Development of BIM-based Contract Information System plugin for Revit (BIM-CIS)

Final Year Project Report

BE Civil Engineering

by

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This is to certify that the BE Civil Engineering Project entitled

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Dedication

We dedicate this research to our beloved PARENTS and respected INSTRUCTORS, who prayed for us and gave us encouragement and moral support throughout our endeavor.


بسم الله الرحمن الرحيم

Acknowledgment

Success comes at the price of hard work and dedication. But it can not be achieved by oneself. Similarly, this project is completed with the hard work of the respective authors with the dedicated support of many individuals and organizations. So authors will proceed with sincere gratitude to all of them.

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Abstract

The AEC industry in the world faces many problems regarding contract disputes and miscommunication between contractors and clients when it comes to any construction project. Manual studying of such mammoth documents when referring to any part of the building is a major challenge to the contractor, and it is an unreliable traditional method that needs to be made efficient and digitized. So, incorporating this issue we developed a prototype within the BIM environment to mitigate the problem of contract disputes by digitizing it in a Revit 3D model and connecting all related clauses to its relevant structural items. To achieve this objective, we will be developing a plugin. For the development process, Microsoft Visual Studio is used as the programming platform and Revit API is used as the programming interface that is provided by Autodesk. C# is the programming language used for coding in Visual Studio for plugin development.

The BIM Contract Information System plugin (BIM-CIS) was developed for integrating related clauses with the 3D model and digitizing the contractual work in the construction industry. This plugin takes data manually as we have to first add all the contractual clauses and details in the 3D model and when it is completed it can be viewed directly by just a simple click on any item in the model.

This project will have a lot of impact on the AEC industry, especially for the contractors and the BIM users, as it provides solutions for contractual disputes and links contracts with the drawing model. This is also useful as it gives information about the contractual clauses related to every item and helps to integrate it with drawings.

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List of Abbreviations

API	Application Programming Interface
BIM	Building Information Modeling
CAD	Computer Aided Design
AEC	Architecture Engineering and Construction
USD	United States Dollars
UK	United Kingdom
BIM-CIS	Building Information Modelling Contract Information System
BIS	Business Innovation and Skill
US	United States
IT	Information Technology
DLL	Dynamic Link Library
OOP	Object Oriented Programming
GUI	Graphical User Interface
JSON	Java Script Object Notion
GUID	Global Unit Identifier
PDF	Portable Document Format

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1. Introduction

1.1 Preface

With ever increasing demand of AEC (Architecture, Engineering and Construction) industry, it has always been difficult to keep pace with contract details because of segregated contract storage, contract language and limitations of contract clauses, shortcomings of contract control during execution, setbacks and faults in contract approvals and contract signatures and overlooked important dates and workflow tasks (Heck 2022). As a result of broad technological advancements in AEC industry to handle contract issues, BIM (Building Information Modeling) is anticipated as potential implementation environment. There is a trend of developing plugins to enhance BIM execution in handling modern construction issues. The way of information generation and management, communication between the team members has seen a change due to BIM. Previously, BIM protocol utilized 3D,4D,5D modelling. However, the integration of the model with technical specifications of the contract is a major area of concern. The contradictions between contract and execution can be overcome by aid of a plugin that integrates contract clauses to real life 3D model of the structure in BIM environment. This provides additional information about structural members of BIM model without skimming through contract details. It makes the execution process time saving and economically efficient. Through better coordination and control, any amendments or changes can be made during the execution phase avoiding risks of being faced with serious consequences. More than 70% of construction organizations in the AEC industry have an underachieving development. This is because of quality issues, cost overruns and prolonged projects that can develop into disagreements if they are not fixed. One of the major causes of the issues mentioned earlier is negligence to technical and particular specifications mentioned in the contract. Details mentioned in contract may be neglected that may lead to disapproval of the deliverable or entire re-construction causing a lot of disruption and delay in project. The probability of disagreements in construction projects is increasing and it is casting an undesirable effect on the AEC industry. The value of the mean worldwide AEC disagreement is USD31.7 million, it lasts up to 12.8 months. Moreover, indirect costs of un-productivity, stress and fatigue, revenue reduction, discredit are generated (Gibbs, Emmitt et al. 2014). Furthermore, resources apart from the AEC industry remain used to resolve the clash resulting in money migrating to other sectors. Disagreements rise from the construction industry’s inadequacies but

there has been little improvement even with the publication of various papers which admitted the sector's leftover area. The UK has defined some objectives to bring about positive change, BIM is one of them(Government 2012). Through this environment, an immense amount of knowledge can be gathered at a single platform which can be accessed by all stakeholders electronically.

BIM has attained worldwide recognition, improvement and has decreased the number of stays and disagreements in the AEC industry. It is arguable that the BIM has been restricted by distinguishable hurdles to its adoption, and some of them can be controlled by contract document (Chan, Olawumi et al. 2019). The aim of this project is to pave the way through integration of contract clauses incorporating technical and particular specifications into BIM software for smooth flow of data throughout the execution phase. Any sort of information needed about a certain building member can be accessed through a single click rather than going through every huge pile of contract documents. Technical and particular specifications of a certain structural or non-structural member is attached manually to 3D model and progress is monitored throughout the project lifecycle.

1.2 Problem Statement:

A contract contains a lot of specifications which sometimes can reach up to several hundred pages. It contains all additional information including general and technical specifications associated with members or components of structure focused by the project. The contract must be consulted while reviewing/inspecting various components of the project. This process is sometimes hectic. Engineers, technical staff and consulting agency may have to go through multiple pages to reach out the details of intended building component. Having information about a certain task prior to construction is vital for quality assurance and quality control. Moreover, the item must be completed in synchronization with the respective clause/specification. This problem can be solved by using Plug-in (Add-on) in BIM environment. The software named Autodesk Revit and developed plug-in BIM-Contract Information System (BIM-CIS) will be integrated. It will be used to link the contract specifications with their corresponding components in the 3D Model. It will enable end user including stakeholders and construction team members to access information about any component by just a single click. This will lead to a lot of benefits that will make management

of construction projects easier. The contractor can plan the project without consulting the contract and the client can arrange materials according to it.

1.3 Objectives

The objective of this project is:

- To develop a BIM based Contract Information System (BIM-CIS) plugin for enhanced management of contracts involved in a project.

1.4 Research Significance

The motive behind the advancements in construction industry is to make tasks easy to handle and manage those tasks effectively. Increased use of BIM (building information modeling) in construction industry has started the process of evolution and development of new techniques and plugins. The major concern of integrating the contract clauses to model of the structure is dealt with by aid of such plug-in. It will ease the contract management and avoid future disruptions or lag in the project due to any sort of legal or managerial issues regarding contract, since entire additional information would be in reach of all stakeholders involved in the project through electronic mediums. Moreover, project focuses on enhancing the Revit's technical role and the user interfaces, other aspect of project includes the importance of plugin development on the main procedures of Revit plugin. Additionally, in future we can explore connecting such methods with contracts and Revit. It suggests the essential changes required to assist the incorporation of such developments within the industry and emphasize their influence on the authorized and contractual features. This plugin will integrate contract clauses with the designed model of the structure. Users can access each minor detail about a certain component of the structure through a single click. It paves the way of implementing the contract without any confusions or contradictions regarding a certain member mentioned deep inside the contract details

2. Literature Review

2.1. Background

Success of any project is directly connected to how well the contract has been written. Civil law governs contracts for construction work. The contract contains important and supplementary terms. Construction contracts' relationship to several fields, including law, construction, management, and so forth, is the fundamental issue. Each of those circumstances needs to be assessed and clearly laid out in the contract. Construction contracts become a multimodal and complex document as a result. It is vital to conduct a structural study of the building contract before drafting it. This article's objective is to propose a model of information system whose primary function is to facilitate the preparation of construction contracts by providing a tool for contracts structural analysis. Specialized information systems for preparing construction contracts allow for the collection of large amounts of relevant data, the implementation of specialised models for contracts evaluation, as well as the ability of using accumulated knowledge in many contract-related domains.(Trinkūnienė and Trinkūnas 2014)

In construction projects, the client pays the contracting team in installments as per the contract for the task done so far, so that the contracting team may invest in the resources needed to finish the project. After the client has accepted the contractor's prerogative for the value of the progress, the progress payment is given. When the imbursement circumstances of the contract document are unclear, discrepancies between the employer and the contractor may occur(Choi and Kim 2016, Abotaleb Ibrahim and El-adaway Islam 2017). Through BIM it is now possible to use new technology to improve the conservative construction progress imbursementnt method. Building informatmodelingling (BIM) enables the digitization of building information and also project collaboration platform for integrating and merging contract documents, including the managing of payments.(Chong, Fan et al. 2017)

2.2 Importance of Contract Management

The construction industry is a competitive and complicated environment where people with several skills, perspectives, and levels of construction procedure knowledge coexist. Participants from a different professions are present in this complex world of construction, and each intends to maximize the use of their own knowledge while pursuing their own objectives. Nonetheless, conflict and dispute are two different notations, according to (Fenn, Lowe et al. 1997).

Conflict occurs whenever there are competing interests. Conflicts can not be avoided in the construction sector due to different ideas presented by different members. Conflicts quickly develop into differences if they aren't addressed with proper supervision. One of the biggest problem that stops a construction project from being finished are the disputes and issues within the organizational members (Cakmak and Cakmak 2014).

In order to finish the construction project on time, within subjected finances, and with the essential level of quality, it is very important to understand the main reasons that why such disputes happen. Construction industry experts often unclear about the distinctions between disagreement and dispute, and this is especially true in the construction business according to (Acharya, Dai Lee et al. 2006).

Number of hazards occur when a project is being done. These hazards are some time from contracts and can impact seriously on the performance of the project. These issues can be resolved by proactive communication, and they can stop them by warning each other to upcoming risks, therefore, the inclusion of early warning clauses in the contract provisions is essential.(Elkhayat and Marzouk 2022)

The creation of contracts is not an easy task, rather one can call it a hectic job that needs a thorough grasp of the type and provisions of the construction project. Any construction contract must have reasonable provisions which account for each party's obligations and risks. Disputes and claims come from a lack of comprehension and implementation of the commercial agreement. Thus, a well-written contract helps in the project's efficient delivery and completion. Contractual standardization helps in making similar relations and clauses that both teams will settle on. (Elkhayat and Marzouk 2022).

2.3 Contract Disputes

According to common consensus, contracts are a significant source of conflicts since their terminology can be confusing. The contracts are likely to be more complex as a result of the rise in complexity in the nature of work. Change orders are necessary for a project to be successfully completed because the construction industry's nature makes it impossible to determine the full scope of work at the time of tendering. The owner's changing requirements and subsurface conditions are frequently unpredictable, which results in additional effort. In residential construction projects, extra work is known to be a major source of disagreements, especially when the owner/engineers and the users are two separate entities. Although only the owner and his engineer are entitled to speak with the contractor because they are parties to the contracts, potential users occasionally make ideas to the contractor directly that result in disagreements.(Iyer, Chaphalkar et al. 2008)

2.4 Problems in construction related to Contract documents

Construction projects range from homes to motorways, hospitals, and many more types of buildings. It is one of the greatest revenue-producing sectors in the global economy. Several other associated industries are created as a result of it, including those in steel, concrete, lumber, carpet, furniture, paint, paving, mining, and shipping, to name a few. Yet because the construction sector is so complicated, a lot of things can affect how a project turns out. The difficulties involved in managing building projects progressively worsen as they get more intricate. Opportunities exist for people interested in the industry, and there is a great need for qualified construction managers.(Dmaidi, Mahamid et al. 2016).

