EOT CLAIM MANAGEMENT SYSTEM USING BUILDING INFORMATION MODELLING

FINAL YEAR PROJECT UG-2017

By

Abdullah Aamir Khan

Abdul Malik

Muhammad Ammar Ijaz

Muhammad Usama Bin Maqsood

Project Advisor

Dr.-Ing. Abdur Rehman Nasir

NUST Institute of Civil Engineering

School of Civil and Environmental Engineering

National University of Sciences and Technology

Islamabad, Pakistan

2021

EOT CLAIM MANAGEMENT SYSTEM USING BUILDING INFORMATION MODELLING

FINAL YEAR PROJECT UG-2017

By

Abdullah Aamir Khan (G.L) - 212052

Abdul Malik - 208134

Muhammad Ammar Ijaz - 208079

Muhammad Usama Bin Maqsood - 221134

Project Advisor

Dr.-Ing. Abdur Rehman Nasir

NUST Institute of Civil Engineering

School of Civil and Environmental Engineering

National University of Sciences and Technology, Islamabad, Pakistan

2021

This is to certify that the Final Year Project titled

EoT Claim Management System
Using Building Information Modelling

Submitted by

Abdullah Aamir Khan (G.L)	- 212052
Abdul Malik	- 208134
Muhammad Ammar Ijaz	- 208079
Muhammad Usama Bin Maqsood	- 221134

Has been accepted towards the requirements
for the award of undergraduate degree

Bachelor of Engineering in Civil Engineering

Dr.-Ing. Abdur Rehman Nasir
Assistant Professor
Head of Department Research
NUST Institute of Civil Engineering (NICE)
School of Civil and Environmental Engineering (SCEE)
National University of Sciences and Technology, Islamabad, Pakistan

ACKNOWLEDGEMENT

We are grateful to Almighty Allah for giving us opportunity to complete this research document by granting us strength, courage, and perseverance. Without the constant guidance and support from our Project Advisor Dr.-Ing. Abdur Rehman Nasir, and respected faculty of CEM department, this research would have been impossible to complete.

We would also like to thank Engr. Imran Khan Niazi, Planning Engineer, Banu Mukhtar Contracting (Pvt.) Ltd. for inspiring us to work on this subject as well as our industry correspondents who supported us throughout the course of project and provided valuable feedback on improving our product to meet the industry needs.

ABSTRACT

Delays are an integral part of construction projects. In case of delays caused by reasons that are not in the control of the contractor, the contractor is entitled to Extension of Time (EOT) after the approval by the stakeholders involved. EOT Claim is one of the leading causes of disputes in construction contracts. EOT Claim generation is a lengthy process that involves specialised skills and knowledge of construction contracts. Building Information Modelling (BIM) is an emerging area of study and practice in the construction industry providing automation in a large number of construction processes. The following study focuses on the development of an Automated EOT Claim Management System that is capable of calculation of delays and EOT entitlement to contractors by using As Planned vs. As Built method of delay calculation and analysis. The system is built with the aid of a visual programming framework supported by Autodesk Revit called Dynamo. The developed plugin is capable of calculation of EOT Delays, generation of EOT Claim Document and visualisation of delays in 3D and 4D. The system aims at automating the process of EOT Claim generation by minimising human efforts.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER-1

1. INTRODUCTION

1.1. Study Background

Construction industry is one of the top contributing industries in the GDP growth of an economy. It has a very vital role in the development of a nation. An economy's productivity performance can only be as good as the performance of its constituent parts. The construction industry is a significant contributor to the economy in most countries (Wahab & Vogl, 2011)

The world is developing at a quick pace and thus we are seeing new construction projects and ventures springing up all around us. Construction projects may seem straightforward from an outer perspective, but a construction project is a complex system with multiple operations being carried out, interactions of materials and supply chains being integrated with each other, diverse labour force and several stakeholders working together to make sure that the project is delivered as per the scope of work and in the given time.

With such a complex product development cycle, construction projects often encounter delays. Typically, delays can be defined as, to make something happen later than expected; to cause something to be performed later than planned; or to not act timely; we can describe each of these definitions as a delay to an activity of work in a schedule. On construction projects, as well as on the projects where a schedule is being used to plan work, it is not uncommon for delays to occur. (Trauner Jr., 2009). These delays may occur because of numerous reasons, such as weather, technical issues with the project or fault of the stakeholders involved. Construction contracts clearly stipulate a specific time or date to the contractor to complete the work, as per the conditions and specifications mentioned in the tender. Contractor is liable to pay an agreed upon price in case of delays as Liquidated and Ascertained Damages (LAD). The purpose of LAD is to serve as a compensation for the damage caused to the client's interest because of the delay caused by the contractor. In case of delays caused by being out of the control of the contractor, the contractor is granted an extended period for project completion after the approval of concerned stakeholders involved. This extended time for project completion is called Extension of Time (EOT).

When a contractor demands EOT, the contractor must submit all the required documents stating the facts and reasons that caused the delay as evidence. A vital part in establishing EOT entitlement is for the claimant to produce documentation to show not only that they are not responsible for the delays but also demonstrate the other parties that are responsible. This can either be the employer or other third parties, such as "Acts of God," or so on. Most standard forms of contract provide clauses dealing with EOT in construction projects (Yusuwan & Adnan).

This research aims at automating the system of EOT claim generation by Building Information Modelling (BIM). Building Information Modelling: is a business process for generating and leveraging building data to design, construct and operate the building during its life cycle. BIM

allows all stakeholders to have access to the same information at the same time through interoperability between technology platforms (National Institute of Building Sciences).

1.2. Research Significance

Construction industry is one of the largest employments generating industries in the world. The construction, renovation, maintenance and demolition of buildings and civil engineering projects together accounted for over 273 million (part-time and full time) jobs worldwide in 2014, constituting an estimated 8.6% of the total global employment (Infrastructure and Cities for Economic Development (ICED), 2018).

Construction industry, being the driving force behind the world's economy, still lacks technological advancements as compared to other industries. Construction industry has experienced a lack of efficiency improvement. It has only managed to reach approximately half of the efficiency improvements compared to other industries in the last 50 years (Kraatz, Hampson, & Sanchez, 2014).

One of the major reasons for the construction industry lagging other industries in efficiency is lack of digitalization and automation. This lack of automation and digitization puts hindrances in the workflows of construction processes. The sub-optimal working process is caused by fundamental problems with time overruns, quality problems, conflicts between stakeholders and a low level of knowledge transfer between actors (Kraatz, Hampson, & Sanchez, 2014).

Pakistan is a developing country that is currently enjoying relatively vigorous growth in construction activities. Today, construction is the second largest sector in Pakistan's economy after agriculture. Roughly 30-35% of employment is directly or indirectly affiliated with the construction sector. The construction sector in Pakistan has played an important role in providing jobs and facilitating revival of the economy (Farooqui & Ahmed, 2008).

EOT claims are prevalent in all types of construction contracts. Literature suggests that these EOT claims are on upsurge, worldwide. For example, out of $1.7 million worth claims presented over the past 74 years to American Arbitration Association (AAA), the number of EOT claims reached to almost 25% (Construction, 2013).

Optimization in the construction process can not only benefit the local construction industry but also provide a boost to the industry worldwide by minimizing the hindrances in construction workflows.

1.3. Problem Statement

In construction projects, preparing extension of time (EOT) claims of the excusable delay events needs significant efforts to identify activities and liabilities, applying delay analysis, specify causes and effects of each event, and substantiate evidence. Achieving the steps of (EOT) claim preparation needs collecting and organizing the documents throughout the project life cycle (El-Samadony, Tantawy, & Atta, 2020). Manual way of collecting and organizing that amount of information makes the system prone to human errors and causes issues in

compliance with contract clauses. This system can also be manipulated to be used in the favour of a particular stakeholder because of human interference.

The world is growing and moving towards digitalization and automation; it is a need of time to automate the process of EOT Claim generation. Automation in EOT claim generation can mitigate the risk of human error, reduce the human effort, and develop unbiased claims in compliance with FIDIC Contract Conditions.

1.4. Research Objectives

The research aims at:

- Studying the current practices of EOT Claim generation, types and causes of delays.
- Minimizing the human efforts involved in the EOT Claim generation by providing an automated system.
- Visualizing the delays in 3D and 4D in a BIM Environment.
- Minimizing the conflict of interest in EOT Claim management process.
- Providing a uniform system for Claim management for the organization adopting the system.

1.5. Scope and Limitations

The research aims at development of a Revit plugin capable of calculating EOT Claim by using the Project as planned vs. as built schedule in the form of an excel sheet. The plugin will ask the user to link the schedule activities to the Revit-3D model and then calculate the prevalent delays. The system will ask the user to link the delayed activities with the corresponding FIDIC clauses and will determine that whether the contractor is entitled for EOT or not for that respective delay, same step will be repeated for all activities and total EOT will be calculated. This EOT can be displayed as a summary report or as a proper EOT Claim document by the template provided by the user. Human interference at the steps mentioned above is the limitation of the system.

1.6. Summary

EOT claims are an integral part of delays that occur in a project and very common in the construction industry. Conventionally, these EOT Claims have been generated by manual methods that makes them susceptible to human error and conflict of interests of stakeholders. Conventional method of EOT Claim generation is also very lengthy and the contractor needs a solid background knowledge of FIDIC clauses to generate an EOT Claim. The developed system aims at eliminating the before mentioned problems by developing an automated system for EOT Claim generation that can generate the EOT by using BIM and visualize the delays in 4D.

CHAPTER-2

2. LITERATURE REVIEW

2.1. Problematic Issues in EOT Claim Management

Claims are one of the biggest problems being faced by our industry. The trivial methods accompanied with wrong practices being used in our industry and the fact that mostly the claims are assessed at the end of the project has made it quite difficult for the professionals to solve the disputes that arise between the parties. Because of constant changes in key members connected to the project by both sides and poor record keeping has made it impossible to solve the claims. One of the biggest problems in current claim solving techniques is the selection of the right technique for the project and then the provision of correct data by both the parties, which ultimately makes this process difficult, time-consuming, and tedious (Shami, February 2018). Mostly the technique to solve claims is discussed and decided among the clients and contractor before the start of the project. Furthermore, different issues that arise during a project lead to claim generation like unorganized information and record keeping, which would ultimately lead to less information being available at the time of claim preparation. Too many documents and poor paperwork compiled by the contractor also proves to be very inconvenient once the project faces a halt. The problematic issues as shown in Table 1 were considered for the purpose of the project, out of which more focus was on: (1) Concurrent delays; (2) Noncompliance with contract requirements; (3) Complexity in determining cause and effect; (4) Insufficient personnel to prepare claim; and (5) Lack of experts. These were the issues which were kept in mind while designing the project.

Table 1: Problematic Issues in Claim Management

S. No.	Problematic Issues in EOT Claim Management	References
1	Too Many Documents	3
2	Lack of Records	7
3	Poor Record Keeping	1
4	Unorganized Information Regarding Claim	1
5	Verbal Instructions	1
6	No Standard Format	32
7	Incomplete Documents	3, 14, 29
8	Non-Compliance With Contract Requirements	17
9	Poor Paperwork	1
10	Concurrent Delays	6, 14
11	Unavailability of Documents	1
12	Complexity In Determining Cause and Effect	6, 28

13	Lack Of Communication	1
14	Poor Techniques	6
15	Unavailability Of Updated Programs	6
16	Incompetent Personnel to Prepare Claim	1
17	Incompetent Personnel to Assess Claim	3
19	No Computerized Documentation	1

2.2. Major Causes of Claims

There are two major types of claims being generated in our construction industry. These claims arise due to various reasons as shown in Table 2 (Marzouk, 2008). These claims are variation orders and extension of time claims. When a claim is to be made by a contractor, the responsibility has to fall on either the employer (if the contract obligates the employer) or due to Force Majeure which is also called "Act of God". Based on these causes, it is evident that almost all construction projects would face delays due to any of the reasons mentioned, and ultimately leading to claims.

Table 2: Major Causes of Claims

S. No.	Major Causes of Claims
1	Too Many Documents
2	Lack Of Records
3	Poor Record Keeping
4	Wrong Cost Estimate
5	Cash Flow Problems
6	Natural Site and Weather Conditions
7	Contracts Management
8	Problems Related to Communication
9	Economic And Political Conditions
10	Poor Management
11	Sociocultural Factors
12	Interim Payment Delays
13	Incomplete Drawings

2.3. Sub-Clauses Identifying Claim Practices as per FIDIC Red Book 1999

Claims are always generated while a project is going on. Mostly, it is decided between the clients and the contractors prior to the start of the project that what steps would be taken by the parties in case of a conflict. For reference, the most widely used book for new contracts globally is the "FIDIC Red Book 1999". FIDIC deals with all sorts and types of claims that can be

encountered on site and provides all solutions decided upon by multiple experts from the field. These rules are agreed upon by the employers and contractors, mentioning the sub-clauses which cover claims related matters arising in a project. A list of relevant sub-clauses is shown in Table 3 from FIDIC Red Book 1999 (The FIDIC forms of Contract) against which claims can be made and the party upon which the responsibility falls.

Table 3: Sub-Clauses Identifying Claims from FIDIC Red Book 1999

Sub-Clause No.	**Title**	**Responsibility**
1.8	Care and Supply of Documents	Employer
1.9	Delayed Drawings or Instructions	Employer
2.1	Right of Access to the Site	Employer
2.2	Permits, Licences or Approvals	Employer
2.5	Employer's Claims	Contractor
4.2	Performance Security	Contractor
4.7	Setting Out	Employer
4.12	Unforeseeable Conditions	Force Majeure
4.20	Employer's Equipment and Free-Issue Material	Employer
4.24	Fossils	Force Majeure
7.4	Testing	Employer
7.6	Remedial Work	Contractor
8.1	Commencement of Works	Employer
8.4	Extension of Time for Completion	Employer
8.5	Delays Caused by Authorities	Force Majeure
8.6	Rate of Progress	Contractor
8.9	Consequences of Suspension	Employer
8.10	Payment for Plant and Materials in Event of Suspension	Employer
9.2-A	Delayed Tests	Employer
9.2-B	Delayed Tests	Contractor
9.4	Failure to Pass Tests on Completion	Contractor
10.2	Taking Over of Parts of the Works	Employer
10.3	Interference with Tests on Completion	Employer
11.4	Failure to Remedy Defects	Contractor
11.11	Clearance of Site	Contractor
13.7	Adjustments for Changes in Legislation	Employer
16.1	Contractor's Entitlement to Suspend Work	Employer

17.4	Consequences of Employer's Risks	Force Majeure
19.4	Consequences of Force Majeure	Force Majeure

2.4. Major Delay Analysis Techniques for Calculating EOT

2.4.1. As-Planned Method

This method also explains the planned start and finish dates with the actual start and finish dates including the critical and near critical paths. It helps the engineer to identify delayed starts and the activities whose durations were extended.

