# SMART FACILITY MANAGEMENT

**FINAL YEAR PROJECT UG 2013**

**By**


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This is to certify that the

Final Year Project Titled

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has been accepted towards the requirements

for the undergraduate degree

**in**

**CIVIL ENGINEERING**


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# ABSTRACT

Buildings and public infrastructures are crucial to our societies as they provide habitations, workplaces, commodities and services indispensable to our daily life. As vital parts of facility management, operations and maintenance (O&M) ensure a facility to continuously function as intended, which take up the longest time in a facility's life cycle and demand great expense. Therefore, computers and information technology have been actively adopted to automate traditional maintenance methods and processes, making O&M faster, more reliable and cheaper in many ways. Augmented reality (AR) offers a new approach towards human-computer interaction through directly displaying information related to real objects that people currently perceive. People's sensory perceptions are enhanced (augmented) with information of interest naturally without deliberately turning to computers but instead using a mobile and portable device like tablets, mobile phones or a VR headset. Hence, AR has been proved to be able to further improve O&M task performance. The research motif of this thesis is user evaluations of AR applications in the context of facility maintenance. The studies look into invisible target designation tasks assisted by developed AR tools in both indoor and outdoor scenarios. A 2d barcode based positioning system was made and synchronized with the digital data so that it can be juxtaposed in real-time.

# DEDICATION

We would like to dedicate our work to our parents. It is because of only them, we have come this far. They have always been there for us. Whenever we needed their help of any time, they never denied us. They are the ones due to which we have fulfilled our dreams of becoming an engineer.

# ACKNOWLEDGEMENT

Carrying out a project requires hard work and sheer determination. First and foremost, thanks to ALLAH ALMIGHTY without whose help it wouldn't have been possible.

A special thanks to our university NUST, and our department NICE. Without their assistance and dedicated involvement in every step throughout the process, this project would have never been accomplished.

Apart from the efforts, the success of any project depends largely on the encouragement and guidelines of many others. We would like to take this opportunity to express our gratitude to the people who have been instrumental in the successful completion of this project. We would like to show our greatest appreciation to Dr. M. Jamaluddin Thaheem, Lec Bilal Ayub and Lec Fahim Ullah. We can't say thank you enough for their tremendous support and help. We feel motivated and encouraged every time we attend the meetings. Without their encouragement and guidance this project would not have been materialized.

The guidance and support received from all the members who contributed and who are contributing to this project, was vital for the project. We are grateful for their constant support and help.

And last but most importantly, we all like to pay gratitude to our PARENTS who have been supporting us throughout our life and are still supporting us in performing the project

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# CHAPTER 1

## INTRODUCTION

Buildings and public infrastructure are of vital importance in order to sustain our societies and the continuous development and well-being of its members. Architecture, engineering, construction and facility management industry plays a significant role in the economy of most of the countries. Employment and investment is considered a backbone for the economy and the construction industry has a huge share in it. Now a days construction projects are becoming huge and complex with large budgets, long duration and involving multiple parties with each with a different skillset. Collaboration and information sharing among these parties is important for the success of any construction project. Construction industry always seem active to adopt information technology to improve project performance (Yujie Lu et al.,2014).

A typical kind of interactions between computers and their users nowadays follows such a pattern: whenever the users want to access information stored in computers, they pause the current work in hand and divert their attention to computers. They move mice or type on keyboards to interact with user interface (UI) control elements displayed by the computers to retrieve the desired information. After that, they switch their attention back to the previously interrupted work and continue. There is a seam between the physical world we live in and the cyberspace we heavily rely on and the constant attention switches dictated by the conventional computer UI is by no means natural. For instance, an on-site construction worker can obtain 2D drawings of the design of a wall via her laptop but she needs to mentally map the 2D design (usually with different views as well) to the 3D space constantly during the construction. This mapping process is time-consuming and error-prone thus requiring a lot of practical experience. Is there a technology that can bridge these two worlds and thus lightens the mental workloads of the aforementioned worker? The answer is augmented reality (AR).

### 1.1 Problem Statement

The conventional construction methods are heavily relying upon the paper works. These method are highly in-efficient and take a lot of time. There is also a big problem when updates happen to the building during the construction works. The model is usually not uploaded and the as-planned drawings differ from that of as-built and the difference not documented anywhere. There is also an issue of getting data of different details from different teams as the data sharing is very limited. As the new constructions are moving towards more and more complex simple 2D drawings cannot provide enough information.

### 1.2 Objectives

There are plenty of AR applications which have been proposed for almost all the phases of a buildings life cycle such as architectural design and construction for the purpose of facilitating collaborations and improving performance, albeit the majority of the systems are prototypes which have not been put into practice. FM concerns all the post-completion operations and services that ensure a facility to function continuously as intended. By nature, FM spans the longest period of time in the facility’s life cycle and claims the most economical expenses. Therefore, substantial benefits can be gained by employing AR in FM when task performance is improved and overall costs are reduced. Unfortunately, this combination has not yet received much attention in the FM community (Xiangyu Wang et al., 2013)

Thanks to the advances of microelectronics, computers nowadays are being continuously miniaturized. While their sizes diminish, their processing power does not suffer. A case in point is the mobile devices like smartphones and tablet computers people carry around in their pockets or briefcases every day. Most of them not only feature a multi-gigahertz central processing unit with multi-cores, a dedicated graphical processing unit, large memories and a big, high resolution screen but are also equipped with a suite of sensors such as mega-pixel cameras, inertial-measurement units, Wi-Fi interface and GPS receiver. The popularity of powerful portable computers signals the arrival of ubiquitous computing and AR is indisputably a better UI choice for it since the user's view of the world and the computer interface literally become one through AR.

The focus is examining user task performance taking into consideration human perceptive and cognitive factors. It is our belief that as technologies advance and the field evolves, AR systems will boast accurate tracking results, convincing integration of the virtual objects with their real counterparts and sophisticated yet natural interaction mechanisms. But in the end all these systems have to be put into the hands of their users to realize their values .Human-machine systems that determine the ultimate task performance, not the AR systems alone albeit being well-crafted. More specifically, in the thesis maintenance tasks were studied in the built environment with the assistance of hand-held AR.

**1.3 Scope of Study**

The project tries to establish an environment in which collaboration between different sectorial bureaus can be achieved. Its aim is to provide a post construction reactionary facility management system. A single building was selected for modeling purpose. The building was redeveloped in a virtual environment where all building layers (architectural, structural, plumbing and electrical) were included in a single merged model using Revit modeling software. Analysis and simulation of the 3d model can be done in the created work space.3D model can be connected with other engineering software programs for detailed engineering analysis of structural reinforcements and other facility management systems.

BIM extension application should work smoothly on a mobile device having camera and 3D gyroscopic sensors. Model uploaded on the cloud can be accessed through this application by the authorized stakeholders. Fast internet is required because of the constant connectivity between the mobile device and the online cloud. The application used in this study is only available on IOS. However, there are dozens of other applications where BIM models can successfully integrate, present on android and windows platforms. The mobile device used in this study was Apple ipad air 2.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Augmented Reality

Computers have been well integrated into our daily lives in this age of information. As hardware technology advances, computers are becoming faster, smaller and cheaper. The continuous miniaturization allows computers to be portable and ubiquitous. Traditional UI such as graphical UI rests upon the fact that information stored in computers is separated from its related objects in the real world. To interact with the information, users need to divert their attention to the computers. This distraction creates a gap between the computer world and the real world (Jun and Katashi 1995), which is not desirable as computers nowadays tend to permeate around us and information is so readily accessible at any time. Augmented reality is a totally different approach when it comes to human-computer interaction displaying information of  real objects on a computer or mobile screen.people can use this without deliberately looking towards the computer screens (Tobias and Steve 2004).Augmented reality is sometimes called as mixture of real environment and virtual environment. Another definition of AR perceives computer generated objects in real world environment. This type of AR is sometimes referred as diminished reality (Siavash et al,. 2003).

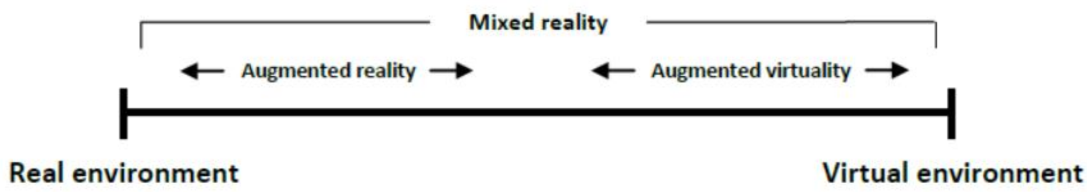



**Figure 2-1 Augmented Reality Chart (Paul and Herman 1999)**

### 2.2 Need for augmented reality

All other fields of engineering are actively putting use of 3D modeling while in civil engineering, especially in Pakistan, 2D CAD files approach are still followed. Due to this many problems arise in both pre construction and post construction of phases of the projects. These 2D drawings are very difficult to understand by clients because of the lack the technical knowledge and also they don't know how to read them. These problems cause cost overruns, time overruns and in many cases litigation. Buildings are getting bigger and complex day by day. To deal with this complexity accurate and real-time information to the engineers and facility managers should be provided of the building. This can be done by application of augmented reality into our facility management systems. Augmented reality takes 3D modeling onto another level by integrating existing environment with the 3D model and gives information through visualization on a portable mobile device. It is actually the interaction between the digital world created in the computer and the real world environment.

### 2.3 Augmented reality in construction industry

In construction projects, while the building information modeling (BIM) and virtual reality (VR) technology are widely used to present 3D objects, but the use of the VR technology for construction objects is regarded less practical as it only presents 3D graphic images and lack the sense of the actual site. To address this problem, recently, the augmented reality (AR) technology is being used increasingly in the construction projects. The AR technology combines VR objects with real objects, and is expected to be useful in testing workability of a construction project with a full consideration of the site. By visualizing construction elements against the background of an actual project site ,work processes are easier to comprehend and this technology can also be used in the later stages of the project as well as post construction phase in order to save costs associated with error and reworks.

### 2.4 Smart cities:

Smart cities have got great importance and popularity in the last two decades, both in literature and international policies (Albino et al, 2015). The concept of smart cities is quite different from just the use of technology in cities (Albino et al, 2015). In 1990's this "Smart city" word was used for the first time and at that time the just the use of ICT in the infrastructure of city was considered as being smart. Albino et al (2015) defines smart city as the combination of three I's instrumented, interconnected and intelligent. Instrumented means the use of sensors, devices, meters or simply ICT to get real-time data and then the use of that data for communication between different city services by putting then in computing platforms gives us interconnectivity. After communication come the use of that data for making better decisions for the city by making certain models and the use of complex analytics.