The inadequacies in contract papers that result in disputes were the key problems that drove the development of the current system. Even while having a failsafe contract would significantly lessen complications, it is almost impossible to have one.(Iyer, Chaphalkar et al. 2008).

2.5 Advancements in contract management

BIM technology has been around for approximately 50 years in one shape or another. Researchers at Georgia Institute of Technology introduced the theory of BIM to the AEC sector for the first time in the late 1970s. The clearest example of their research's impact on industrial technology development comes from Autodesk's introduction of the CAD concept (AutoCAD) in the early 1980s. This was followed by Graphisoft, who debuted their first "Virtual Building Solution" (now known as ArchiCAD) in 1986. This marked the beginning of the "revolution" in software that allowed architects to produce virtual 3D blueprints of their projects as opposed to the conventional 2D drawings) (Bataw, Kirkham et al. 2016)

Smart contracts are computer protocols that make the negotiation or performance of a contract easier, more accurate, or more enforced, or that do away with the need for a contractual provision altogether.(Szabo 1994)

The idea of writing the contents of an agreement into a tangible object stands in stark contrast to the usual paper contract, which, once agreed upon, is typically only referred to as a reference when the parties are at odds.(McNamara and Sepasgozar 2018)

2.6 BIM concept and modelling

AEC firms who use the most recent technology will put themselves ahead of the competition since they are eager to use and adapt to new technologies in a highly competitive sector. Construction industry is one of the fastest growing in US, European Union, and the other countries in the world. It is expected to change traditional methods to automation methods and it is still in its starting phases in the AEC industry. As an outcome, it is important as well as highly obligatory to make and implement methods and technological advancements within the AEC sector. In this way, the construction industry has the probable to honestly change the construction industry. One of the

most important and auspicious developments in the AEC sector is the use of building information modelling (BIM) as a tool to administer data digitally. This is due to the fact that BIM, which uses a method to manage construction design plan in a digital format to use it during a project's useful lifecycle, constitutes a paradigm change.(Alizadehsalehi, Hadavi et al. 2020)

Computer Aided Design (CAD) provides provisions the representation of elements in building as to be constructed in 3D. BIM is generally understood as a tool that is termed as to describe a variety of activities in the construction industry. In AEC industry BIM refers to a set of technological advancements and resolutions that are intended to improve collaboration within organizational setup. This increases the efficiency and the project becomes productive by enhancing design, construction, and maintenance practices (Miettinen and Paavola 2014).

Building information modelling (BIM) and sustainability studies have gained traction over the past few years as a result of the growing demand for construction industry. Although some studies have examined the development in these two areas independently, they have not addressed the significant connections between them or examined how they have progressed together over time.(Al Hattab 2021).

There are many well-established Building Information Modeling (BIM) tools that may be useful in specific applications. Nonetheless, problems with adoption and execution still exist, especially when using BIM tools on-site during the construction process. We provide an empirical case study of how a cutting-edge "Site BIM" technology was applied to a significant hospital construction project. The project's principal contractor created BIM-enabled tools that site employees could use to obtain design information and record data about the quality and progress of their work while on the job. According to accounts, "Site BIM" was developed through an informal prototype process that was exploratory and emergent, despite being considered successful and actively supporting users. Rather than using formal procedures, the construction project absorbed technical IT abilities through informal arrangements and partnerships. Employees on the construction project drove implementation rather than the corporate IT function(Davies and Harty 2013).

2.7 Role of BIM in effective Contract management

Building information modelling (BIM) is a technique and a technology that has altered the conventional building procurement procedure. Contractual standards for BIM implementation are lacking in third-world nations, which slows and complicates the adoption of BIM. Past studies have discovered a gap in the contractual ties, roles, and hazards that follow(Mosse, Njuguna et al. 2020)

BIM has always continued to develop clear improvements and always supported AEC industry. BIM users will need to go through a well-organized process of change which encompasses their internal organizational borders with other clients and suppliers. Model below shows the improvements in UK which is shown by UK department of Business innovation and skills (BIS). This model shows 3 levels out of which major industry is in level 1 which few have entered level 2 and 3(Institution 2016).

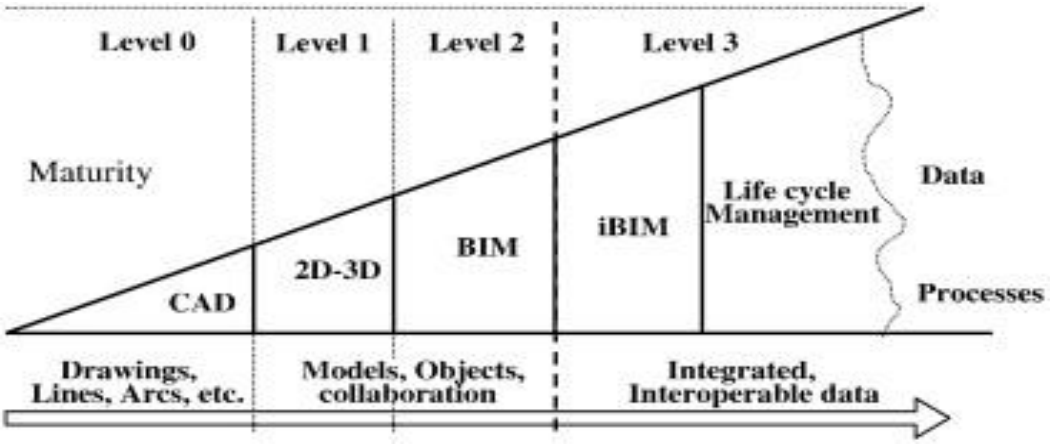

Figure 2.1: BIM improvements in UK

Currently, from a broad perspective, building information modelling (BIM) technology development and application start slowly in our nation, construction practices are imperfectly scaled, system , policy and regulations have not yet been made so it needs to be developed. At the intersection of the new information age of blockchain security, cloud computing, and intelligent society the aim is to carry out the historical goal of BIM technology diffusion (Yang and Liao 2016).

BIM encourages multidisciplinary integration, yet, it has been challenging to promote the effectiveness of BIM deliverables because the industry's current legal frameworks are insufficiently designed to support the practice principles behind BIM. Evidently, BIM won't provide its notable advancement above conventional practice procedures until the problems associated with its legal frameworks are clarified and made to be more useful for contract administration and procurement. A technique to change current technical operations (and commercial processes) in the fields of architecture, engineering, construction, and facilities operations is provided by building information modelling (BIM). Published data strongly suggests that BIM improves project results and contractual relations, this represents a significant divergence after common difficulties (Olatunji 2014).

2.8 Problems in using BIM in contract management

Building information modelling (BIM)-enabled building projects provide a number of advantages that have drawn much recent attention. Yet, during practical deployment, BIM-based contract monitoring and lawful issues have emerged as critical concerns for all concerning parties, and there are still a lack of efficient contractual frameworks to mitigate contractual problems and thorough investigations.(Fan 2020)

A way to change current practical processes in fields of architecture, engineering, construction is provided by building information modelling (BIM). Published data clearly indicates that BIM improves project outcomes and contractual relationships, as though this marks its significance from issues.(Olatunji 2014)

The information and data that we collect allowed us to identify financial advantages and productivity as well as experience of our team on BIM. This collection of experience of the project participants as a team allowed for the definition of the decision-making process before commencement of work on BIM to start different projects. The implementation of BIM urgently calls for the making of useful tools for exchange of information between different software paraphernalia, enabling well-organized and direct management and checking processes between project team and other officials that are hired on a specific project. (Migilinskas, Popov et al. 2013)

Delay in construction increases as the time passes and the deadlines that are set forth, get missed as written in contract or later again set by the contractor for project delivery. As the project is running behind the schedule, we see that it is actually a typical issue in almost every construction project. For the client this means so much, loss of money and potential stakeholders is one of the issues. Furthermore, these delays cause increased overhead costs and this later results in overhead expenditures for the contractor. With money having worth related to time, the delay causes high labor and construction costs. Delays can often result in increased overhead expenses for the contractor due to extended work periods, higher material costs due to inflation, and higher labor costs (Assaf and Al-Hejji 2006).

3. Methodology

3.1. Introduction

The research methodology that was adopted in this study is discussed and explained in this chapter. It will include complete understanding of how the problem was identified to be solved and how it was solved to get the output that was required. Firstly, the research gap was identified by literature review and then the BIM contract Information System (BIM-CIM) was developed. The followed plugin was developed using C# language and on Visual Studio platform by Microsoft. This working was done via REVIT API that is developed by Autodesk Studio to develop plugin for REVIT.

3.2. Parameters and tools

The following table discusses about different parameters and tools used to achieve the success of different aspects involved in the project.

Table 3.1 Parameters and tools

Parameters	Targets
BIM platform	**Autodesk REVIT 2023**
Integrated development environment	**Microsoft visual studio 2019**
Programming language	**C#**
Database configuration	**Revit directory**
Project template	**Class library**
Software development framework	**.NET framework**
References	**Revit API .dll**

3.3. Research Design

The following flowchart is a structured approach that outlines the step-by-step process for development of required plugin for managing contract effectively. The flowchart provides a visual representation of the methodology, illustrating the sequential flow of activities and decision points involved. The methodology consists of several steps, each serving a specific function and contributing to the overall outcome. It begins with problem identification through literature review and finding the gap in industry. After gap in the industry was established, criteria for contract details were evaluated to determine the appropriate interface for the plugin. It was found that there are three different types of contract specifications used on the field including general, particular and technical specifications.

The services, resources, and supplies known as general conditions are those that contractors in general offer to guarantee that projects are finished as planned and according to the drawings. They cover expenses for managing the site, the project, handling the materials, and picking up the garbage. The term "Particular Conditions of the Contract" refers to clauses that are unique to a project and the nation in which the work is being carried out. They are usually used for the addition, omission, and alteration of the contract's general conditions. Technical specifications are created to ensure uniformity and to give guidance to building contractors on how the work should be done, the caliber of the construction, and methods of quality assurance.

The development of plugin was carried out in visual studio using C# with Revit API (Application Programming Interface) provided by Autodesk. De-bugging and Refactoring was done to eliminate flaws in the code. Finally, plugin file was obtained in the form of .dll file and loaded into the Revit as an add-in.

Finally plugin was tested in Revit model by adding all the specifications and displaying them one by one. Plugin was working fine. This resulted in successful integration of contract details with Revit 3D model in BIM environment.