2.4.2. As-Planned vs. As-Built Method

The dates and durations of selected activities are compared from the as planned schedule to the as built schedule and the difference between the dates is considered being the delay in the activity. The main advantage of this method is the fact that it is very simple and inexpensive. As far as the disadvantages are concerned, one of the biggest disadvantages is that it ignores concurrent delays that occur during the project and also cannot cater to the causes of the delay (Keane & Caletka, 2008).

2.4.3. Impact As-Planned Method

This method is also being used in our construction industry. This method deals in such a way that the analyst dealing with the claims lists down the excusable delays or the delays to which contractor is entitled to extension of time and then inserts the new extended duration to the activities being discussed. The analyst now reads the newly formed revised completion dates and compares these dates with the planned completion dates (Keane & Caletka, 2008).

2.4.4. Window Method

This method deals with the claims in such a way that the analyst analysing the claims generated by the contractor or the client simply forms small windows against the activities and then deals with those windows separately. The claims of extension of time or cash are dealt by analysing the delays caused in every window (Keane & Caletka, 2008).

2.5. Existing Research and Research Gap

After careful study and extensive research about the topic, we found that there has been some research already done in this field which focused on development of a system or a software which can make the process of claim management easier or maybe automate the system altogether. Some software’s or systems were formulated along with flow charts which explained the process of claim management and claim preparation and eased our way through the process.

According to a research conducted by Vahid Shahhosseini & Hossein Hajarolasvadi which was formulated on the topic of developing a conceptual framework helping in claim management using the technology of BIM. A system was developed to improve the efficiency and accuracy of BIM to deal with claims. A Communication Management Subsystem (CMS) was developed by the writers with a purpose of collecting projects documents and information which could be used for future references. (Shahhosseini, V. & Hajarolasvadi, H. , 2018). The information which was collected was added to BIM resulting in a new model called "contract model". Another similar effort to improve the documentation of the project was conducted by Goedert and Meadati in 2008. They proposed a method in which the information related to the construction processes and the documents can be integrated with BIM which would be very helpful for analyzing claims through BIM and in management of the overall facility (Shahhosseini, V. & Hajarolasvadi, H. , 2018). The results to these research proved the fact that although BIM is equipped with such tools and facilities to achieve our goals but there are still some limitations and the software, and the system devised needed some changes to fulfill our requirements.

Working on the same principles, Al-Gahtani et al. (2006) introduced a system also referred to as web-based software "Total Float Management" which could also be used for delay analysis. It could link Primavera P6 and Microsoft Project, importing all the schedule directly in different formats. It was also used for claim management and analysis purposes as it made the procedure less time taking and easier (Shahhosseini, V. & Hajarolasvadi, H. , 2018).

2.6. Application of BIM and Associated Programming Tools in Construction Industry

2.6.1. Emergence of BIM as an Effective Management Tool

In the foreseeable future it is likely that a large proportion of the construction industry will be 'BIM aware' and 'BIM competent' rather than 'BIM expert' (Ghaffarianhoseini, et al., 2017). The building planning and designing has been conventionally being done by using a number of software that involve software for planning, designing, documenting, structural design, and analysis, building systems design and drafting software. These softwares had little or no integration among them and thus the designing of a building or infrastructure was a very slow and inefficient process. The design also had a lot of conflicts since due to lack of coordination and integration among various systems. These solution of all of these problems under one single program (BIM) is the unique selling point of BIM. The integration of disciplines and stages in design and construction activities is a key aim of major projects and an underlying theme of integrated approaches to project delivery (Liu, Sander, & Marcel, 2017). As per the survey conducted by students at University of Lahore in 2014, BIM was being used in 27% of the AEC organizations, with a comparatively higher rate of adoption by the Architectural professionals as compared to other AEC professionals. 96% of the professionals involved in the survey voted in favour for implementation of BIM in Pakistan's Construction industry (Masood, R., M.K.N., & A., 77).

2.6.2. Role of Revit as a Prominent BIM Tool

Building Information Modelling (BIM) is a process of integration and collective creation of a project information that forms a reliable basis for the decisions involved in project life cycle. Autodesk Revit is considered as one of the most important and widely known tool for BIM. This is because of the reason that Revit offers tools that not many other software can. It offers a bidirectional associativity of the views in a model; all the information of a BIM Model is stored in a central project file. A single change anywhere in the model is automatically updated in all the views. Revit treats the 3D object involved in modelling as real objects by associating real life material qualities, attributes, and conditions to the objects. Revit also offers a variety of tools such as Structural Analysis, MEP Design and HVAC Design and Analysis, and a BIM model made in Revit can be exported in various formats and can be used in other software of Autodesk's AEC package thus making it an essential tool for BIM workflow (Zolotova, Vatin, Tuchkevich, & Rechinsky, 2015).

2.6.3. Use of Dynamo as a Visual Programming Tool in Revit

Dynamo is an open-source graphical programming environment for design. Dynamo consists of various nodes, each having a specific function of its own. These nodes can be linked to each other to make a script which can perform the specific task that it is designed for. Visual Programming provides a link between the geometry of various objects involved in BIM Model and the raw data involved with them. Modern AEC Organisation implement Dynamo and other visual programming tools into their BIM work flows to make complex designs and automate the lengthy workflows by automated means.

CHAPTER-3

3. METHODOLOGY

A framework proposed by B. Ali et al. (2020) for research in the area of construction management, is modified according to the need of this project. Figure 1 shows the methodology framework followed during this project in three phases including: (1) Identification of issues in EOT claim generation and causes of delays through literature review; (2) Developing a plugin in Autodesk Revit which calculates EOT delays and visualizes them; and (3) Developing of user manual of product, testing the product on several models and then evaluation by industry experts.

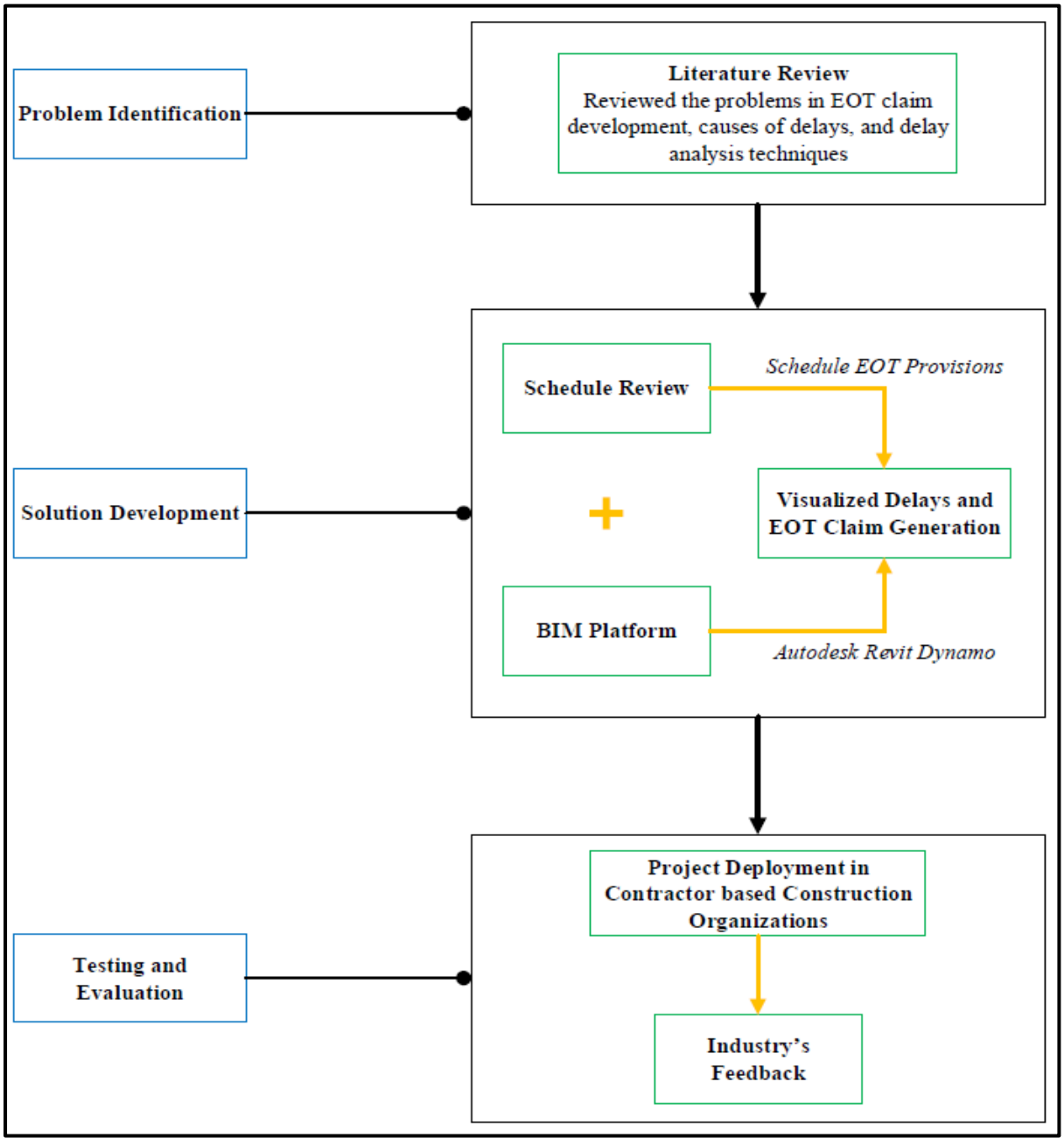

Figure 1: Methodology Framework

3.1. Problem Identification

In the first phase, an extensive literature review was done to identify key parameters that would affect the course of research. Problematic issues in EOT Claim Management were short-listed out of which nine issues were selected which were to be addressed by the plugin. The research also focused on finding the causes of delays against which the claims were to be generated finding. Based on these causes, FIDIC Red Book has defined certain parameters which hold the stakeholders responsible for respective causes under twenty-eight sub-clauses.

Next, twenty-six research papers were studied to find existing progress in automated EOT claim generation. Certain frameworks were suggested in the research papers catering to the need for automation but practical work to automate the processes was not held.

3.2. Solution Development

In the second phase, deliverables of the plugin were finalized. The plugin was designed to achieve delay analysis and calculation of delays minimizing concurrent delays using As-Planned vs. As-Built delay analysis technique, due to its simplicity and popular usage by contract and claims specialists; project the delays in 3D and 4D on the building components that are being affected by the delays; and finally print the findings of the plugin in a standard template.

3.3. Testing and Evaluation

In the final phase, a user manual was designed to aware the users regarding the process flow and minimizing technical errors and bugs to obtain desired results from the project. Results were compiled while assessing the limitations of the project. The product was reviewed by academia and evaluated by industry experts by identifying its need in industry, implementation, effectiveness to improve process, interface usability, and visualization.

4. RESULTS AND DISCUSSION

4.1. Process Framework

Figure 2 shows the process framework of the developed system to generate and visualize EOT delays. The developed plugin interacts with Autodesk Revit for model visualization providing a base platform for delay projections and simulations. The plugin framework is based in Dynamo which extracts data from tabular form, executing calculations, and displaying desired results.

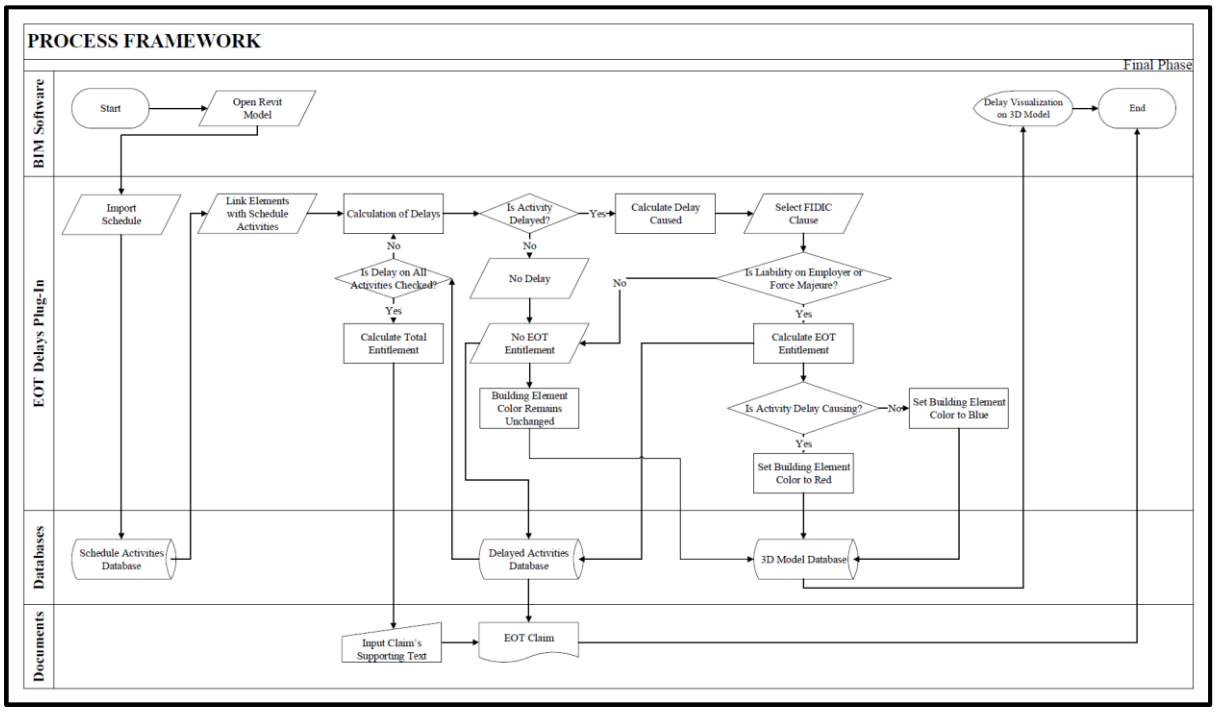

Figure 2: Process Framework of EOT Delay Tool

The plugin commences by importing the desired Revit model for the project. Schedules developed in third party software are imported in the plugin are saved in the Dynamo database in XLSX format. The user is prompted to link the elements from the schedule activity to the building element for which it was scheduled. At the back end, a process is runs which identifies if the activities were on time or delayed.

The plugin separates the delayed activities from the on-time activities. It further checks for the reason of delay based on clauses of FIDIC Red Book 1999 which delegate the responsibility of delay on employer, contractor, or force majeure. If the liability falls on employer and force majeure, EOT is entitled to contractor.

For visualization, activities involving delays are then sorted into either delay causing activities that actually contributed to delays or delayed activities that actually did not contribute to delays but were delayed due to other delay causing activities. All data is stored in database in each step. For visualization data is accessed from database and delays are visualized as per given

setting by user. For summary and EOT Claim document data is accessed from database and reports are printed as per given setting by user.