### 2.5 Dimension of smart city

Dimension of a smart city are simply the parameters which makes a city smart. After the review of many papers, the dimensions of smart cities were identified which were smart governance methds, smart people, smart economic techniques, smart mobility, smart environment, smart living environment (Albino et al,2015; Lombardi et al. 2012). Nam and Pardo (2011) has identified that the key factors of smart cities are technology, people and the institutions (government). However, ICT was the most common factor that actually made a city smart

**2.6 3D Modeling**

For the last several there has been a vast expansion in the urban areas mainly due to rural resettling, growing economies and enhanced infrastructure. In such conditions development can't be monitored and planned using traditional maps which consumes enormous amount of time and requires technical skills. Hence there is a need for efficiently utilizing the urban space and keeping in view the urban planning, designing and architectural.

3D modeling also helps in determining the future course of  action in urban environment decision making by means of visualization .Visualization is basically one of the purposes of developing 3d model by 3d illustrations of the real world which can be an important tool for urban planning ,facility and utilities management ,geometry and texture of urban surfaces ,property management ,ecommerce and educational purposes by creating a virtual environment using VR technology and then navigating into the model by walking .Walking in 3D models refers to moving on the surface as seem in games .

Over the years several methodology and different software have been used to create 3D models of great quality to facilitate visualization of urban environment. These involve data collection by draping and extruding 2D features, terrestrial photographic techniques i.e. laser scans and ground based modeling. Based on the data acquired processing is carried out in order to generate 3d models with various attribute modes.

## 2.7 BIM in Construction

BIM can be called as one of the most promising recent developments in the construction industry (S.Azhar 2011). It was build for about a decade ago with the sole purpose of providing an environment from which different 3D building information can be retrieved any time during the project lifecycle (L.Y.Ding et al.,2012). BIM is considered important in the construction industry for the operationt, exchange, and sharing of information among project stakeholders such as engineers, architects, contractors, owners, and subcontractors , although it is important to note that its technologies are being implemented more slowly in the construction industry than 2D computer-aided design (CAD). By enabling visualization of the details of the prospective work, BIM assists construction planners in making crucial decisions.BIM is important for planners because it not only contain geometric data but a great amount of engineering data can also be saved in BIM models and used during and after construction phases of the project (Zeng and Tan 2007). BIM is crucial as a tool for information sharing of the building designs and this system enables not only integrate differnt pieces of information but also saves information throughout lifecycles of the building.

There are many BIM commerce tools for creating BIM models (e.g., Autodesk Revit, Trimble Tekla, and the Graphisoft ArchiCAD software). Most of these commerce tools provide software development kits (SDK) for programming purposes. For this study, Autodesk Revit is selected as the main BIM tool because it provides more SDK support than other commerce tools. Furthermore, the use of Autodesk Revit allows the easy export of all of the information regarding a BIM model to a database through open database connectivity.

## 2.8 BIM in facility management

Facility management is the occupancy phase after construction. It can benefit from BIM for not only 3D visualization of the building but also for space-planning, renovations and other maintenance tasks. An integrated BIM system is more than capable of supporting facility management practices. BIM technologies are essential for the operating phase of the building. Owners can be motivated to opt for BIM technologies by telling them its countless advantages like design assessment, cost reliability, sustainability analysis, schedule management and asset management. Uses of BIM in facility management are (Eastmanet al., 2008)

- Managing facility assets
- Efficiently performing building commissioning
- Editing of facility management databases
- Using editing and visual modules to analyze the impact of maintenance on the facility

Having a detailed and comprehensive BIM model, which embeds the required information as well as the 3D geometry of all the objects in the facility, could be used as a database that can be integrated with an AR approach to provide an ambient intelligent environment for facility mangers (Gheisari, 2013). The industry's view on this new approach of accessing information from BIM models should be investigated and their feedback should be considered for future prospects for further research. This study also aims to investigate the level of industry interest and use of BIM for operations and maintenance. This investigation explores the main technological elements of how BIM integration with AR and making the data accessible through handheld mobile devices in an operations and maintenance environment for professional facility managers.

### 2.9 BIM dimensions

- 3D
- 4D
- 5D
- 6D
- 7D

#### 2.9.1 3D (Existing coordinates)

BIM revolves around an integrated data model from which various stakeholders such as Architects, Civil Engineers, Structural Engineers, MEP System Engineers, Builders, Manufacturers and Project Owners can extract and generate views and information according to their needs. 3D BIM's visualizations capabilities enables participants to not only see the building in three dimensions before ground is ever broken, but also to automatically update these views along the project life cycle, from earliest conception to demolition. BIM 3D helps participants to manage their multidisciplinary collaboration more effectively in modeling and analyzing complex spatial and structural problems. Furthermore because accurate data can be collected along the project life cycle, and stored in the Building Information Model, new value can be added to predictive models allowing resolving issues proactively.

#### 2.9.2 4D (Scheduling)

4D-BIM (four-dimensional building information modeling) is used for construction site planning related activities. The fourth dimension of BIM allows participants to extract and visualize the progress of their activities through the lifetime of the project.

The utilization of 4D-BIM technology can result in improved control over conflict detection or over the complexity of changes occurring during the course of a construction project. 4D BIM provides methods for managing and visualizing site status information, change impacts as well as supporting communication in various situations such as informing site staff or warning about risks.

### 2.9.3 5D (Estimating)

5D-BIM (fifth-dimensional building information modeling) is used for budget tracking and cost analysis related activities. The fifth dimension of BIM associated with 3D and 4D (Time) allows participants to visualize the progress of their activities and related costs over time.

The utilization of 5D-BIM technology can result in a greater accuracy and predictability of project's estimates, scope changes and materials, equipment or manpower changes. 5D BIM provides methods for extracting and analyzing costs, evaluating scenarios and changes impacts.

### 2.9.4 6D (Sustainability)

6D-BIM (sixth-dimensional building information modeling) helps perform energy consumption analyses.

The utilization of 6D-BIM technology can result in more complete and accurate energy estimates earlier in the design process. It also allows for measurement and verification during building occupation, and improved processes for gathering lessons learned in high performance facilities.

#### 2.9.5 7D (Facility Management)

7D-BIM (seventh-dimensional building information modeling) is used by managers in the operation and maintenance of the facility throughout its life cycle. The seventh dimension of BIM allows participants to extract and track relevant asset data such as component status, specifications, maintenance/operation manuals, warranty data etc.
The utilization of 7D-BIM technology can result in easier and quicker parts replacements, optimized compliance and a streamlined asset life cycle management over time. 7D BIM provides processes for managing subcontractor/supplier data and facility component through the entire facility life cycle.

## 2.10 Smartphones and tablets in Construction

AR technologies can be easily linked with different IT technologies. The user of smartphone can identify his location using built-in GPS in his phone. This location data can then be sent to the server where augmented model is prepared, and then the AR system can visualize real object with AR object.

## 2.11 Tracking and Registering

Tracking and registration is important because just mixing the digital data with real data without any spatial link would be totally meaningless and useless. A spatial link needs to be developed in order to produce a feasible and fully functional facility management system.

### 2.11.1 Sensor based tracking

This type of tracking utilizes a wide range of positioning sensors functioning on various measuring principles which include mechanics, magnetism, sound, inertia and radio waves (e.g.

wireless local area networks and navigation satellites) to attain positions and orientations of cameras and/or other physical objects of interest in the environment. Each technology has its tracking accuracy and range and the measured information can either be absolute with respect to a global coordinate system or relative.

### 2.11.2 Vision based tracking

This type of tracking is based on a video stream of the physical environment, like its name. Although optical sensors, such as simple webcams, are still required for video recording, it mainly relies on analyzing the video frames using image processing and computer vision techniques rather than the sensor hardware itself to report the posed information.

### 2.11.3 Hybrid tracking

Hybrid tracking combines more than one tracking technology together in order to overcome each

Component technology's weaknesses so that overall tracking performance may be improved. GPS, magnetometers and many other types of sensors can be combined together to make a more accurate tracking system.

### 2.11.4 Radio-frequency identification based tracking(RFID)

RFID utilizes electromagnetic fields to naturally recognize and track labels appended to the items. The labels contain electronically put away data. passive labels gather vitality from a close-by RFID observer cross examining radio waves. Dynamic labels have a neighborhood control source, for example, a battery and may work at a large number of meters from the RFID observer. Not at all like a standardized identification, the tag does not should be inside the observable pathway of theobserver, so it might be inserted in the followed question. RFID is one technique for Automatic Identification and Data Capture.

### 2.11.5 2D Barcode based tracking

This technology is explored as a means of providing organized and reliable real-time display of information. The 2D barcode technology also posses the ability to deliver information on the required location, including video, audio, and also in the form of text. Barcode technology was developed during the 1950s and it spread rapidly during the years after. With the benefits of higher limit, bring down cost, expanded security, traceability, hostile to corruptibility, and misstep rectifying usefulness, the 2D scanner tag has been broadly connected since 90s. 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 2-2 Stacked linear code** **Figure2- 3 Stacked matrix code**

Although many types of 2D barcodes exist, as shown above, the linear barcode is the most popular type of 2D barcode used in World. Stacked linear code was used in the study. The advantages of the linear code are as follows:

**(1) High capacity of data content:** the code can record dozens of characters or numbers.

**(2) Various data types:** the information sorts put away in the 2Dbarcode incorporate picture, sound, words, and fingerprints, with the limit with respect to Multilanguage expression;

**(3) Ease of production:** the shape and scale of the barcode are customizable and are easily made by software and a printer, at a low cost.

**(4) Convenience:** the linear barcode can easily be identified by a tablet or a mobile phone and is readable in any direction

### 2.12 Computer Software Applications

In order to develop a BIM based Facility management system, a number of applications which can easily integrate with BIM models and sync it with a mobile device with a proper positioning system were studied. There were dozens of applications which can be used in building a mobile facility management system. BIM 360 was selected for the project as it is simple and is considered a better option in the construction industry.