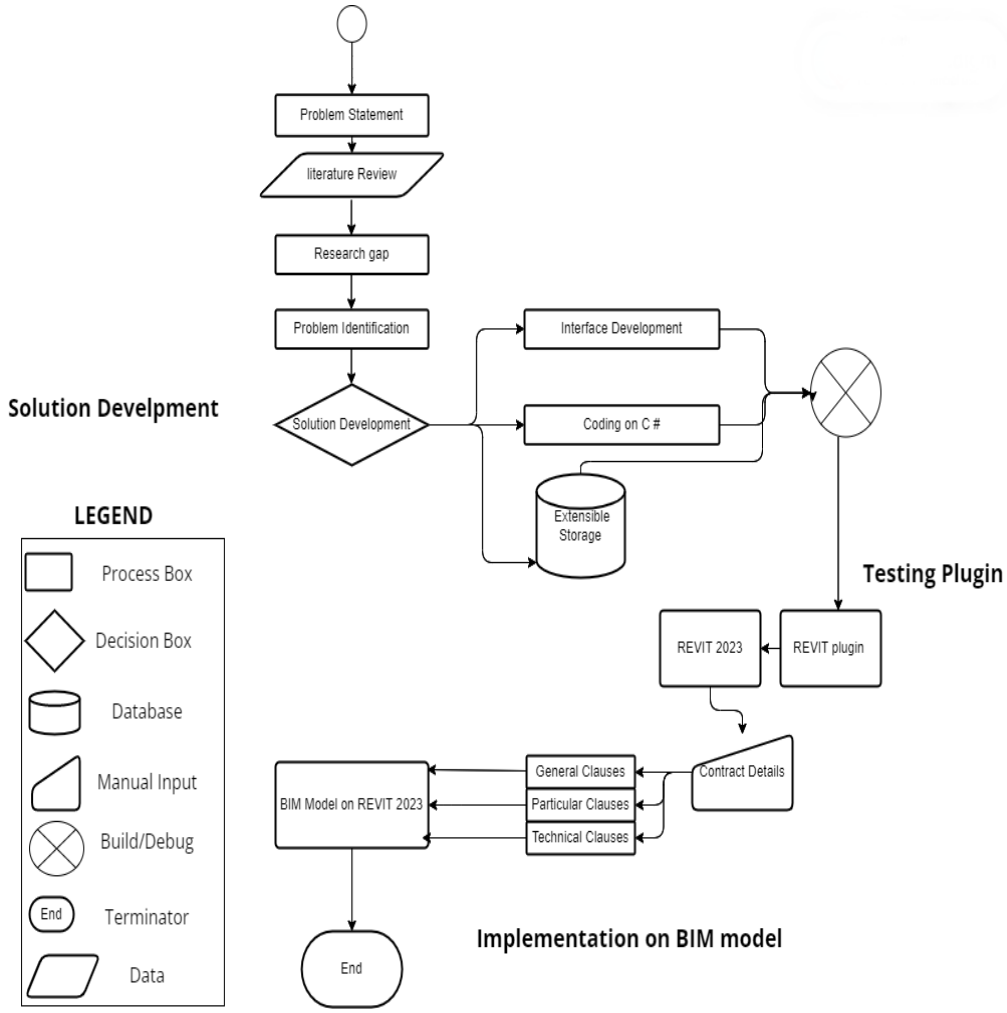

Figure 3.2: Research Design

3.4. Programming

Since the plugin was developed through programming so it needed some specific programming language to be used and some other technical terms which made the process of coding possible.

Following details explain all the data and terms that were used in our programming language.

3.4.1 C# Programming Language

Microsoft created the contemporary general-purpose programming language known as C# (pronounced "C sharp"). Since its initial release in 2000 as a component of the.NET framework, it has grown in popularity due to its ease of use, adaptability, and durability. The development of a variety of applications, including desktop software, add-ins, WPF forms, web applications, games, mobile applications, and business solutions, is frequently done in C#.

Following types of programming structures can be made through it:

- Object Oriented Programming (OOP)
- Syntax and Structure
- Integrated development environment
- .NET framework

3.4.2 REVIT API

A collection of classes and methods known as the Revit API are made available by Autodesk, the mother of all BIM software and modules. Through the useful functions of the Revit API, programmers can add to and alter the functionality of Revit by creating their own programs, plugins, or scripts.

The Revit API has the following salient features:

The Revit API is available via the.NET API and is primarily intended to be used with the.NET framework. As a result, programmers can create code using managed languages that are compatible with the.NET framework, such as C#.

3.4.3 .dll Extension

The file type known as ddl (Dynamic Link Library) is frequently used in Windows operating systems to store and distribute resources and reusable code that several programs can utilize

simultaneously. It is a kind of binary file that includes functions, data, and other resources that can be dynamically linked to an executable program at runtime. It also contains compiled code.

Here are some crucial things regarding dll:

- Dynamic linking: At runtime, dll are loaded into memory and linked to an executable program, enabling the executable program to use its resources and functionalities. Program can utilize dll without having to physically include their code in the executable thanks to dynamic linking.

- Functionality Extension: By adding new features like custom controls, data processing algorithms, device drivers, or plugins, dll can increase an application's functionality. Applications can be adaptable and readily include new features by dynamically loading dll rather than recompiling.

3.4.4. Class Library

Our project was made in Template of Class Library .NET FRAMEWORK to work on the coding process. This is a type of template that divides the various functions of modules that are generally used in programs. It also does work of taking load that is unknown when starting application.

3.5. Development of BIM Contract Information System (BIM-CIS) Plugin

3.5.1 BIM platform

As rapid advancement and development have been done in BIM and ICT for extensive reasons and objective, regarding AEC industry, with respect to sustainability, project control techniques and others. By using BIM, we have to link contract with Revit Model

Autodesk Revit 2023 will be used for modelling of building, and Plugin usage in the end which would be linked with BIM model. Our main concern is with Autodesk Revit 2023

as plugin would be integrated there which is our objective. Revit is used to build architectural, structural model which is then linked with the plugin and contractual clauses were added.

3.5.2 Plugin Development

In the second phase, plugin was developed for Contract management in Autodesk Revit 2023. A detail study was done to understand the problem in relating contracts with drawings and a solution adopted to it was to develop a plugin within BIM environment to support our problem and link it with construction industry. BIM software API were studied and BIM Contract Information System plugin was developed. Most BIM software has an API that may be used to enhance it features. A commonly-used programming language (i.e. C#) was used to create the plugin using Microsoft Visual Studio using .NET frame work(.NET). A data connection was made within Revit data library where Revit saves its work and data such that contractual clauses have to be saved somewhere.

3.5.3 PLUGIN Design Code

The plugin programming was done in C# language on Visual Studio Platform as shown in figure 3.8.

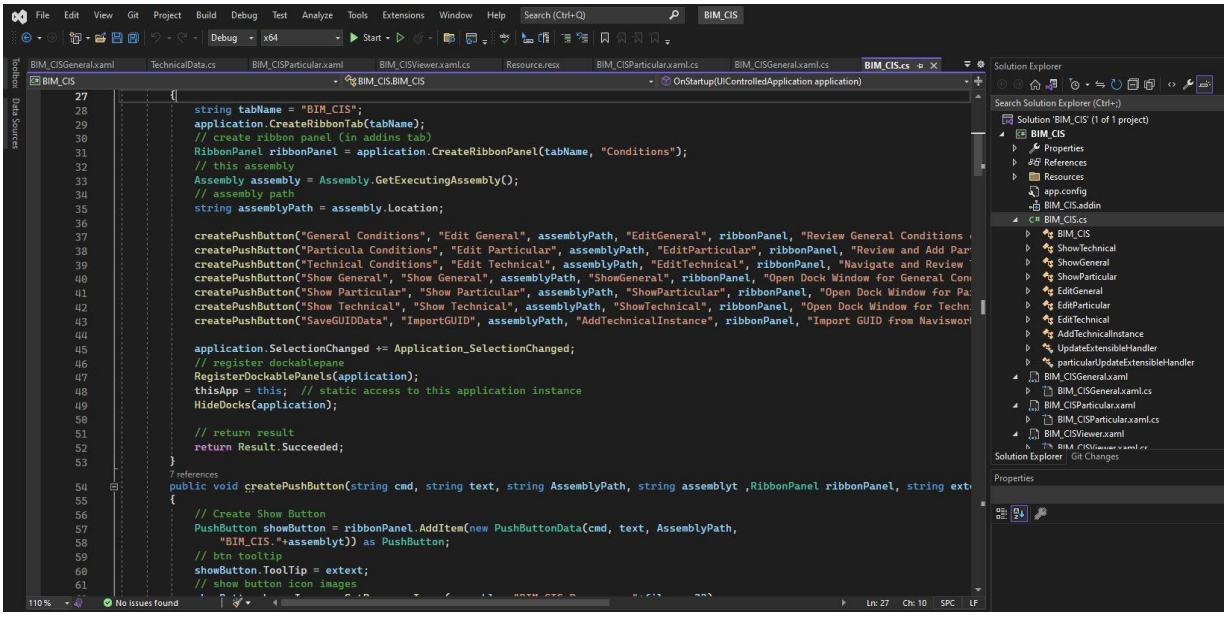

Figure 3.3: Plugin algorithm

3.6. Technical Conditions output interface in code

The GUI of the plugin during test run is shown in Fig 3.4

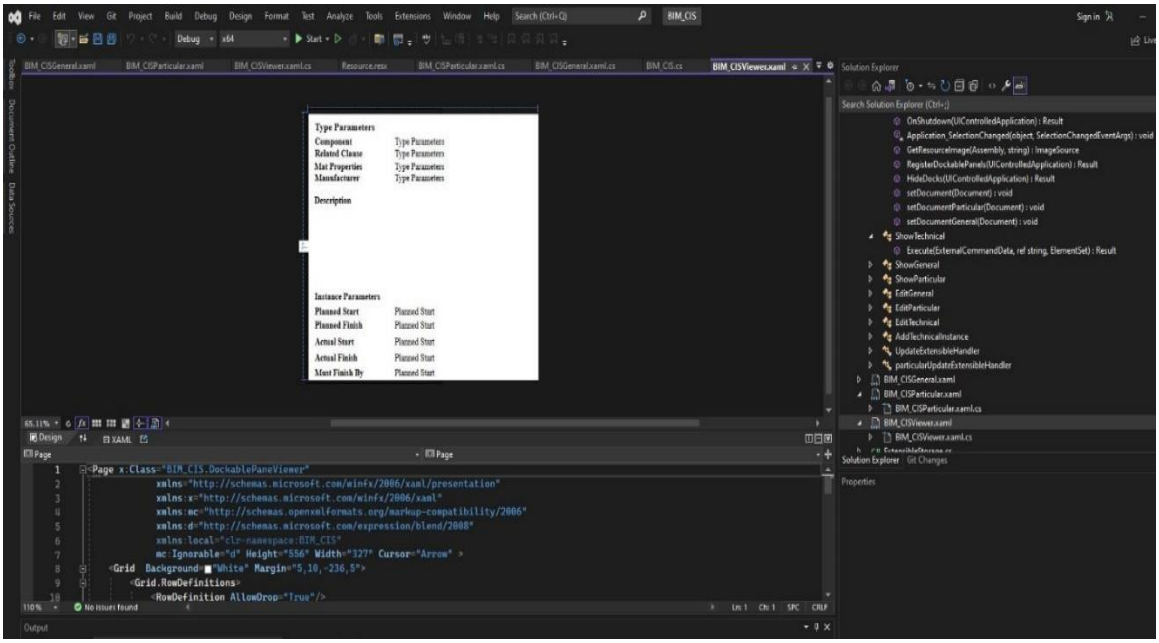

Figure 3.4: GUI during test run

3.7. GUI of Plugin

Following Figure 3.10 shows the graphical User Interface of the developed plugin in Revit 2023 environment.

Figure 3.5: GUI of BIM-CIS plugin

3.8. Plugin evaluation and validation

In the last phase, the plugin was checked, tested and validated for its defined functions and objectives.

As we have to link the contractual clauses with the Revit model, a small scale model (MCE Concrete Laboratory) was developed for this purpose to apply it on a real life problem and try to link the clauses. The structure included architectural and structural aspects. Following image shows a Revit model in figure 3.6.