4.2. General Introduction of User Interface and Working of the Application

The program is designed to be used by Claim/Contract Engineers who have certain background knowledge of claims, contracts, and construction laws. This plugin will make it convenient for our user to analyse entitlement of claims, visualize and simulate the extent of delay on the project, and print a claim document in a predefined format. The plugin is a prototype program developed for research purposes using Revit based modelling and Dynamo based virtual programming.

The EOT Delays Toolbar as shown in Figure 3 is split in four segments to carry out different commands of the program. It shows the additional toolbar of EOT Delays with all buttons programmed to perform relevant tasks in Autodesk Revit environment.

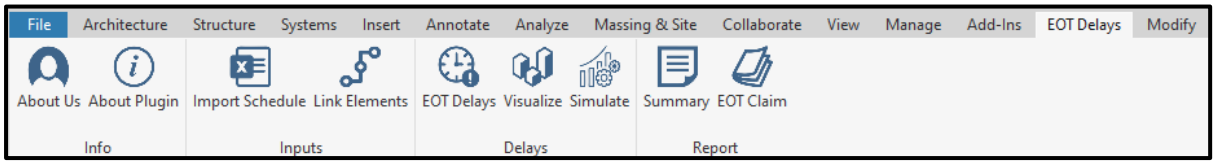

Figure 3: Toolbar User Interface

The first segment named info in the toolbar is used as a detail for the developers of the plugin and plugin itself and for contact queries.

The second segment named inputs imports the tabular data from the project schedule on which the delay analysis will be made and links the data entries in the excel sheet with 3D model elements in the Revit database.

The third segment named delays carries out the main calculations of delay analysis for the project and projects the delays under said parameters on a 3D model. It also simulates the delays of the project in 4D.

The last segment named report provides documentation of delay in summarized or detailed form, respectively.

4.3. Plugin Framework

The plugin framework is developed following the sequence of processes explained in flow chart in Section 4.1.

4.3.1. Exporting Schedules from Third Party Software

The plugin uses excel schedule for calculation. If project is scheduled in any other software such as Primavera or MS Projects, then schedule must be exported into excel format that can be done by selecting relevant option during export of schedule as shown in Figure 4 and Figure 5. The plugin only uses Activity Name, Planned Start, Planned

Finish, Actual Start, and Actual Finish dates from schedule in same order. Thus, it is very important that the project schedule is exported in similar template from third party software. If this template is not possible with the software, then manually changes in excel file can be made to set the excel schedule in required format to be used effectively.

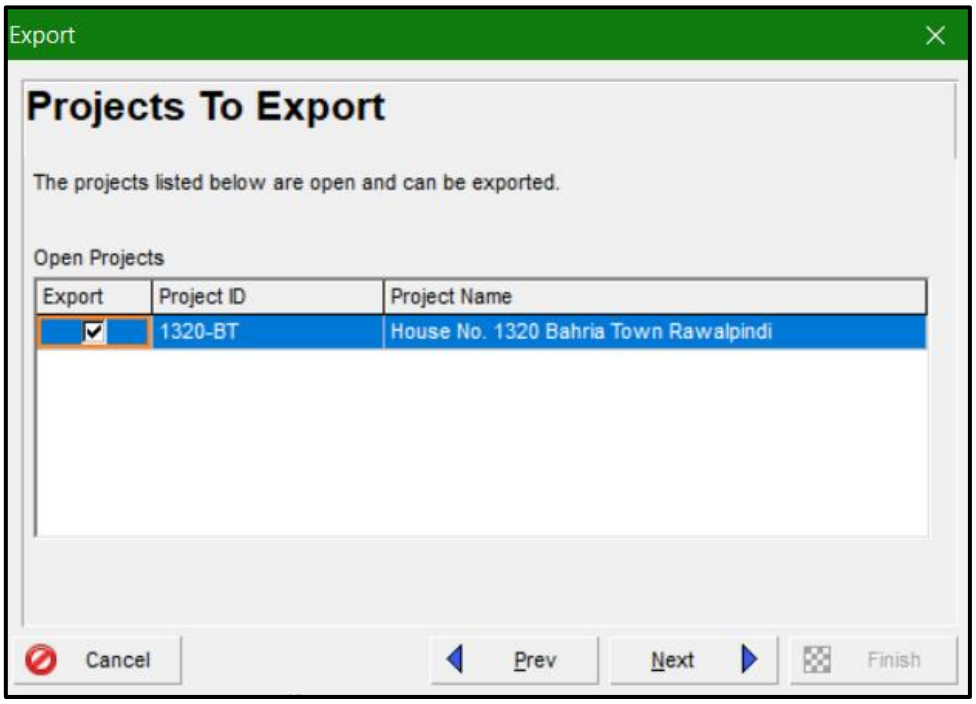

Figure 4: Project Schedule, Primavera

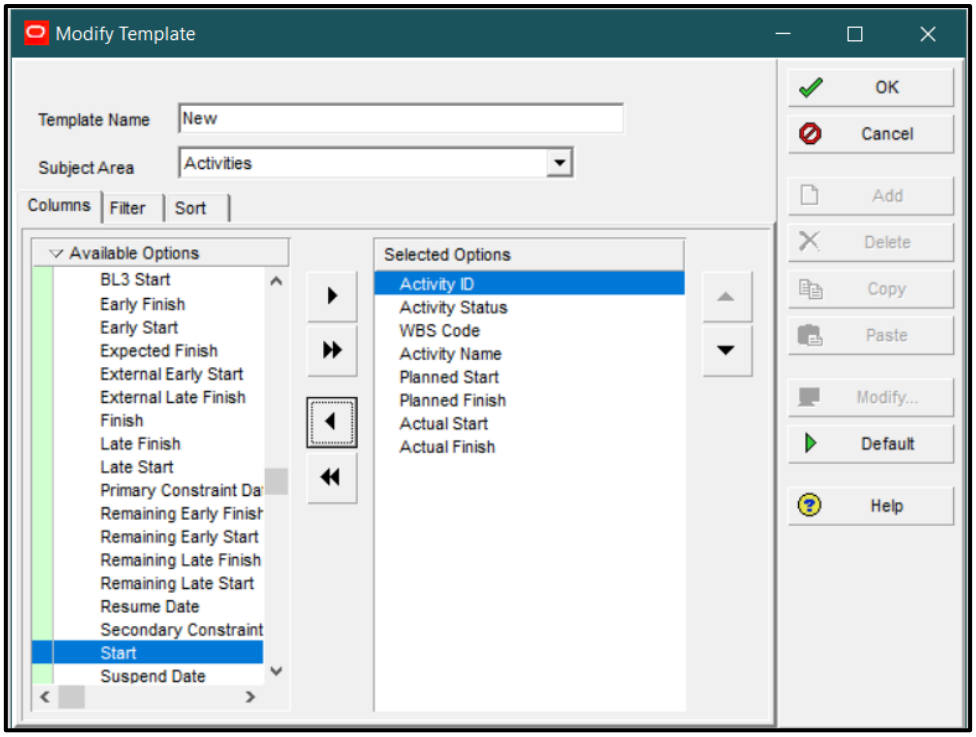

Figure 5: Export Template, Primavera

4.3.2. Importing Project Schedule

Import Project Schedule provide simple user interface with button to link excel file containing project details and then sheet name with default value "Sheet 1" as shown in Figure 6 that can be changed if sheet name is different. It will then display the project schedule as shown in Figure 7. The details are saved in plugin's database, so any changes made in project schedule at this time are stored for future use.

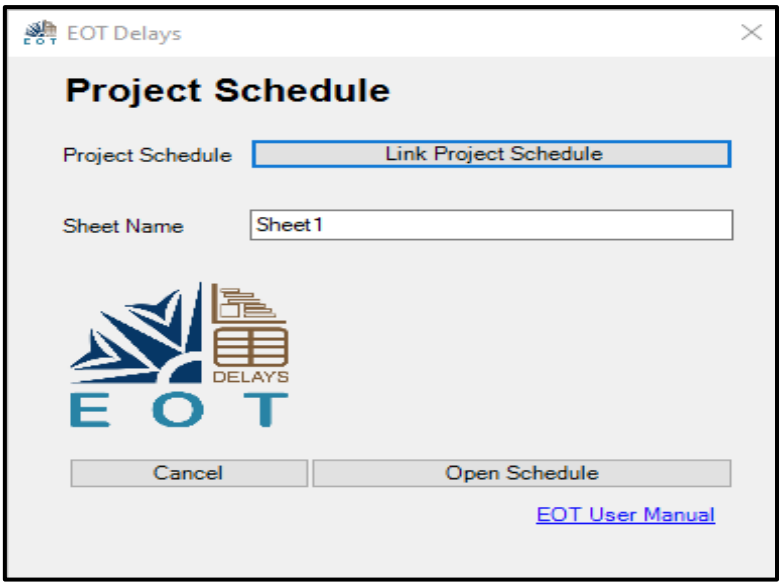

Figure 6: Import Schedule

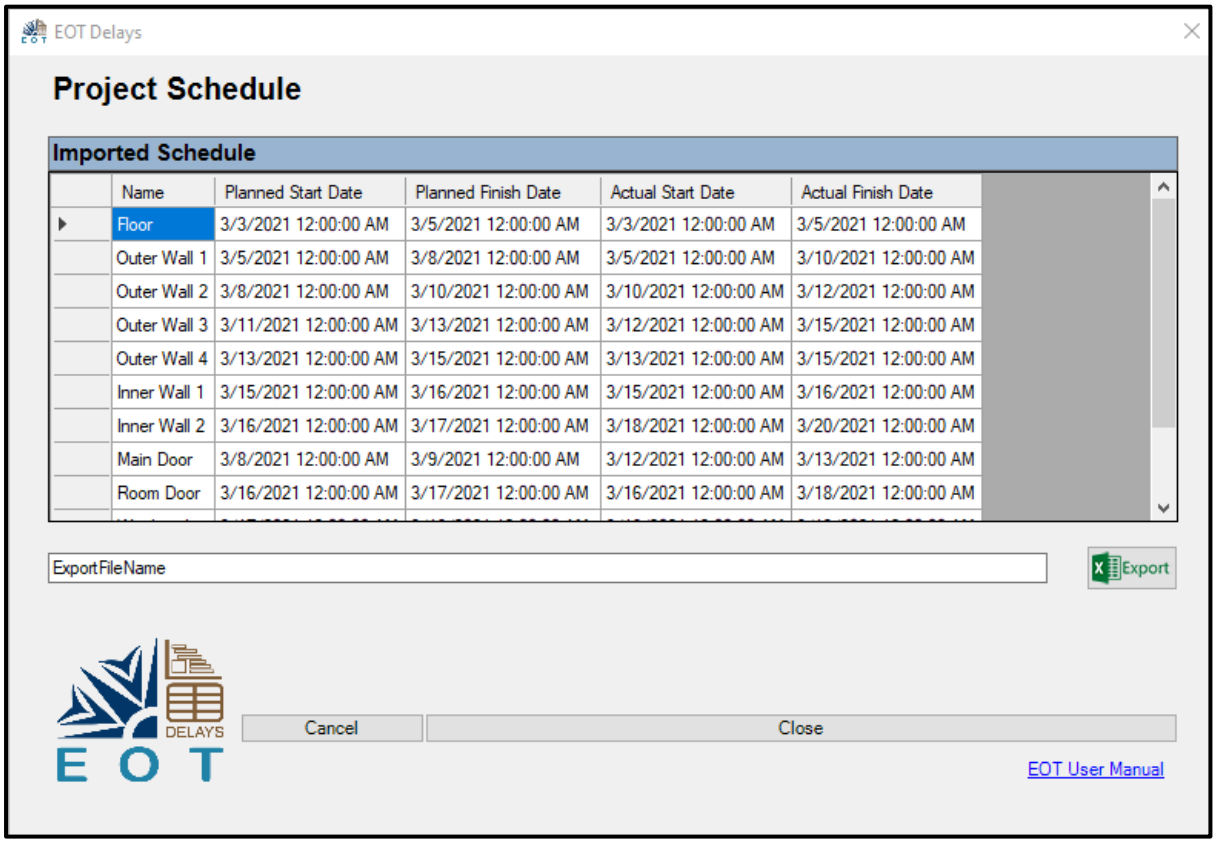

Figure 7: Display of Project Schedule

The complete backend script was programmed in dynamo to import the schedule as shown in Figure 8. The first component of this program prompts to link the schedule of project with model in Revit as shown in Figure 9. The second component takes data from schedule file into the program as shown in Figure 10. The final component of this program displays the data for any changes and then saves it to the database as shown in Figure 11.