#### 2.12.1 BIM 360

This application comes after releasing some improvement and joining some of its components with a current Autodesk mobile application item called BIM 360. Like Navisworks it gives the client a 360 degree perspective of the environment in 3D on a tablet PC. It can recognize conflicts with an assortment of apparatuses on screen while moving. This is especially helpful for experts that need to take a compact form of a 3D demonstrate nearby and get to it for all intents and purposes with some other key partners

BIM 360 is critical not only to be an augmentation of Navisworks for cell phones additionally an application that can reenact the complexities of vast 3D display . This is critical in this point of reference survey as this will be a test amid advancement to mimic a lot of 3D substance on gadgets with lesser figuring power. This is a test in numerous portable application stages that expect to reproduce complex 3D , as streamlining assumes a key part amid improvement (Jie et al., 2011). BIM 360 additionally empowers online coordinated effort of a particular 3D demonstrate on a cloud based framework expanding the act of collaboration and association between venture members. An assortment of instruments empower clients to pinpoint issues and spare the view they were in all together for various clients to discover. Remarks and bolts can be drawn and saved money on the 3D display and the application can discuss this data with a principle Navisworks desktop PC program (Schwaiger, 2013).

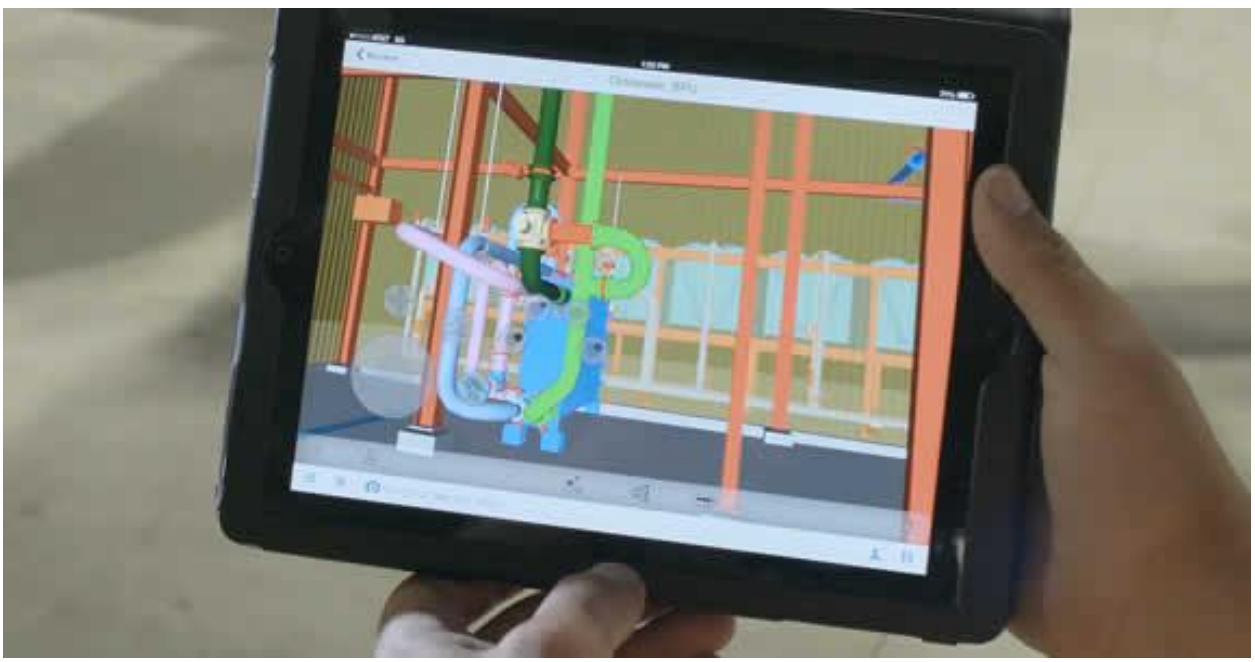


**Figure 2-4 BIM 360 virtual simulation view on an apple iPad tablet computer (Autodesk, BIM 360, 2013)**

### 2.12.2 BIM 360 Field

This application has generally indistinguishable elements to the BIM 360 by empowering the client to imagine 3D models. This application however is diverse in that it uses a type of increased reproduction by utilizing 2D scanner tags that are stuck to surfaces inside the building. In spite of the fact that a Barcode is utilized the 3D condition recreated on the tablet is generally 100% virtual and depends on sensors, for example, the gyroscope and accelerometer inside the tablet to direct the client. This is not the same as increased reality which is a blend of both genuine and virtual protests on screen. By initiating this application the tablet PC camera is exchanged on and guides the client to center the tablet onto the standardized identification. Once the camera has centered onto the standardized tag the BIM model is superimposed for all intents and purposes into position on screen which can be in front or anyplace around the client. This application contains comparative capacities to Autodesk 360 and BIM 360 in its capacity to share documents internet utilizing cloud sharing administrations where office staff can speak with on location work force utilizing a particular digitized 3D demonstrate.


**Figure 2-5 showing BIM Filed demo (BIM field,2013)**

Aspects which were considered before selecting the application:

- **BIM Industry Standard practice**

  Identifying BIM products that are used for 3D BIM in industry and how information is displayed using the interface

- **Capacity to handle 3D content**

  This was important for all mobile application precedents as the case 3D model for the application would be industry standard and have a very high 3D content.

- **Special functions/important features**

  Analyzing for what makes each precedent different from the other and the aspects that could inform the design of the Graphical User Interface (GUI)

- **Approach to displaying information on screen**

  How does the application operate and display certain types of information about a 3D model, and how does it handle task related information to a 3D model visually.

- **Positioning System**

  Navisworks and 3Don used a GPS based positioning system where as BIM Field and BIM Anywhere made use of barcode or QRcode for location.

- **Cloud Sharing**

  BIM Anywhere, BIM 360, BIM Field and AutoCAD 360 had cloud based information sharing capabilities. The ability to share the 3D model with stake holders with ease is important consideration for this systems feasibility.

- **Deactivating 3D layers**

  For every portable application there was a dependable capacity that empowered the client to basically see 3D content covered up between layers. The capacity to dismember the model utilizing deactivation option which turn on or off  layers of the 3D model to uncover shrouded parts could be valuable and essential.

# CHAPTER 3

## METHODOLOGY

### 3.1 BIM

The US National Building Information Model Standard Project Committee has the following definition for the Building Information Modeling (BIM):

*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 life-cycle: defined as existing from earliest conception to 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.

The study has focus on facility management within the buildings by using BIM models.

### 3.2 AUTODESK REVIT

Autodesk Revit is building data demonstrating program for planners, basic specialists, MEP architects, creators and contractual workers created byAutodesk. It enables clients to plan a building and structure and its parts in 3D, comment on the model with 2D drafting components, and get to building data from the building model's database. Revit is 4D BIM able with instruments to arrange and track different stages in the building's lifecycle, from idea to development and later destruction.Revit application  particularly works for Building Information Modeling (BIM), engaging outline and development experts to convey thoughts from idea to development with a planned and steady model-based approach. It incorporates the usefulness of the majority of the Revit disciplines (design, MEP, and structure) in one bound together interface.

### 3.3 BIM 360

BIM 360 development administration program empowers practicality at whatever time, anyplace access to venture information all through the building development lifecycle. BIM 360 enables those in the field to better expect and act, and those in the back office to streamline and deal with all parts of development execution. It incorporates the accompanying programs:

1) BIM GLUE

2) BIM FIELD

3) BIM DOCS

4) BIM LAYOUT

5) BIM PLAN

6) BIM INTEGRATION

#### 3.3.1 BIM GLUE

BIM 360™ Glue® is a cloud-based BIM management and collaboration product that connects your entire project team and streamlines BIM project workflows from pre-construction through construction execution. With virtually anywhere, anytime access to the most recent project models and data throughout the project lifecycle, BIM 360 Glue helps you review projects and resolve coordination issues faster, while advancing the construction layout process.

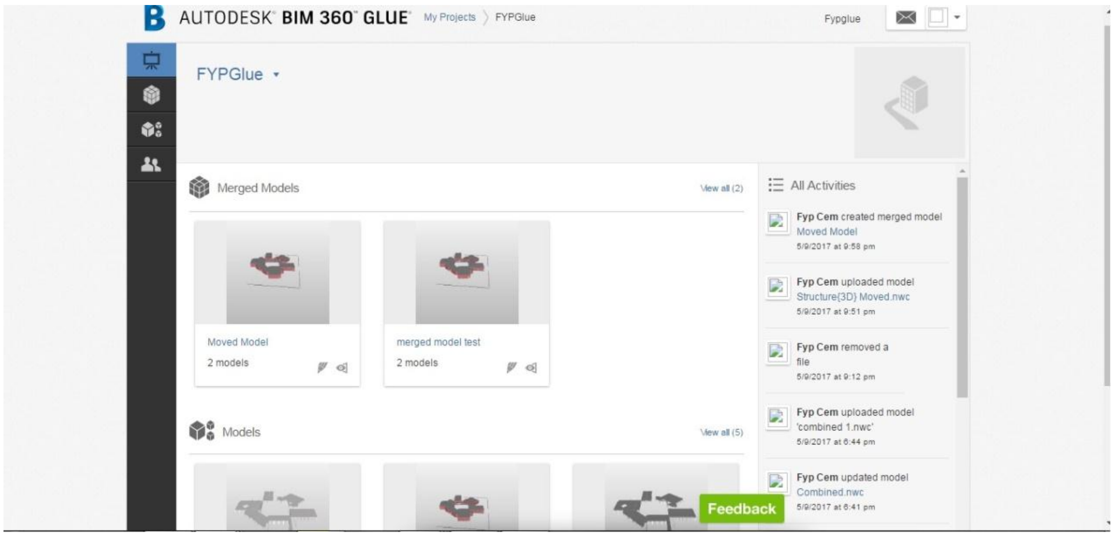



**Figure 3-1 BIM 360 UI**

### 3.3.2 BIM 360 FIELD

It puts critical information into the hands of those in the field, helping to improve quality, safety and commissioning for construction and capital projects of all types. Autodesk® BIM 360 Field is field management software for 2D and 3D environments that combines mobile technologies at the construction site with cloud-based collaboration and reporting.

It Captures system and equipment information electronically, right in the field, to help save time and reduce errors. Access and view: photos, operation and maintenance manuals, manufacturer cut sheets, and more, for any piece of equipment.