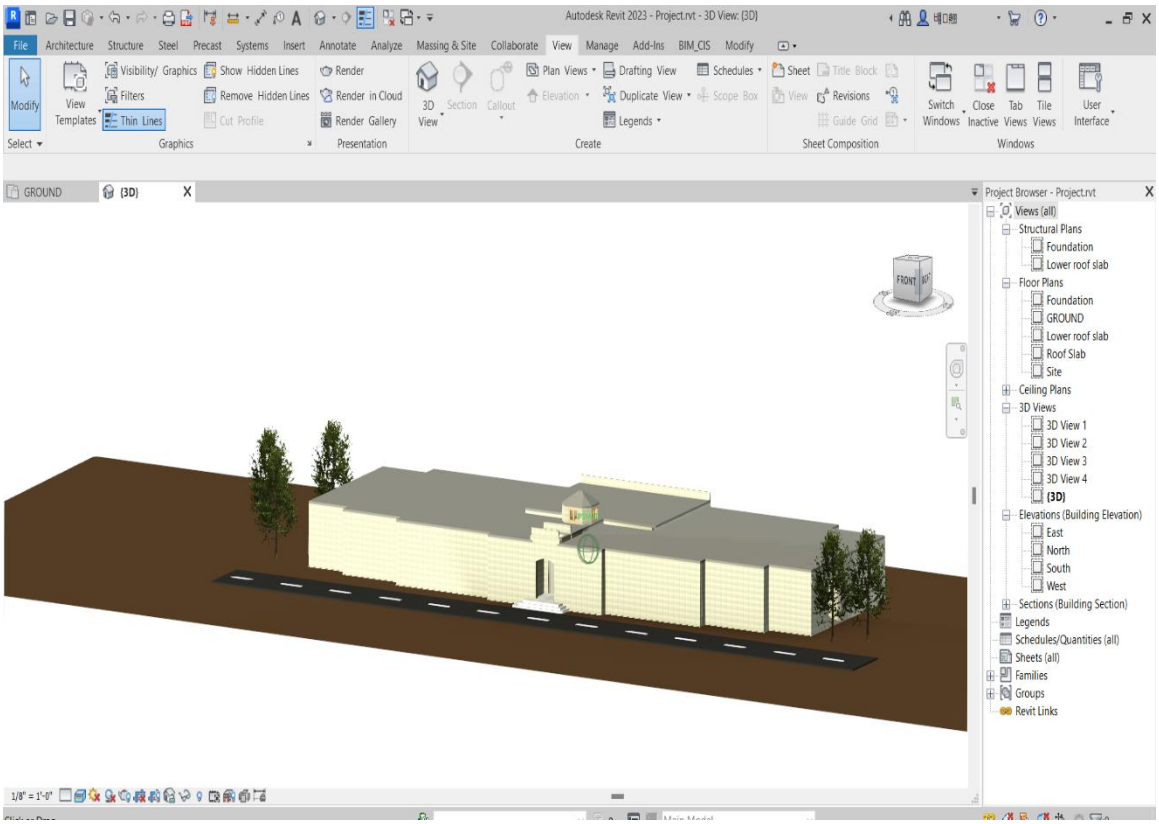

Figure 3.6: Revit BIM

4. Results

4.1. Introduction

In this chapter, the working of BIM-CIS plugin will be shown to enlighten the usage and functionality of plugin.

Pre-requisite steps before use of plugin:

- 3D model was developed in Autodesk Revit including architecture and structural model.
- Data was transferred to Autodesk Navisworks and scheduling was done.
- Contract of the structure was studied and understood.
- Model was shifted from Navisworks to Revit to add clauses with each component.

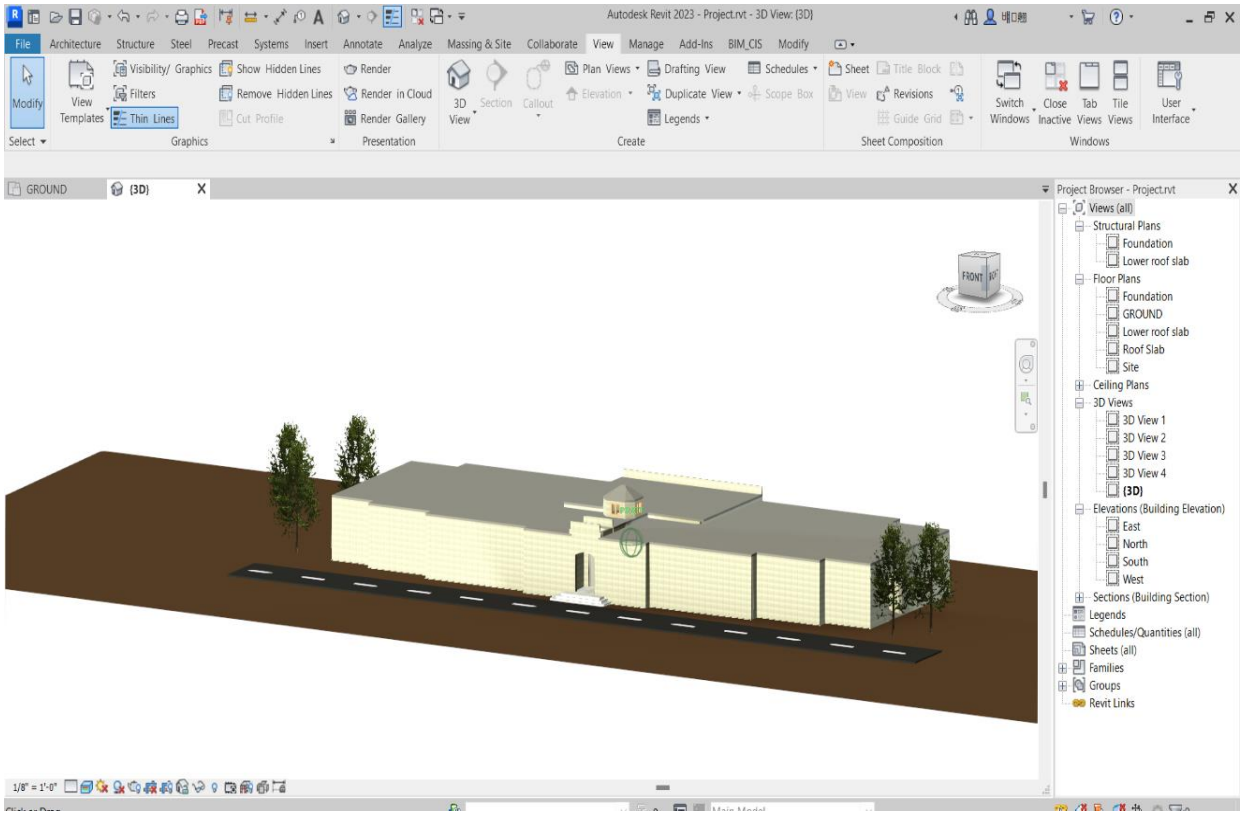

Figure 4.1: BIM model in Revit

The model shown in figure 4.1 is a single-story building with an approach road. 3D model was designed in REVIT.

4.2. General Conditions

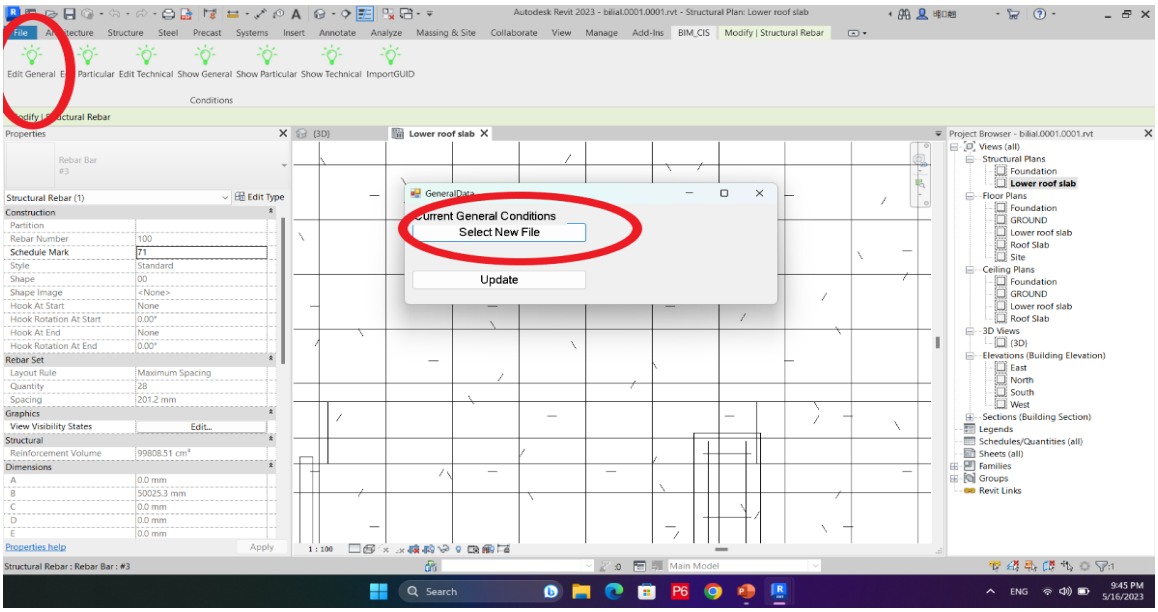

Figure 4.2: General Condition Selection

By clicking the “Edit general” option a dialog box will open where we will select a file that is to be loaded in the project as shown in figure 4.2.

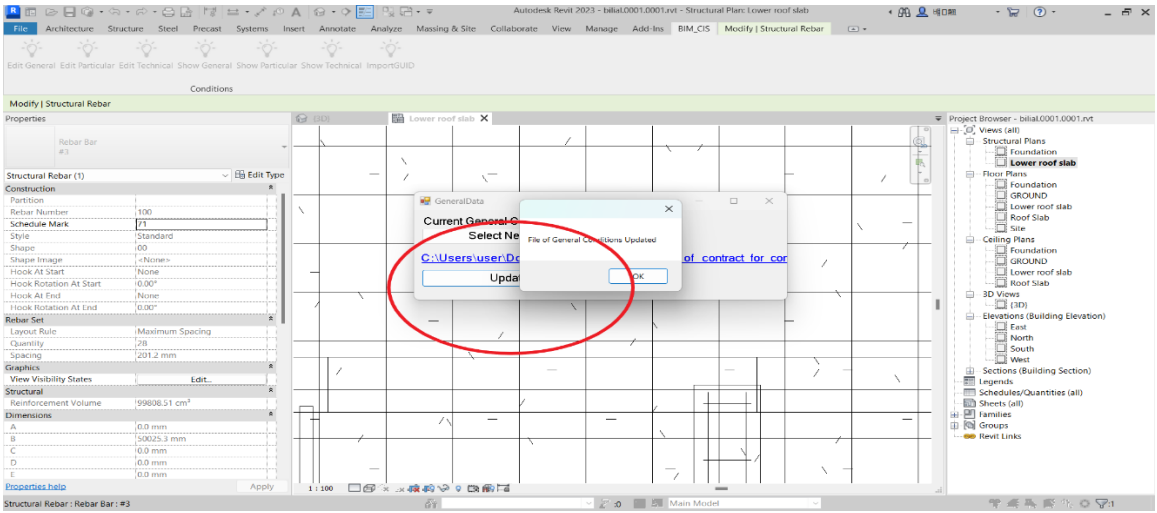

Figure 4.3: General Condition Updated

After clicking select new file option, update it and select the pdf file from your computer or any other database that comprises of general conditions related to the project. Then add the file and select update button. The file will be updated as shown in figure 4.3.