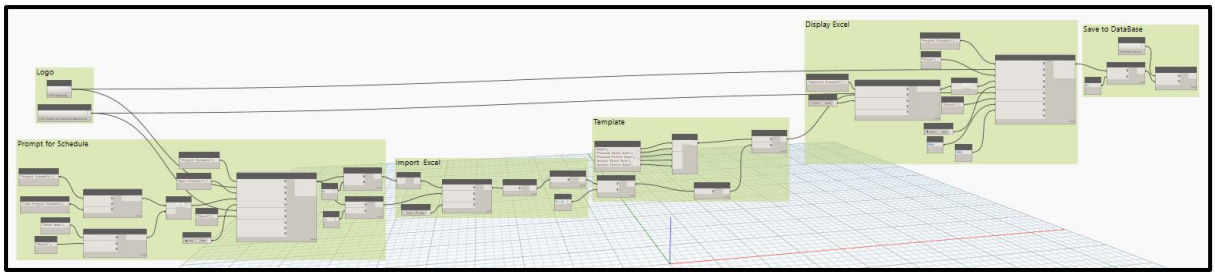

Figure 8: Import Schedule, Complete Dynamo Script

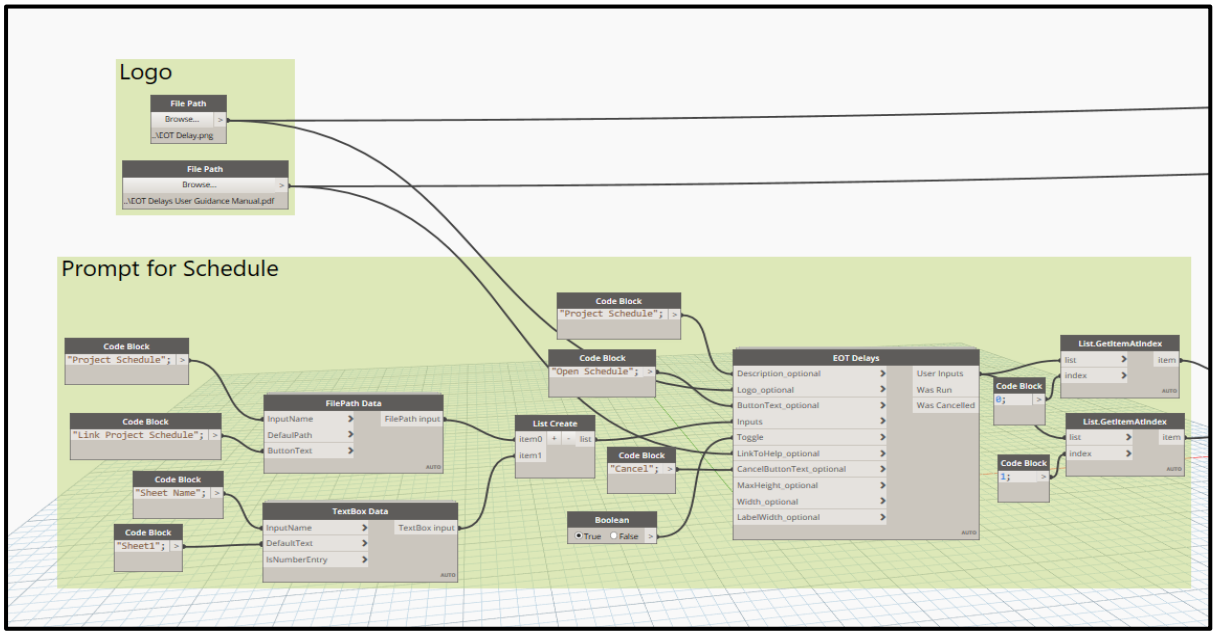

Figure 9: Import Schedule, Dynamo Script-1

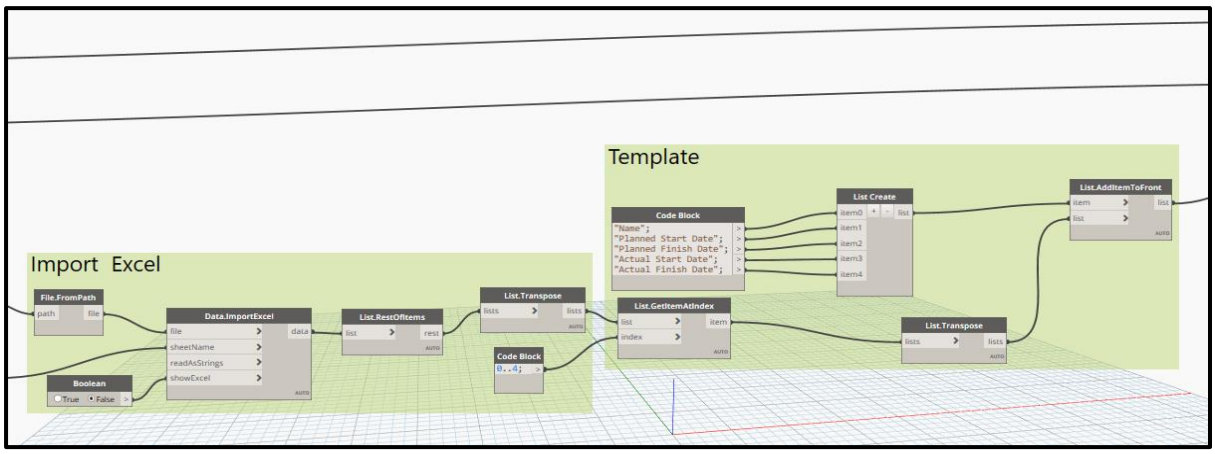

Figure 10: Import Schedule, Dynamo Script-2

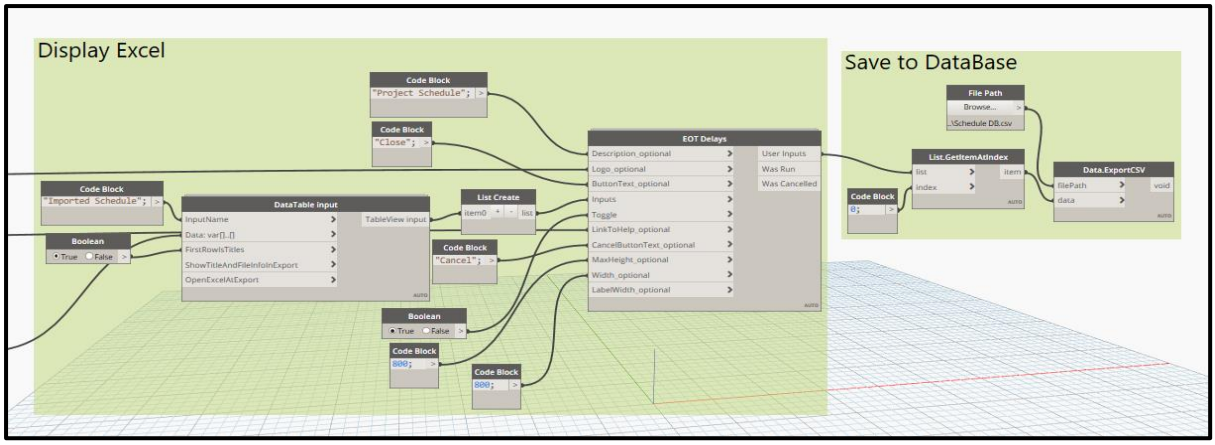

Figure 11: Import Schedule, Dynamo Script-3

4.3.3. Linking Model Elements to Schedule Activities

In this step, schedule data is accessed form database and each activity is prompted to be linked with the model elements as shown in Figure 12. This is be done by clicking the button in front of activity and then selecting corresponding element in model. The data is then stored in database which will be used for visualization and simulation of delays.

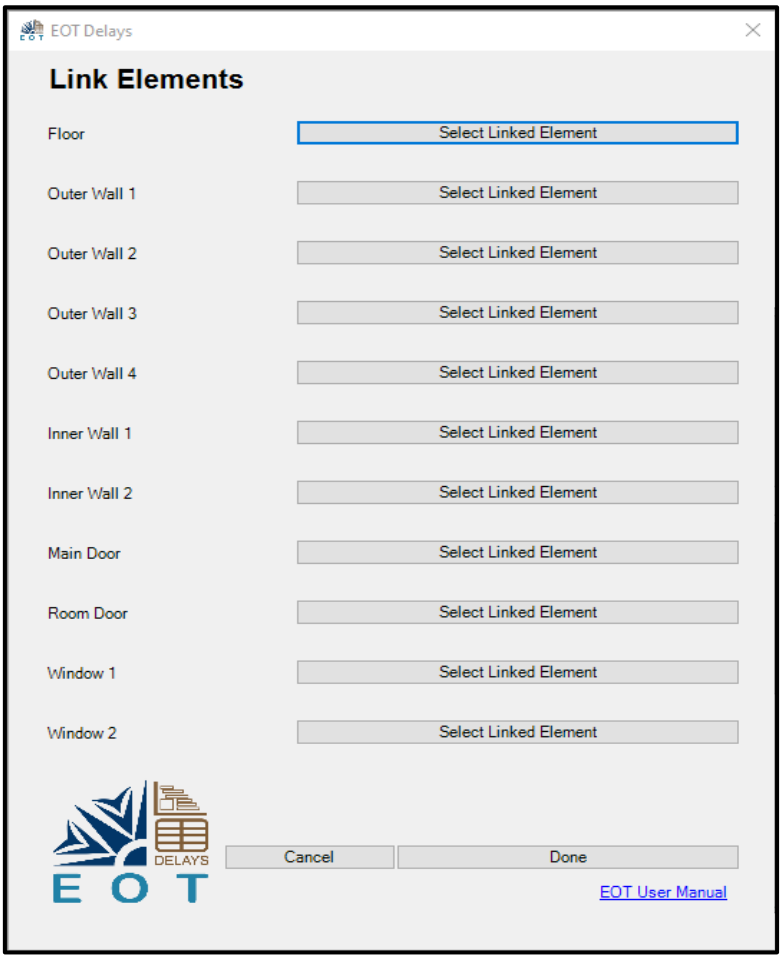

Figure 12: Link Model Elements

As shown in Figure 13, the dynamo script obtains the activities data from database, prompting the user to link it with the elements, and store the file path for future requirements.

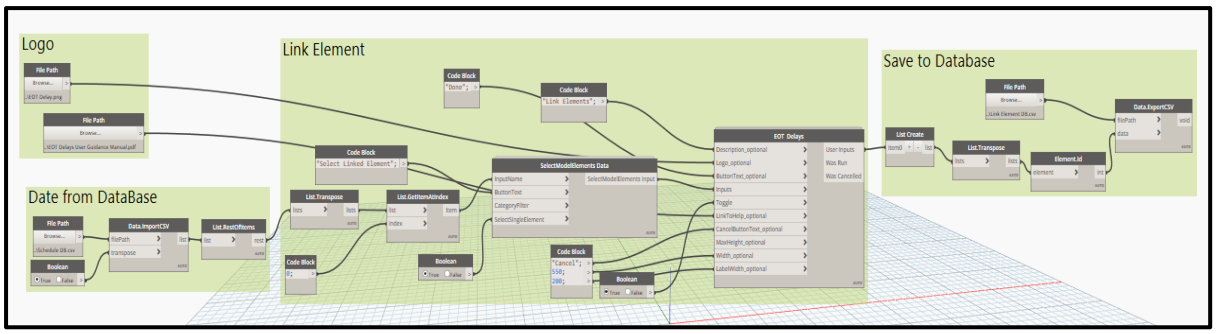

Figure 13: Link Elements, Complete Dynamo Script

4.3.4. Calculation of EOT Entitled Delays

Figure 14 shows the detailed dynamo script used to execute the processes upon clicking the "EOT Delays" button from the plugin toolbar. This is most important part of plugin that takes data from database and calculate delays, links relevant FIDIC sub-clause, and determines EOT entitlement to contractors.

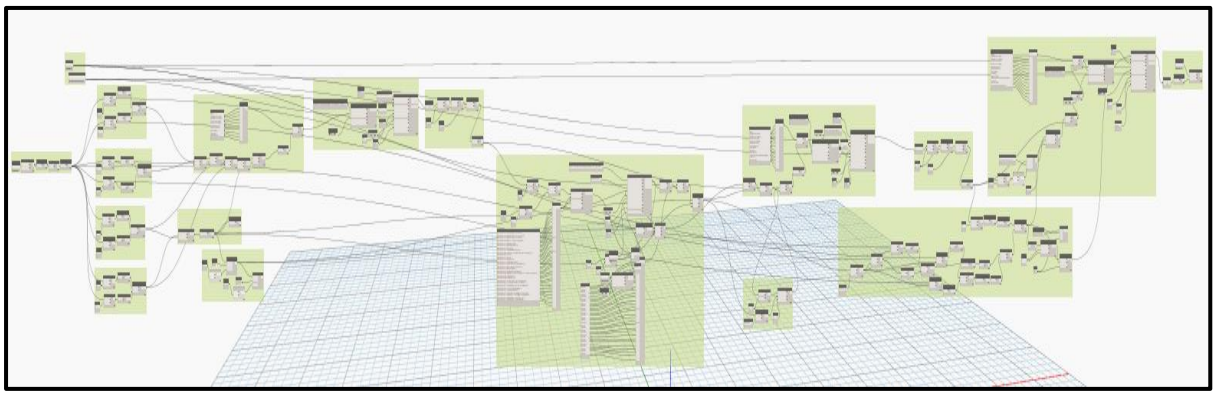

Figure 14: EOT Delays, Complete Dynamo Script

4.3.4.1. Calculation of Delays

For calculation of delays, data is accessed from database, and planned duration and actual duration are calculated. For calculation of delay caused, start delay and end delay for each activity is calculated. The difference of start delays, and end delay is equal to delay caused by those activities. These planned duration, actual duration, start delay, end delay and delay caused are shown in Figure 15.

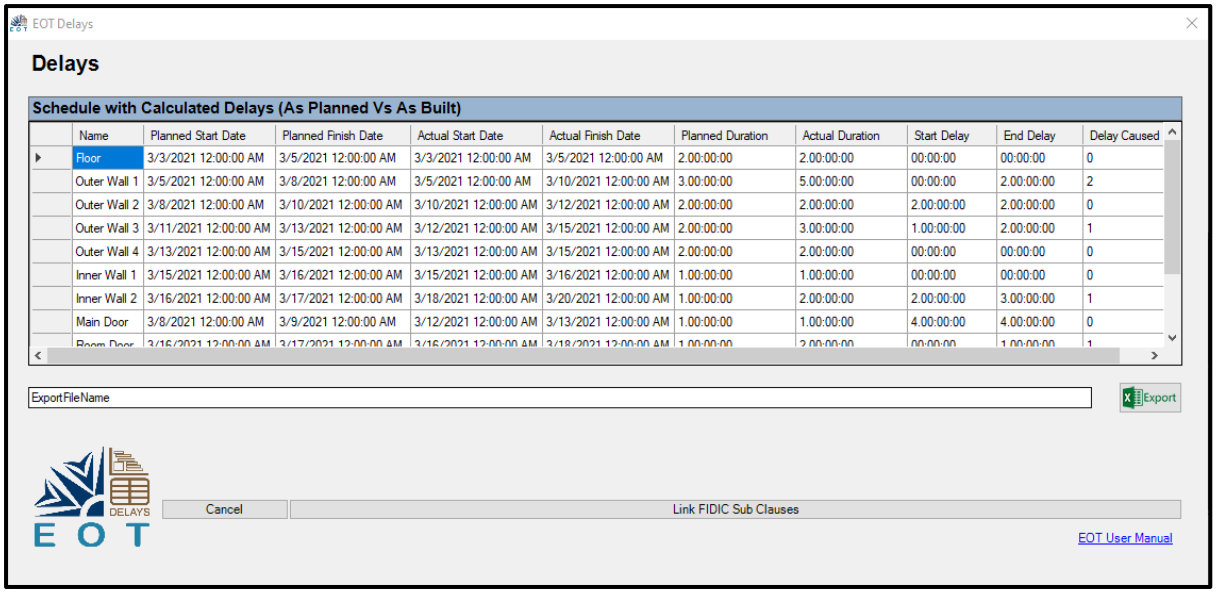

Figure 15: Calculation of Delays

As shown in Figure 16, the backend dynamo script obtains the data from database and performs calculation to obtain planned duration, actual duration, start delay, end delay and delay caused. In Figure 17, the detailed backend dynamo script shows the conversion of durations into a standardized format to display the dates.

