B. Tech. Project Report

INFORMATION RETRIEVAL FOR THE END-USERS IN A BUILDING INFORMATION MODEL

Submitted

By

120104075 Tarun Sahu

Under the supervision of

Dr. Dhirendra Nath Buragohain

DEPARTMENT OF CIVIL ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI

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CERTIFICATE

It is certified that the work contained in the project report entitled "**End-User Information Retrieval in a Building Information Model**", by **Tarun Sahu** (120104075) in collaboration with **Aniruddha Dave** (120104020) has been carried out under my supervision and that this work has not been submitted elsewhere for the award of a degree or diploma.

Date: 29th April 2016

Dr. Dhirendra Nath Buragohain
Emeritus Professor
Department of Civil Engineering
Indian Institute of Technology Guwahati

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Date: 29th April 2016

Student's name

120104075 Tarun Sahu

ABSTRACT

The Construction industry in India had always been an ever growing industry and has a major share in the Indian economy. Presently, the construction sector faces many issues which would be required to get resolved. For the Indian construction industry to keep up with the high growth rate, it will have to adopt state of the art technologies. The problem with the new technology is that they are perplexing to the end user due to which it is required to be made more user friendly. In our present research work we have attempted at building plugins for Autodesk Revit, a Building Information Modelling software, so that the end user can extract and operate on the information easily. A plugin has been developed named 'BIM Search' with two commands namely, 'BIM Ask', to make queries related to the structural information and 'Structure Archive' which extracts all the structural data of the model. The data extracted can be exported to .xls format. The plugin also has an added feature to visualize the elements from which the data is extracted in the 3D BIM model. The plugin was tested on Revit model of a steel plant and the test results are studied.

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LIST OF SYMBOLS AND ABBREVIATIONS

Abbreviations	Description
AEC	Architecture Engineering Construction
API	Application Program Interface
BIM	Building Information Modeling
CAD	Computer Aided Design
MEP	Mechanical Electrical Plumbing
NBIMS	National Building Information Modeling Standard

CHAPTER 1

INTRODUCTION

1.1 Construction Overview: India

The Construction industry in India had always been an ever growing industry and has a major share in the Indian economy. The contribution to the Indian economy by the construction industry is approximately more than 8% (Planning Commission, 2011) [1] and provides employment to a large number of people.

There are mainly three segment in the construction industry, namely:

1. Real Estate Construction: Commercial and Residential Construction
2. Infrastructure Construction: Railways, Roads, Power
3. Industrial Construction: Oil and Gas refineries, Pipelines, Textiles

It has been estimated that the total investment in the infrastructure sector may result in US$500 billion worth of construction demand.

The construction industry in India needs to be prepared to exploit the maximum benefits from its projected growth. Presently, the construction sector faces many issues which would be required to get resolved. One of the major issues is the lack of standards and the low usage of technology (Planning Commission, 2011)[1]. Since the industry is highly fragmented, most of the contractors are not well equipped to handle the growing demand which leads to another major issue- time and cost overruns.

The construction industry needs to largely adopt new technologies and deploy project management strategies over the complete lifecycle of projects to ensure a rapid growth.

1.2 Objective of the Present Work

The purpose of this research is to build an information retrieval Add-in for the Building Information Modelling software Autodesk Revit. The objectives are as follows:

- To build an add-in in Autodesk Revit to simplify the process of extraction of information from a Building Information Model.
- To visualize the information that is being extracted.
- To develop a function to export the information to .xls format.
- To develop a search bar function for users to make queries.

1.2 Structure of the Project Report

The project report flows from presenting the objective in Chapter 1 to a background on Building Information Modeling (BIM) in Chapter 2. In Chapter 2 the application, benefits and status of BIM adoption in India are explained. Chapter 3 describes the methodology used for the development of the plugin. It gives the details of the functions performed by the plugin. Conclusions and recommendations for future work are presented in Chapter 4.

CHAPTER 2

Building Information Model

2.1 Building Information Model

Building Information Modelling is technology, tool and a process for designing, construction and management. BIM has been viewed by different disciplines with a different perspective. While evaluating the business sense of BIM, Aranda-Mena et al. (2008)[2] noted that "For some, BIM is a software application; for others it is a process for designing and documenting building information; for others it is a whole new approach to practise and advancing the profession which requires the implementation of new policies, contracts and relationships amongst project stakeholders."

Many professionals view BIM as extension to 3D Computer Aided Design (CAD) models but BIM is much more than that. The National BIM Standards committee of USA has defined BIM as "Building Information Model (BIM) is a digital representation of 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" (National Building Information Modeling Standard (NBIMS) 2015)[3].

BIM makes it possible to share a single virtual information model from the design team to the contractor to the owner where each professional can add up data to the model specific to their discipline.

2.2 Applications and Benefits of BIM

A Building Information Model can be used during the complete lifecycle of a project right from its inception phase to the demolition and renovation phase. BIM allows to handle a single

virtual information model from the design team to the contractor to the owner where each professional can add up data to the model specific to their discipline.