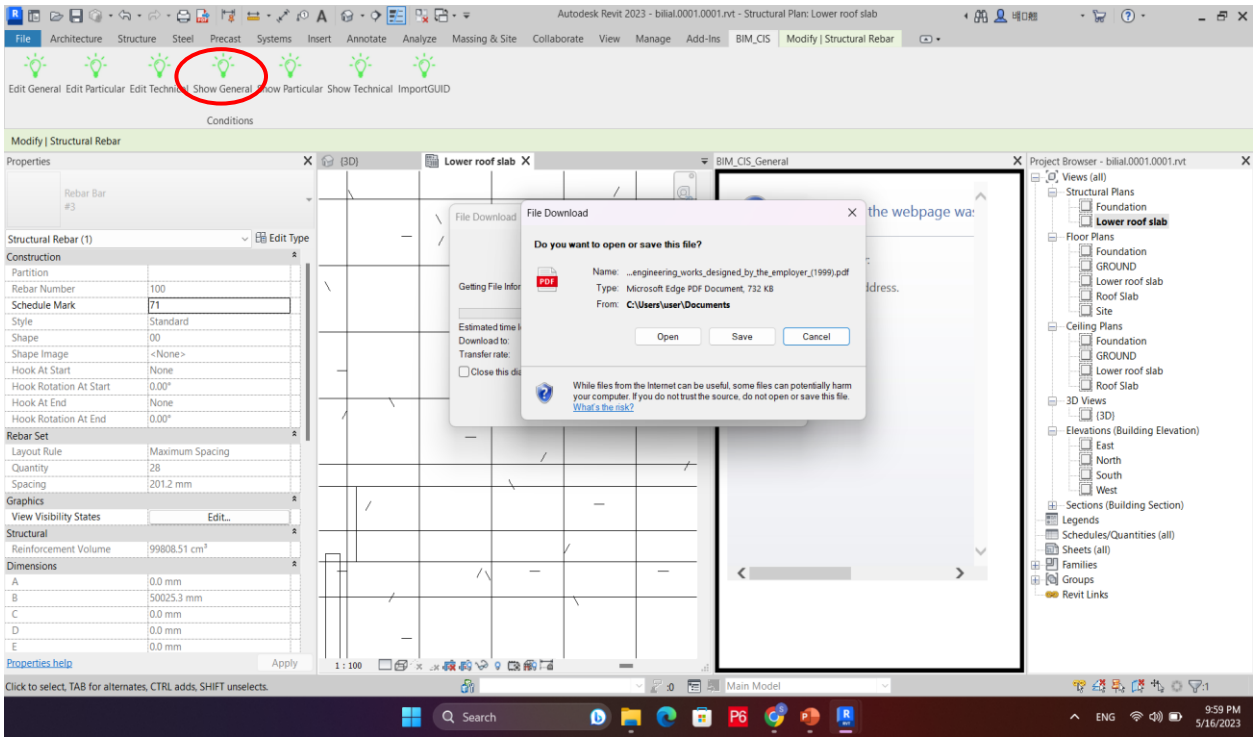

Figure 4.4: General Condition Displayed

Refer to figure 4.4, for displaying general conditions, select “show general” from menu bar and open the file attached. PDF will open up in PDF viewer and conditions can be viewed and consulted.

4.3. Particular Conditions

Now for particular conditions click on the button “edit particular” in menu bar. An interface will appear with various options as shown in figure 4.5.

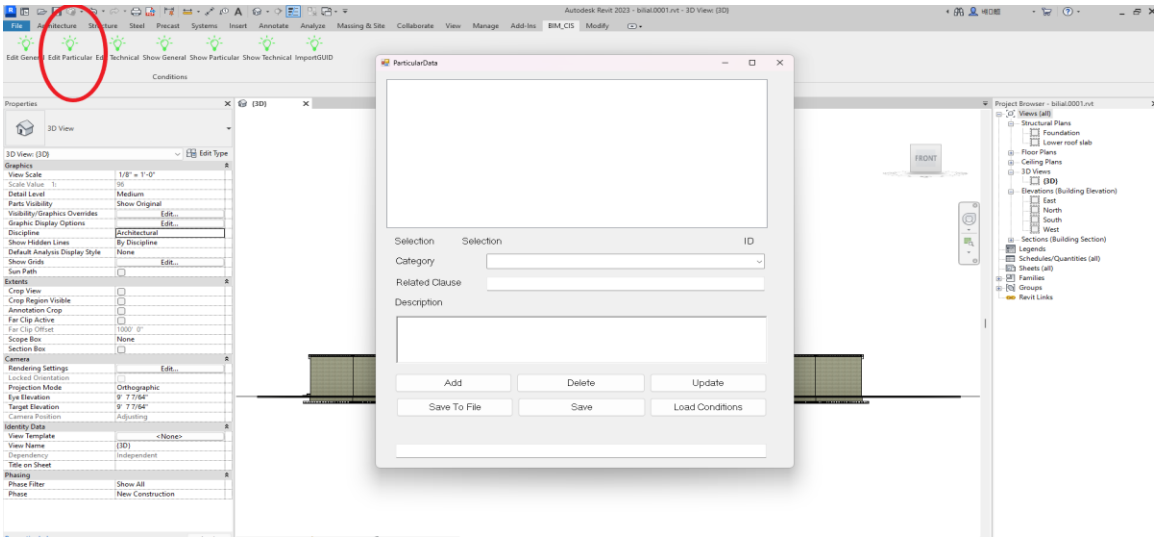

Figure 4.5: Particular Conditions box

Consult the contract and add details of particular conditions one by one and save the conditions to a file. as shown in figure 4.6.

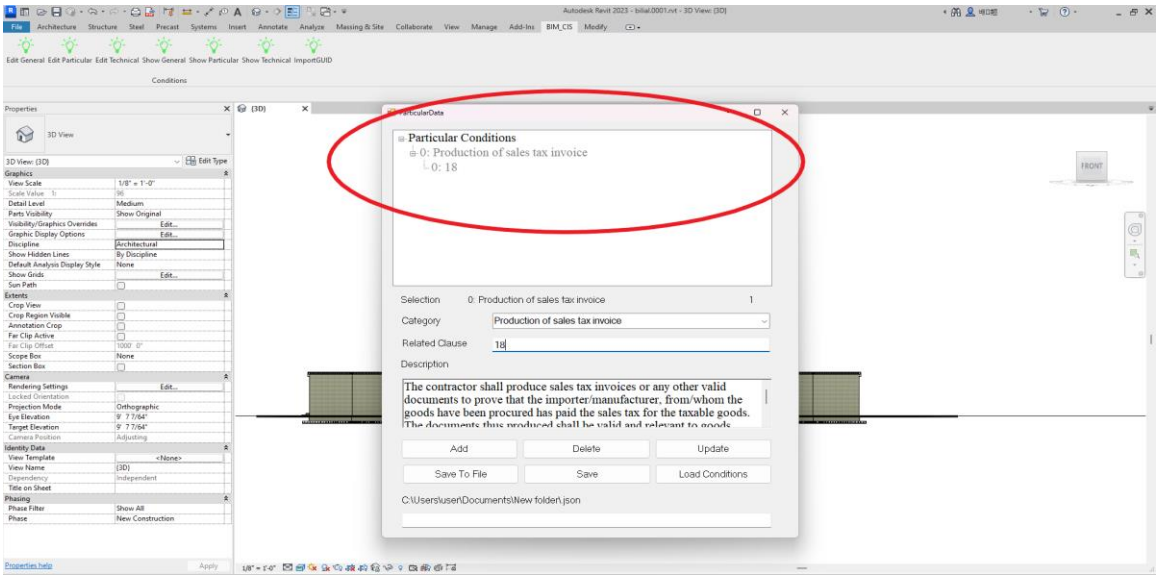

Figure 4.6: Particular Conditions Update

Now, for displaying particular conditions, click on “show particular” button and conditions will appear in a tab just besides REVIT model as shown in figure 4.7.

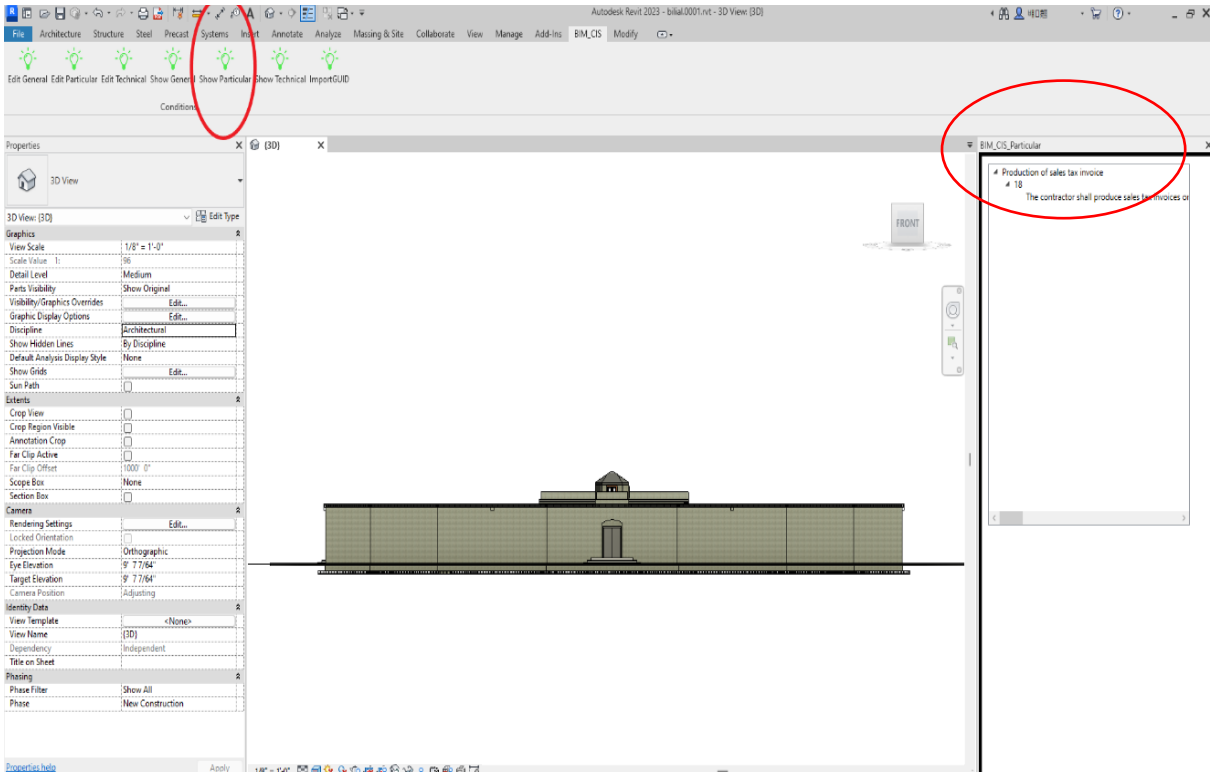

Figure 4.7: Showing Particular Conditions

4.4. Technical specifications

Now, the most important aspect regarding execution of project is being discussed that is the technical specifications. The third and main part of plugin is addition of technical specifications. Technical specifications comprise of description of technical aspects such as strength and shape of a material, manufacturer, and related clauses. For adding technical specifications, click on “edit technical” button. An interface will appear with a library of all the items used in the project. Select and item and double click to add it on the interface. Then add details as shown in the figure 4.8.