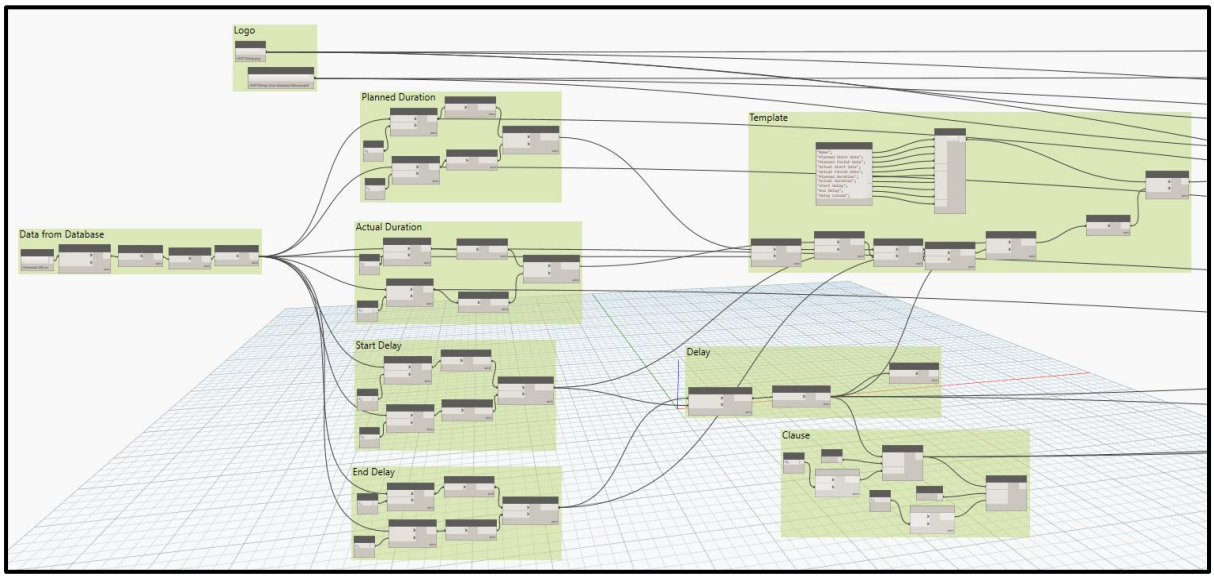

Figure 16: EOT Delays, Dynamo Script-1

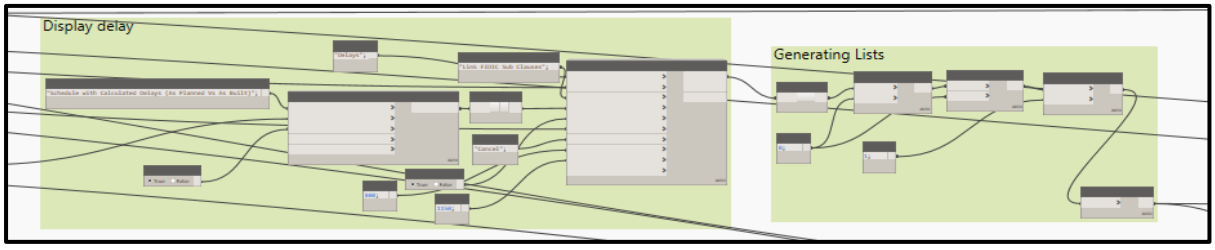

Figure 17: EOT Delays, Dynamo Script-2

4.3.4.2. Linking FIDIC Clauses

For Linking FIDIC sub-clause to the delay caused, only activities with delay caused greater than zero are separated and are prompted to link relevant FIDIC 1999 sub-clause using dropdown selection as shown in Figure 18. Details of FIDIC sub-clauses can be accessed from user manual.

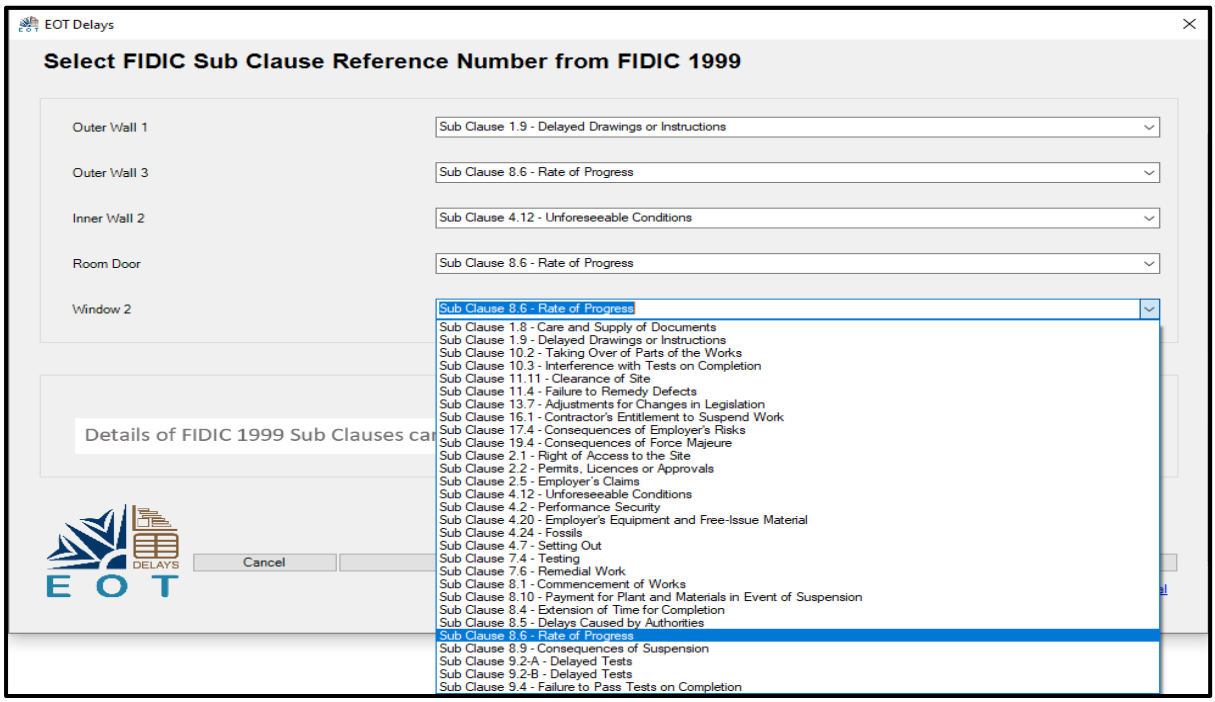

Figure 18: Link FIDIC Sub-Clauses

In Figure 19, the detailed backend dynamo script shows the nodes that prompts to link relevant FIDIC 1999 sub-clause by dropdown menu and assign the liability to either contractor or employer for the delay.

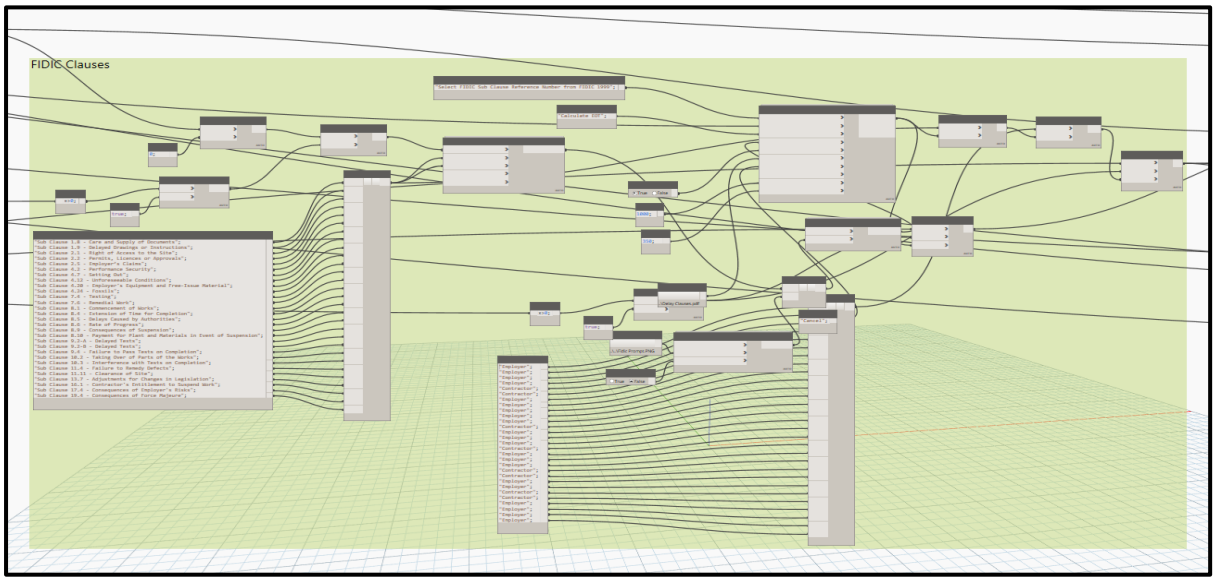

Figure 19: EOT Delays, Dynamo Script-3

4.3.4.3. Determination of Entitlement to Contractor

The data of FIDIC sub-clauses is then analysed and liability of each delay is determined. The delay liable to employer and force majeure are entitled to contractor. These delays liable are then shown as an entitlement against each activity as shown in Figure 20. The final delay is calculated as a summation of the complete impact minimizing concurrent delays and shown in the table as in Figure 21. The data is stored in database to be used in printing summary and report.

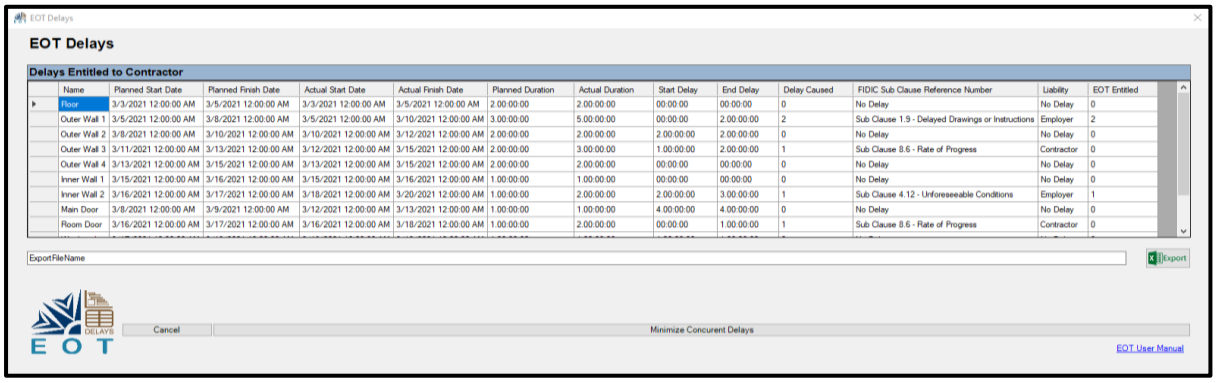

Figure 20: EOT Entitlement

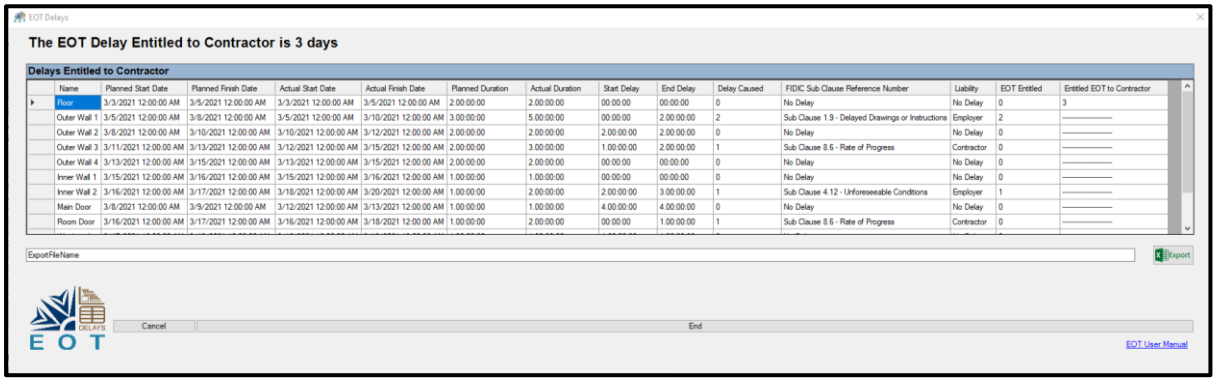

Figure 21: EOT Entitled to Contractor

Figure 22 shows the detailed backend dynamo script to calculate and display EOT delays against each activity; then minimizing concurrent delays and finding the total entitlement to which the contractor is entitled.

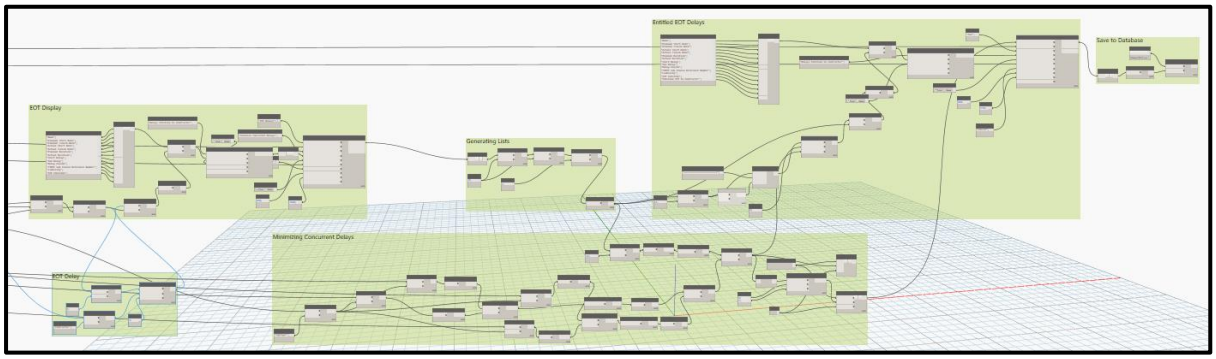

Figure 22: EOT Delays, Dynamo Script-4

4.3.5. Visualization in 3D

Data is accessed from database and then visualization settings are prompted as shown in Figure 23. The user can set colours or use the default colours for delay causing or delayed elements. The model elements change colour as per input and can be better visualized in the shaded version of model as shown in Figure 24.