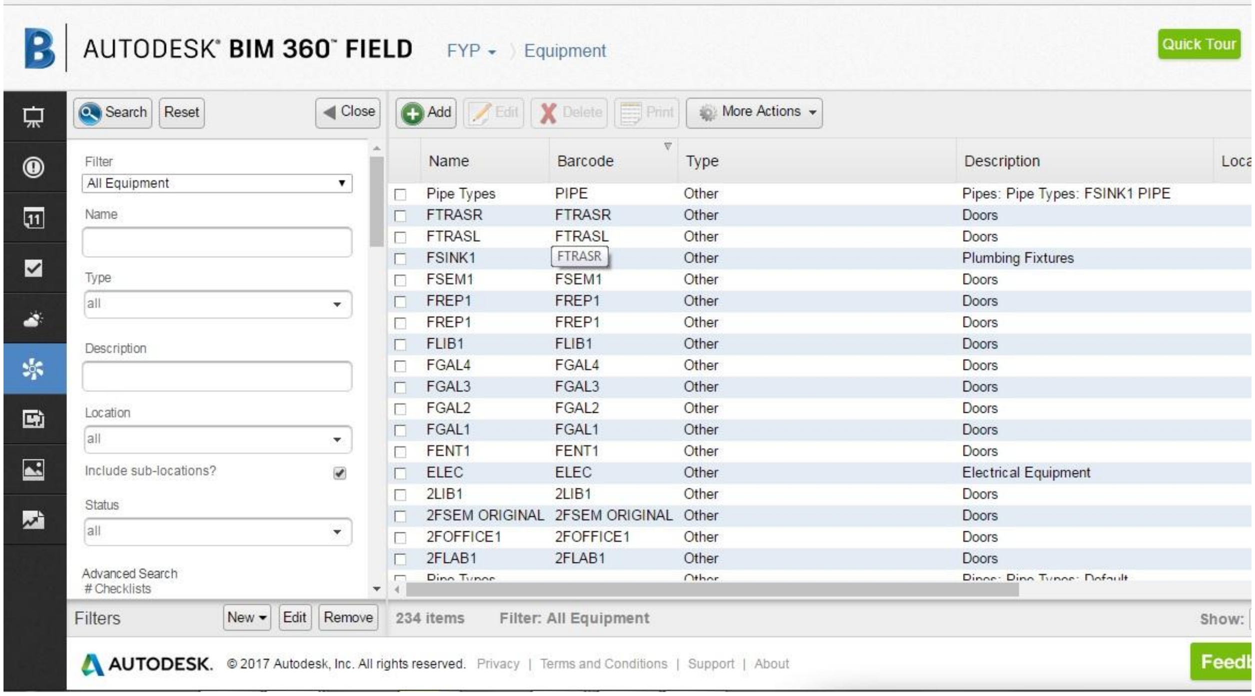



**Figure 3-2 BIM Field UI**

### 3.4 Steps involved:

#### 3.4.1 Step 1: Collection of required data

1) Collect all the AutoCAD drawings of the building.
2) The drawings should be as build not as planned.
3) Organize the drawings according to their type.

#### 3.4.2 Step 2(a): Converting CAD drawing to RVT

1) All the CAD drawings were reconstructed in REVIT

2) All the basic elements like gridline , levels were copied
3) First architectural model was made from the architectural drawings
4) After architectural model structural model was made by reconstructing the structural drawings.
5) Electrical drawings were also made on Revit and were integrated with the initial architectural model.
6) After electrical pluming drawings were converted and were integrated to the architectural model as well.

### 3.4.3 Step 2(b): Project formation on BIM 360 GLUE

1) From the official page of BIM 360 GLUE (https://bim360.autodesk.com/bim-360-glue) BIM 360 GLUE pc version is downloaded.
2) After the download the accesses of web based BIM 360 GLUE is given
3) In the web based version project can be created
4) After the creation of the project Admin rights are given
5) Admin rights are the rights which allow other users to open the project from different accounts.

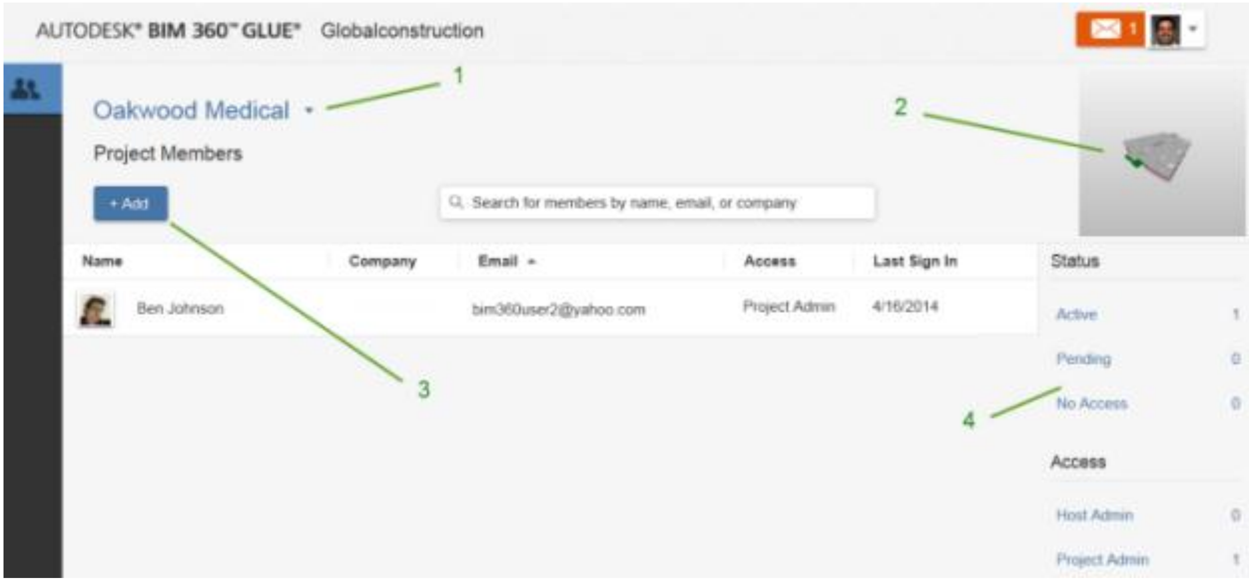



**Figure 3-3 BIM 360 Glue UI**

1. **Project drop-down**. Use the project drop-down to switch between projects that you have access to.
2. **Project Image**. The image that represents the project on the project page in Glue desktop. Click to change the image.
3. **Add Members**. Select to start adding members to the project.
4. **Project Member Metrics**. A project summary that displays the current member status and access rights metrics.

### 3.4.4 Step 2(C): Creation of project on BIM 360 FIELD

1) From the official page of BIM 360 FIELD (https://bim360.autodesk.com/bim-360-field) Access to the online application can be obtained.
2) After the online access is given project can be created
3) The project which is created asks for the requirements of different fields to be filled e.g. company's name, project start and finish dates and cost etc.

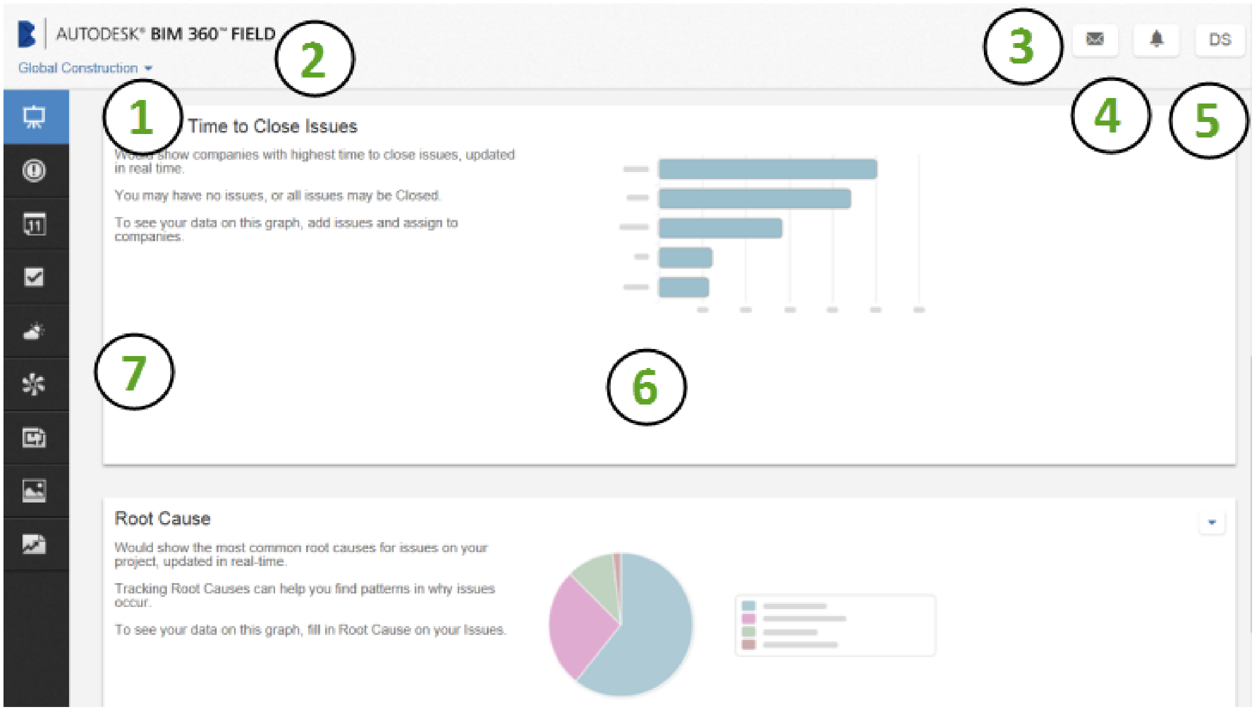



**Figure 3-4 Steps illustration on BIM Field UI**

1. **Active project**. Use the drop-down to select the active project.
2. **Home page**. Click to return to the project overview home page.
3. **Messages**. Add home page messages that are visible to all project members.
4. **Inbox**. Opens your Field message inbox. Use it to add issues by email.
5. **Profile/help menu**. Access user settings and the account and project administration tools. This menu also includes links to BIM 360 Field help, BIM 360 Support, BIM 360 community forums, and the BIM 360 Idea Station.
6. **Project summary dashboards**. Set up and share project tracking dashboards.
7. **BIM 360 Field toolbar**
    - Project overview home page
    - Assign issues
    - Create tasks

- Create and fill out checklists
- Create daily update reports
- Manage equipment
- Add files to the project library
- Tag or download photos
- Run and distribute reports

### 3.4.5 Step 3: Uploading the model to BIM 360 GLUE

1) For the model to be uploaded on GLUE an add-in is required in Revit
2) THE GLUE add-in converts the Revit model into the required GLUE format
3) After converting, the model can be directly uploaded the required project created in the BIM 360 GLUE earlier.
4) All the models can be uploaded and the uploading time depends upon the internet speed and the complexity of the models.
5) Usually the structural model takes a lot of time for uploading.

