for Excel sheet and other formats in dynamo. By selecting the node and connect it to the output it will generate the sheet. Dynamo make this type of tasks easy through visual programming.

2.7.2 Access your building data

A big part of BIM in general and Revit, in particular, is all that data. The model which is made in Revit has building data which can be easily extracted by using BIM approach and through Revit software after which this data is used for many useful purposes. This data can be easily converted to excel sheets which can be stored on web interface or computer and one can easily create schedules of equipment's by using this process. A complete detail of buildings equipment and assets can be easily access through dynamo as shown in Figure 9.

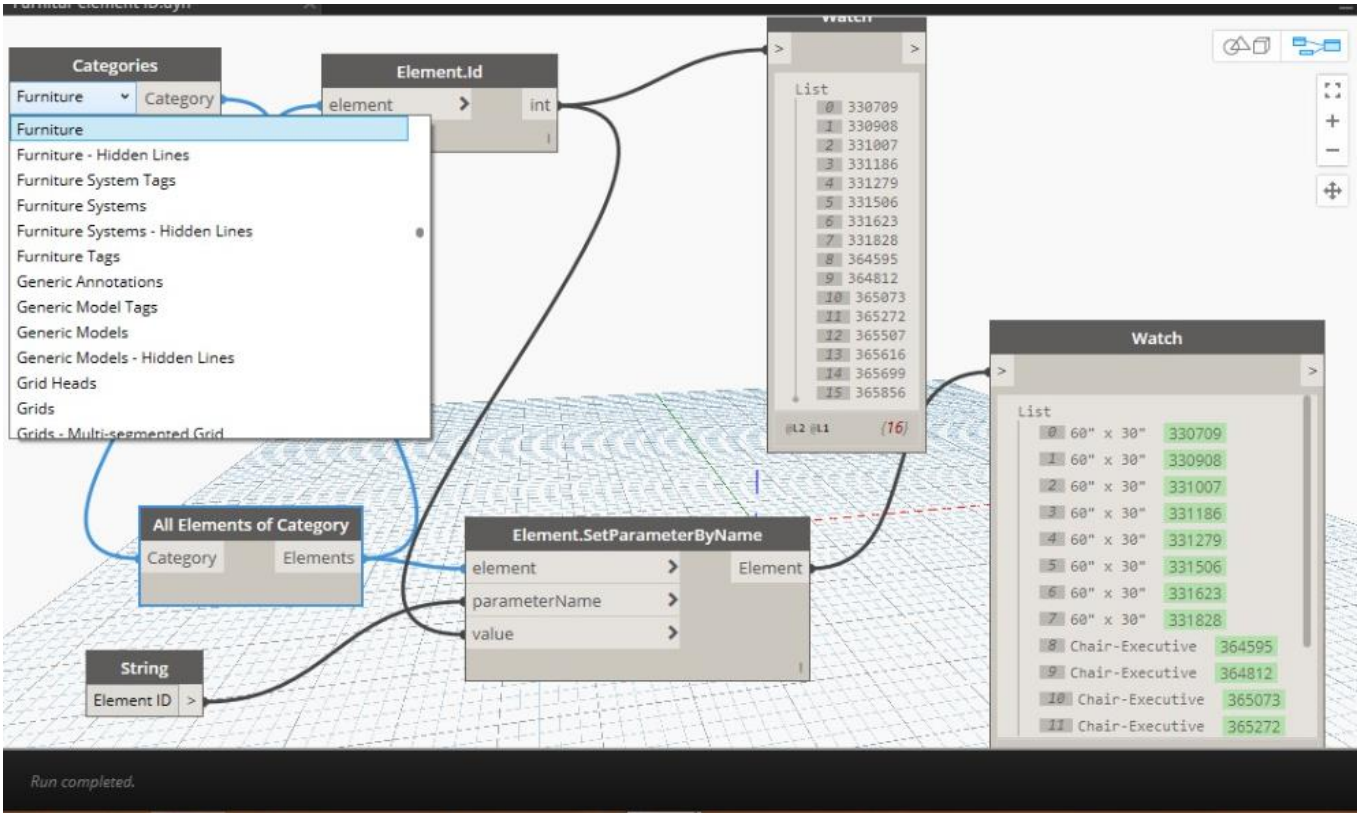


Figure 9 Data access through Dynamo

2.8 Barcode based tracking

A barcode is a label provided on element or equipment and readable with the help of machine readable and information of item is stored in the label which can be accessed by scanning it. This technology is used for the purpose of providing organized and reliable real time display of information. The Barcode technology also has ability to send information on the required location e.g. audio, video and in the form of text. The barcode technology was first used in 1950 and after few years it spread rapidly for different purposes. The main benefits of QR code are low cost, higher limit, expanded security, hostile to corruptibility, traceability. The real attributes of the 2D scanner tag are its ability to speak to information substance and its course of action of a particular geometric chart in a generally little grid territory that can record huge amounts of information. The 2D Stacked Code and the 2D Matrix Code are the two normal sorts of standardized identification arranged by their outline rule.

Figure 10 Stacked Linear Code

Figure 11 Stacked Matrix Code

There are different types of barcodes available in the market shown in Figure 10 & and 11 which are 2D barcodes. The linear barcodes are most popular barcodes used now a days in world. The stacked linear bar code is used for our project. The advantages of linear codes given below

High capacity of data content: The code can store large amount of characters and numbers

Various data types: The information sorts put away in the 2D barcode incorporate picture, sound, words, and fingerprints, with the limit with respect to Multilanguage expression;

Ease of production: The scale and shape of bar code can be adjusted according to the need and easily made by software. Now a day's online software's are available on websites where one need to put scale and shape of barcode and it will be made in seconds.

Convenience: The linear barcodes are easily identified by barcode scanner available in mobile phone and can be readable in any direction.

CHAPTER 3

METHODOLOGY

3.1 BIM

BIM is a word which is used in construction sector and many people think that it is a software which is completely wrong. BIM is a approach used for building construction and management. Actual definition of BIM is given as:

Building Information Modeling (BIM) is a digital representation of the physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its lifecycle: defined as existing from earliest conception and demolition.

The use of BIM is not just restricted to the design and planning phase of a work but extends throughout the life of as project in terms of cost management, construction management, facility management and operation.

BIM is not only restricted to planning and design phase of a project but its use goes on throughout the life of a project in terms of construction phase, management phase and facility management.

Our Project is based on facility management in which BIM approach is used. Facility management extends throughout the life of building. BIM approach provided us complete information of a building which is very important in facility management. This information contains building equipment's and appliances information. Every element of a building has unique id in BIM model. BIM model recognize every element whether it is fan, light etc and all the information of building is provided through BIM which we have used in our Facility management Project**.**

3.2 Revit

Revit is a building information modeling software by Autodesk. It has been widely used for architectural, structural, plumbing, electrical modeling not only in design phase but also to monitor or to check the progress of a project. It is also used in facility management related projects. The 3D model created in Revit consists of all the details about the building components like walls, bricks beams, doors, ceiling fan etc.

After first understanding of problem and literature review our first task was to decide the approach and use of advanced software for our Project. We used Autodesk Revit for making 3D Building drawing for our project. Revit made the 3D model in a very less time as compared to AutoCAD. It is an advanced software which easily created different sections and provided us complete information of a building. Revit recognize the building equipment's and structure and it

is connected to Dynamo through which all the information is extracted. In Revit all building elements were given unique id which we have used for our facility management Project.

After Architectural drawing the other plans like ceiling, elevation were made easily by selecting for that option.

3.3 Dynamo

Dynamo is a visual_programming tool that works with Revit and visual programming is done in dynamo for many purposes including data extraction from BIM model. Dynamo extends the working power of Revit by providing access to Revit API (Application programming interface).

After completion of 3D model on Revit software next task was to extract all the building information into excel or any other format sheets which was one of the most important tasks. Dynamo helped in automating this whole process. All the building data which includes furniture, electrical and mechanical equipment's which were placed in a building and its model were extracted through the use of dynamo. In dynamo there are different nodes which were connected and there was option of category which include every category of elements. All the element information was extracted into excel sheets and also the unique id which was assigned through Revit software also placed Infront of that element.

Dynamo also saved time by reducing the effort of repetitive tasks. There are different packages in dynamo in which some nodes are already made. By selecting these nodes and connect it we got our output. All the data of building was extracted by using dynamo into excel sheets. All the excel sheets were placed on database from where element information was collected automatically for facility management in case of faulty equipment.

3.4 Research Methodology

This study was executed in three phases to achieve the research targets.In first phase an intial study was conducted to find the study gap.Fundamental objectives were also developed in this phase.Then in second phase a detailed literature review was performed concerning the established objectives and partial data was collected.The third and final stage covered data collection analysis and gave the automated facility management results.

3.4.1 Phase 1

Phase 1 of our research methodology consists of basic research steps such as selection of topc,development of research problem and research objectives.Research papers,articles ,conference papers help us to find study gap in current research.At this phase , different questions like work already done on proposed topic ,relevance to national need and basic advantages are answered.

3.4.2 Phase 2

After completion of 1st phase detailed literature review is carried out to find out the detailed features that can be combined together to achieve the facility management results .Various

softwares were available we selected it according to our feasibility and project rquirement.A BIM approach is used and revit software was best for the features which was needed for our project.A Revit has access to Application programming interface through which dynamo is conncected by revit and all the essential building data was extracted ito excel sheet files.These files containing building data were placed on separate database.

3.4.3 Phase 3

After 2nd phase all the processes were cobined together to get the results and to check whether the results were same as calculated through research process or have different values.After all this process we got the required results which was BIM enabled automated facility management.Our project streamlined the whole process and saved time and building asssets and complete record of building maintenance was saved in data base which can be checked anytime for personal use.

A complete three phase process is shown in Figure 12.