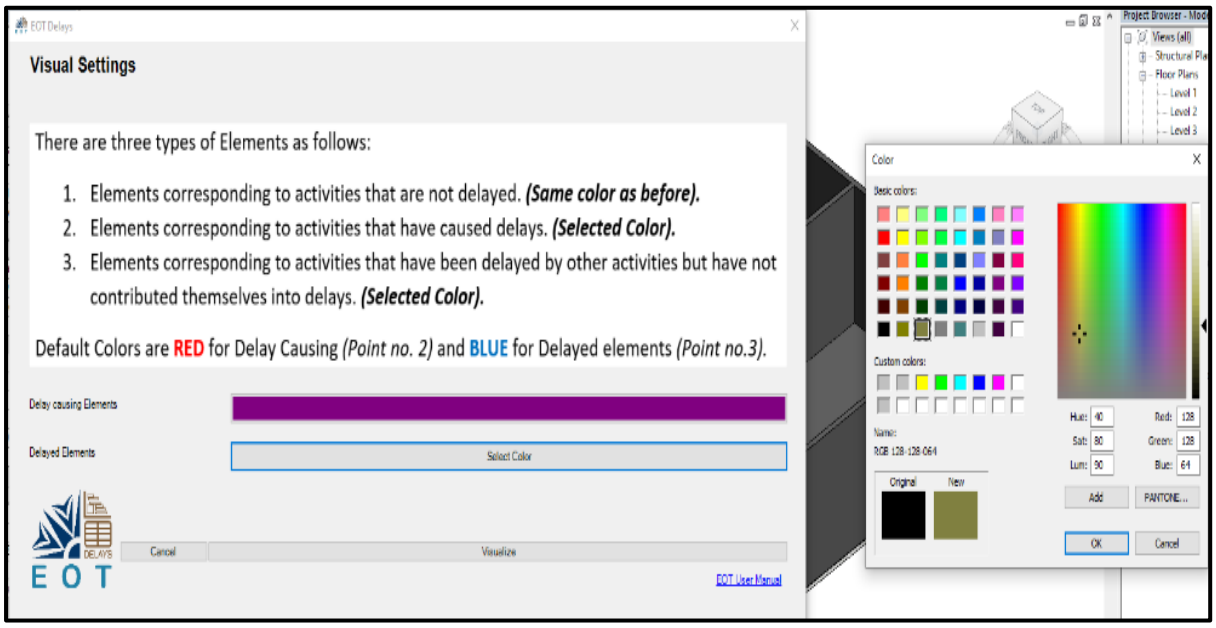

Figure 23: Visualization Settings

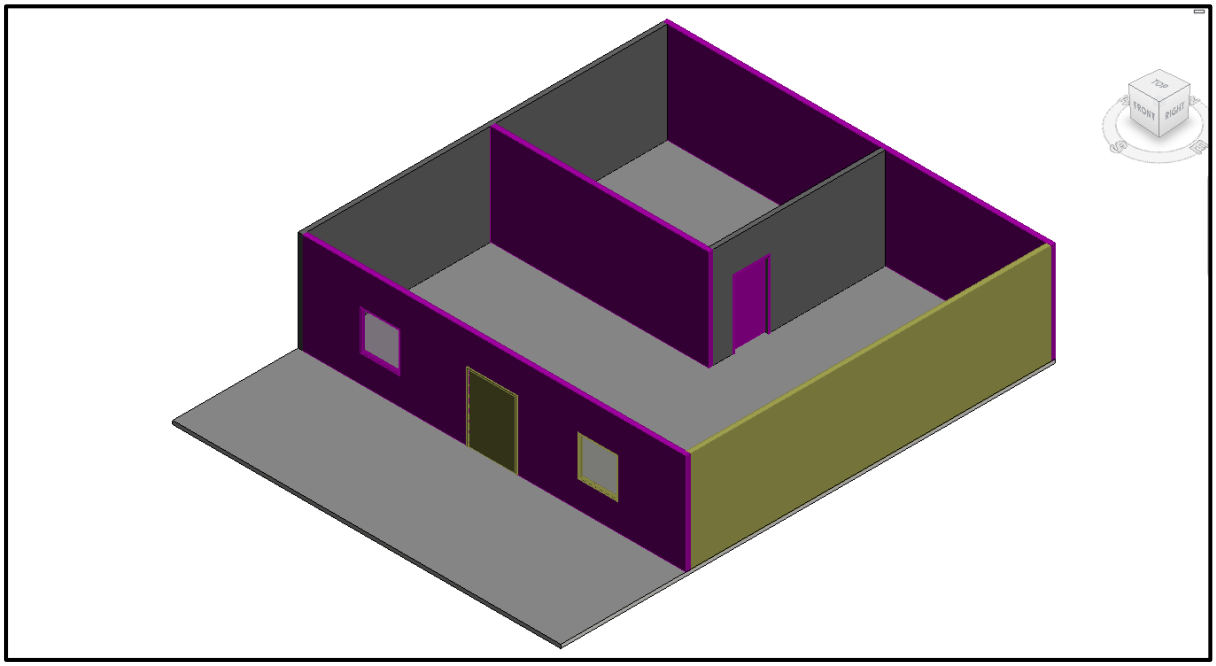

Figure 24: Model Visualization

Figure 25 shows the detailed backend dynamo script showing the nodes being used to select the shading colours for the Revit model in 3D. It also specifies the default colours if no colour changes are opted by the user. These selections are used to identify the impacted elements in the model.

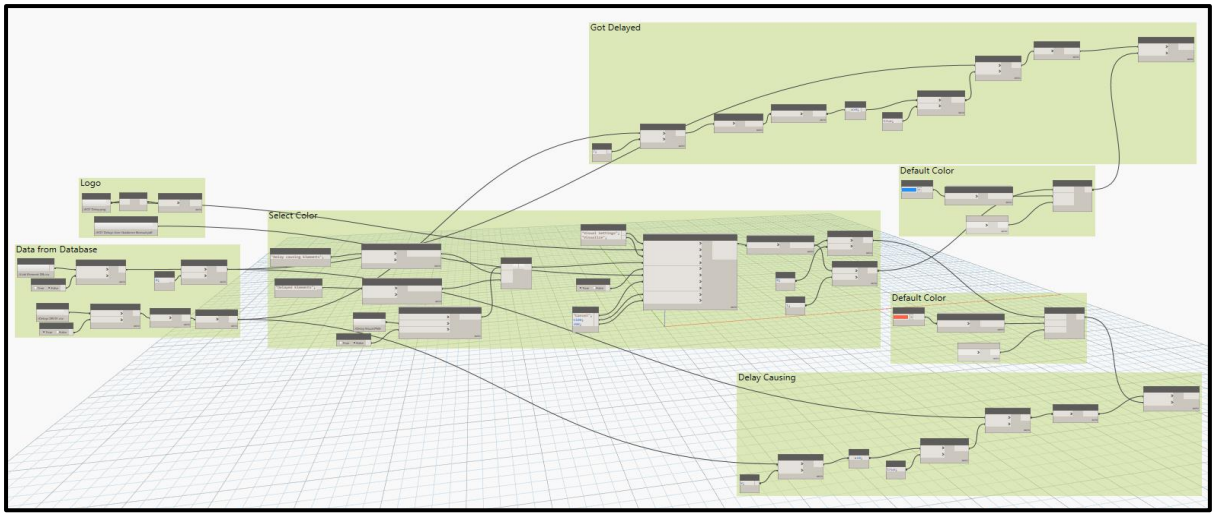

Figure 25: Visualization, Complete Dynamo Script

4.3.6. Simulation in 4D

Data is accessed from database and then simulation setting is prompted as shown in Figure 26. The user can set colours or use the default colours for delay causing or delayed elements. The model elements change colour as per input and appear in their construction order with the speed as specified in input of simulation settings. The model slowly builds up and obtains solid colours for the model in the order of activities as shown in Figure 27. This simulation adds 4D aspect to Revit model and is effective for delay visualization in large structure in which some may lie under other elements and thus cannot be viewed in visualization of delays.

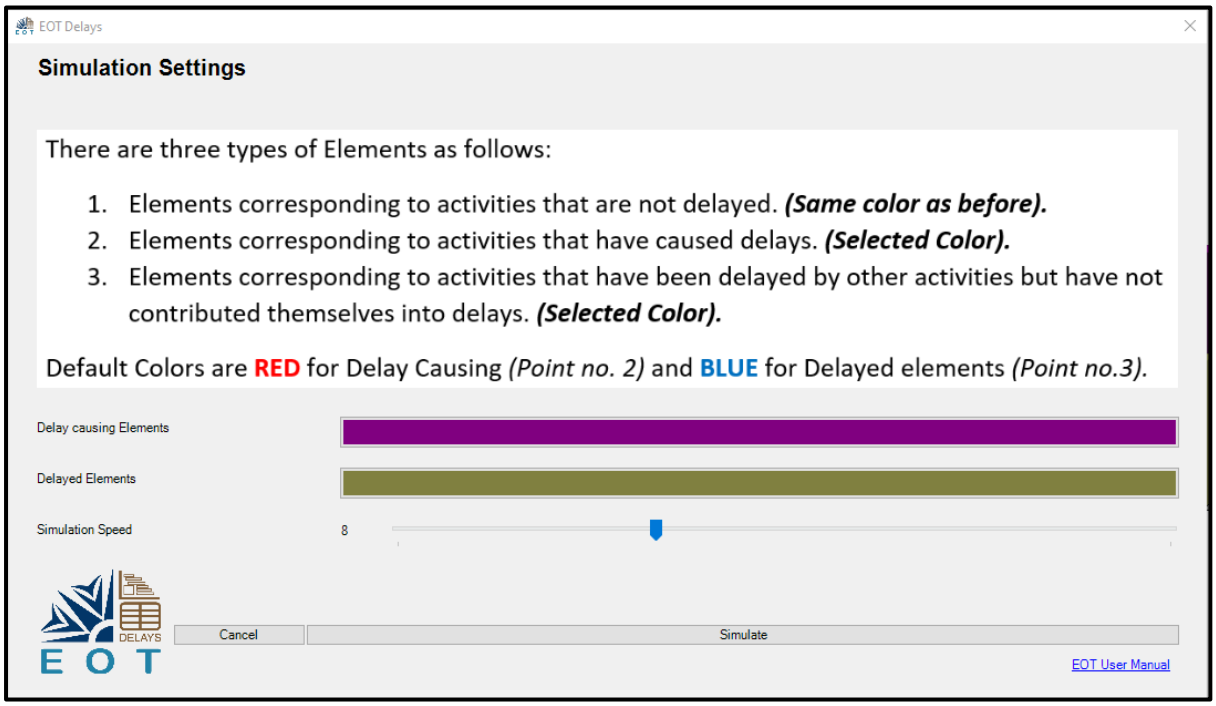

Figure 26: Simulation Settings

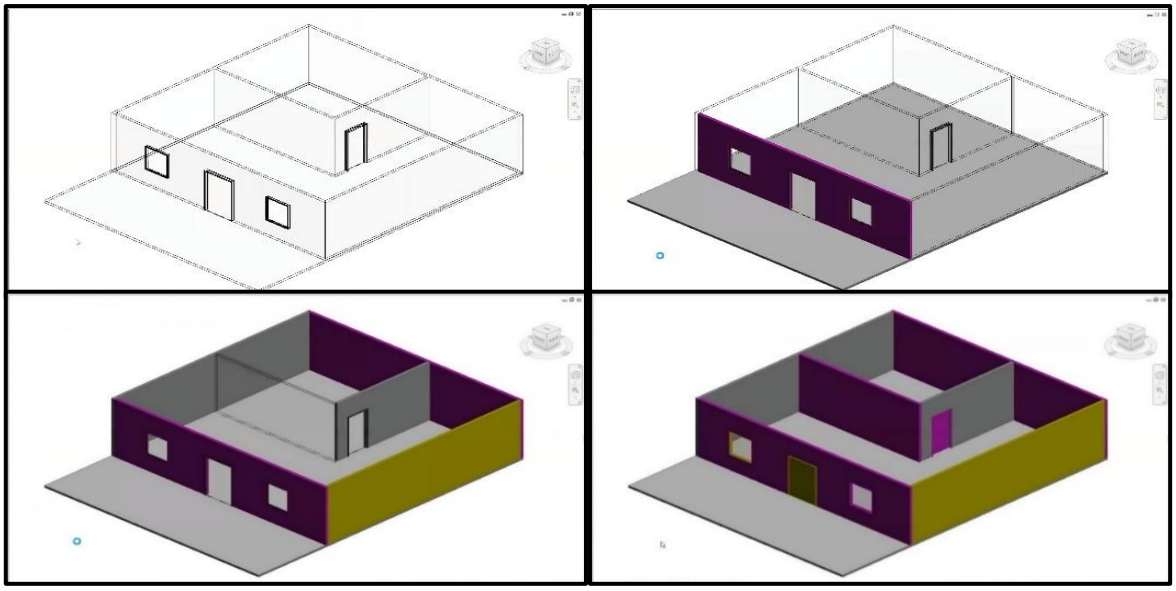

Figure 27: Model Simulation

Figure 28 shows the complete backend dynamo script being used for settings selection of simulation and displaying the model elements as per selected parameters. Figure 29 shows the detailed dynamo script for data retrieval from the database, prompting simulation settings, and selecting each model element as delayed or delay causing. Figure 30 the detailed dynamo script to run the simulation in 4D. It also specifies the default colours if no colour changes are opted by the user.