A Building Information Model has variety of applications throughout the project life cycle. Azhar S. (2011) [4] has summarized the following applications of BIM -

1. Visualization
2. Fabrication/Shop Drawings
3. Code Reviews
4. Cost Estimation
5. Construction Sequencing
6. Conflict, interference and collision detection
7. Forensic Analysis
8. Facilities Management

The main benefit of a BIM model is the accurate geometrical representation of the parts of the building in an integrated data environment (CRC Construction Innovation 2007) [5]. Azhar S. (2011) [4] has summarized the following benefits of a BIM model-

- Faster and effective processes: The information can be more easily shared and operated on among the stakeholders.
- Better design: BIM makes it easier to conduct rigorous analysis, perform simulations and in benchmarking the performance. This improves the entire design process by allowing improved and innovative solutions.
- Controlled whole-life costs and environmental data: Lifecycle costs and environmental performance can be easily obtained.
- Better production quality: Automation in the production supply chain can be easily integrated with BIM.
- Automated assembly: The digital product data obtained from BIM can be used for manufacturing and assembly processes.
- Better customer service: The building proposals are better understood by the stakeholders due to accurate visualization.
- Lifecycle data: The information stored in the models can be used for facility management.

2.3 BIM Tools

A large number of Building Information Modeling tools have been developed. The following lists different BIM authoring tools with their primary functions:

- **Architecture**

1. Autodesk Revit Architecture
2. Graphisoft ArchiCAD
3. Nemetschek Allplan Architecture
4. Gehry Technologies - Digital Project Designer
5. Nemetschek Vectorworks Architect
6. Bentley Architecture
7. 4MSA IDEA Architectural Design (IntelliCAD)
8. CADSoft Envisioneer
9. RhinoBIM (BETA)

- **Sustainability**

1. Autodesk Ecotect Analysis
2. Autodesk Green Building Studio
3. Graphisoft EcoDesigner
4. IES Solutions Virtual Environment VE-Pro
5. Bentley Tas Simulator
6. Bentley Hevacomp

- **Structures**

1. Autodesk Revit Structure
2. Bentley RAM, STAAD and ProSteel
3. Tekla Structures
4. CypeCAD
5. Graytec Advance Design
6. StructureSoft Metal Wood Framer
7. Nemetschek Scia
8. 4MSA Strad and Steel
9. Autodesk Robot Structural Analysis

- **Mechanical Electrical Plumbing (MEP)**

1. Autodesk Revit MEP
2. Bentley Hevacomp Mechanical Designer
3. 4MSA FineHVAC + FineLIFT + FineELEC + FineSANI
4. Gehry Technologies - Digital Project MEP Systems Routing
5. CADMEP (CADduct / CADmech)

- **Construction (Simulation, Estimating and Const. Analysis)**

1. Autodesk Navisworks
2. Solibri Model Checker
3. Vico Office Suite
4. Vela Field BIM
5. Bentley ConstrucSim
6. Tekla BIMSight
7. Glue (by Horizontal Systems)
8. Synchro Professional
9. Innovaya

- **Facility Managment**

1. Bentley Facilities
2. FM:Systems FM:Interact
3. Vintocon ArchiFM (For ArchiCAD)
4. Onuma System
5. EcoDomus

The figure 2.1 depicts the use of different BIM tools at different phases of construction.

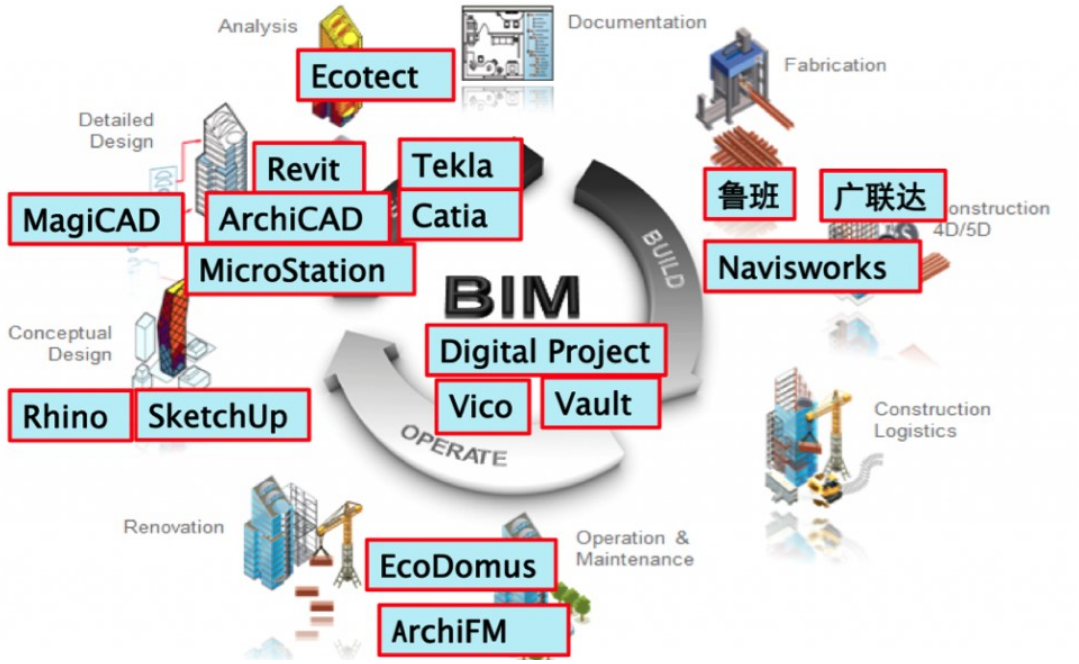


Fig 2.1: BIM Tools

2.4 Status of BIM in India

BIM is more popular among experienced professionals since they understand the value proposition of BIM. The use of BIM is in more use in large enterprises, where there is large strength of technical staff, making BIM implementation more beneficial in large and complex projects. Since the use of BIM is quite recent in India, there is some trust issue in adopting this technology.