### 3.4.6 Step 4(a): Merging the models

1) After uploading comes the merging of all the models into a single merged model having all the models of architecture, structure, electrical and plumbing combined.
2) It is in this step that the different layers are created.
3) Careful merging is required and it will be best merged only if all the models are made on the same grid and on the same defined levels.

### 3.4.7 Step 4(b): Creation of equipment sets

1) Equipment Sets are groups of objects that share the same properties. By grouping objects into equipment sets, easy integration with BIM 360 FIELD is possible.
2) For the project different equipment sets like doors, electrical fixtures, pipes etc. were created.
3) It is done by right clicking on the objects and defining equipment sets.

### 3.4.8 Step 5: Uploading the merged model from GLUE to FIELD

1) After all the equipment sets have been defined now the model can be uploaded to BIM 360 FIELD.
2) For uploading the model, the model is opened in the GLUE pc version and is uploaded from there to the field.
3) It will ask you about the project in which the model needs to be uploaded.

### 3.4.9 Step 6: Opening the model in field and defining the barcode numbers

1) After uploading the model from BIM 360 GLUE it can be viewed in the FIELD web based application.
2) To view the model first the model needs to be selected from the project admin tab and inserted in the models tab.
3) After selecting the model now the model can be viewed on any device having BIM 360 FIELD installed.
4) For assigning the barcodes "view equipment tab" is there.

5) In the view equipment tab different identifiers for the predefined equipment are there for this project different barcode names were given to different equipment.

### 3.4.10 Step 7: Making the barcodes

For generation of the barcodes an online site was used (https://www.barcodesinc.com/generator/index.php).

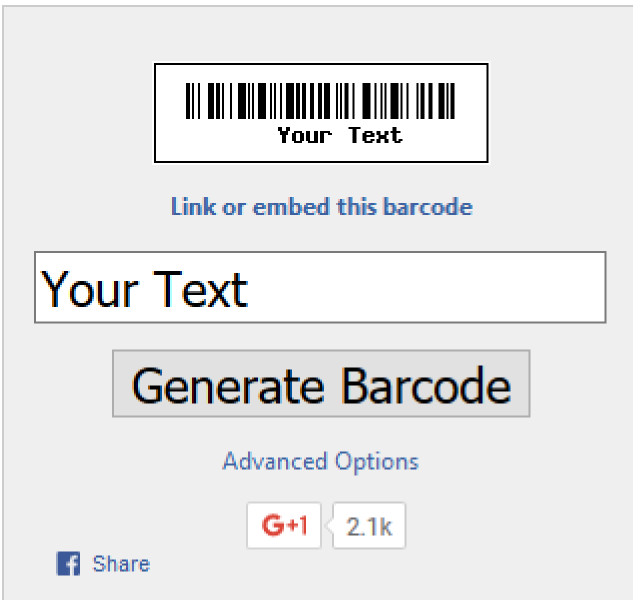



**Figure 3-4 Barcode generation**

# CHAPTER 4

## RESULTS

### 4.1 Model

The model developed in the project was of NIT SCEE building. The 3D model of NIT was constructed which had the data of all the structural, electrical, plumbing and architectural. The model was constructed in a virtual environment. All the facilities of the building were specified. The model was then uploaded to the cloud using BIM 360 glue and then using BIM 360 field was transferred to the mobile device. Some of the features of the building are:

- Architectural
- Structural
- Plumbing
- Electrical

#### 4.1.1 Architectural

The architectural model consists of different details of the walls, doors and windows. The complete model of the NIT SCEE model is shown in Figure 11

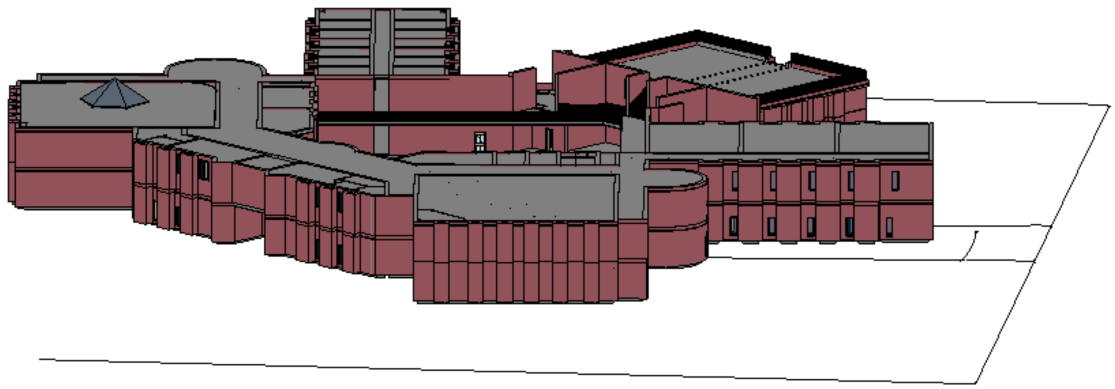
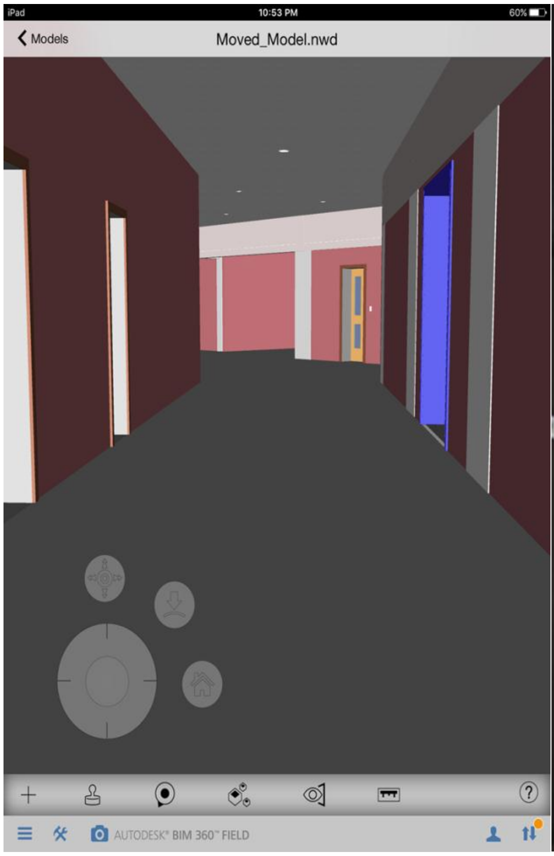


**Figure 6  Architectural Model**

The model in Figure 11 shows the completed architectural model of NIT SCEE building. This model was developed with the help of Revit software. It contains all the information about the architectural drawing in a 3D environment.



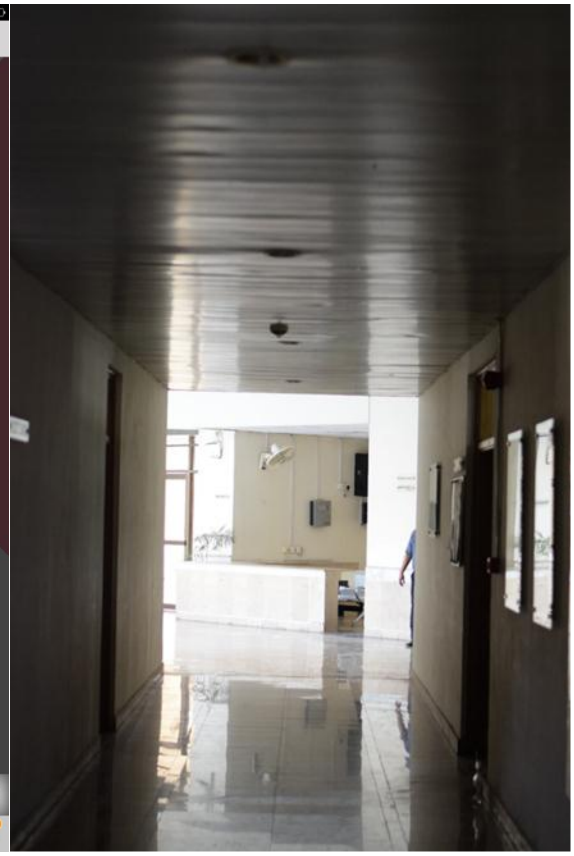


**Figure 7 Virtual view** **Figure 8 Real view**

In figure 12 and figure 13 the side by side comparison of the real time image of that area to virtual image of the same area can be seen.

### 4.1.2 Structural

The structural model consists of the details of different columns, beams slabs and structural rebar. The model was made according to the data provided in the AutoCAD drawings.

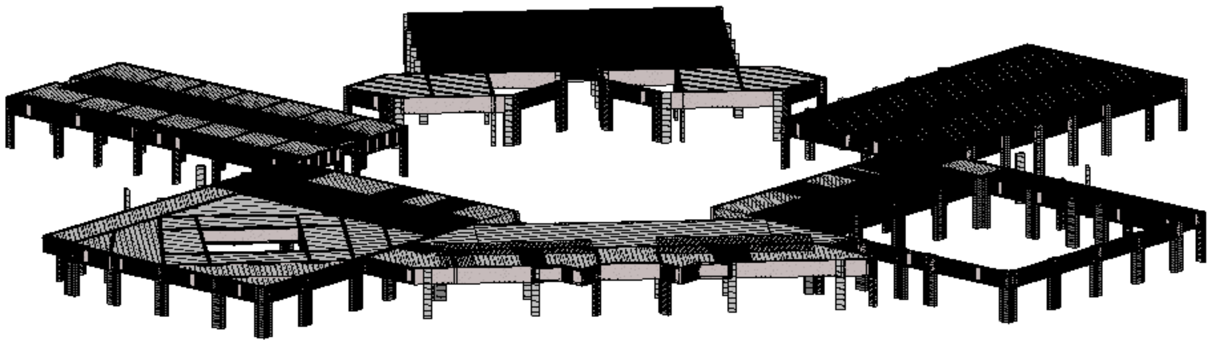
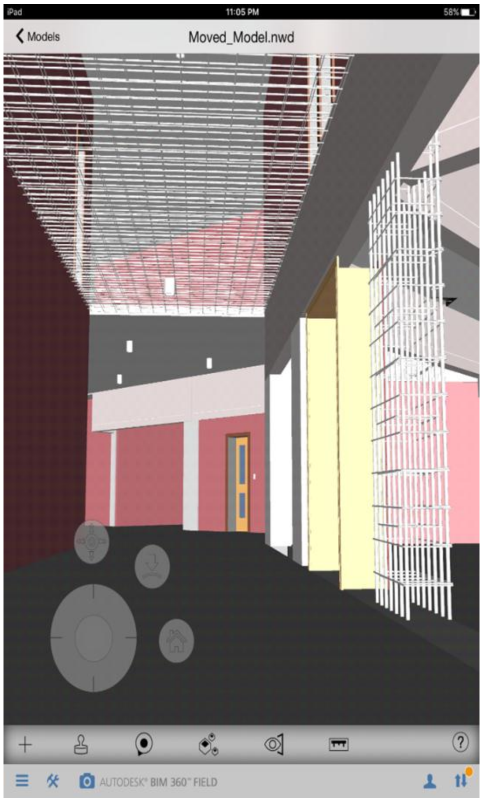


**Figure 9 Structural model of ground floor**

In the figure 14 , the structural model of ground floor of NIT SCEE building containing columns, beams, slabs and structural rebars can be seen. This model was also made according to the details provided in the AutoCAD drawings.it has the information about all the structural units including the steel bar number used in it.