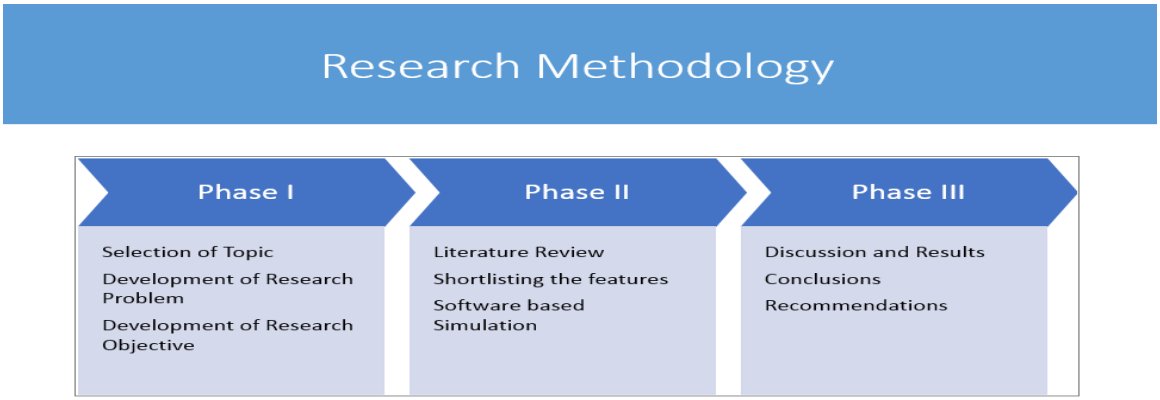


Figure 12 Research Methodology

3.5 Steps Involved

A series of steps was involved in completing this project. The steps are explained further in an orderly fashion**.**

3.5.1 Survey Conducted

A detailed survey was conducted to get an idea of the level of knowledge people have about facility management. The sample of survey included people related to construction sector, people working in government or private sector, students from different educational institutions and people working in maintenance industry. The results of the survey are as shown

1- Are you aware of the term facility management?

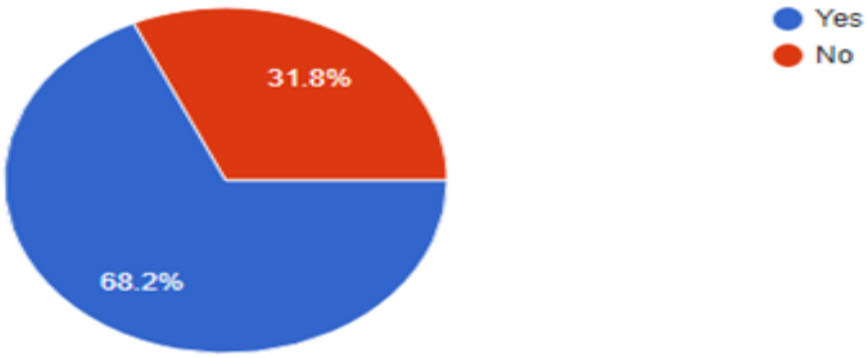


Figure 13 Survey Result 1

As per Figure 13, nearly 68% people out of total sample were aware of the term facility management. Some had modicum knowledge of the subject and some were more cognizant of the subject.

2- Do you know the difference between conventional and automated FM?

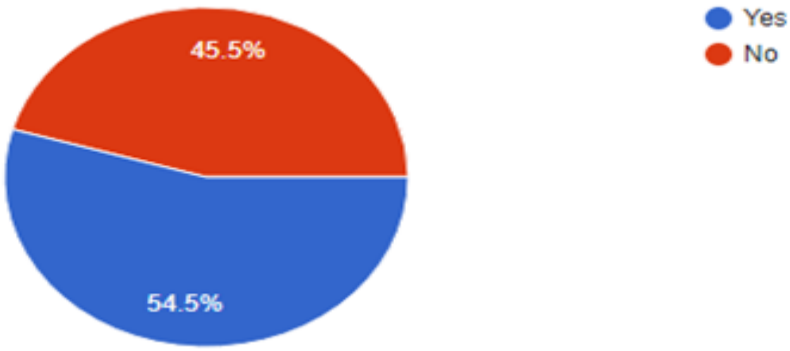


Figure 14 Survey Result 2

As per Figure 14, nearly 50% of people out of total sample were aware of automated facility management with majority just having a general concept of the subject. The remaining percentage was completely unaware of the subject. However, when explained, majority showed interest and were looking forward to using the system.

3- Do you find it cumbersome to go through hierarchical steps to get the issues/glitches fixed?

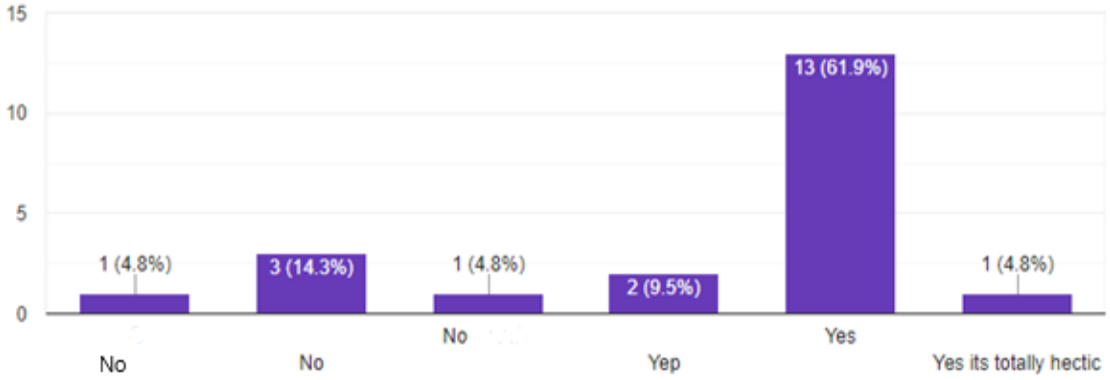


Figure 15 Survey Result 3

A large number of people found it hectic and tome wasting to go through the current conventional system of facility management.

4- Does the conventional system i.e. manually lodging complaint, getting approvals take unnecessary delays?

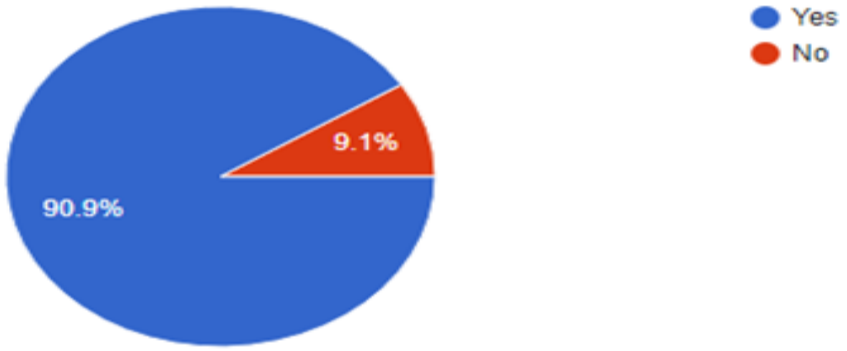


Figure 16 Survey Result 4

This was the question where a large majority of people agreed. As per Figure 16, nearly 90% people agreed that this traditional system of maintenance causes redundant delays.

5- Will you find it more feasible if all you need to do is scan a QR code and your issue will be addressed with no delays?

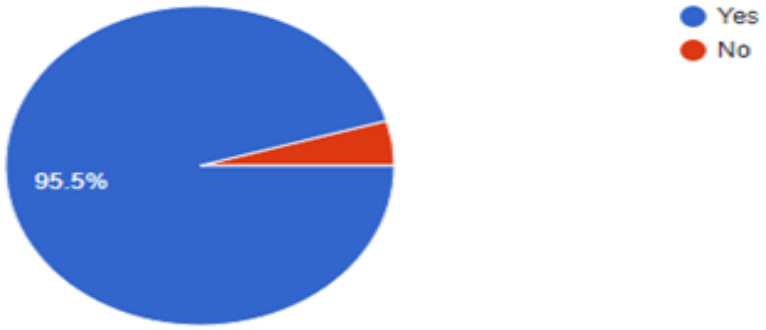


Figure 17 Survey Result 5

According to Figure 17, nearly 95% people welcomed the invention of a system that will make the process of facility management streamlined and give real time access to the users.

3.5.2 Collection of Required Data

a) Collect all the drawings of the building

b) The drawings should be as built, not as planned

c) All the drawings i.e. architectural, structural, electrical, furniture, plumbing was thoroughly checked to know about any missing data

3.5.3 Converting Drawings into Revit Model

a) All the drawings were reconstructed in Revit

b) Grid lines, levels and all other basic elements were copied to avoid any discrepancy

c) Architectural model was built first using architectural drawings

d) Then all other models i.e. structural, electrical, furniture, plumbing were created using CAD drawings.

A 3D Revit building Model is shown in Figure 18. It shows the details of the model incorporated in the model. These details can be updated any time.

Figure 18 3D models of the building

3.5.4 Project Parameters

Project parameters were assigned in Revit which included Element Id, working status. The element Id parameter was the most useful in identifying the building components and later on updating the status of the component.

3.5.5 Assigning Element Ids

Element Ids were assigned to each element of the building using Dynamo. The element Ids were added using Dynamo code as shown in Figure 19. In the code, under the categories function element Ids can be sought for any category by just selecting the desired category. Each element has a unique element Id that helps in identifying each component. This is the information that was most helpful in accomplishing this project. There is a glut of components in a building and this feature of element Ids associated with BIM helps in pointing out elements which are not working.