2.4.1 Awareness of BIM in India

According to the study done by RICS School of Built Environment, Amity University [6] it was observed that only 22% respondents reported that they use BIM for their projects. 27% respondents were aware of BIM and were actively considering the adoption of BIM. Surprisingly, 43% respondents were aware of BIM but were still insure about its adoption in the near future. 8% respondents reported to be unaware of BIM as visible in the figure 2.2.

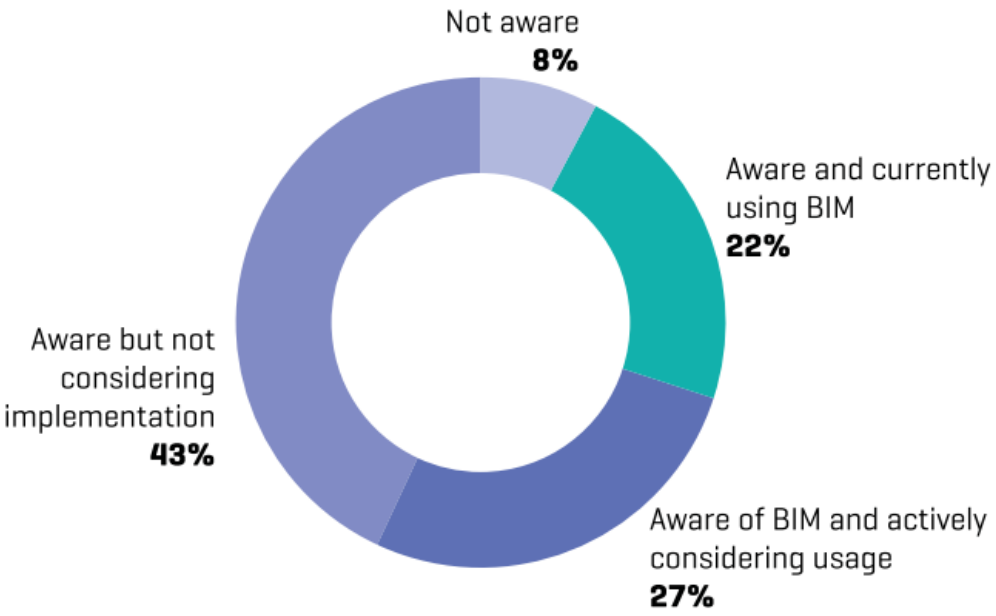


Fig 2.2: Awareness of BIM in India

2.4.2 Functional Usage of BIM in India

Most of the professionals reported using BIM for improving coordination and the detection of clashes. Since it becomes quite easy to generate quantity takeoffs and construction schedules, a large number of respondents reported using BIM for the same.

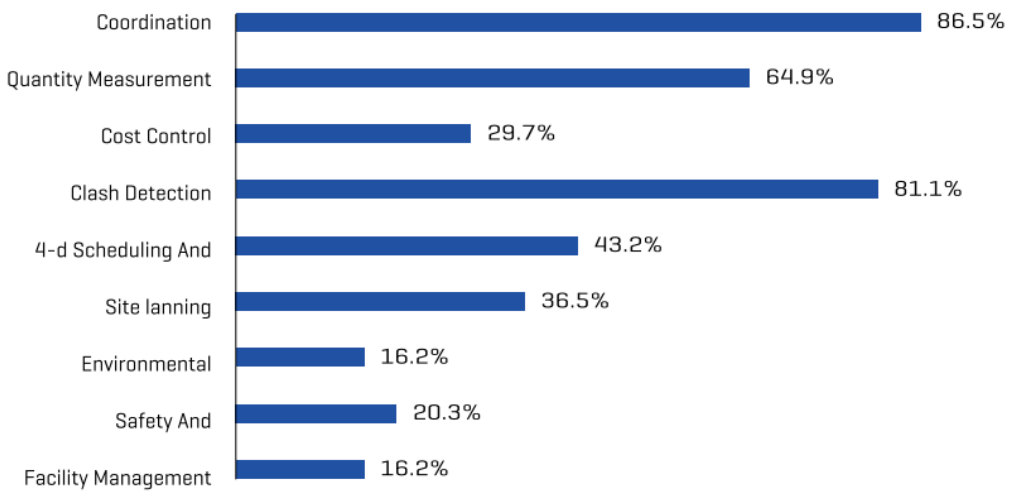


Fig 2.3: Functional usage of BIM in India

2.4.3 BIM Softwares used in India

There are a large number and variety of BIM software available globally as well as in India. Most of the BIM professionals in India use Autodesk products. Nearly 80% of the respondents in the survey reported using Autodesk Revit. Other popular softwares used by the BIM professionals in India are Autodesk Naviswork and Sketchup with nearly 40% and 38% respondents using them respectively.