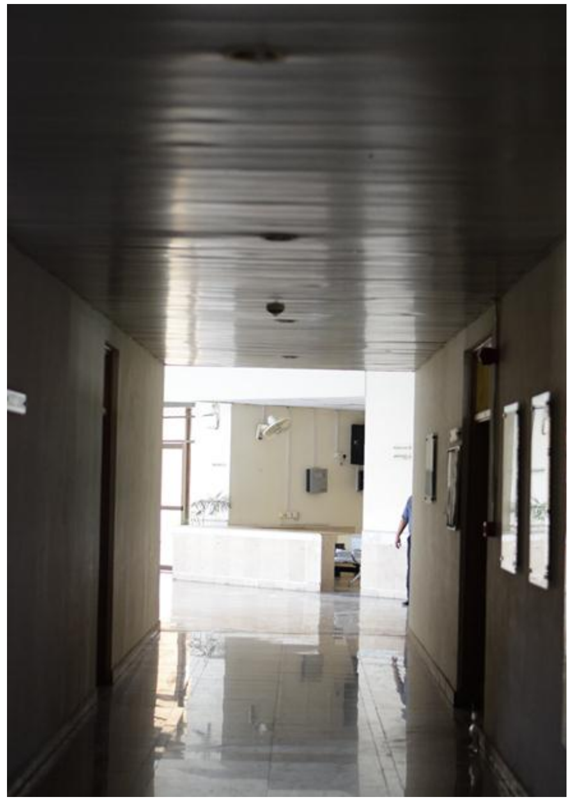
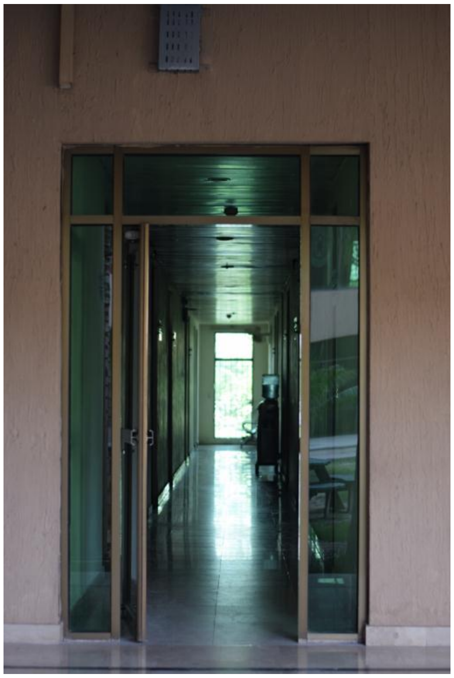



**Figure 10 Virtual view with structural details** **Figure 4-6 Real time view (structural)**

In the figure 15, the slab on the above floor as well as the details of the column is also visible. This area is the same as that in figure 13, but this time architectural layer has been removed and the structural detail of that area can be seen.

Another comparison between a real time image and its virtual counterpart are shown in Figure 16 &17.



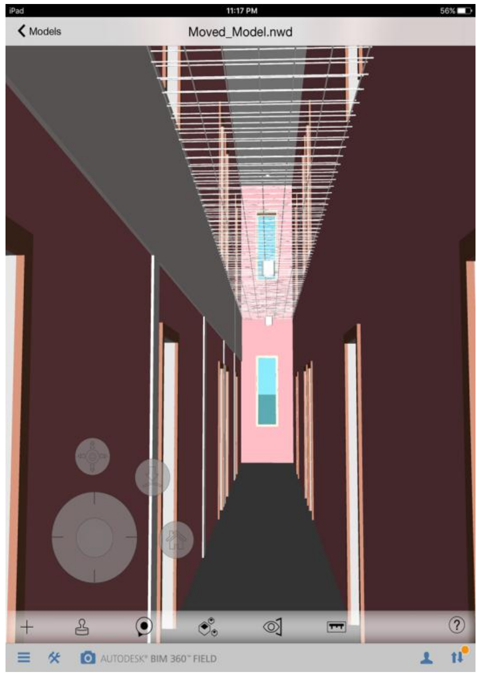



**Figure 11 Real time view** **Figure 4-8 Virtual view with structural details**

The above floor is removed to show the details of the rebar in Figure 17.

#### 4.1.3 Plumbing

The plumbing model was made according to the details provided in the drawings .Different pipes were used in the NIT model. Pipes used in the building were of different sizes and diameter.

**Figure 4-9 Plumbing details of NIT**

In Figure 18, the plumbing pipeline system laid under the NIT SCEE building can be seen. There are different sizes of pipes used in the system.

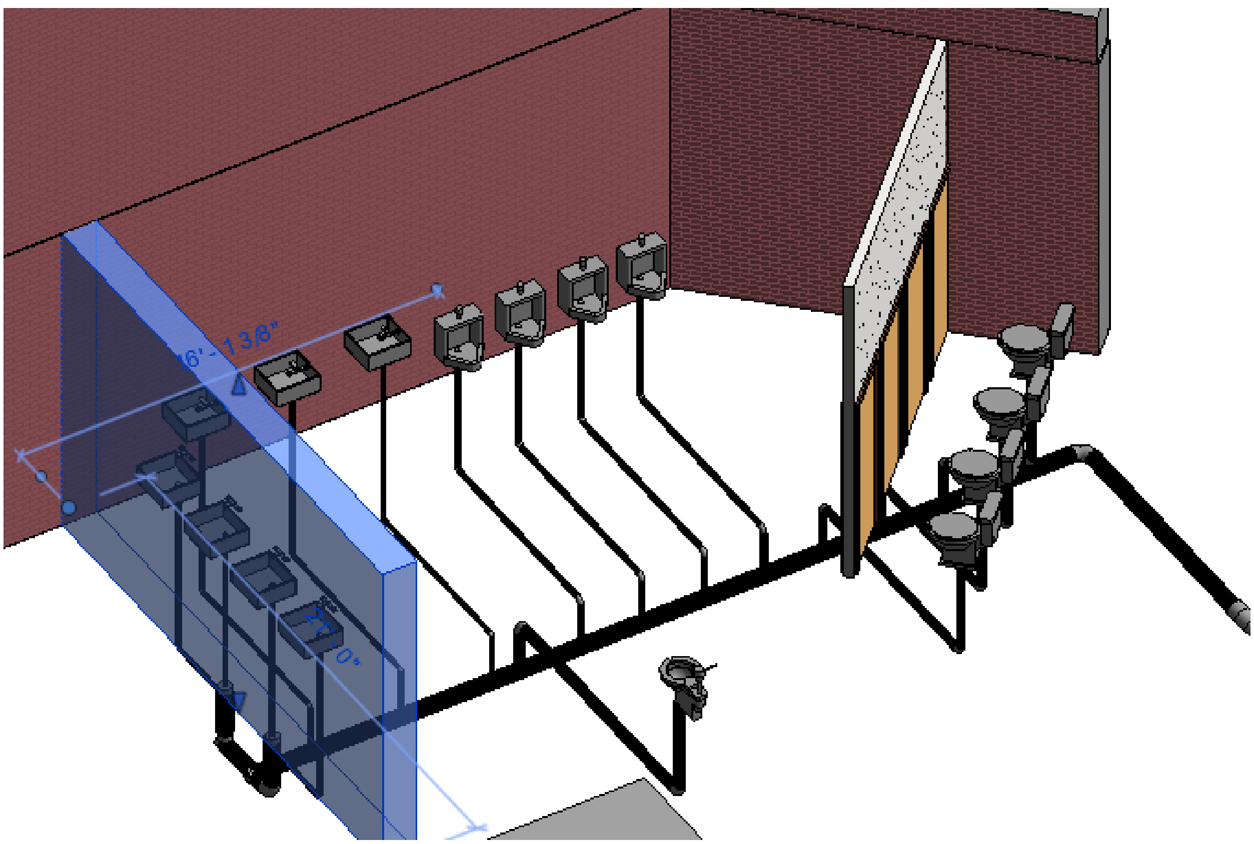



**Figure 4-10 Plumbing details in washroom**

In figure 19, the plumbing line from different sinks and toilets moving to a sinkhole into the main pipeline can be seen. In the above figure (Figure 19) some of the layers were turned off to see the pipeline system through the washroom.