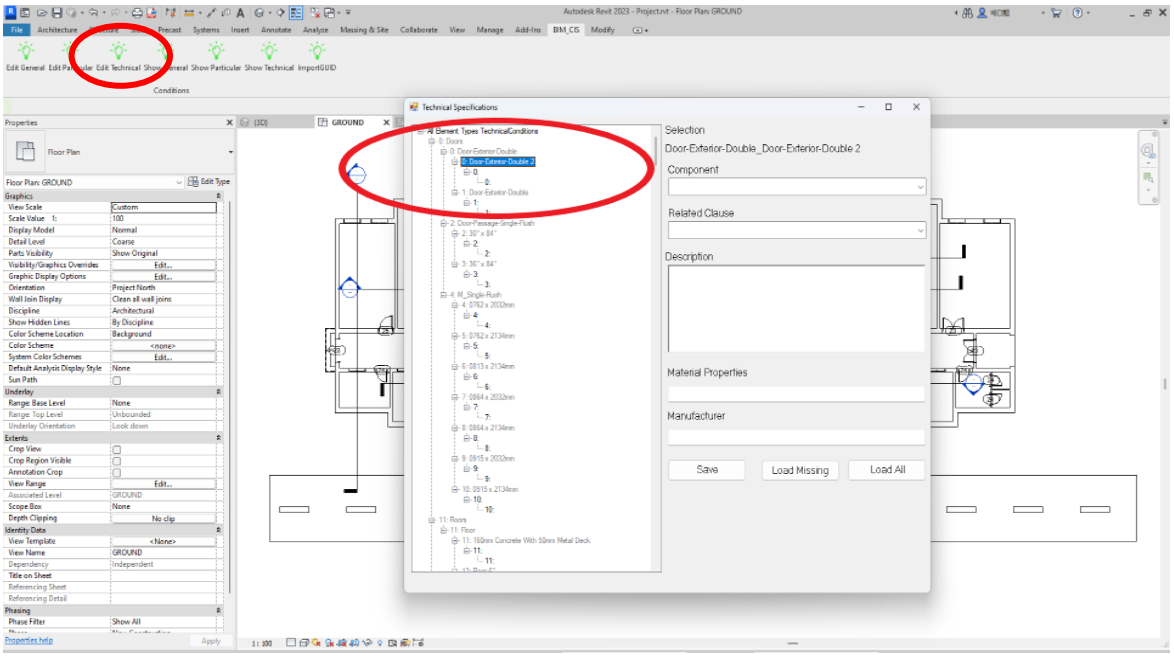

Figure 4.8: Selection of component for technical conditions

After adding the data, click on the save button and technical specifications of the component will be saved as door in this case.

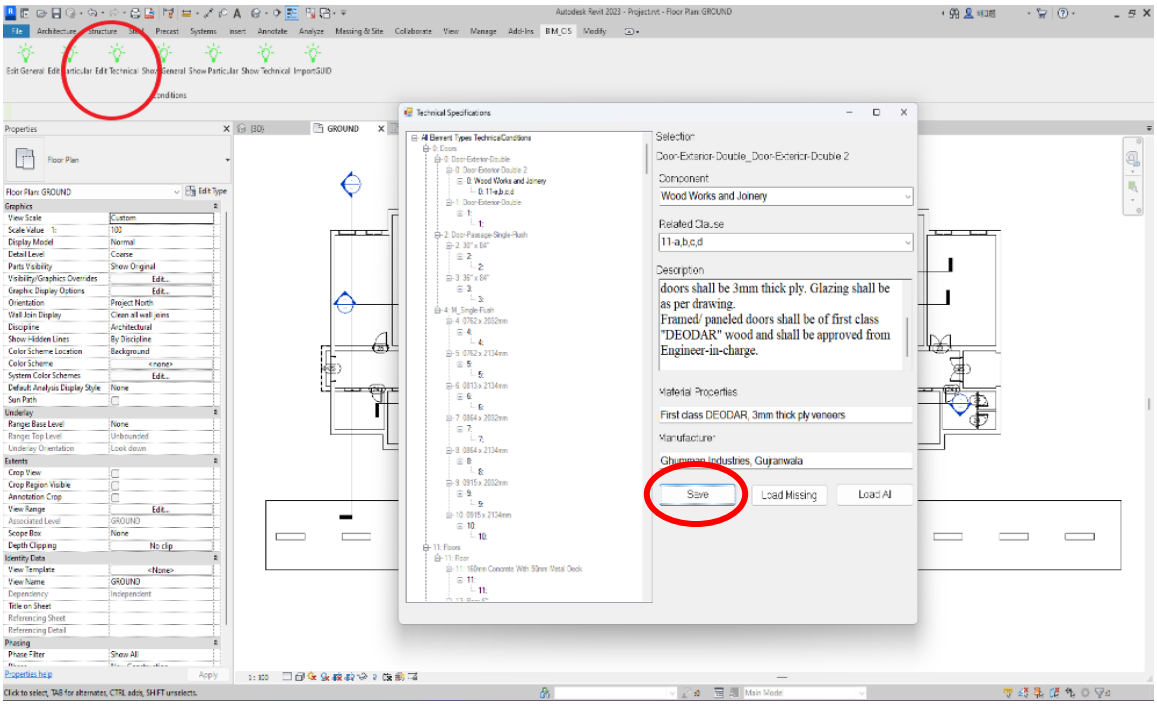

Figure 4.9: Addition of Technical specifications

Now for displaying technical specifications, click on “show technical” and take the cursor to the components that were selected while adding technical data and click on the component, The technical specifications will appear as shown in figure 4.10.

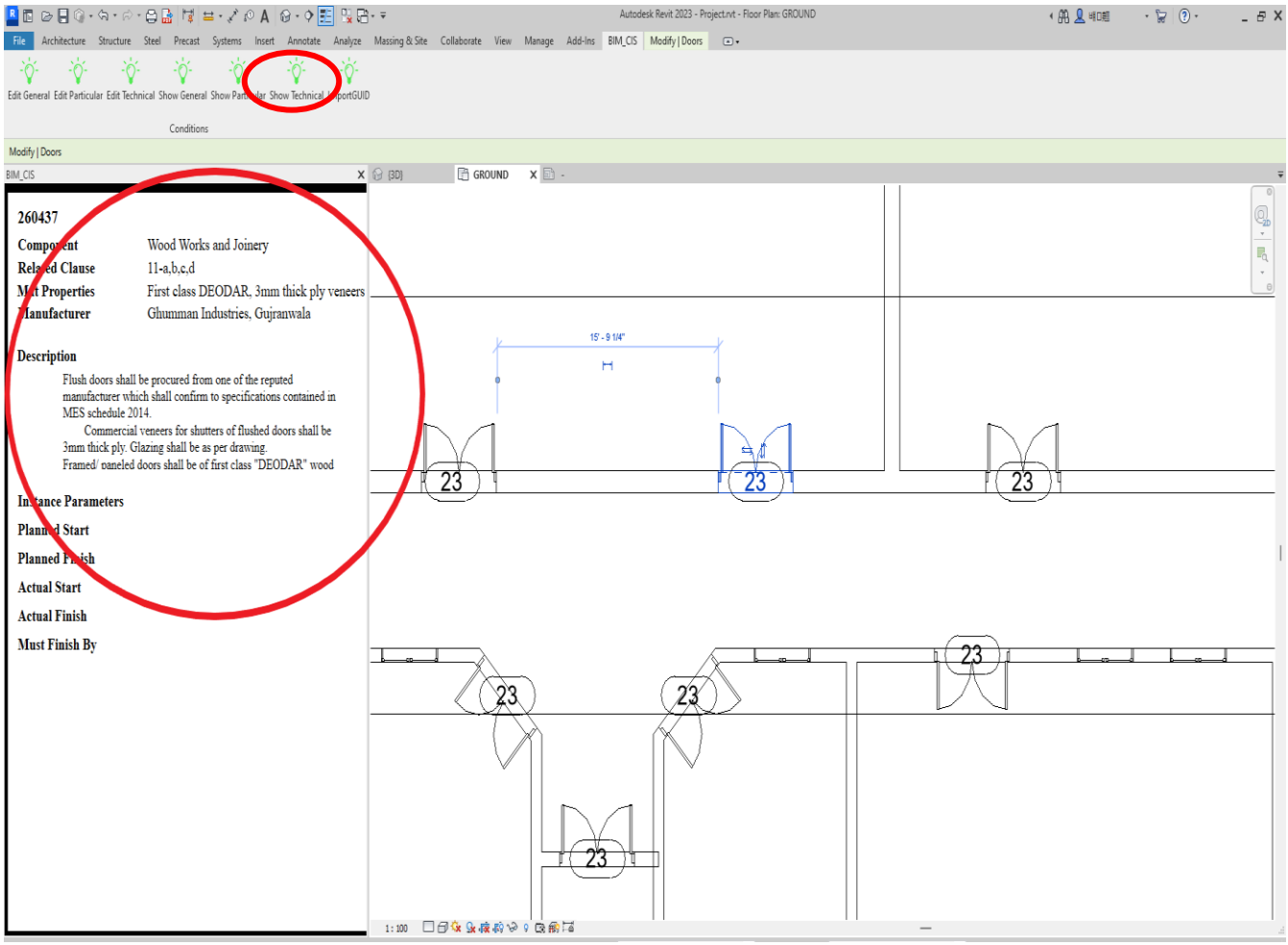

Figure 4.10: Showing Technical specifications

Refer to figure 4.11 the cursor is depicting the family and type of steel bars before use of plugin.

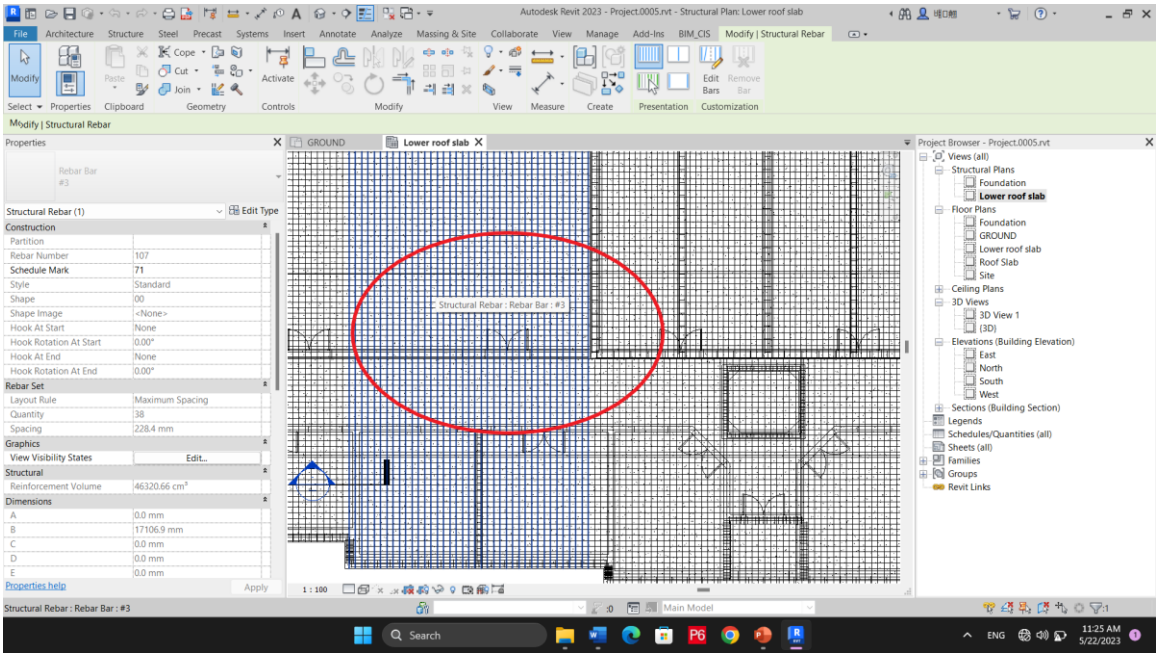

Figure 4.11: Before use of plugin

After use of plugin, details of component mentioned in the contract can be visualized as shown in figure 4.12.