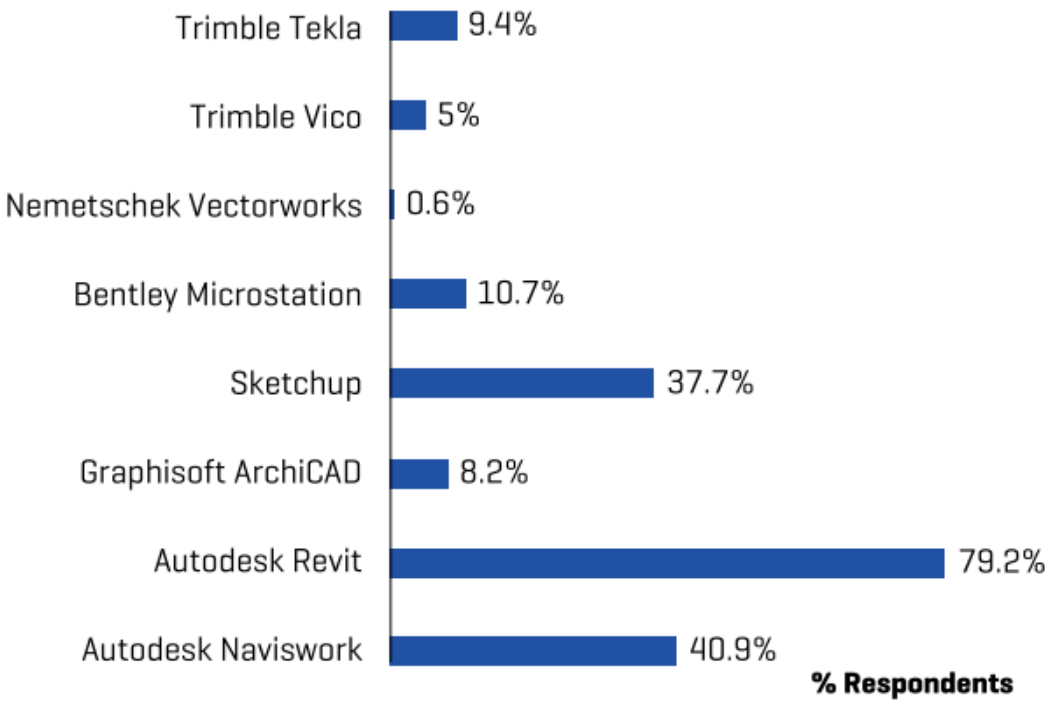


Fig 2.4: BIM softwares usage in India

2.5 Challenges of BIM Adoption in India

The Indian construction industry has shown reluctance towards the adoption of new technologies. Most of the professionals are aware about the benefits of BIM implementation but have reservations about the high cost of its implementation. As BIM is not just a software but is a whole new approach to the construction industry, it requires revamping and restructuring of entire organizations to become capable of using BIM effectively.
The following sections show the barriers to BIM adoption in India as observed by Nanajkar (2014)[7].

2.5.1 Disruption in workflow

The adaptation to BIM use demands complete change in workflow in the organization. Similar situation had come in 1980s when the new system of 2D CAD had come into use. The current Architecture Engineering Construction (AEC) industry is used to working with 2D CAD systems, and has reluctance in changing towards new system.

2.5.2 High Cost of Software and Hardware Upgradation

The high cost of BIM software compared to 2D CAD software is another problem in way to implementing BIM. The upgradation cost will be much higher than the project budget. Thus the initial cost has been a prevailing barrier to the adoption of BIM by the AEC firms in India.

2.5.3 Training Employees

Adapting to the use of new software will require investing in giving training to professionals. Investing in human resource will only be possible in large capital industries. Most of the AEC firms in India are not keep to spend much in skill development of their technicians.

2.5.4 Inexpensive and Abundant Labour Resources

In Indian both skilled and unskilled laborer are abundant and easily available as compared to other developed countries. So spending high cost on adaptation on BIM is avoided in AEC firms of here.

2.5.5 Slow Adoption of Technology

Most of the professionals in India are very well aware about the potential benefits of BIM usage, but the rate of adaptation is very slow because of the fragmented nature of the Indian AEC industries.

CHAPTER 3

Information Retrieval

3.1 Background

Different stakeholders require to query a model to find information within a model or across a set of different models, compare models and evaluate the differences between them. Current BIM tools and software's do not provide appropriate systems by which a construction practioner can retrieve all the construction specific information (materials, cost estimation, spatial information) from the model. To fill this gap we have worked towards the development of a plugin that could retrieve all the construction specific information from the model. According to a survey conducted by the Rics School of Built Environment, Amity University, India, the major BIM software's used by the respondents are Sketchup, Autodesk Naviswork and Autodesk Revit. Autodesk Revit was used by 79.2% of the respondents clearly showing it as the most favoured BIM software in India. Due to this reason, Autodesk Revit was chosen for the development of a plugin for information retrieval.