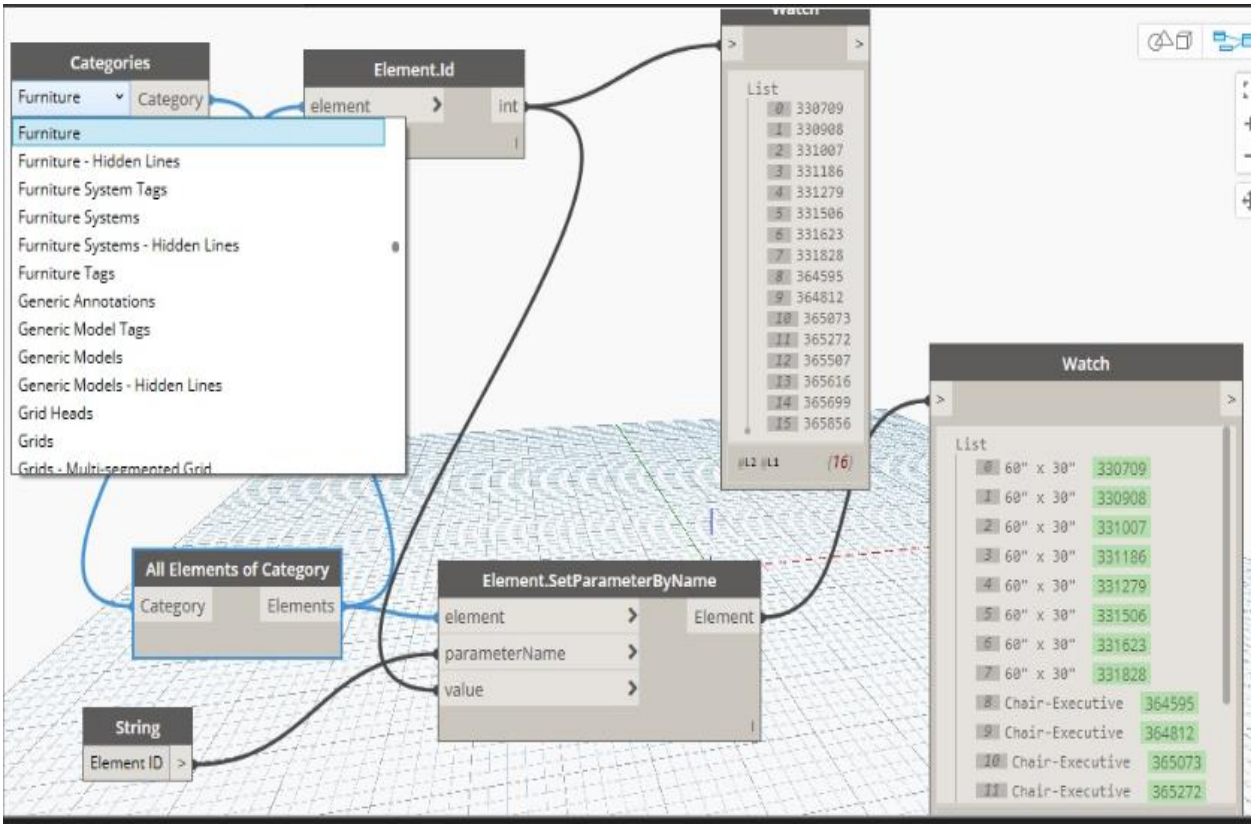


Figure 19 Dynamo code for Element Ids of furniture

As mentioned above, new parameters had already been added in project parameters. The values for new parameters were filled using the Dynamo code as shown in Figure 18. Similar codes were used for other elements of the building. Element Ids for any component can be extracted using the code in Figure 14. All one needs to do is to change category under the 'categories' function. In this way, element Ids of the building components like furniture, electrical, windows etc. were extracted.

A family and type with their element ids is shown below in Figure 20.

A	B
Family and Type	Element Id
Basic Wall: Main Wall- 8" 2	304980
Basic Wall: Main Wall- 8" 2	305196
Basic Wall: Main Wall- 8" 2	305437
Basic Wall: Main Wall- 8" 2	306195
Basic Wall: Main Wall- 8" 2	306383
Basic Wall: Main Wall- 8" 2	306508
Basic Wall: Main Wall- 8" 2	306752
Basic Wall: Main Wall- 8" 2	307094
Basic Wall: Main Wall- 8" 2	307260
Basic Wall: Main Wall- 8" 2	307610
Basic Wall: Main Wall- 8" 2	307897
Basic Wall: Main Wall- 8" 2	308108
Basic Wall: Main Wall- 8" 2	308625
Basic Wall: Main Wall- 8" 2	308714
Basic Wall: Main Wall- 8" 2	308866
Basic Wall: Partition- 4" Brick 2	309116
Basic Wall: Partition- 4" Brick 2	309198
Basic Wall: Partition- 4" Brick 2	309323
Basic Wall: Partition- 4" Brick 2	309630
Basic Wall: Partition- 4" Brick 2	310082
Basic Wall: Partition- 4" Brick 2	310391
Basic Wall: Partition- 4" Brick 2	310588
Basic Wall: Main Wall- 8" 2	311126
Basic Wall: Main Wall- 8" 2	311507
Basic Wall: Partition- 4" Brick 2	311582
Basic Wall: Partition- 4" Brick 2	311807
Basic Wall: Main Wall- 8" 2	311964
Basic Wall: Partition- 4" Brick 2	312063
Basic Wall: Partition- 4" Brick 2	312262
Basic Wall: Partition- 4" Brick 2	316930
Basic Wall: Main Wall- 8" 2	366393
Basic Wall: Main Wall- 8" 2	370443

Figure 20 Element Ids Incorporated

3.5.6 Extracting Data from Revit Model to Excel

When all the required data was completed, then it was extracted to Excel. A Dynamo code was built to directly create Element Ids and export to Excel**.** This code helped in extracting room related data i.e. room numbers along with element Ids.The code used for extracting room element ids is shown in Figure 21. In this way, all the relevant information was extracted.

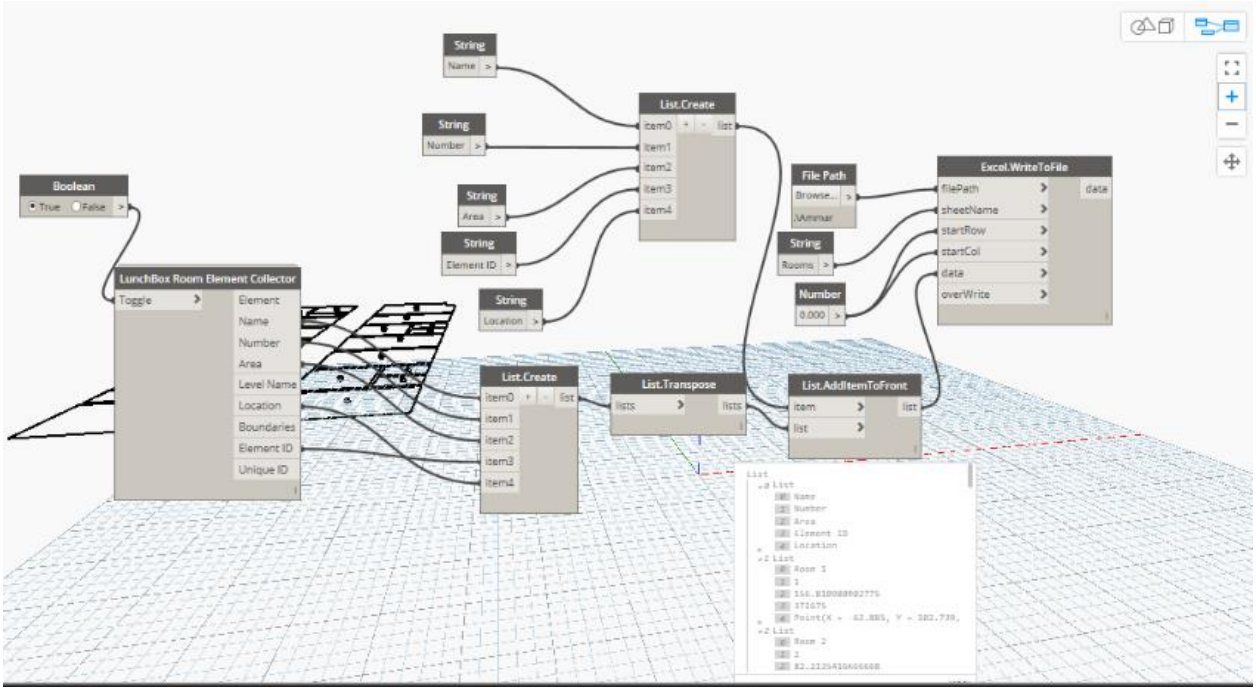


Figure 21 Dynamo code to assign and import data (For Rooms)

The resulting Excel file is as shown in Figure 22.

Name	Number	Area	Element Il	Location
Room 1	1	156.811	371675	Point(X = -62.885, Y = 102.739, Z = 0.000)
Room 2	2	82.21354	371678	Point(X = -55.573, Y = 105.807, Z = 0.000)
Room 3	3	241.8472	371680	Point(X = -37.155, Y = 103.993, Z = 0.000)
Room 4	4	190.2405	371682	Point(X = -61.232, Y = 89.842, Z = 0.000)
Room 5	5	190.7639	371684	Point(X = -37.760, Y = 91.016, Z = 0.000)
Room 6	6	108.875	371686	Point(X = -56.312, Y = 77.949, Z = 0.000)
Room 7	7	33.02138	371688	Point(X = -65.655, Y = 80.376, Z = 0.000)
Room 8	8	38.64204	371690	Point(X = -66.140, Y = 74.794, Z = 0.000)
Room 10	10	109.8056	371694	Point(X = -40.312, Y = 77.997, Z = 0.000)
Room 11	11	35.63802	371696	Point(X = -31.243, Y = 80.090, Z = 0.000)
Room 12	12	35.63802	371698	Point(X = -30.963, Y = 74.369, Z = 0.000)
Room 13	13	190.0521	371700	Point(X = -35.708, Y = 67.671, Z = 0.000)
Room 14	14	190.2405	371702	Point(X = -59.707, Y = 67.113, Z = 0.000)
Room 15	15	190.2405	371704	Point(X = -60.405, Y = 54.695, Z = 0.000)
Room 16	16	190.7639	371706	Point(X = -36.684, Y = 53.997, Z = 0.000)
Room 17	17	108.875	371708	Point(X = -57.172, Y = 41.369, Z = 0.000)
Room 18	18	34.98861	371710	Point(X = -66.214, Y = 38.970, Z = 0.000)
Room 19	19	36.6748	371712	Point(X = -65.845, Y = 44.137, Z = 0.000)
Room 20	20	110.7361	371714	Point(X = -40.011, Y = 41.184, Z = 0.000)
Room 21	21	36.02344	371716	Point(X = -31.153, Y = 43.583, Z = 0.000)
Room 22	22	34.36719	371718	Point(X = -31.153, Y = 38.416, Z = 0.000)
Room 23	23	197.1701	371720	Point(X = -36.688, Y = 29.996, Z = 0.000)

Figure 22 Excel file for Room Data

Now, this room data and components data were manipulated and converged to a single database. Each component was linked to its room number using the room's element Id.

3.5.7 (a) Adding Working Status

Another parameter that was added using dynamo is working status. This additional parameter can be used to update the 3D model in Revit. For instance, when a complaint is lodged the element Id or Ids for the respective element is shown and saved in the dashboard. When the complaint is in progress, the element Id can be used to assign the status of not working in Revit and when the complaint is resolved, the status can be updated to working. This gives additional real time information about the current maintenance status of the building which is generated by dynamo code shown in Figure 23.