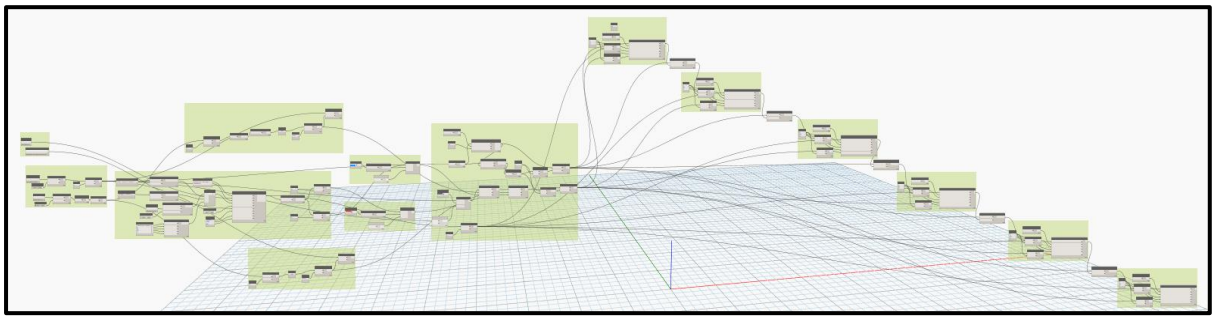

Figure 28: Simulation, Complete Dynamo Script

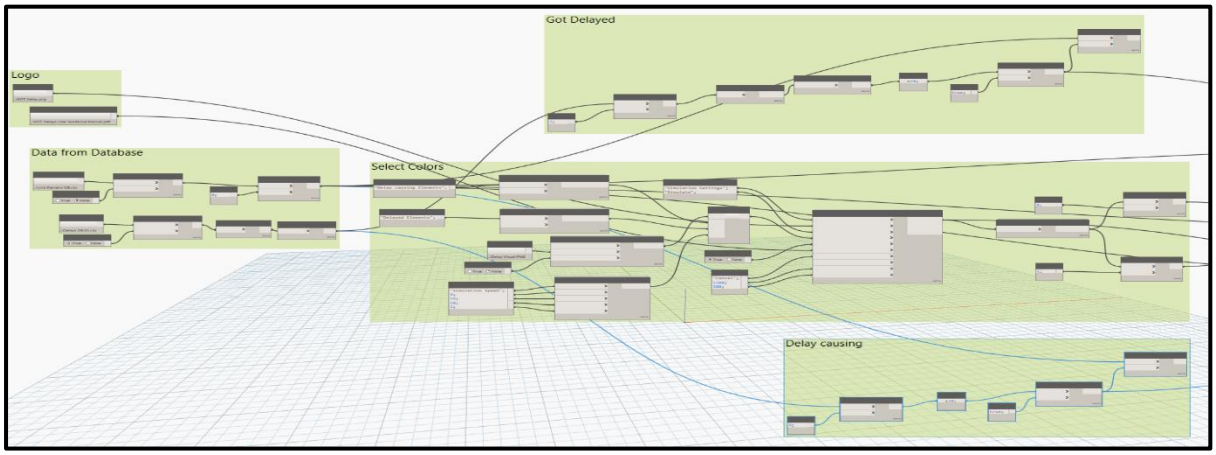

Figure 29: Simulation, Dynamo Script-1

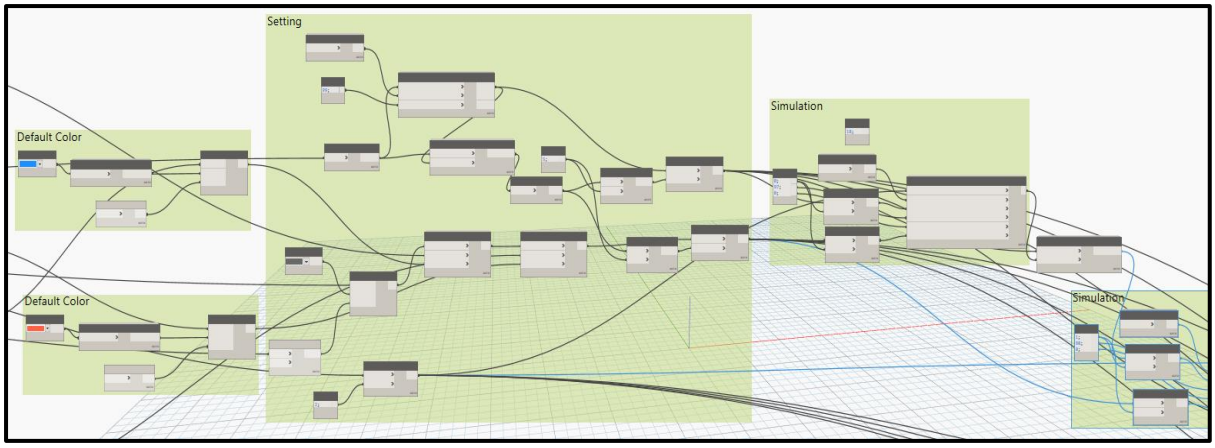

Figure 30: Simulation, Dynamo Script-2

4.3.7. EOT Summary

Data is accessed from database and print setting for summary is prompted as shown in Figure 31. The columns of data selected in setting are printed in summary along with EOT entitled days to contractor and date and time from system. Figure 32 shows a sample summary report covering the selected columns as well as the summary of delays to which the contractor is entitled by the employer.

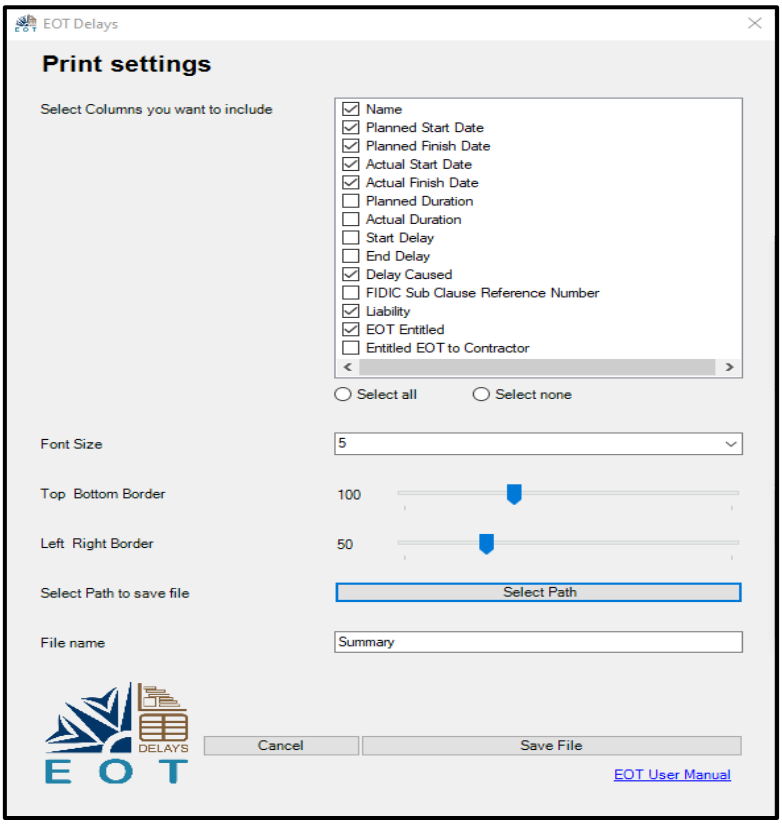

Figure 31: Print Setting for Summary

EOT Delays Summary Report:

Date & time of print: Wednesday, 28 April 2021 17:11:40

Extension of time entitled to Contractor is 3 Days

Name	Planned Start Date	Planned Finish Date	Actual Start Date	Actual Finish Date	Delay Caused	Liability	EOT Entitled
Floor	3/3/2021 12:00:00 AM	3/5/2021 12:00:00 AM	3/3/2021 12:00:00 AM	3/5/2021 12:00:00 AM	0	No Delay	0
Outer Wall 1	3/5/2021 12:00:00 AM	3/8/2021 12:00:00 AM	3/5/2021 12:00:00 AM	3/10/2021 12:00:00 AM	2	Employer	2
Outer Wall 2	3/8/2021 12:00:00 AM	3/10/2021 12:00:00 AM	3/10/2021 12:00:00 AM	3/12/2021 12:00:00 AM	0	No Delay	0
Outer Wall 3	3/11/2021 12:00:00 AM	3/13/2021 12:00:00 AM	3/12/2021 12:00:00 AM	3/15/2021 12:00:00 AM	1	Contractor	0
Outer Wall 4	3/13/2021 12:00:00 AM	3/15/2021 12:00:00 AM	3/13/2021 12:00:00 AM	3/15/2021 12:00:00 AM	0	No Delay	0
Inner Wall 1	3/15/2021 12:00:00 AM	3/16/2021 12:00:00 AM	3/15/2021 12:00:00 AM	3/16/2021 12:00:00 AM	0	No Delay	0
Inner Wall 2	3/16/2021 12:00:00 AM	3/17/2021 12:00:00 AM	3/18/2021 12:00:00 AM	3/20/2021 12:00:00 AM	1	Employer	1
Main Door	3/8/2021 12:00:00 AM	3/9/2021 12:00:00 AM	3/12/2021 12:00:00 AM	3/13/2021 12:00:00 AM	0	No Delay	0
Room Door	3/16/2021 12:00:00 AM	3/17/2021 12:00:00 AM	3/16/2021 12:00:00 AM	3/18/2021 12:00:00 AM	1	Contractor	0
Window 1	3/17/2021 12:00:00 AM	3/18/2021 12:00:00 AM	3/18/2021 12:00:00 AM	3/19/2021 12:00:00 AM	0	No Delay	0
Window 2	3/17/2021 12:00:00 AM	3/18/2021 12:00:00 AM	3/19/2021 12:00:00 AM	3/21/2021 12:00:00 AM	1	Contractor	0

Figure 32: Printed Summary

In Figure 33, the complete backend dynamo script of EOT Summary is shown consisting of Print Setting, PDF Setting, Data, and PDF Printing sections. Figure 34 shows the detailed backend dynamo script which commences by prompting the user to select the print settings and fetching the data as per the selections made for columns to be displayed and formatting options. Figure 35 shows the detailed backed dynamo script setting the parameters to be converted to PDF and sorting information so it can be effectively shown as a printed PDF summary.

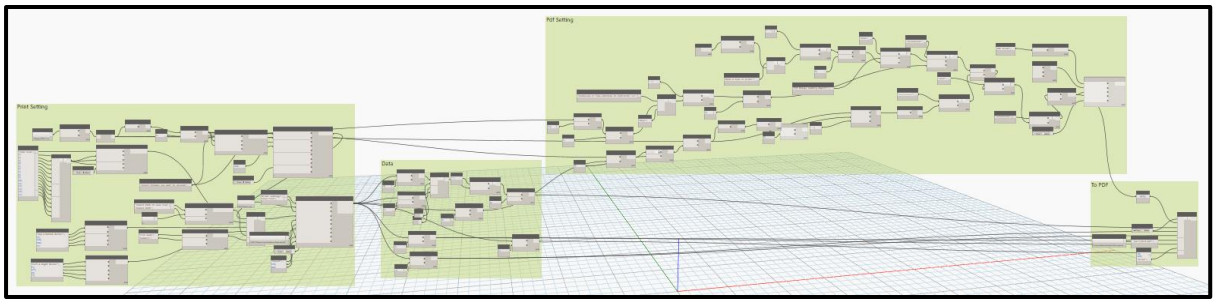

Figure 33: Summary, Complete Dynamo Script

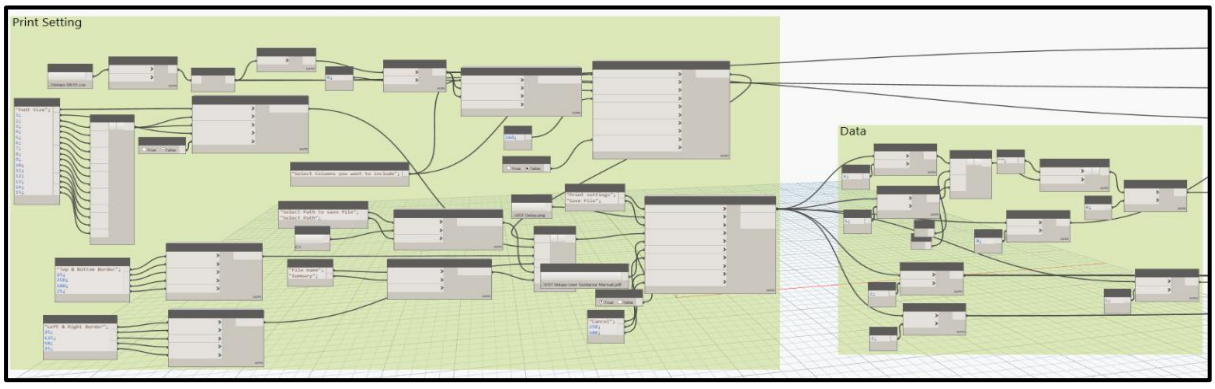

Figure 34: Summary, Dynamo Script-1

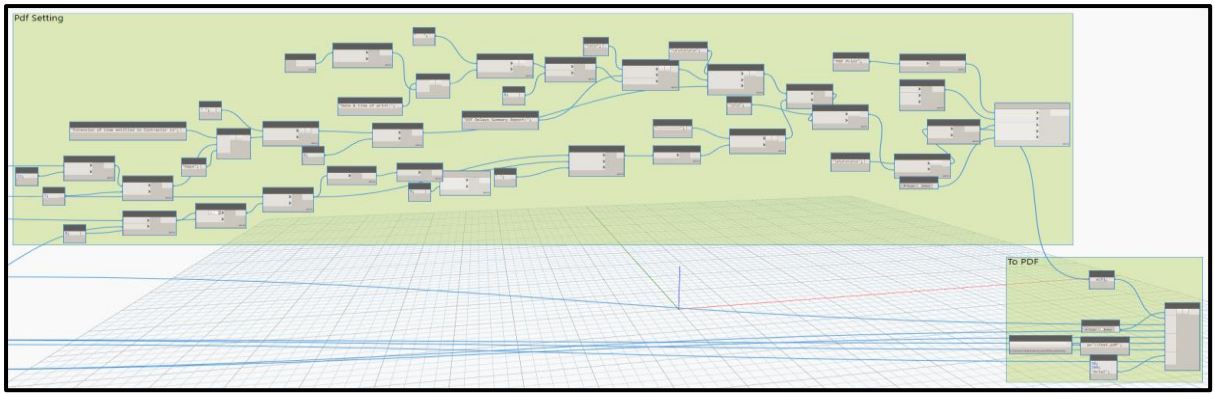

Figure 35: Summary, Dynamo Script-2

4.3.8. EOT Claim

The final step to automate claim generation is printing the PDF report of claim. Delays have been calculated and final entitlement of the contractor is found. The reports require additional information from the users as shown in Figure 36 in case the employer wants to validate the authenticity of the document and make the claim compliant to the conditions of contract.

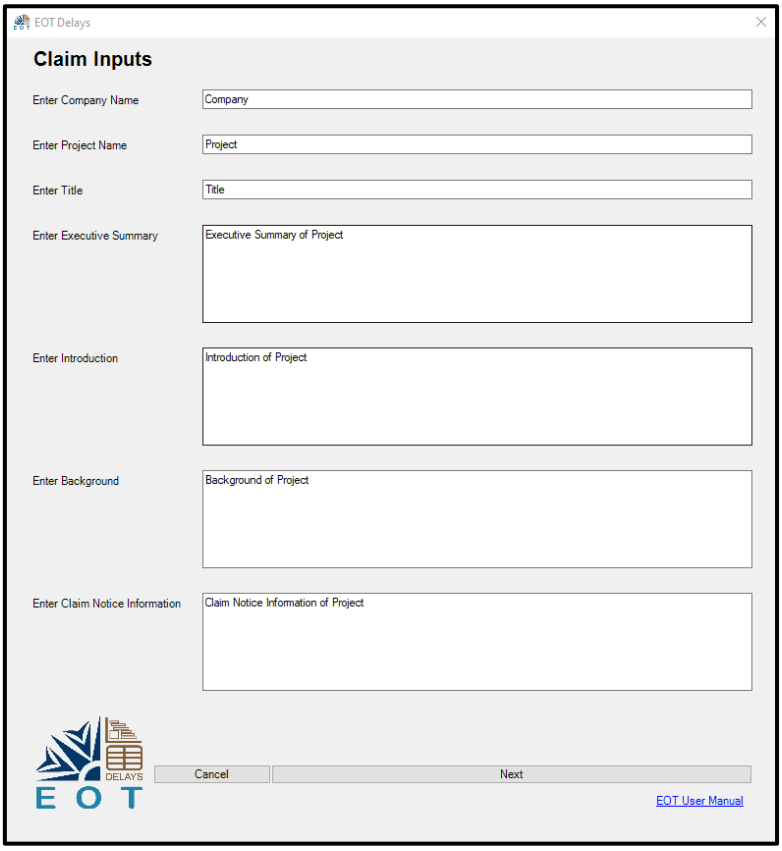

Figure 36: Claim Inputs

Data is accessed from database and print setting for EOT claim is prompted as shown in Figure 37. The columns of data selected in setting are printed in the EOT claim along with EOT entitled days to contractor and claim inputs by the user.