3.2 Methodology

The development of the plugin is done in 3 major steps, namely Retrieval, Extraction and Displaying Results. The building data is first retrieved using Application Program Interfaces (API). Further the retrieved data is filtered to get the relevant plug information. The extracted information is then stored in variables which later is saved in text form. The stored text form enables easy retrieval while showing results. Lastly, the retrieved information is displayed in Windows form or dialog box, which is easy to handle and interactive with user with drop down menus, buttons and clickable data sheets.

3.2.1 Retrieval

A Revit model contains numerous information about the building, from constituent element's information to the cost and scheduling of the process. It is necessary to pick out the data of our interest in a workable, and sortable form. The programming is done using Revit APIs which provided the inbuilt functions to get desired data in form which can be manipulated easily to show results. The APIs used are namely RevitAPI.dll and RevitAPIUI.dll. Both APIs were added to the program code via references.

3.2.1.1 RevitAPI.dll

RevitAPI contains all the elements information, classes in which they are used and the functions associated with them. For example the Storagebindinglists, collections, Instances of family members like beams, columns, walls etc.

3.2.1.2 RevitAPIUI.dll

RevitAPIUI contains all the functions to run the plugin, to get the information from the live document in use, executing commands and displaying the results. The live data form UI document like the elements in selection or to highlight any element in the application while user is using it is done using functions form RevitAPIUI.

3.2.2 Extraction of Relevant Information

Revit APIs provide only the pointers to the complete list of elements in the documents. Since only some part of the data is useful, Elements filters were created to extract the relevant information. In our case, we were only interested the structural elements to calculate the quantity of materials used hence we filtered the elements first on the basis of their material, i.e. either steel or concrete of any grade and stored them in a separate sortable list. Further, we filtered the elements on the basis of their type like beams or columns.

3.2.3 Displaying the Results

The Results are displayed in Windows form popup. The popups contain data grid view, text box, buttons which makes the results intractable with the user.

The search results are combined in a sortable data class called SearchHits which along with the elementUniqueId, contains the name (optional), volume, coordinate and price. These values are stored while the extraction phase and displayed in the dialog box in tabular form. Each result is shown as a single row, which is clickable and have one to one correspondence to the 3D view in the BIM model.

3.3 Interface

The BIM_search plugin be visible in the add-in tab after installation and looks like in the figure 3.1

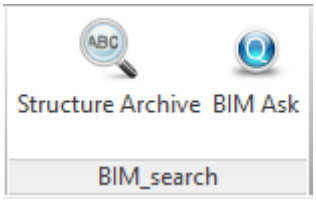
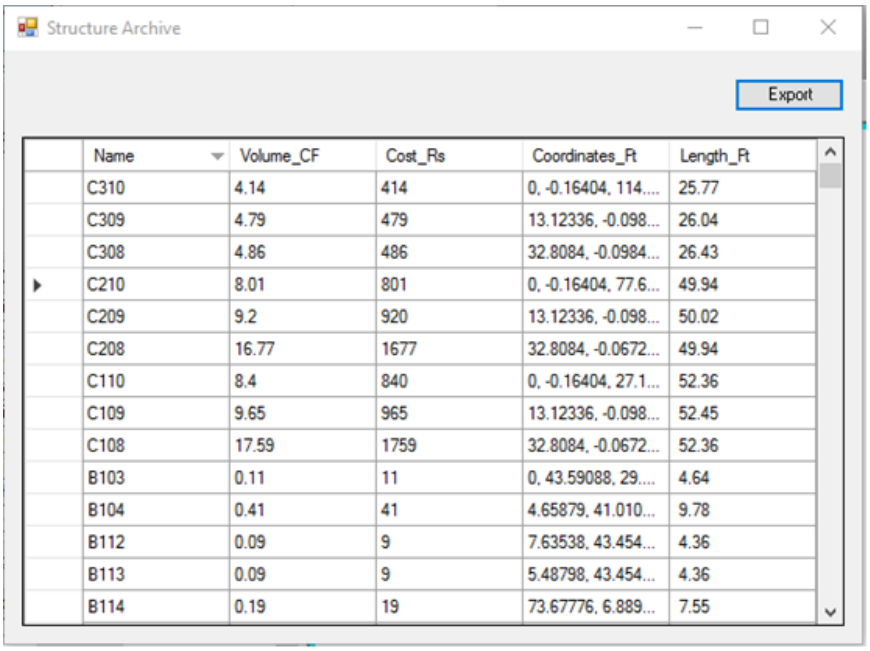


Fig 3.1: BIM Search

3.3.1 Structure Archive

Figure 3.2 shows the popup window Structure Archive that appears after clicking on the Structure Archive button. The windows contain a table of structural elements and an export button. Each row is clickable and is linked to corresponding 3D model.



Name	Volume_CF	Cost_Rs	Coordinates_Ft	Length_Ft
C310	4.14	414	0, -0.16404, 114....	25.77
C309	4.79	479	13.12336, -0.098...	26.04
C308	4.86	486	32.8084, -0.0984...	26.43
C210	8.01	801	0, -0.16404, 77.6...	49.94
C209	9.2	920	13.12336, -0.098...	50.02
C208	16.77	1677	32.8084, -0.0672...	49.94
C110	8.4	840	0, -0.16404, 27.1...	52.36
C109	9.65	965	13.12336, -0.098...	52.45
C108	17.59	1759	32.8084, -0.0672...	52.36
B103	0.11	11	0, 43.59088, 29....	4.64
B104	0.41	41	4.65879, 41.010...	9.78
B112	0.09	9	7.63538, 43.454...	4.36
B113	0.09	9	5.48798, 43.454...	4.36
B114	0.19	19	73.67776, 6.889...	7.55

Fig 3.2: Structure Archive Dialog Box

Structural Archive command also generate a temporary view of the building model with only those elements are visible which are of our concern i.e. beams and columns. Figure 3.3 shows the temporary view of Beams and Columns in steel plant.