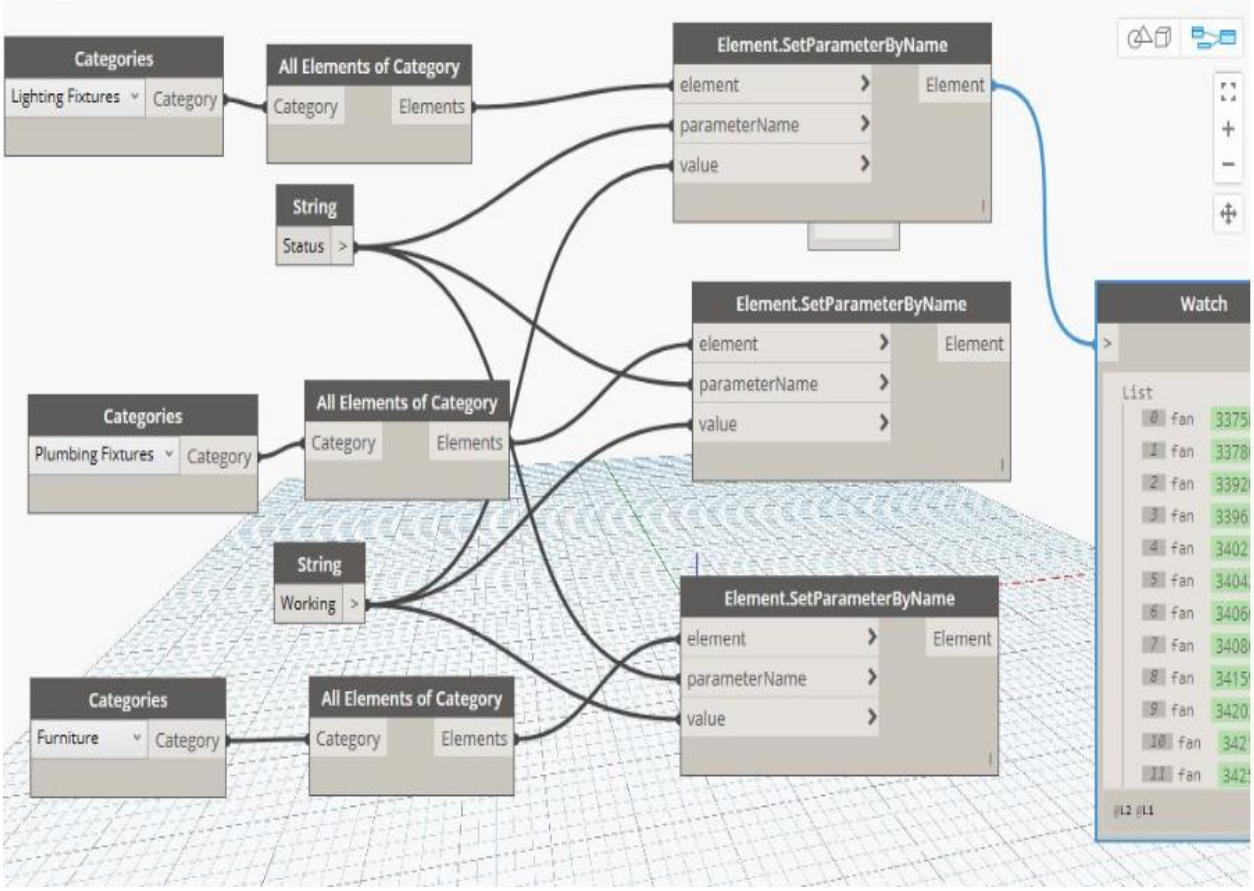


Figure 23 Assigning Working Status

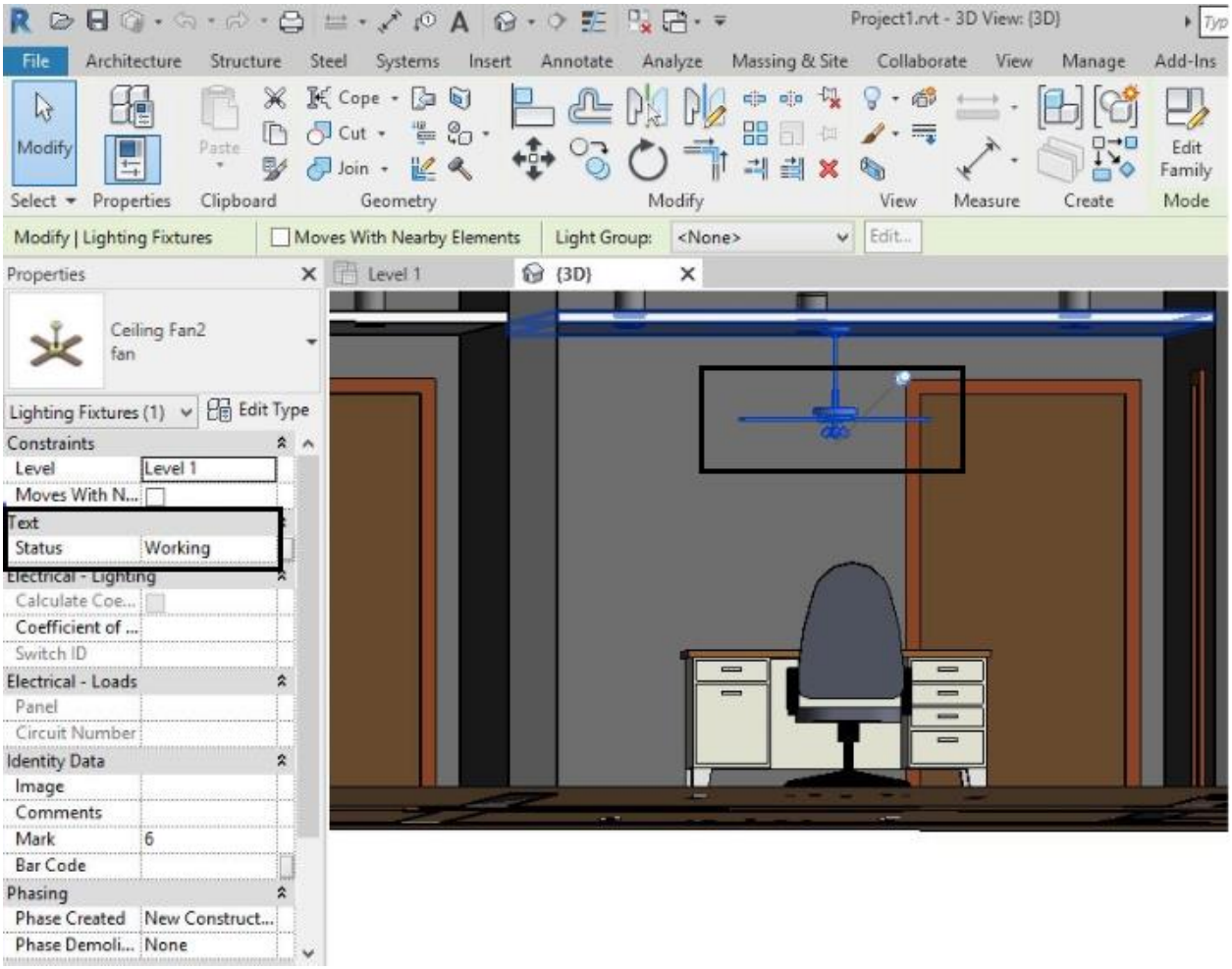


Figure 24 Highlighted Equipment along with status

The Figure 24 shows Faulty equipment with status.

3.5.8 Converging Data

To converge data, php programming was used along with the tool 'EXCEL2MYSQL. The php script does the function of parsing the data in Excel files and adds the data from excel files in the database against the respective table in the database. To create a database, 'EXCEL2MYSQL' was used that converts excel data into database in the form of tables. Now when a complaint is lodged, the system takes query from database and displays all the data related to the room number as per Element Id. In the database, all the data is saved against the relevant room Id which helps in picking all the relevant elements i.e. elements of the respective room. This data is then displayed in the complaint interface where the user can select multiple elements at a time. The database schema is shown in Figure 25.

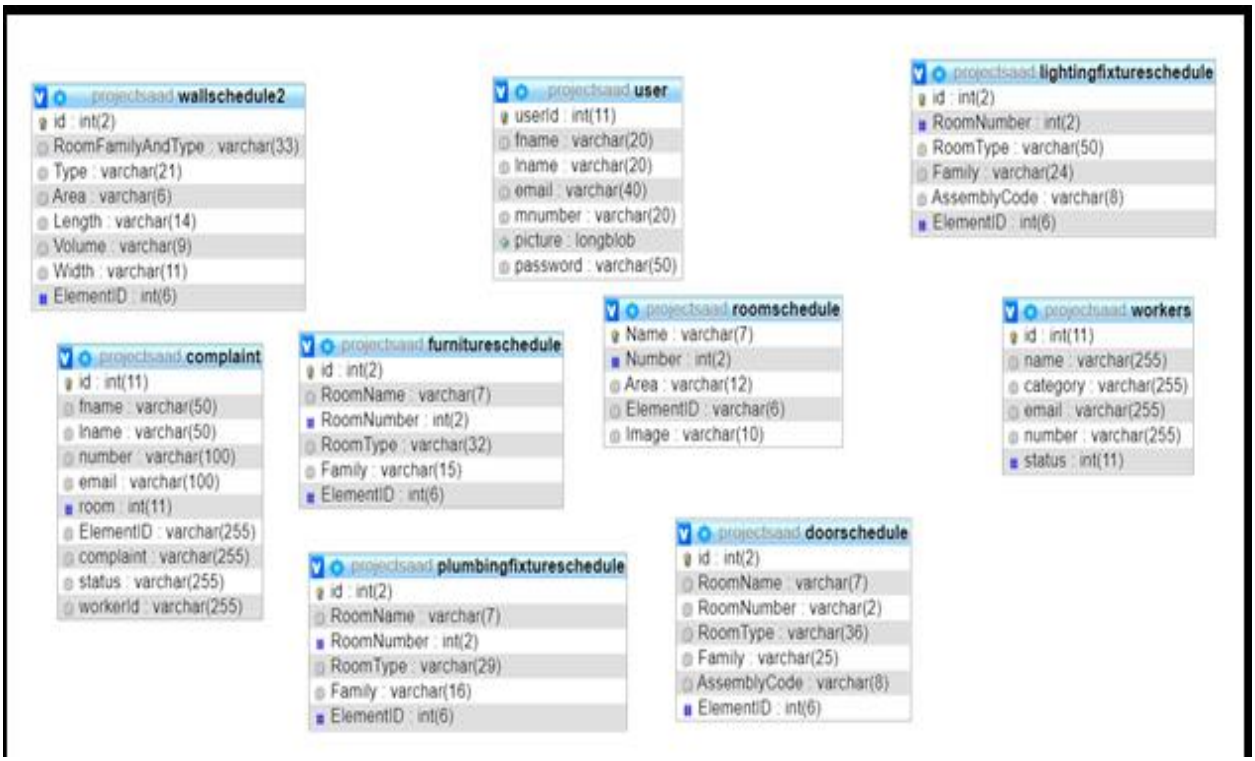


Figure 25 Database Schema

3.5.9 Sending Emails

When the end user sends a complaint, he receives an email confirming the submission of his request. Also, emails are sent to the workers and facility managers for updating about the details, status of complaint. To send the mail we used the PHP mailer built-in function to send the mail to student.