### 4.1.4 Electrical

The electrical lines passing through different places were included in the model .As well as different electrical utilities were also added in the mode

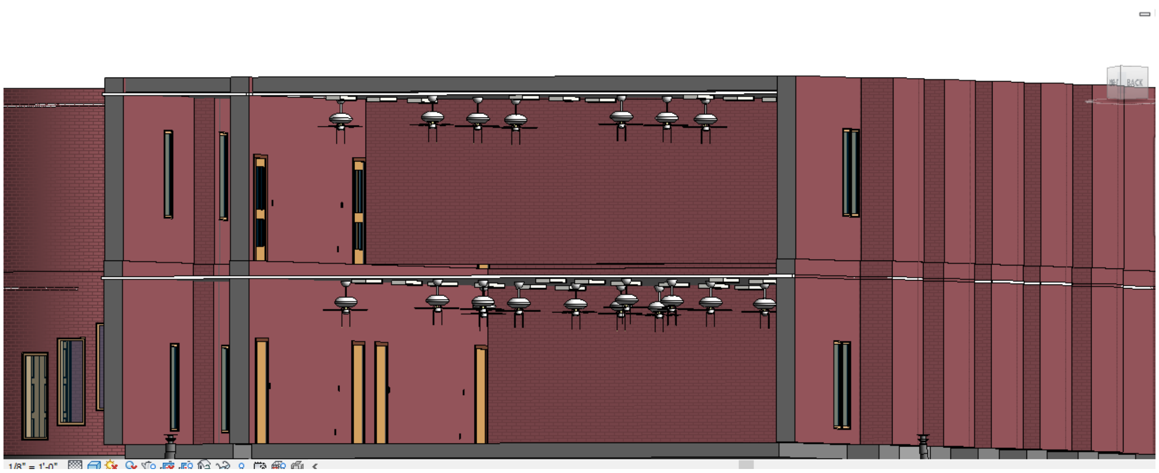


**Figure 4-11 Electrical Details**

Figure 20 shows different utilities of the electrical model such as fans and lights. Electrical model can help in identifying different utilities in a building and also identify the wire lines passing in a building. Thus if a problem in electrical wires arrive it can easily be resolved.

## 4.2 Convergence

Initially we had acquired 61 files of AutoCAD 2D drawing from PMO and they were converted into 3D model using Revit software which included the details of all the information of different facilities such as the structural, architectural, plumbing and electrical details. After the drawings were converted to 3D model they were then uploaded to BIM 360 glue. And then using BIM 360 field was integrated with a mobile device.

The following figure 21 & 22 show the process of convergence:

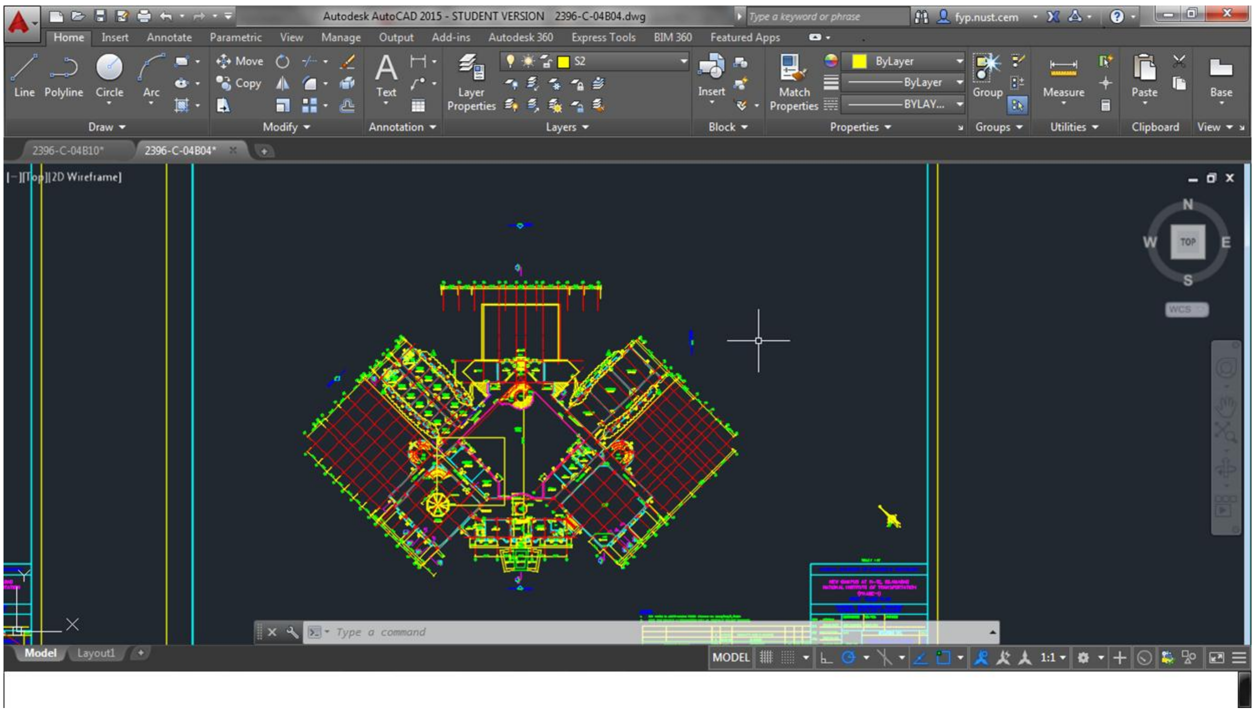



**Figure 4-12 2D AutoCAD drawing**

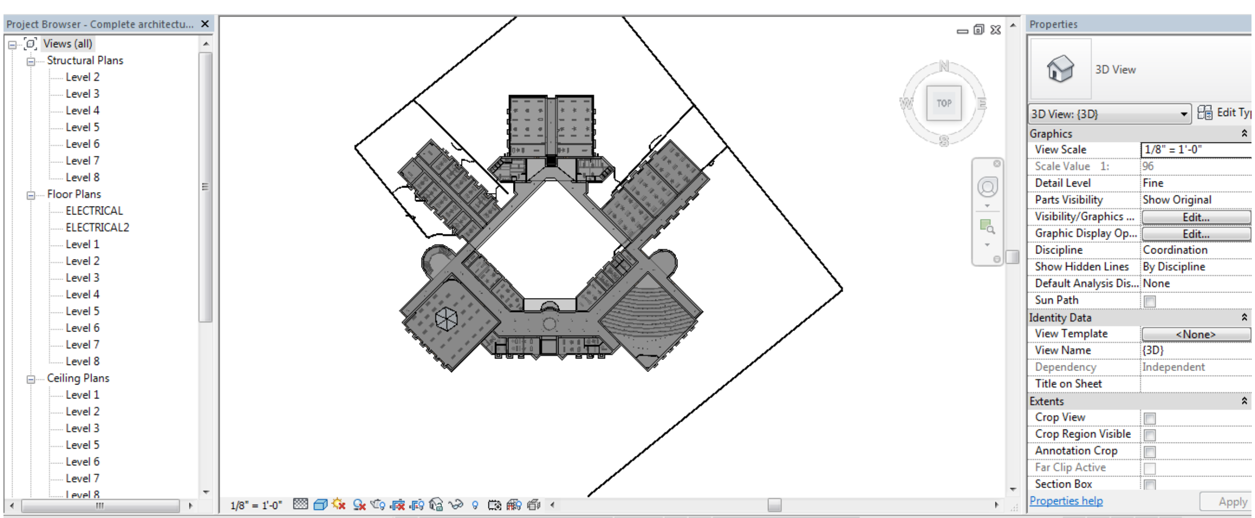


Figure 4-13 3D Revit model

In the Figure 21 it can see that the data is scrambled all over and it is hard to get information from it .While in Figure 22 it can be seen that the data is cleanly available. Plus to get information from any part of the building one has to just click on a particular part of the building and all the information of that part will be revealed on the left side.

### 4.3 Benefit of IT based method over the conventional methods

1) All the drawings are in a single model and the required details can easily be obtained from the model.

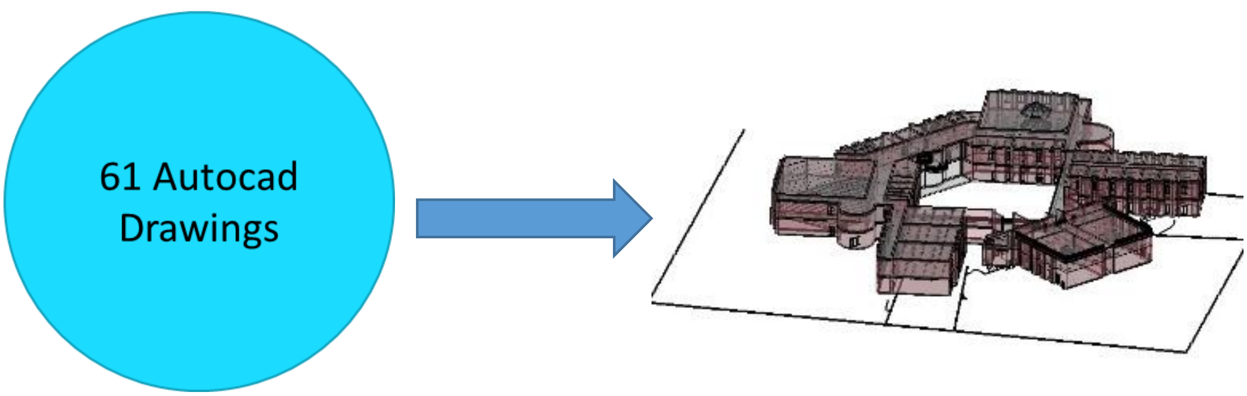



Figure 4-14 conversion to single model

2) The model can easily be viewed on any Mobil device .It makes the updating and viewing process much easier and less time consuming.

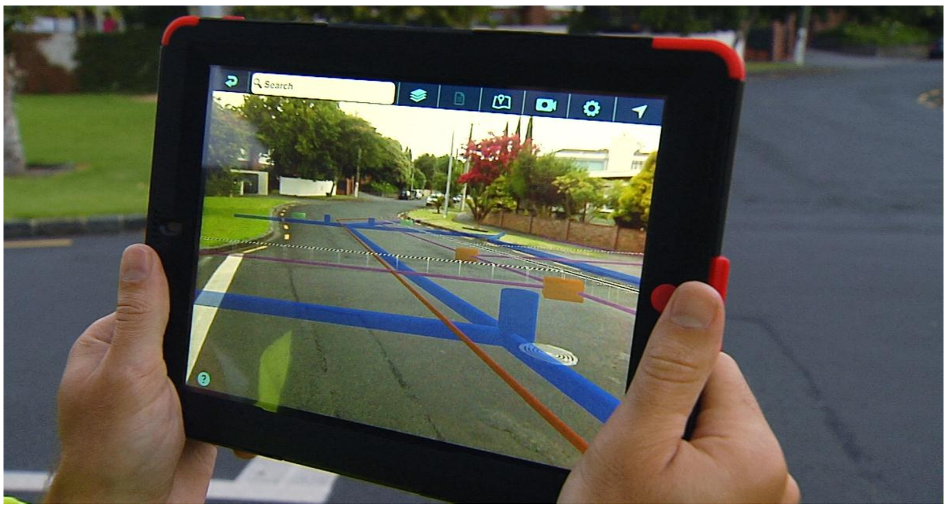



**Figure 4-15 Illustration with Mobil device**

3) This method is based on cloud computing technology and all the data is uploaded and saved in the cloud .As more than one party is involved, thus updates and issues created by one part can easily be viewed by all the other parties.