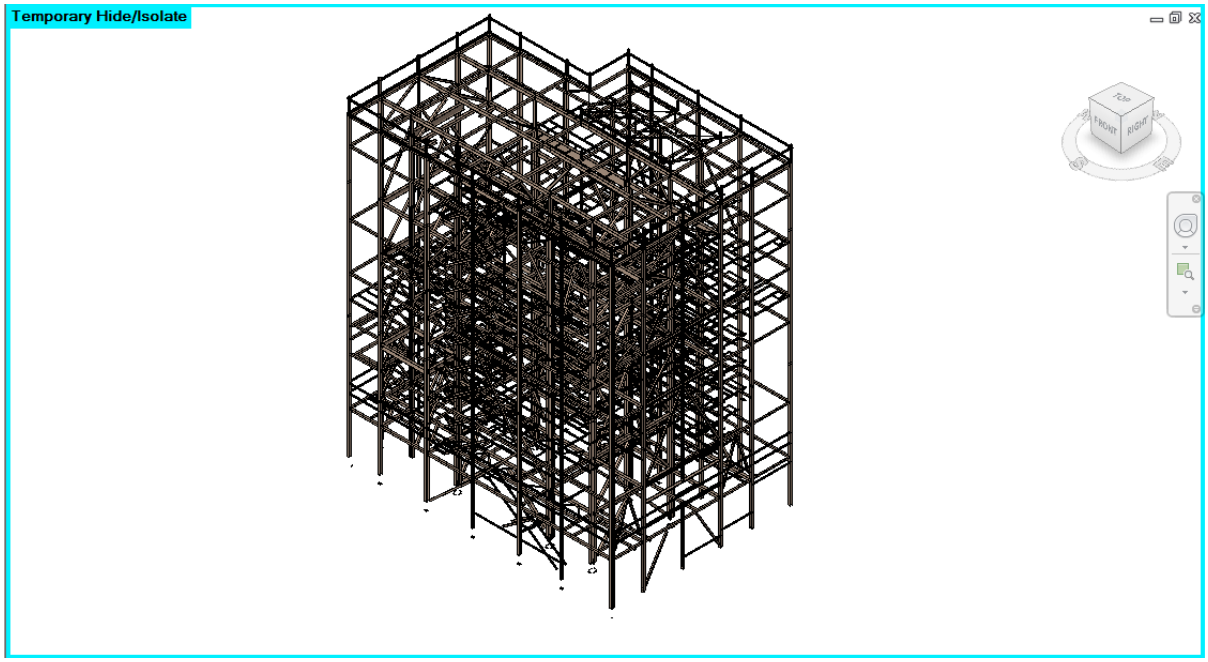


Fig 3.3: Temporary View

Figure 3.4 shows the complete view of Structure Archive window and the temporary view. In the figure the relationship between the element row in windows and the element in the 3D model (in selection) can be seen.