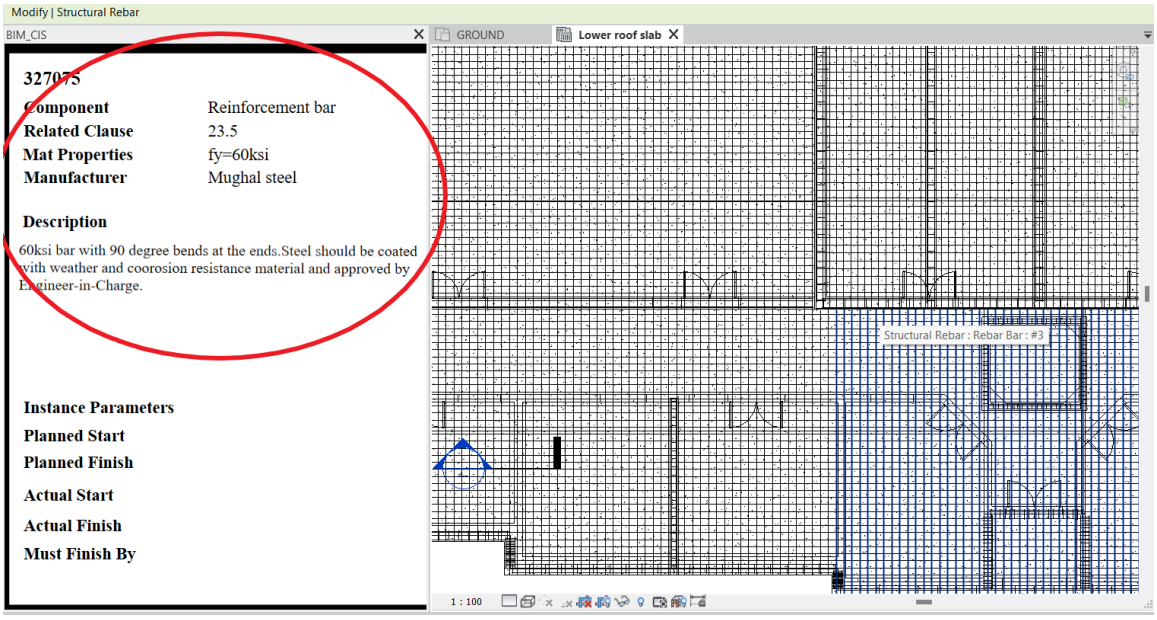

Figure 4.12: After use of plugin

4.5. Importing the schedule from Navisworks

There is a very useful tool added in the plugin that it can link the schedule from Navisworks and update it on Revit model. It will help users to see the planned dates and actual dates anytime for that item to be built. Use the add-in ProTech JSON to import schedule in JSON format as shown in figure 4.13.

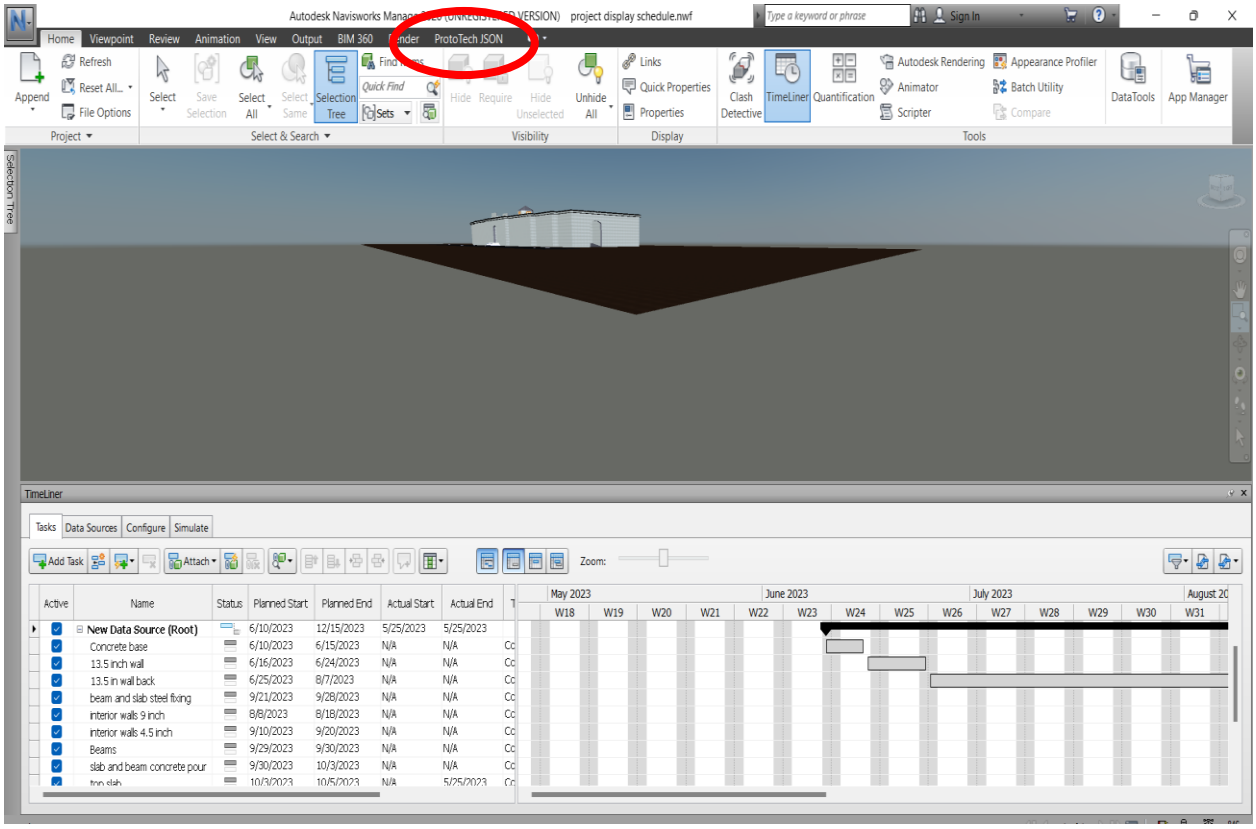

Figure 4.13: Navisworks environment with loaded model and activity

The initial testing model as described previously was added in Navisworks and activities were defined as well as the scheduling was done. Each activity was given a time span to complete and important timelines were added. A JSON file is created using a plugin which is to be imported in Revit environment to schedule it. Export the schedule in JSON format as shown in figure 4.14 below.

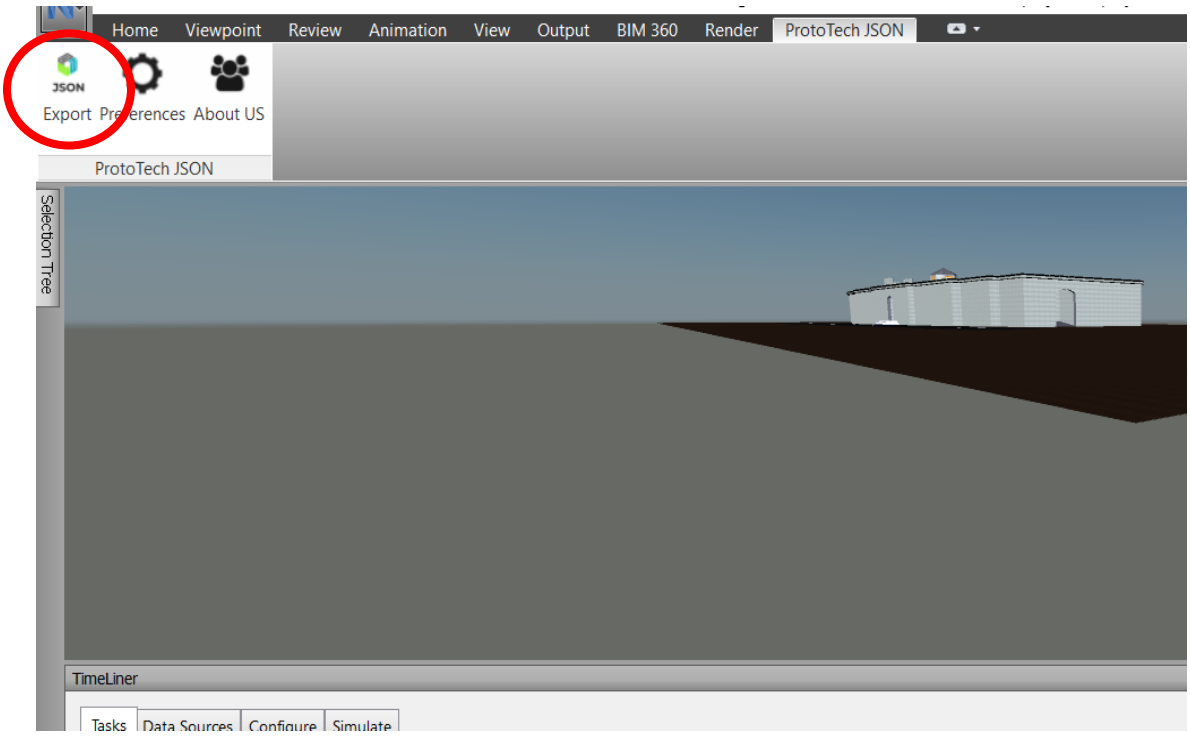

Figure 4.14: Proto tech Json plugin is used to create JSON file

Refer to figure 4.15 below, schedule has not been imported yet and dates tab is blank.

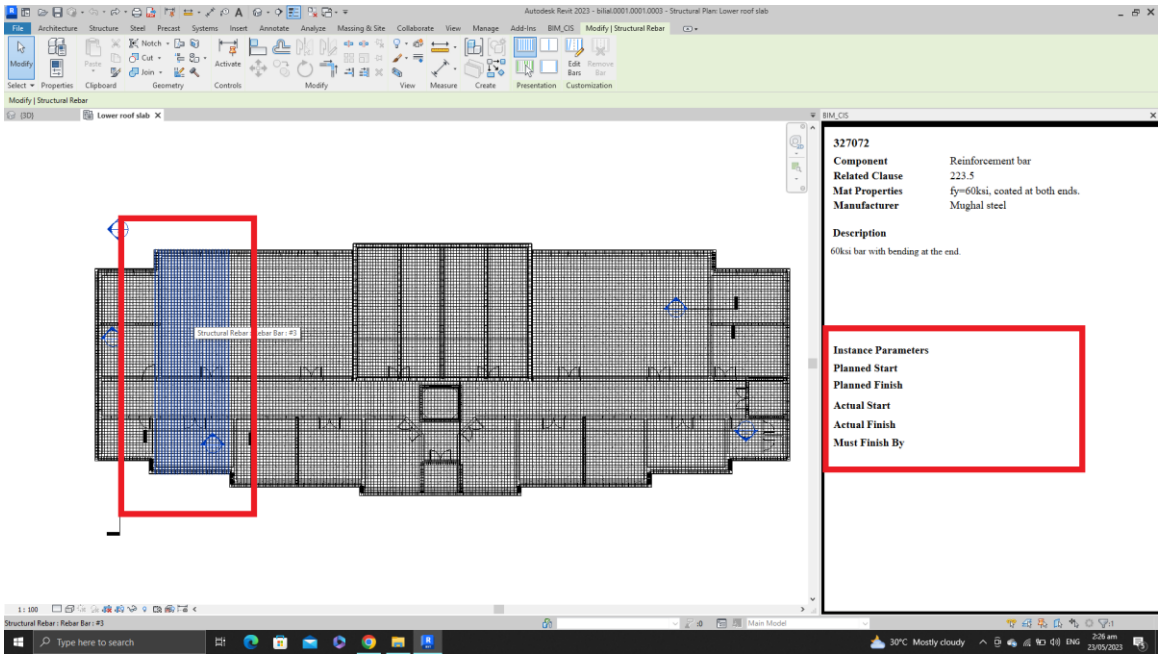

Figure 4.15: Select any item in Revit (Steel has been selected here)

Open the BIM-CIS plugin and import GUID from the JSON file exported from Navisworks as shown in figure 416.