Here we used the HTML template that includes the details like name, room number and some other details of the students so that the student can verify that their mail is submitted successfully and also, they have the proof of the complaint. This helps in permanent record saving at different levels. When the user files a complaint, an email is automatically sent to the user which includes all the details of the complaint along with a unique token number. For date and time function, the date and time class of php was used. A schema for details incorporated un emails is shown in Figure 26.

```php
require("class.phpmailer.php");
$mail = new PHPMailer();
$mail->IsSMTP();
$mail->Host = "smtp.gmail.com";
$mail->SMTPAuth = true;
$mail->SMTPSecure = 'tls';
$mail->Port = 587;
$mail->Username = "xxxxxxxx"; //email of the sender
$mail->Password = "xxxxxxx";  // password of the sender
$mail->FromName = "NUST Hostels";
$mail->AddAddress($pemail); // jis mail pa send krni mail
$mail->IsHTML(true);
$date= date("Ymd");
$mail->Subject = $subject;
$mail->SMTPDebug = 1;
$mail->Body = "<h1 align=\"center\">Your Request has been received.</h1>".
  "<h2><u>Your Token Number</u> :".$date.$getoneElement.$maxId."</h2>".
  "<h2><u>Details of your Request</u></h2>".
  "<h4>"."Name: ".$firstName."</h4>".
  "<h4>"."Mobile #:".$mNumber."</h4>".
  "<h4>"."Room #:".$room."</h4>".
  "<h4>"."Detail:".$complaint."</h4>".
  "<h4>"."Date:".date("Y/m/d")."</h4>".
  "<h3 > We will contact you shortly</h3>";
```

Figure 26 Schema for details incorporated i n emails

So after adding the data in the mail we used the Send () function to send the mail. If the mail is successfully submitted, then we will redirect the user to thanks page and if the function gives error than we will print it which is shown in Figure 27.

```php
if ($mail->Send() == false)
    {
      echo $mail->ErrInfo;
        die( $mail->ErrInfo);
    }
    if ($mail->Send() == true)
    {
        header('Location: ../thanks.php ');
      }
```

Figure 27 Schema for sending emails

3.5.10 Complaint Submission Procedure

a) When the user scans the QR code, the webpage gets the room id from the URL that is incorporated in the QR code. This brings the facility management to the specific room which has faulty equipment.
b) Then the room items are loaded dynamically from the database.

c) Then user writes the selects which facility of the room is not working and he may add further details about the complaint in the text box below and then submit the complaint.
d) After submitting email is sent to the user so that he has the proof of work and the status of the complaint is in review.
e) The user then receives an email confirming the successful submission of complaint.
f) The complaint is then registered in the dashboard where all the details pertinent to the complaint are saved. The element Id of the faulty equipment or equipment's is shown in a separate column.
g) In the dashboard, the status of complaint is changed progressively.

3.5.11 Front End Interface

To make the front-end interface the following tools were used:

a) HTML5
b) CSS3
c) JavaScript
d) JQuery
e) Bootstrap

3.5.12 (a) Back-end Interface

We also developed the backend so that we can interact with database and make the website dynamic. We use the language PHP for backend task and store all the data in the MySQL database.

3.5.13 QR Codes

QR codes for each room were created using an online website. The URL for each room was incorporated in the QR codes respectively. The URL consists of Room Id and this brings to the room number.

CHAPTER 04

RESULTS

4.1 Model

A 3D model of the first floor of NIT building was prepared on Autodesk Revit to validate our system on a real-life example. The model consisted of architectural, furniture, structural and electrical models. The model was an exact replication of the actual building and its components. The information from the model was then extracted using Dynamo. The extracted information was manipulated and converged to a single point and was linked to real time web based interface using programming methods.

4.1.1 Architectural Model

The architectural model consisted of all the details of doors, windows, walls of the building. The model was created using Autodesk Revit. It contains all the architectural details in a 3D environment. Architectural model of our selected building is shown in Figure 23.

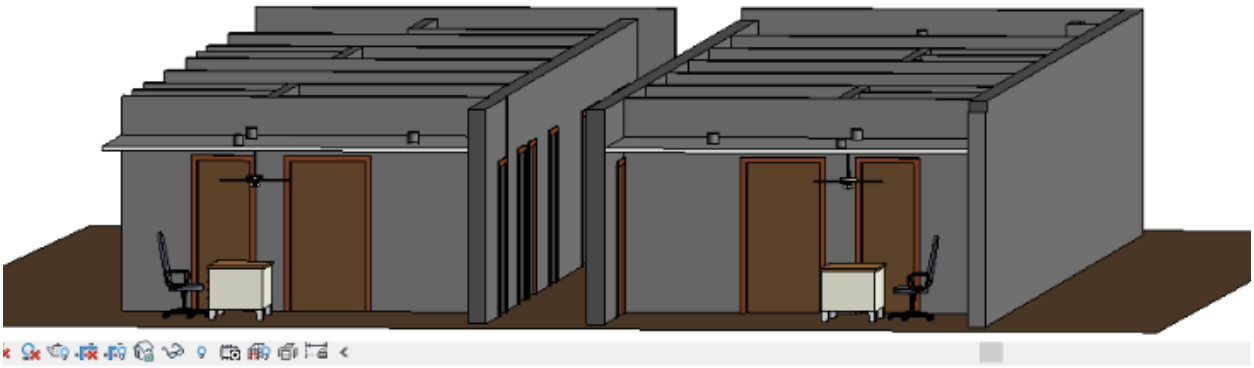


Figure 28 Architectural Model of the selected building (NIT)

4.1.2 Furniture Details

The model was incorporated with furniture details of the building. This included chairs, desks and all the associated material. The furniture details in the model were exact replication of the furniture drawings in a 3D environment. A Furniture detail of building is shown in Figure 29.

Figure 29 Furniture details of the building

4.1.3 Electrical Details

The electrical details included lighting fixtures, fans and all the stuff associated. All the specifications of the electrical drawings were provided in 3D environment. A 3D model is shown in Figure 30.

Figure 30 Electrical details of the building

4.2 Element Ids Generated

The element Ids for all the elements i.e. rooms, architectural, furniture, structural, electrical were generated and grouped by using Dynamo. Dynamo is an extension with Revit which is used to add additional functions while working with Revit. A proper Dynamo code was created using which the element ids were extracted for all the elements.

Element Ids are the key to this project. In Revit, every element has a unique element Id which helps in identifying the respective element which is generated by dynamo code shown in Figure 31. In the similar way, element Ids for other elements were generated. For a particular element, the respective category can be selected under the categories function and the required element Ids will be generated.

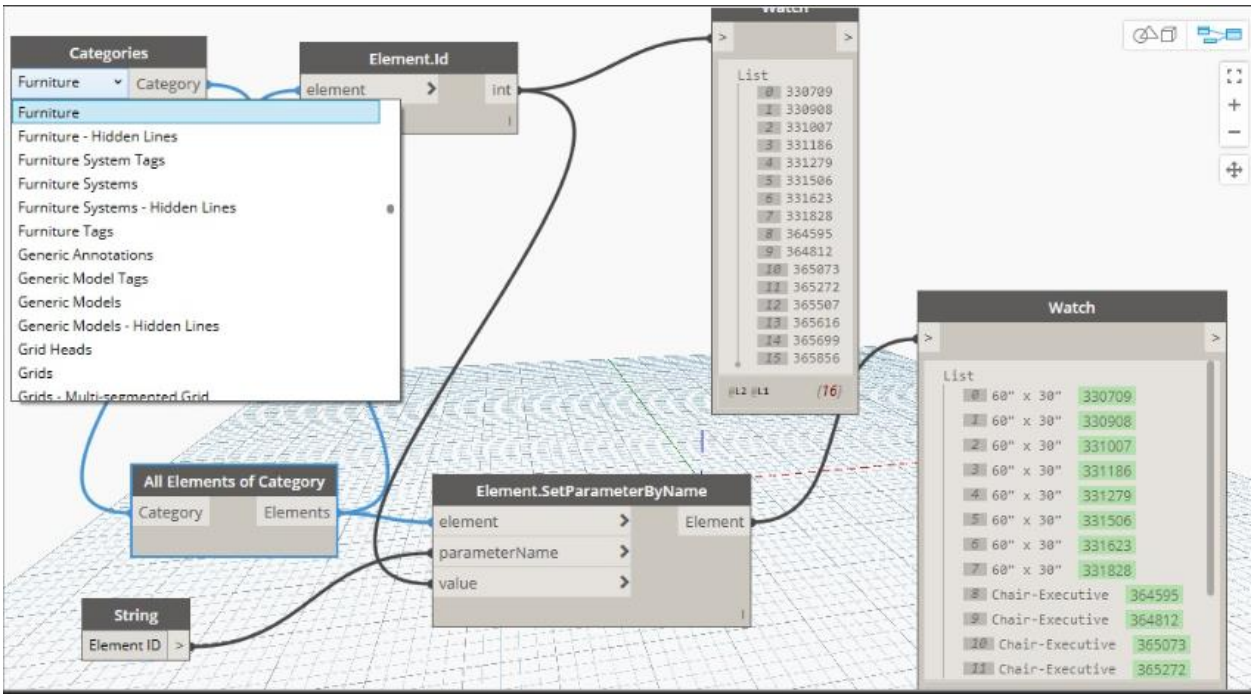
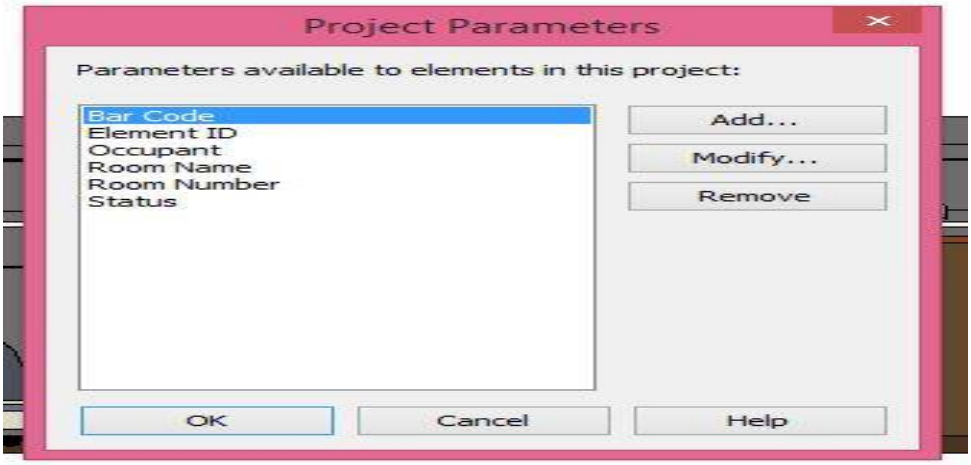


Figure 31 Dynamo code for element Ids generation (Furniture in this code)

4.3 Schedule of Quantities

The schedule created for all the rooms included all the details about the room respectively. The details included element Ids of architectural elements, furniture, electrical elements and apparent plumbing elements. New parameters were added in the 3D model in Revit. A complete detail of project parameters is shown in Figure 32.