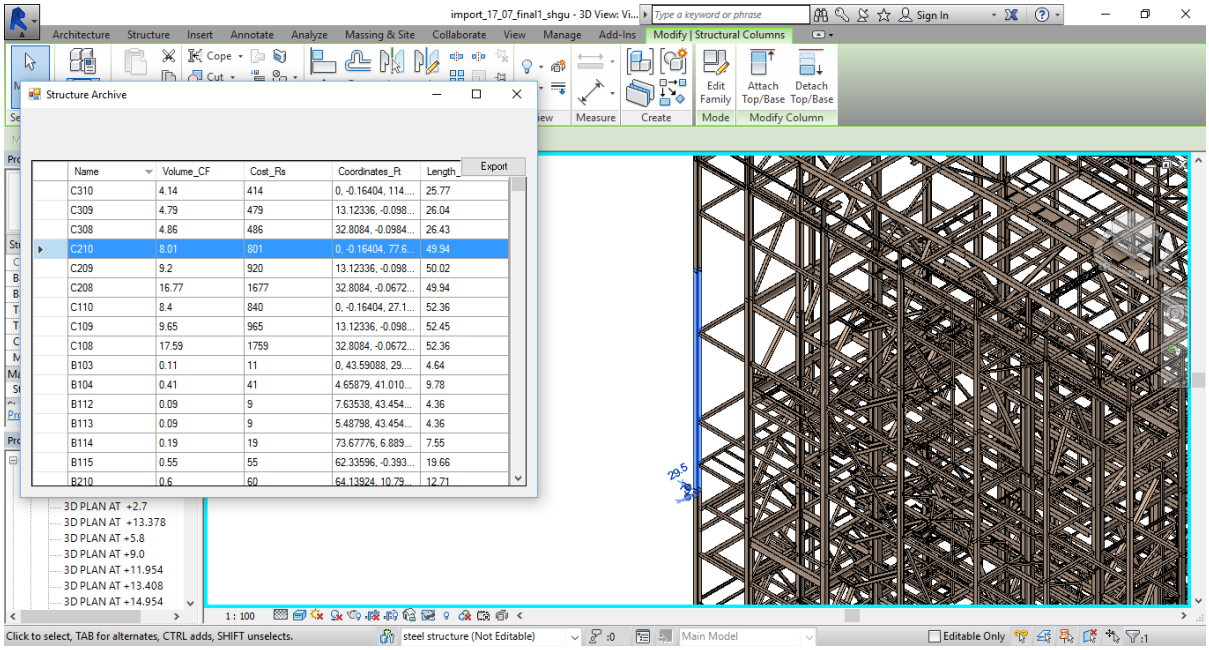


Fig 3.4: Element View functionality in 'Structure Archive'

The table generated in the Structure Archive can be exported to .xl or .xls file by using the export functionality. Clicking the Export button in the window Fig 3.5

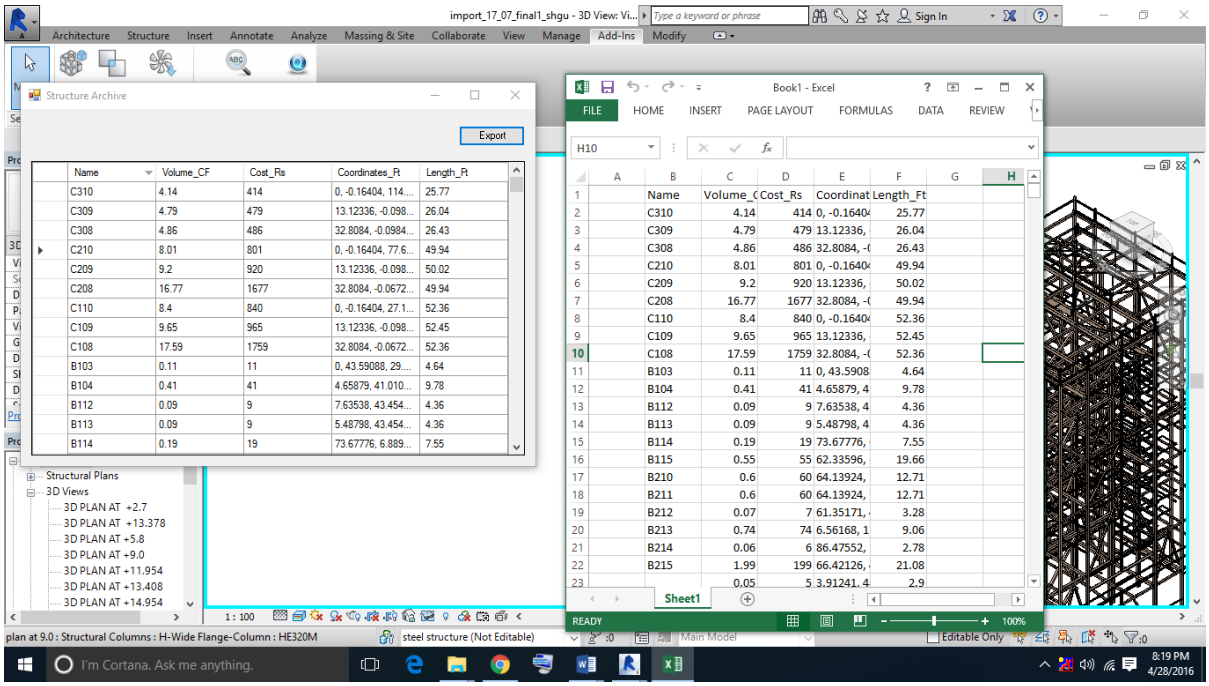


Fig 3.5: Export functionality in 'Structure Archive'

3.3.2 BIM Ask

Ask button brings up a search query windows where the user can put up questions from the drop down menu. Figure 3.6

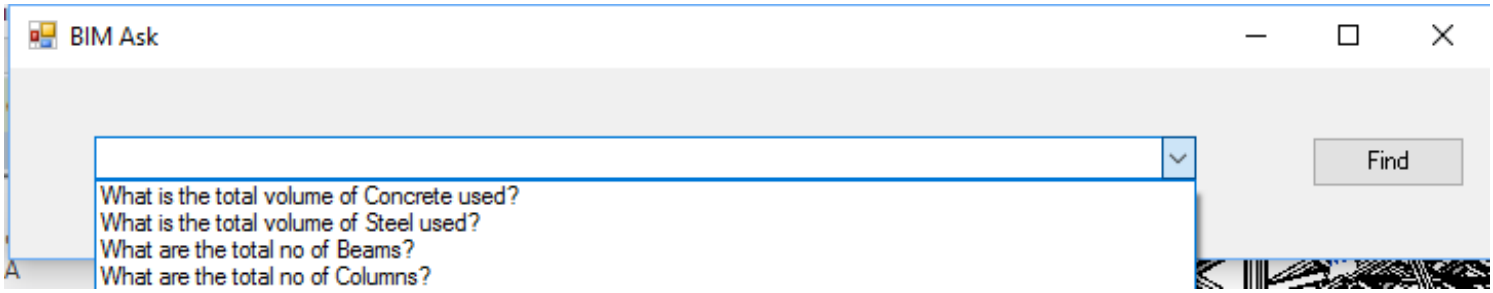


Fig: 3.6 BIM Ask

Question currently computable in BIM Ask are

- What is the total volume of Concrete used?
- What is the total volume of Steel used?
- What are the total no of Beams?
- What are the total no of Columns?