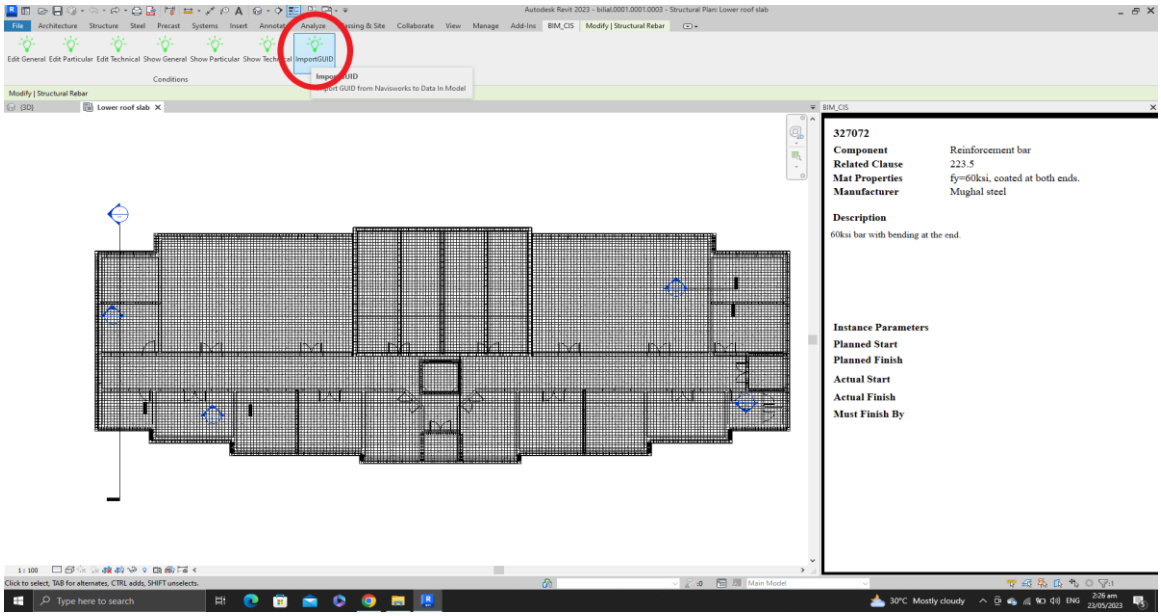

Figure 4.16: Select "Import GUID" option

Locate the JSON file exported from Navisworks and click open as per the figure 4.17.

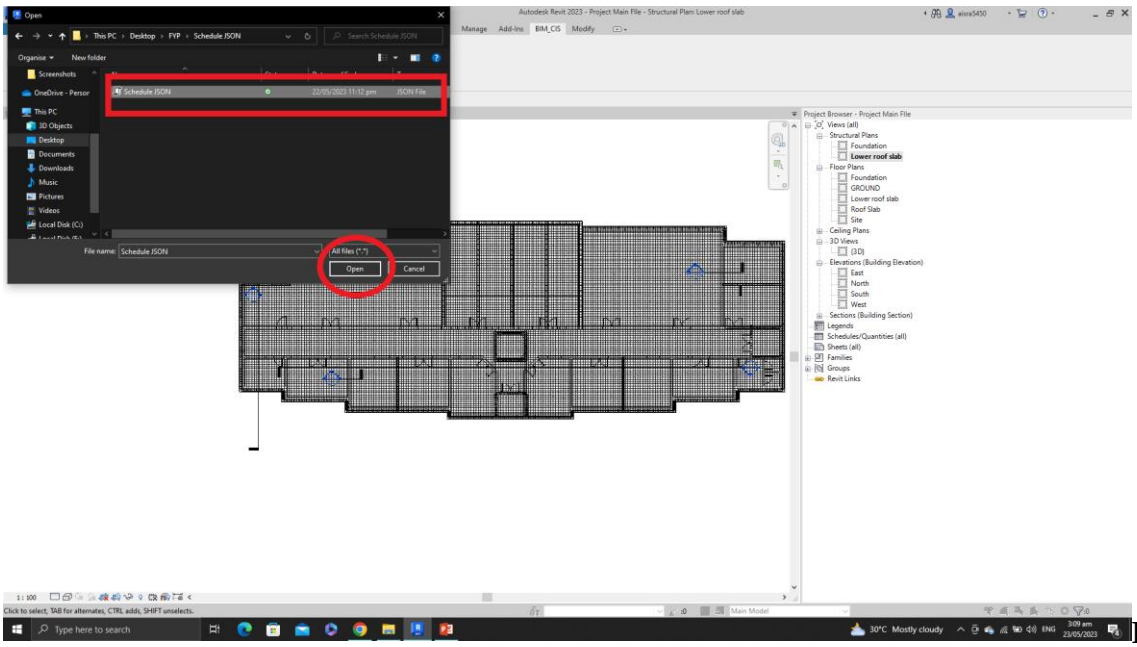

Figure 4.17: Selection of JSON file

Selecting this file will load the activity dates that are linked in Navisworks and it will add in the Scheduling menu in the Technical details box as shown in figure 4.18.

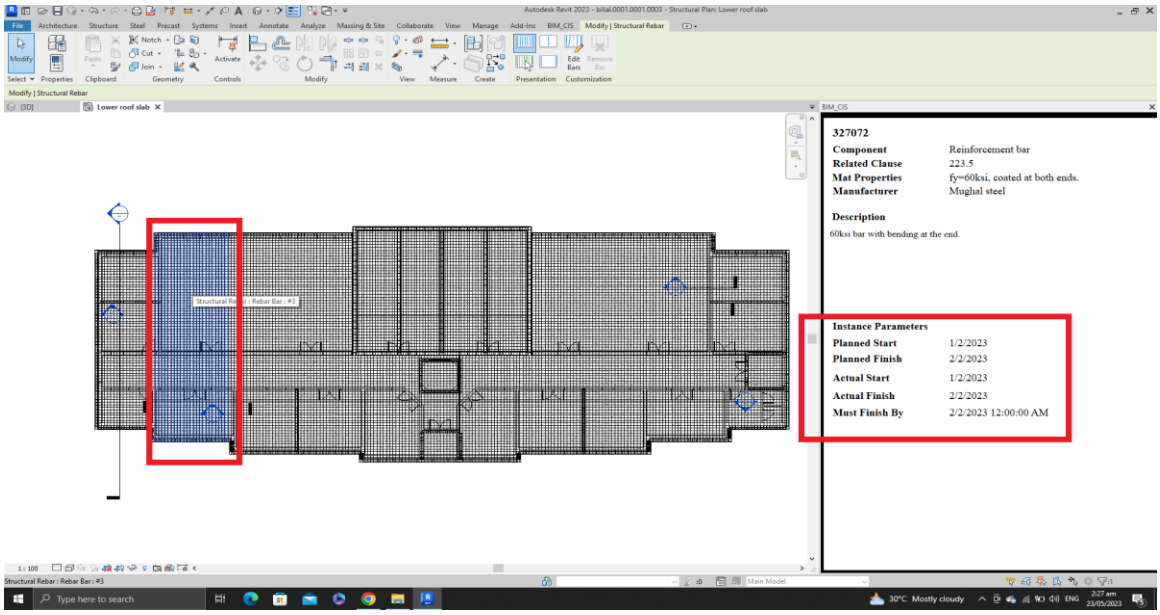

Figure 4.18: Dates are shown as attached to activity

After we are done our model is now linked with contract as well as with the schedule. We have integrated both options in Revit environment to provide ease to contractor as well as to client, which shows that BIM is changing life in AEC industry

5. Conclusion

5.1. Introduction

In this section these is the conclusion and recommendation portion to the research. Important findings and the significance of the project with the academia and with the construction industry**.**

5.2. Conclusion

BIM has grown in popularity across the globe as a means of enhancing productivity and minimizing delays and disputes in the building sector. However, it might be claimed that perceived obstacles to BIM adoption, some of which could be removed by a building contract, have hindered its acceptance.

The goal of this project is to clear the way for a smooth flow of data during the execution phase by integrating contract terms that incorporate technical and specific specifications into BIM software. The current investigation possesses an intelligent BIM plugin that will provide and assist the contractors for effective understanding of contracts in construction projects. BIM is basically the digital explanation of every aspect of construction activity. It can lead to time saving and cost effectives in the project lifecycle. Progress is tracked throughout the project lifespan as technical and precise requirements of a specific structural or non-structural member are manually applied to the 3D model. . Instead of shifting through every mammoth stack of contract documents, all information needed on a certain building member may be accessible with just one click.

5.3. Important Findings

AEC industry is facing challenges in managing contract details which is a major issue in causing of disputes. This challenge was tackled using BIM environment and Revit was selected to lessen the disputes in drawing. Since neglecting technical and particular conditions and specifications

in contract in construction industry can lead to major disputes. BIM adoption has significantly reduced the disputed in many things in construction industry so plugin was developed and integration in Revit provided its possible solution.

5.4. Significance for Academia

The project involves the development of BIM based Contract Information System (BIM-CIS) plugin. This process entails research and development activities, which can contribute to the academia as well as software development field in software engineering. This project can help academia understand methodology, algorithms and techniques used in plugin development as well as provide an understanding to develop practical solutions for BIM. It will help researchers to get into the next dimension of construction industry disputes and work on contract dispute gaps.

5.5. Significance for AEC Industry

This project has a significant role in AEC industry as it will facilitate a convenient access to contract information and improves overall project management. This project gives a streamlined approach to contract management as links every contract specification to the corresponding component in 3D model. It will further help to address the contradictions and the discrepancies minimizing the rejection and disputes.

5.6. Limitations

- The plugin can only work on x64 based system.
- The plugin will only work on Autodesk Revit 2023 and above.
- Data entry is manual which is time consuming.
- Item Library has to be updated

5.7. Future recommendations

Although the primary features and functionalities of the plugin have been thoroughly described earlier, there is still potential for improvement. The current study, as well as the application it generates, can be further enhanced for contract information management by introducing AI (Artificial Intelligence) to the system. Through AI, manually entering the details of contract in the plugin can be minimized.

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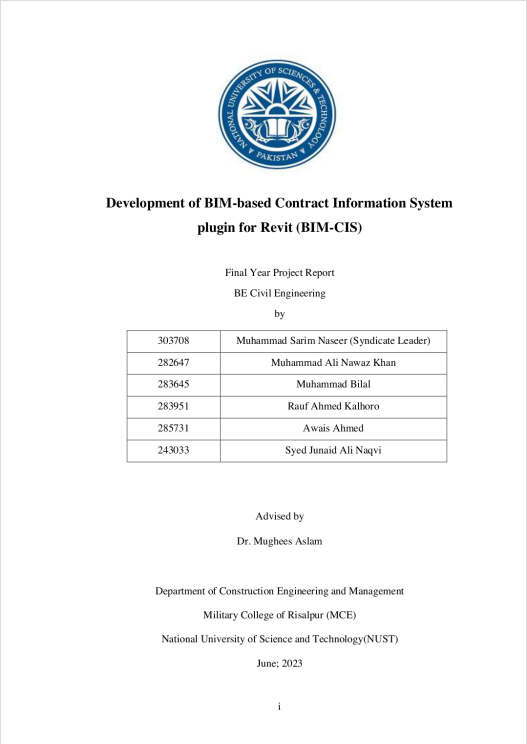

Development of BIM-based Contract Information System plugin for Revit (BIM-CIS)

Final Year Project Report
BE Civil Engineering
by

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