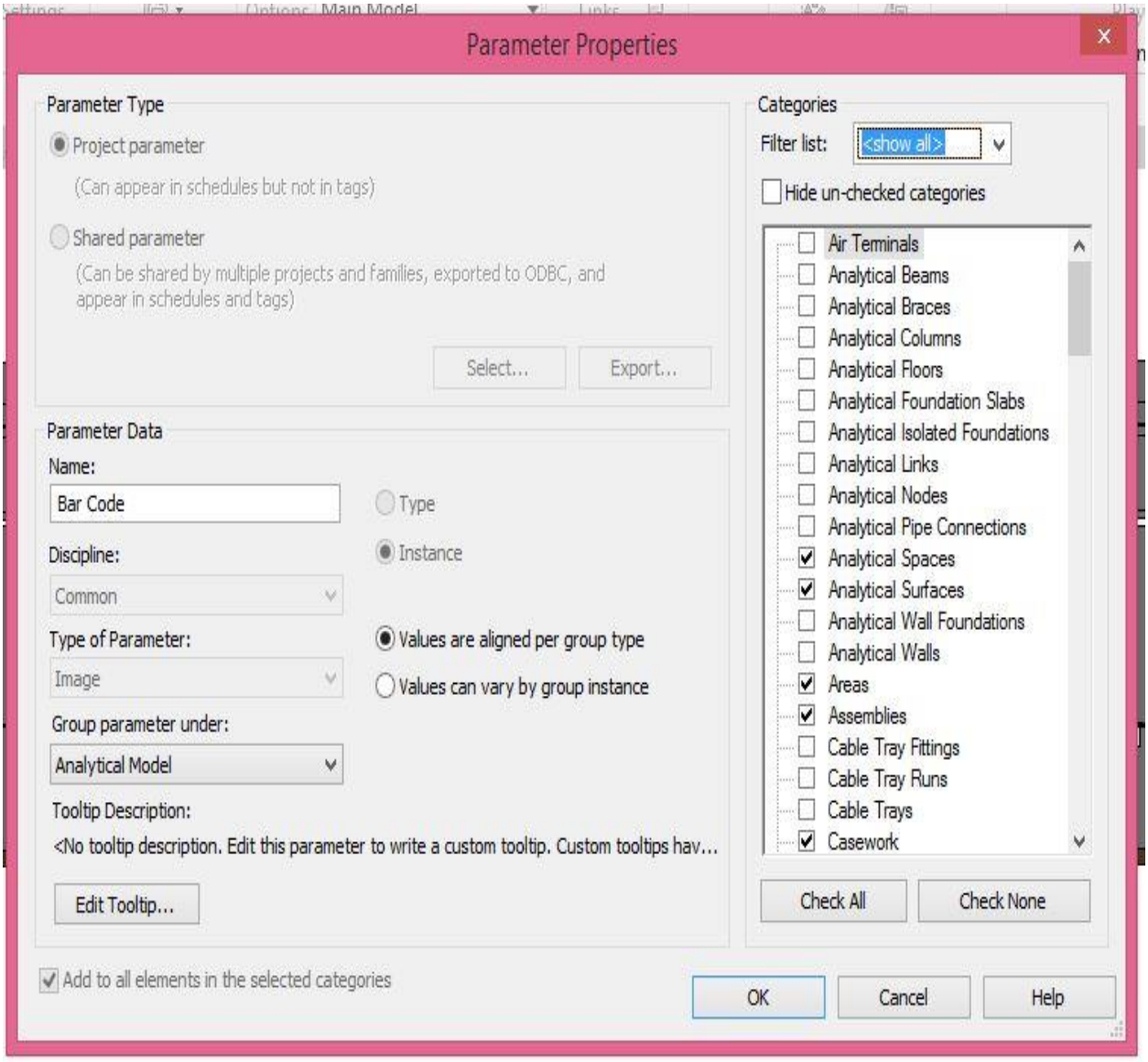
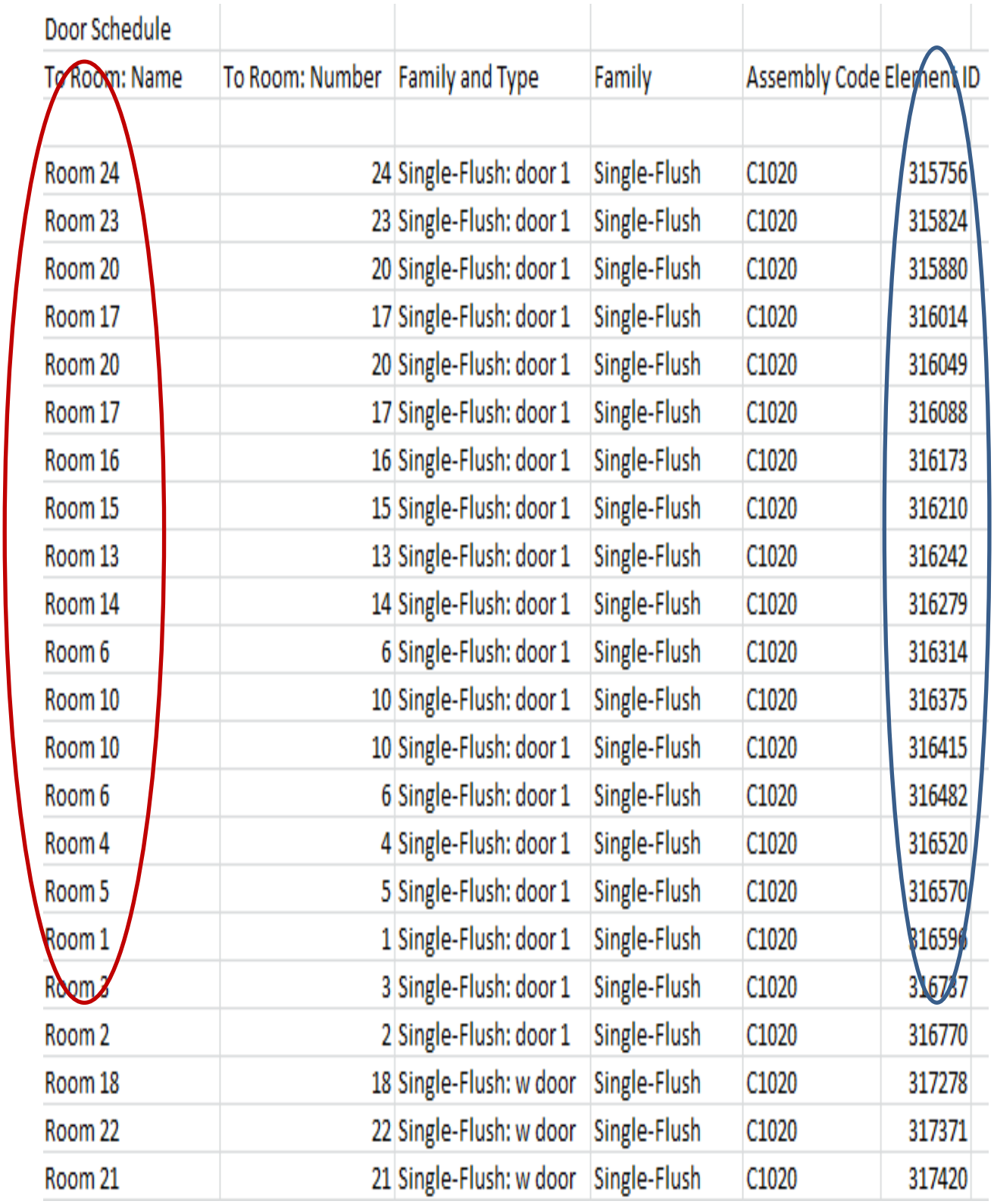


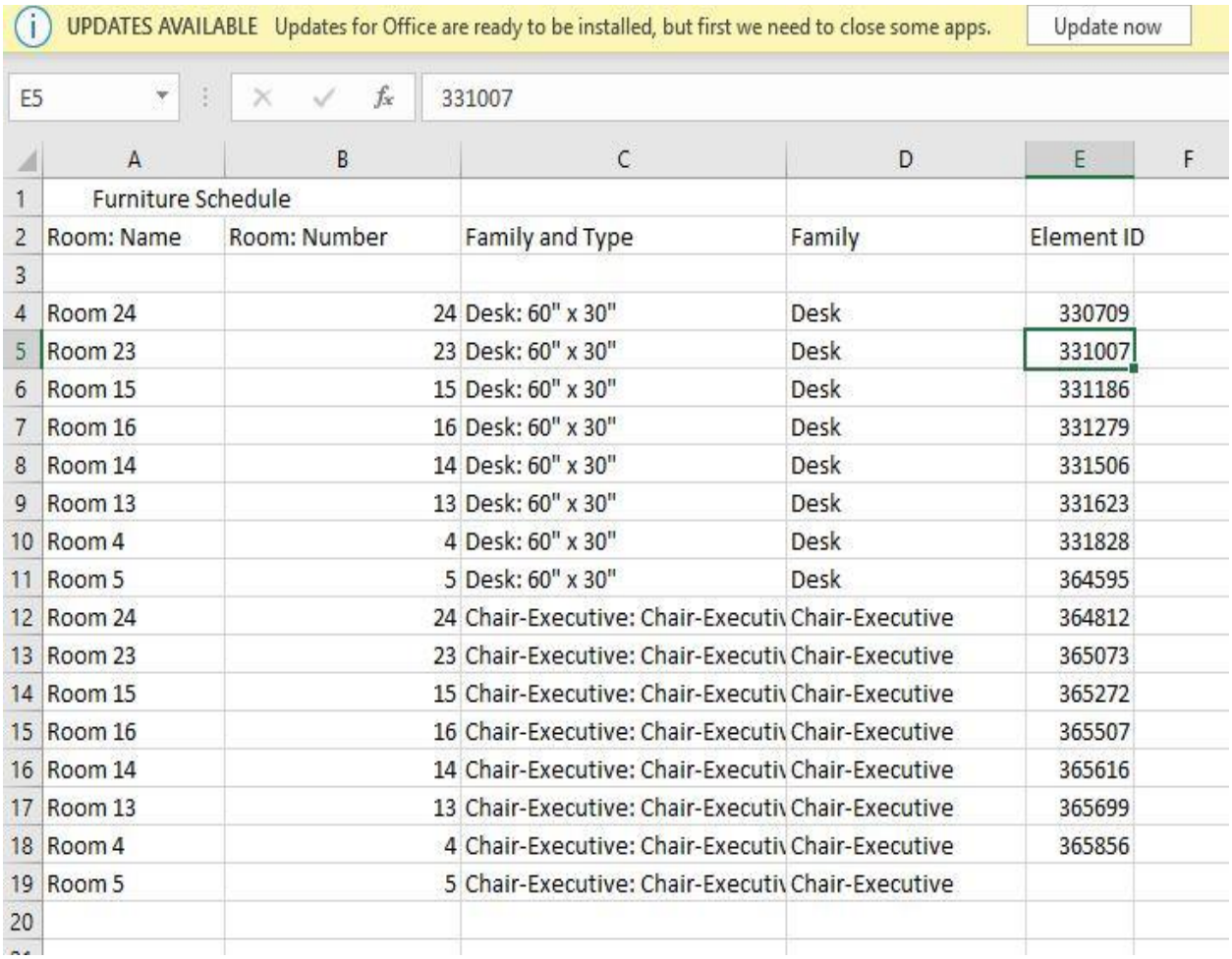
Figure 32 Detailed Project Parameters

After all the values in the schedules were added using Dynamo then these schedules were converted into Excel Files for easy and quick access while converging all this data and thus centralizing all the information to a single platform. A result obtained in excel sheets is shown in Figure 33 & 34.