The answer of any question put up in the text field and pressing find button puts up a dialog box with the corresponding answer with the calculated value as in figure 3.7.

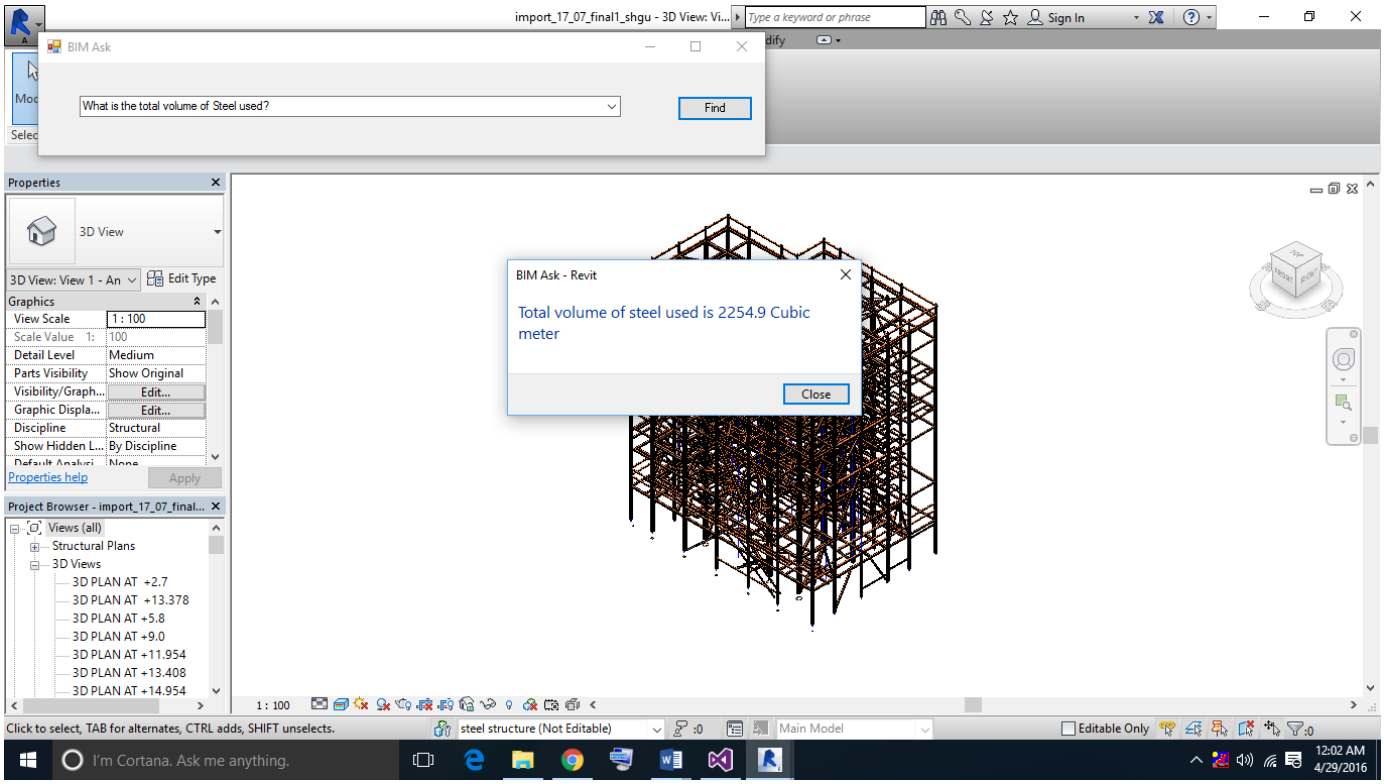


Fig 3.7: BIM Ask Displaying Results

CHAPTER 4

Conclusion and Future Work

4.1 Conclusion

The objective of creating a user friendly interface is achieved by creating the plugin. The developed plugin has two different commands named Structural Archive and BIM Ask. The 'Structural Archive' command retrieves all the data related to the structural model of the data and presents in a dialog box. It can be exported into the format for MS Excel file. The command also has an additional feature for visualization where the data can be clicked to display the corresponding element in the 3D BIM model. The second command 'Ask' allows user to do a query search. Currently, within the scope of present work we have added a few questions that the user can use to query the information. The plugin has been tested on a Structural model of a steel industrial plant.

The results shown have been matching with the correct values.

4.2 Future Work

The Revit plugin created so far tries to answer the basic user queries, like quantity estimation or getting the dimensional information of elements. Since the user queries are not limited to the direct questions, further improvement to incorporate more ingenious questions like what is the no of columns of specific size or of same section type can be done. Further a clash detection functionality could be added for detecting clashes in the Mechanical Electrical Plumbing (MEP) models. Future plugins could also be developed to check the consistency of the BIM model with respect to the design codes and safety rules.

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