**Figure 4-16 Cloud sharing**

4) Barcodes are used for the navigation purposes, first the model made it easy to extract the required data than barcode made the indoor navigation much easier.

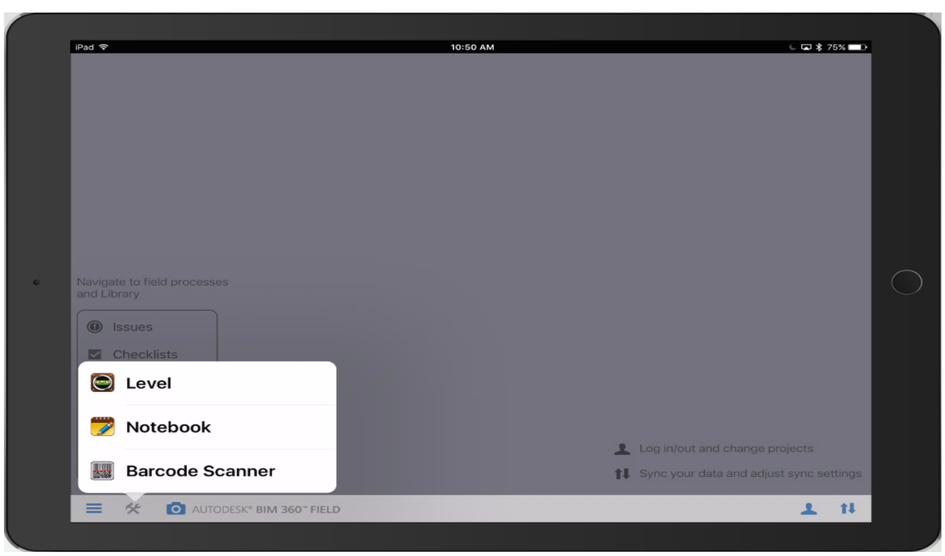



**Figure 4-17**

Figure 26 shows the position of barcode scanner on the Mobil device.

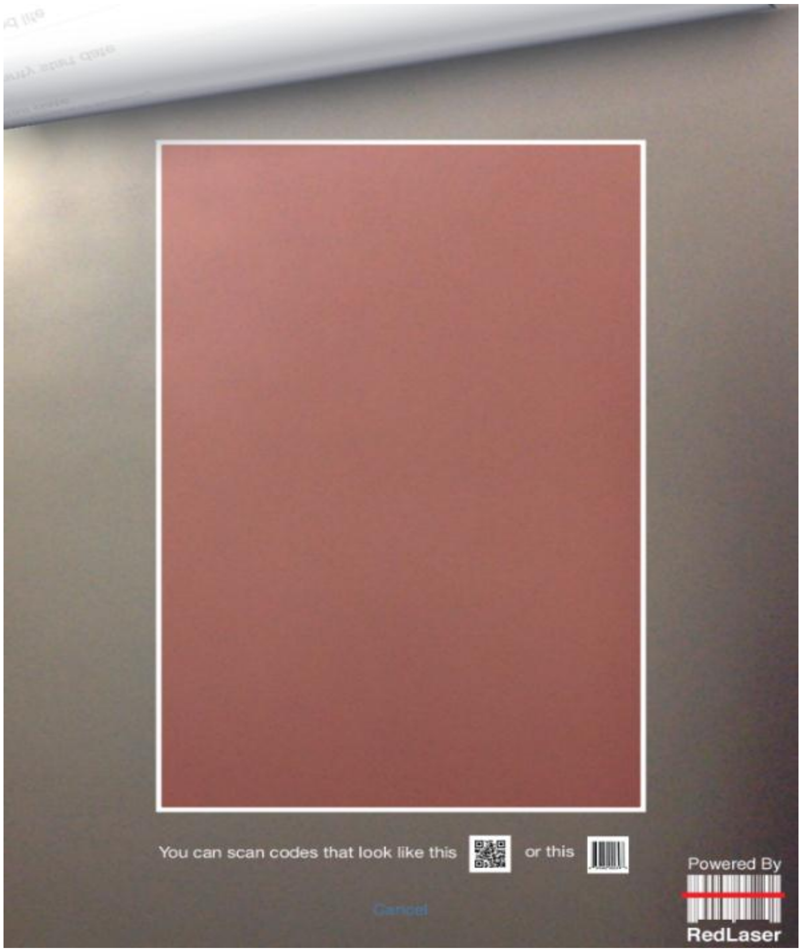



**Figure 4-18**

Figure 27 shows the barcode reading interface of the Mobil device. With the help of this, it can read the barcode by placing the red area of the interface over the barcode and it will read it. This will inform the system of the information associated with the barcode scanned.

5) The issue response time is greatly been reduced by this method.

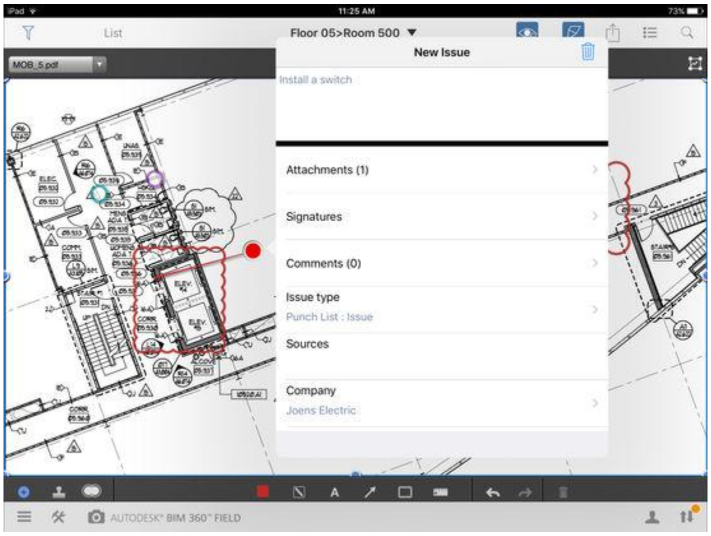



**Figure 4-19**

Figure 18 shows the interface where the issue would be shown after created and the concerned team can check on the issue. The concerned team can use different filters to highlight out the problem.

By simply scanning the barcode through barcode scanner/reader you can easily see the details of different information about the utility to which the barcode is assigned.

**Figure 4-20 Scanning a Barcode**

# CHAPTER 5

## CONCLUSION

### 5.1 Introduction

The use of different software's and information technology in the construction work is extremely helpful for its better development and control. The use of software helps the industry to solve different issues and problems faster than just relying on the conventional ways. Using IT as a tool the facility management of a building can be done with ease. In the project Revit, BIM 360 glue and BIM 360 field were used. These software really helped and providing keen information of a building for facility management with ease. Getting information of different areas of a building is easily available and the coordination between different stakeholders is improved. These soft wares convert the 2D figures into 3D environment that is converted into augmented reality using BIM 360 glue and BIM 360 field. One has not to search for different details of a building from different uncoordinated and scattered drawings and just have to rely on one detailed and combined information body. As the world is moving towards more and more complex designs and structures, relying on simple 2D drawings is naïve. Now in the modern era of construction, it is requiredto have information available with ease and a faster pace, which can easily be achieved by integrating it with different soft wares. The data of the model integrated with open workspace (online cloud) could be easily accessible by all the stakeholders and they could any data and information they require or need. The stake holders could easily inform about the issues in a building (as they could see the structure in virtual world ) through online cloud to the concerned authority, the issue could be resolved and the stake holder be informed through same cloud without the person meeting physically. The completed detailed model synced online with workspace is the ultimate information tool for the stakeholders as it will provide all the details and information on every scale i.e. minute to large, available with ease, and this information updated by the team whenever required. Though the local workers and labors might not catch the information from the software as it requires skill, so for their ease the traditional plan be provided, but with time and proper education they could also benefit from this.

## 5.2 Conclusion

The work here performed to relate the IT with the construction industry helped us to see the importance how useful is it for the construction industry. It helps us to so see how valuable and significant it is to use IT in our construction works. Converting simple 2D drawings into 3D models helps a lot in viewing different features of the building and also obtaining information from the model. BIM and Revit helped in converting these simple 2D drawings into 3D models. The owner and the stakeholders can easily extract information from 3D models and don't need to have the knowledge of the complex drawing. Using the barcodes placed at different parts of the building the owner could inform the management team of the problem at different parts of the building and the management team could reach the position using information available about the position in BIM 360 field and solves the issue. This will revolutionize the maintenance process of construction industry. This could help in both preventive as well as reactive maintenance. Preventive in the case when regular scheduled checks occur and reactive in the case when a problem has occurred such as failure of electrical lines, clogging of sinks etc. The maintenance works carries throughout the lifetime of a building as long as it stands and is functional therefore it is very important to take care of the maintenance job. Sometimes new construction is to be done on site or a hole might be dug, and to avoid hitting the pipeline below the ground 3D model prepared can be used to get the right information. In the current conventional construction industry, during maintenance work, data needs to be extracted from different 2D drawings scattered around and have to work our way to the problem, this issue could be easily solved by combining all the data into one complete model. The models could be easily updated in the model and the information of any change can be noted and stored in the model. And the model can be updated as the changes happen during the construction process . Also the information would not be limited to some specific people but all the stakeholders can have the access to the information. Use of technology in construction work can help change the future of conventional construction, where different facilities and utilities can be easily monitored and looked after, have less problems in its lifetime and provide data continuously.

To truly revolutionize the construction industry using soft wares like Revit, BIM and other IT based technologies which help in simplifying the acquirement of data and its use . And also find a way for the workers and layman to easily understand and get the information from these soft wares.

**5.3 Limitations**

1. The 3D model could be easily constructed for a new building. But for an already existing building this could be hard as some of the data might be lost.
2. If the information or drawings for some of the utilities is not available, it could not be shown in the 3D model.
3. As barcodes for finding the information of different utilities were used, it would be a hectic job to place barcodes everywhere.

4. There could be a difference in the real model and the model developed, depending whether the original plans were updated from as-planned to as-built drawings, and how much of it was updated.

### 5.4 Recommendations

1. The system developed should be tested during actual maintenance and management works.
2. The workers should be also trained on how to use and take information from these soft wares.
3. More accurate devices should be tested out with the software to compare its accuracy with that of the barcodes.
4. Adopt a real time location identifying method by using external sensors or external GPS system.

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