Door Schedule					
To Room: Name	To Room: Number	Family and Type	Family	Assembly Code	Element ID
Room 24	24	Single-Flush: door 1	Single-Flush	C1020	315756
Room 23	23	Single-Flush: door 1	Single-Flush	C1020	315824
Room 20	20	Single-Flush: door 1	Single-Flush	C1020	315880
Room 17	17	Single-Flush: door 1	Single-Flush	C1020	316014
Room 20	20	Single-Flush: door 1	Single-Flush	C1020	316049
Room 17	17	Single-Flush: door 1	Single-Flush	C1020	316088
Room 16	16	Single-Flush: door 1	Single-Flush	C1020	316173
Room 15	15	Single-Flush: door 1	Single-Flush	C1020	316210
Room 13	13	Single-Flush: door 1	Single-Flush	C1020	316242
Room 14	14	Single-Flush: door 1	Single-Flush	C1020	316279
Room 6	6	Single-Flush: door 1	Single-Flush	C1020	316314
Room 10	10	Single-Flush: door 1	Single-Flush	C1020	316375
Room 10	10	Single-Flush: door 1	Single-Flush	C1020	316415
Room 6	6	Single-Flush: door 1	Single-Flush	C1020	316482
Room 4	4	Single-Flush: door 1	Single-Flush	C1020	316520
Room 5	5	Single-Flush: door 1	Single-Flush	C1020	316570
Room 1	1	Single-Flush: door 1	Single-Flush	C1020	316596
Room 3	3	Single-Flush: door 1	Single-Flush	C1020	316737
Room 2	2	Single-Flush: door 1	Single-Flush	C1020	316770
Room 18	18	Single-Flush: w door	Single-Flush	C1020	317278
Room 22	22	Single-Flush: w door	Single-Flush	C1020	317371
Room 21	21	Single-Flush: w door	Single-Flush	C1020	317420

Figure 33 Sample Door Schedule



	A	B	C	D	E	F
1	Furniture Schedule					
2	Room: Name	Room: Number	Family and Type	Family	Element ID	
3						
4	Room 24	24	Desk: 60" x 30"	Desk	330709	
5	Room 23	23	Desk: 60" x 30"	Desk	331007	
6	Room 15	15	Desk: 60" x 30"	Desk	331186	
7	Room 16	16	Desk: 60" x 30"	Desk	331279	
8	Room 14	14	Desk: 60" x 30"	Desk	331506	
9	Room 13	13	Desk: 60" x 30"	Desk	331623	
10	Room 4	4	Desk: 60" x 30"	Desk	331828	
11	Room 5	5	Desk: 60" x 30"	Desk	364595	
12	Room 24	24	Chair-Executive: Chair-Executiv	Chair-Executive	364812	
13	Room 23	23	Chair-Executive: Chair-Executiv	Chair-Executive	365073	
14	Room 15	15	Chair-Executive: Chair-Executiv	Chair-Executive	365272	
15	Room 16	16	Chair-Executive: Chair-Executiv	Chair-Executive	365507	
16	Room 14	14	Chair-Executive: Chair-Executiv	Chair-Executive	365616	
17	Room 13	13	Chair-Executive: Chair-Executiv	Chair-Executive	365699	
18	Room 4	4	Chair-Executive: Chair-Executiv	Chair-Executive	365856	
19	Room 5	5	Chair-Executive: Chair-Executiv	Chair-Executive		
20						

Figure 34 Sample Furniture Schedule

Similarly, other schedules were created with added parameters in the Revit model.

4.4 QR Codes and Filing Complaint

For each room a link was created and in that link all the information had already been arranged and converged. Subsequently, a QR code was generated for each room with the link embedded in the code. When end user scans the QR code a complaint interface appears. This complaint interface incorporates details of both end user and the complaint. All the elements of the respective room appear as per the room Id. The details about the end user are also required as a part of validation process. All this information is saved in the dashboard and also becomes part of the trouble ticket. A filing complaint Page is shown in Figure 34.

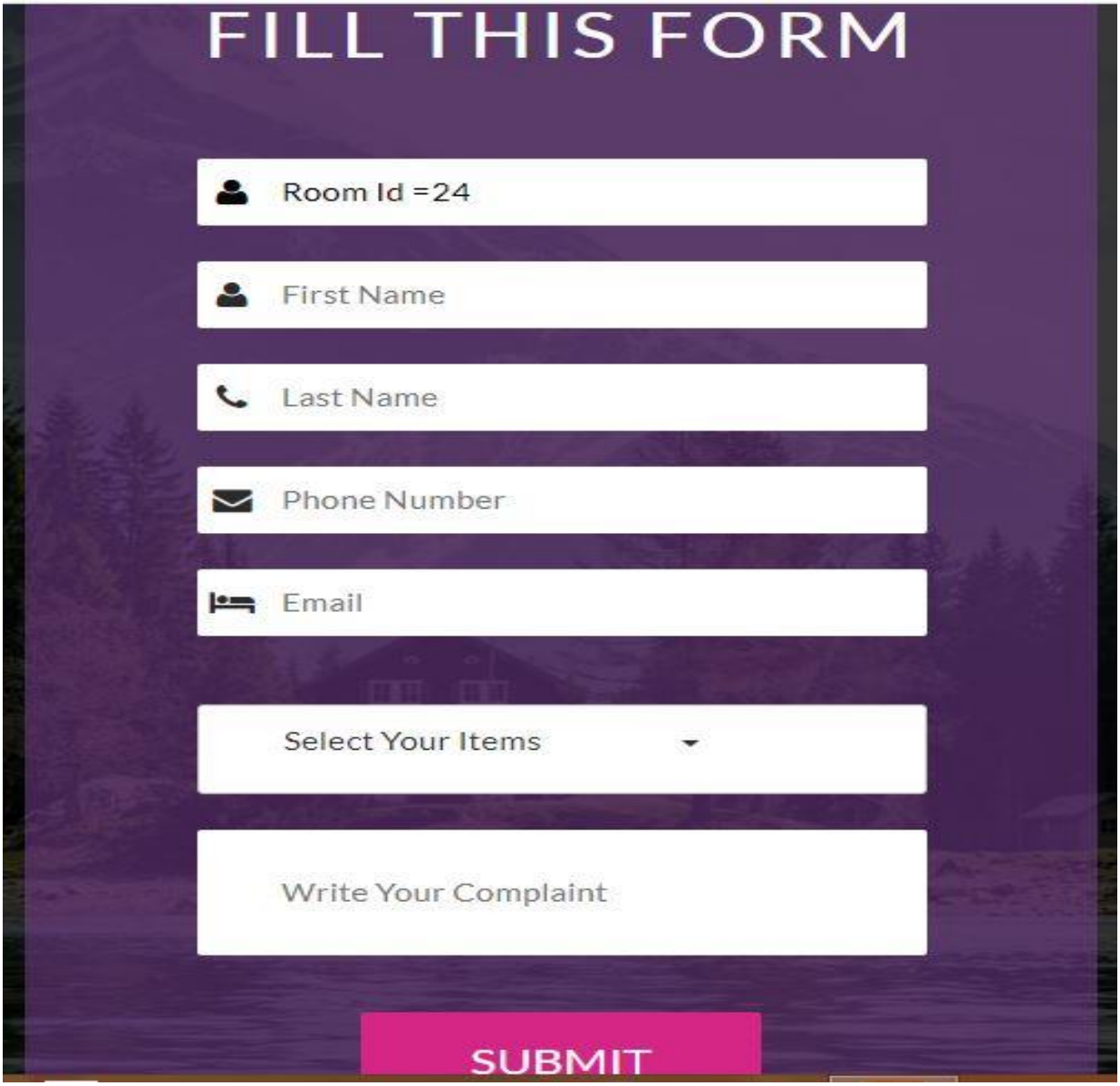


Figure 35 Complaint Interface for end user

4.5 Processing of Complaint

After all the required information has been filled, the complaint is forwarded to the concerned department. The complaint is added in the list and saved on a dash board. There, all the information is stored regarding the complaint. Soon after submission, the complaint waits for approval. After approval, the complaint is sent to the respective worker and assigned the status 'in progress'. As this whole system is centralized, the element id of the faulty equipment is automatically written in a separate column on the dash board. This element id can later be used

to update the status of respective element in the 3D model in Revit. A sign in for dashboard is shown in Figure 35.

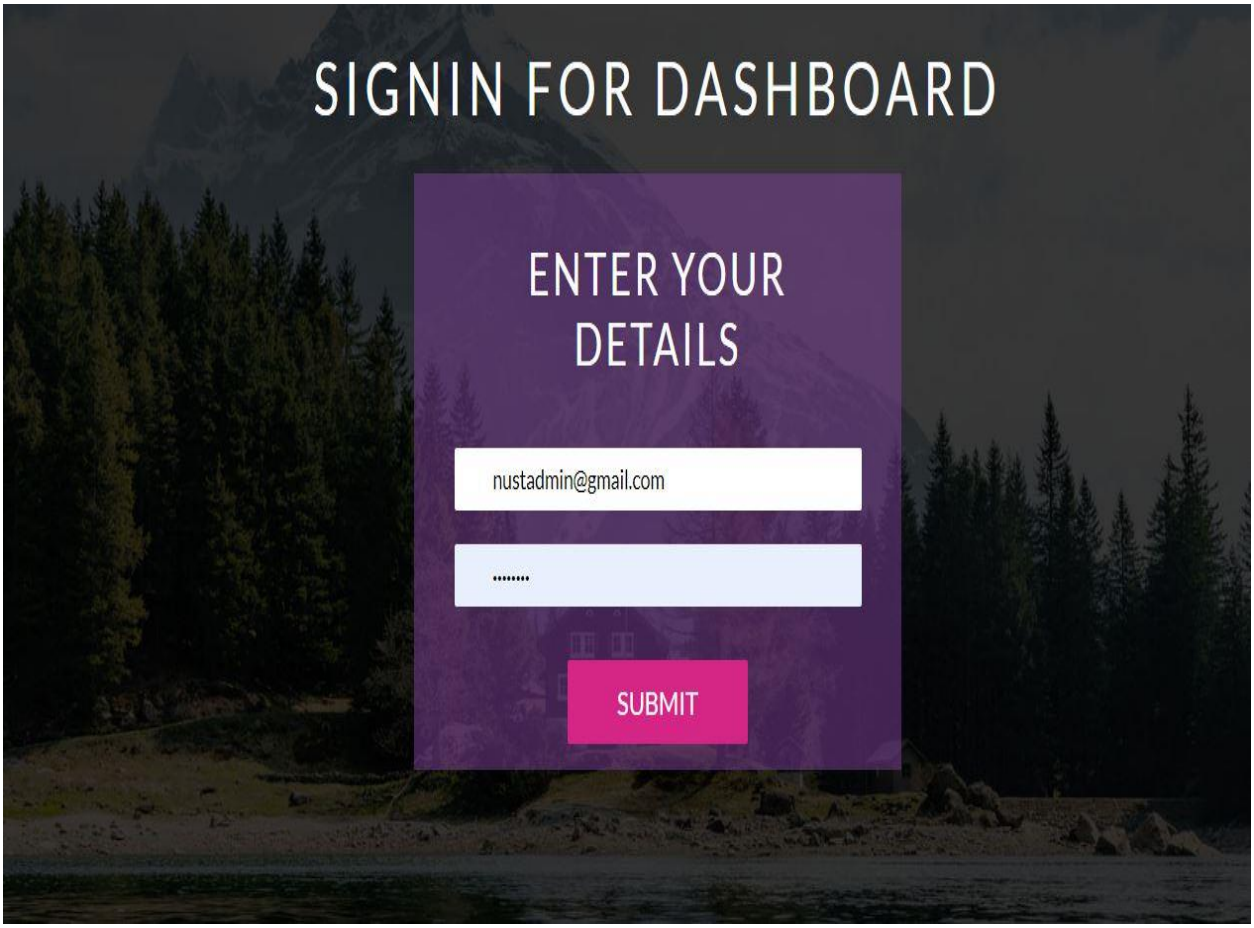


Figure 36 Facility Management or Procurement Office Dashboard

This dash board is in the control of concerned department i.e. Facility Management or maybe Procurement Office. Signing in to this dashboard leads to the complaint record and processing page to which only concerned department can have access. A dashboard with its features is shown in Figure 37.

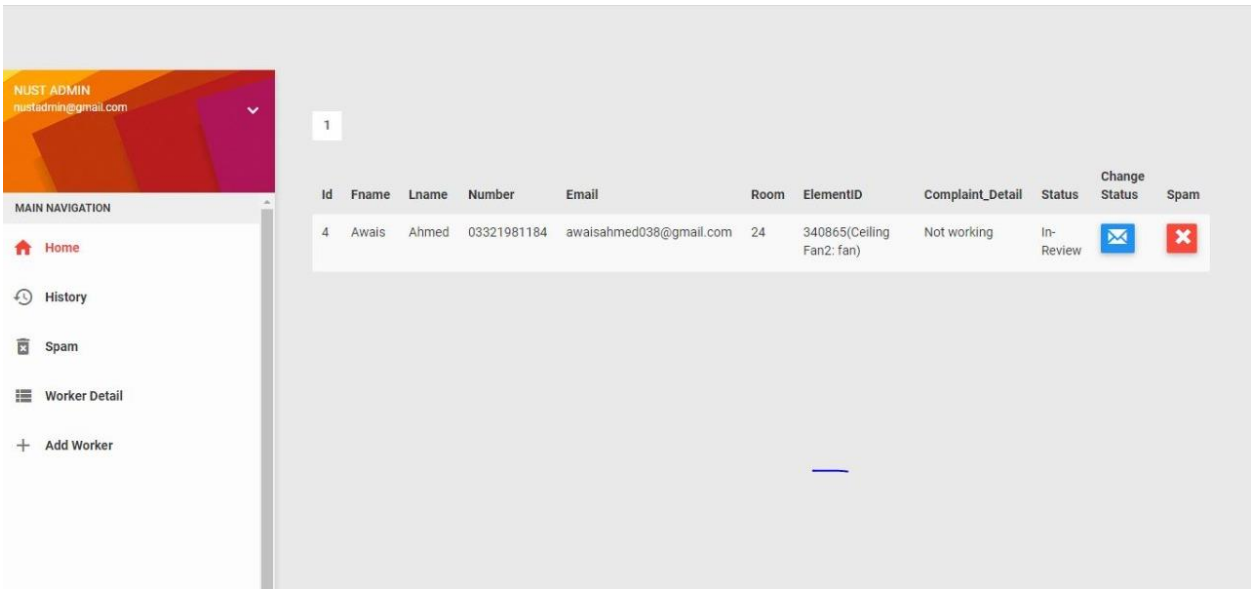


Figure 37 Preview of a complaint received

In this dashboard, the complaints are received and automatically saved for record maintenance.

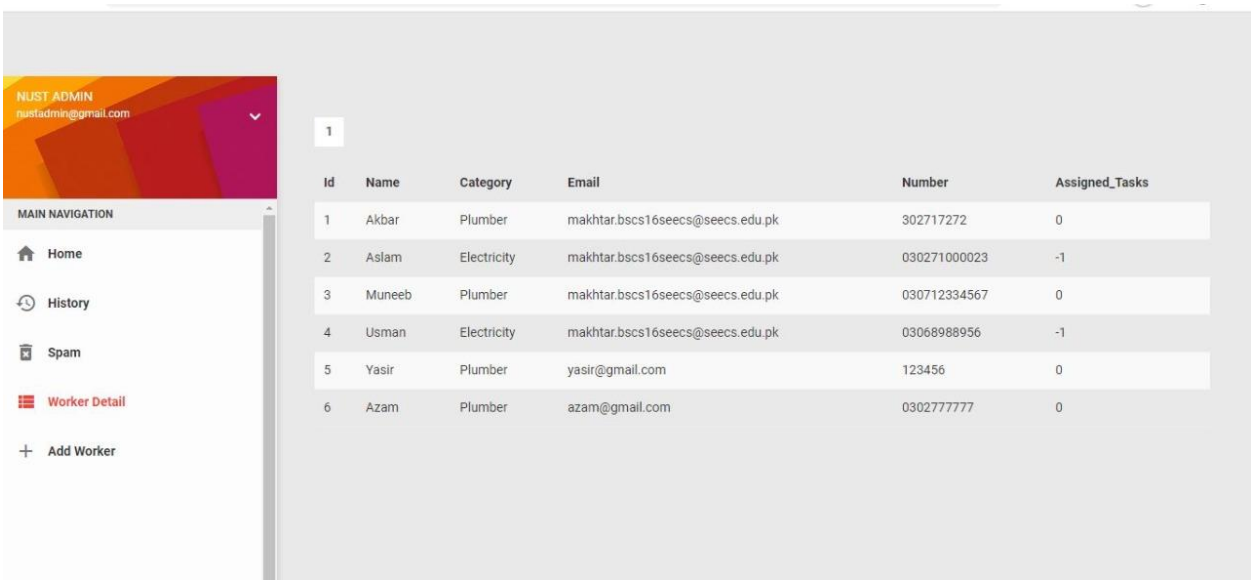


Figure 38 Details of Workers in the database

This is the list of workers that can be edited anytime by the admin which is shown in Figure 38. It can be seen that each worker has a proper record of tasks assigned to him, his contact details and the category he deals in. The admin assigns work as per the nature of the complaint. For

instance, if there is a glitch in the fan, the work will be assigned to the electrician: if an electrician has already been assigned more than one tasks then the admin may assign the work to another electrician. When the work is assigned, the worker receives an email or a text about the details of the complaint. When the work is finished, the worker replies telling about the work finished and subsequently the status of completed is assigned to the task.

4.6 Trouble Ticket Generation

When the end user lodges a complaint an email is automatically sent to the email address provided by him. In this email address, a trouble ticket for the complaint is generated. The complaint is assigned a token number and contains details about the room number and nature of complaint. A trouble ticket format is shown in Figure 39.

Figure 39 Trouble Ticket Format

This ticket comprises a unique token number and all the details of the building. Tis ticket can be used by the end user as a proof of his complaint being lodged. Furthermore, this is a permanent record and can be accessed by the user or the facility management office at any time in future.

CHAPTER 5

CONCLUSION

5.1 Conclusion

The work performed in this project is a depiction of how beneficial is the linkage of modern technology: both IT related and civil engineering in the construction sector. The limitations of 2D drawings and the inconvenience caused by them, especially in the post construction phase i.e. facility management phase, can be eliminated using modern tools like BIM. It is clear in this project how a scattered system of information sharing has been converted to a single platform. The conversion of 2D drawings to 3D drawings has made the extraction, interpretation and convergence of information much easier and systematic. All the different segments involved in the maintenance system are not scattered anymore. They do not have to wait for unnecessary approvals that lead to delays. This project has centralized this system by collecting the dispersed parts and joining them to a single platform. The stakeholders do not have to have detailed knowledge for using this system. Everything is already built in and all they have to do is learn how to use it. These types of projects will revolutionize the maintenance industry. This project is inclined more towards reactive maintenance. The interface developed for dealing with the complaints is automated to a great extent and saves all the redundant time that was once incurred while processing the complaint manually. Another important aspect of this project is record maintenance. In conventional methods, records are maintained on registers which always leads to problems like, loss of record, rummaging through registers to find a previous complaint, no status information and no update system. In this project, a trouble ticket is generated for every complaint which is a permanent record system. In a nutshell, the combination of modern tools and civil engineering will indeed revolutionize the construction sector.

5.2 Limitations

1- If the 2D drawings are not updated with time then there can be errors in the 3D models which can be a problem in ascertaining information.

2- If some drawings are not available then certainly that part cannot be shown in the 3D model.

3- A conflict can occur in physically differentiating between two items that are similar.

5.3 Recommendations

1- The drawings should be regularly updated so that all the data is available in its latest form to avoid inconsistencies in the BIM model.

2- The workers should be properly trained on the use of this system.

3- To avoid conflict when the complaint is about an item which has similar type of items in the same place, the worker should be trained enough to identify the one that is not working.

Alternatively, a coordinate system can be used. Revit has the feature of locating elements by coordinates that can be augmented with a GPS system. Hence, the issue can be resolved.

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