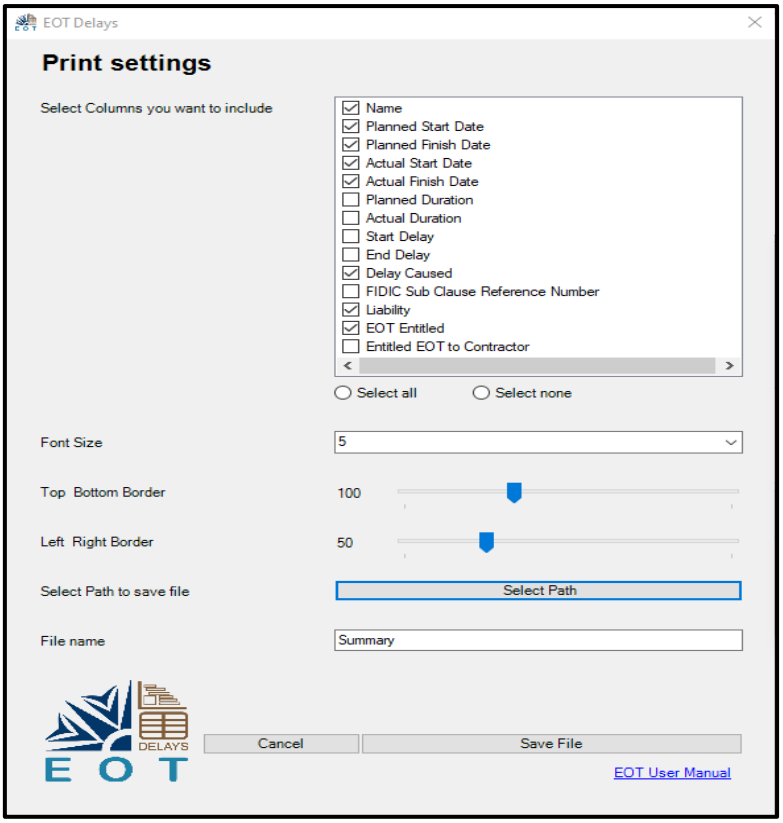

Figure 37: Print Setting for EOT Claim

In Figure 38, the complete backend dynamo script of EOT Claim Report is shown consisting of Settings, Input, Data, and Organize sections. The script commences by claim inputs being inputted by users and the inputs are organized in the desired order for the report. Simultaneously, column and format settings retrieve data from database to be printed in the report. These simultaneous scripts merge at PDF settings to produce an order for the report so it can be beneficial for the users.

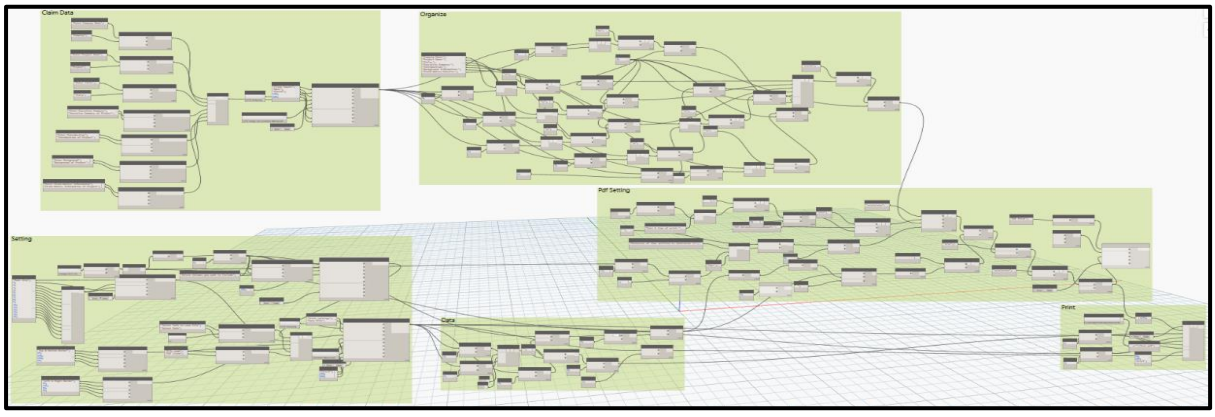

Figure 38: EOT Claim, Complete Dynamo Script

A sample printed EOT claim report is shown in Figure 39. It arranges the claim input data by user as per Figure 36 first covering Company Name, Project Name, Title, Executive Summary, Introduction, Background Information, and Claim Notice Details. Then it prints the details extracted from the delay calculations which are also shown in Summary report specifying the entitlement to the contractor.

Name ----------Planned Start Date ----------Planned Finish Date ----------Actual Start Date ----------Actual Finish Date

Floor ----------3/3/2021 12:00:00 AM ----------3/5/2021 12:00:00 AM ----------3/3/2021 12:00:00 AM ----------3/5/2021 12:00:00 AM

Outer Wall 1----------3/5/2021 12:00:00 AM ----------3/8/2021 12:00:00 AM ----------3/5/2021 12:00:00 AM ---------- 3/10/2021 12:00:00 AM

Outer Wall 2----------3/8/2021 12:00:00 AM ----------3/10/2021 12:00:00 AM----------3/10/2021 12:00:00 AM---------- 3/12/2021 12:00:00 AM

Outer Wall 3----------3/11/2021 12:00:00 AM----------3/13/2021 12:00:00 AM----------3/12/2021 12:00:00 AM---------- 3/15/2021 12:00:00 AM

Outer Wall 4----------3/13/2021 12:00:00 AM----------3/15/2021 12:00:00 AM----------3/13/2021 12:00:00 AM---------- 3/15/2021 12:00:00 AM

Inner Wall 1----------3/15/2021 12:00:00 AM----------3/16/2021 12:00:00 AM----------3/15/2021 12:00:00 AM---------- 3/16/2021 12:00:00 AM

Inner Wall 2----------3/16/2021 12:00:00 AM----------3/17/2021 12:00:00 AM----------3/18/2021 12:00:00 AM---------- 3/20/2021 12:00:00 AM

Main Door ----------3/8/2021 12:00:00 AM ----------3/9/2021 12:00:00 AM ----------3/12/2021 12:00:00 AM---------- 3/13/2021 12:00:00 AM

Room Door ----------3/16/2021 12:00:00 AM----------3/17/2021 12:00:00 AM----------3/16/2021 12:00:00 AM---------- 3/18/2021 12:00:00 AM

Window 1 ----------3/17/2021 12:00:00 AM----------3/18/2021 12:00:00 AM----------3/18/2021 12:00:00 AM---------- 3/19/2021 12:00:00 AM

Window 2 ----------3/17/2021 12:00:00 AM----------3/18/2021 12:00:00 AM----------3/19/2021 12:00:00 AM---------- 3/21/2021 12:00:00 AM

EOT Delays Summary Report:

Date & time of print: Saturday, 05 June 2021 00:00:00

Company Name:
NICE Contractors.

Project Name:
Extension of Time Claim Management System.

Title:
EOT Claim # 1 Narrative - EOT CMS.

Executive Summary:
The agreement between NUST PMO (The Employer) and NICE Contractors. (the Contractor) that was signed on 9th of Dec, 2019 for the grey structure and finishing works (common areas) of Pavilion 02 & 03 at Eighteen whereby the Contractor is responsible for executing and completing the Works and has a fundamental contractual obligation to complete the whole of the Works by 23rd of January 2021, 12 months after the Commencement Date of 22nd January 2020. This document comprises interim particulars of a claim for a thirty two (32) Days extension to the Time for Completion, resulting from delay event described in this document.

Introduction:
This document demonstrates the Contractor's entitlement to an extension of the Time for Completion and refers to the only event of lockdown due to 2019-nCOV pandemic which have caused complete suspension of works. Although it must be recognized that these are not the only events that have given cause for delay, they are, in the Contractor's opinion, the primary issues. The Contractor reserves the right to submit further claims referring to other events which have also given rise to delays. It must therefore be understood that this document is not exhaustive.

Background Information:
The General Conditions of Contract are the Conditions of Contract for Works of Civil Engineering Construction (Fourth Edition 1987) as prepared by the "Federation Internationale Des Ingenieurs-Conseils (FIDIC) and amended by
Conditions of Particular Application.
Clauses of the "Conditions of Particular Application" take precedence over the clauses of the "General Conditions of Contract".

Claim Notice Details:
In accordance with Conditions of Contract, the Contractor has repeatedly advised the Engineer that various events have caused serious delay and disruption to the progress of the Works, resulting in a major impact to the Time for Completion. The project records contain numerous examples of such notification letters.

Extension of time entitled to Contractor is 3 Days

Figure 39: EOT Claim Report

4.4. Testing and Evaluation

The EOT Claim Management System was evaluated by industry's experts against the parameters as shown in Table 4. They showed a promising response towards the "usability" of the system in the construction sector. The use of this system does not create problems for its users. Although, the scores given for "implementation" were low due to change avoidance by the users and lack of expertise in developing BIM models.

The scores on "visualization" and "effectiveness to improve processes" showed the developed system has a potential to be used in the industry due to its novel benefits and system improvement.

Table 4: Industry Feedback Response Results

S. No.	Evaluation Criteria	Minimum	Maximum	Mean Score
1	Need in Construction Industry	4	5	4.2
2	Implementation	3	4	3.4
3	Effectiveness to Improve Process	3	5	4.0
4	Interface Usability	4	5	4.4
5	Visualization	5	5	5.0

4.5. Discussion

4.5.1. EOT Claim Automation and Visualization using BIM

Using Revit as a resource software for the plugin, it provides a collaborative platform to utilize operational features of associated applications. EOT claims were conveniently visualized in Revit. Professionals in the construction industry being familiar with Revit or Revit-like software would easily adapt to the claim automation and visualization environment.

A major limitation of documented claims was understanding the cause and effect of delays which has been addressed using the EOT Plugin environment. It creates a bridge between previous, current, and future practices to adopt easily in the era of virtual and augmented reality.

4.5.2. Dynamo as a Tool of Integrating Self-Made Frameworks in BIM

Dynamo is a versatile visual programming language that make use of specific nodes to perform certain tasks. It also provides flexibility to write custom nodes using python programming language. External dynamo packages are also radially available to be used as per requirements. The plugin uses many external packages such as Archilab, Datashapes, Rhythm, Clockwork, Genius loci, and Logic Dynamics. In addition to this custom dynamo node to print pdfs of summary and EOT Claim were also written.

There is limitation of dynamo to pass data from one dynamo file to another dynamo file. The problem further become intense as there in no database management system of dynamo. External permanent database in CSV format is used in plugin. For real time updated database SQL could be used.

4.5.3. Plugin Utility for Professionals

Plugin is developed keeping in mind to be used on any model under versatile conditions. Several possible conditions of contracts and real-life situations were taken care for during algorithm design of plugin. Plugin is developed from contractor's point of view assigning force majeure to employer's liability thus giving full entitlement to contractor in this case.

The Plugin is tested on academic level on several models generating satisfactory results. Industrial evaluation of plugin was a dream to carry out in CoVID situation. The product will help contractor in managing their EOT claims and visualization of project delays. Delay visualization of ongoing project would help contractors to come up with counter strategies to bring project back on track and much more.

CHAPTER-5

5. CONCLUSION AND RECOMMENDATIONS

Literature from previous research was analysed and this project realizes proposed research frameworks by producing a working plugin. The plugin will advantage professionals in the construction industry to document delays and take necessary action based on the visual aid provided to understand the extent of delay.

Since the plugin comprises of multiple process flows, it provides convenience for future developments and system support for the system. Independent workflows provide easy manoeuvrability for the developer. When the system runs, it stores and saves data in real-time and provide the user with convenience.

The project brings the following benefits to the users: (1) Aids in EOT claim generation; (2) Visualizes the extent of delay; (3) Caters for 4D constraints to identify source of delay; (4) Assist the user to develop future strategies to mitigate the delays; and (5) Keep a record of delay with resource availability to support claim settlements.

The plugin being developed in Dynamo is restricted by predefined command nodes that form the process flow for generating claims. Using object-oriented programming languages such as Python, C++ or C# can be used to expand the applicability to automate delays. The potential of BIM and 4D modelling can be further explored using Autodesk Navisworks which creates a self-dependent environment which does not require third party software to complete the plugin process.

Further recommendations include using Artificial Intelligence, where delays can be assessed against Particular Conditions of Contract; and incorporating claims data obtained from multiple projects to assist the user in developing Mitigation and Contingency Plans to avoid delays in future projects. Similar frameworks can be used in other Delay Analysis Techniques and Employers concerns can be addressed which in terms of delays mean Liquidated Damages.

REFERENCES

1. AzmiBakhary, N., HamimahAdnan, & AzmiIbrahim. (2015). A Study of Construction Claim Management Problems in Malaysia.
2. Bunni, N. G. (n.d.). *The FIDIC forms of Contract.*
3. Chovichien, A., & Tochaiwat, K. (2006). Information System for Managing Employer's Construction Claims. *Technology and Innovation for Sustainable Development Conference* .
4. Construction, M. (2013). National BIM Standard – United States. *3*.
5. DinoBouchlaghem, AbdulkadirGanah, JenniferWhyte, & HuipingShang. (2005). Visualisation in architecture, engineering and construction (AEC).
6. E. Palaneeswaran, M. K. (2008). *Kumaraswamy, An integrated decision support system for dealing with time extension entitlements.*
7. EkambaramPalaneeswaran, & M.Kumaraswamy, M. (2008). An integrated decision support system for dealing with time extension entitlements.
8. El-Adaway, I., Fawzy, S., Ahmed, M., & White, R. (n.d.). Administering Extension of Time under National and International Standard Forms of Contracts: A Contractor's Perspective. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, 8*(2).
9. El-Samadony, A., Tantawy, M., & Atta, M. M. (2020, November 1221). Developing Framework to Optimize the Preparation of (EOT) Claims Using Integration of (LPS) and (BIM) Techniques in Construction Projects. *Journal of Engineering Sciences, Assiut University, Faculty of Engineering, 48*(6), 1196.
10. Farooqui, R. U., & Ahmed, S. M. (2008). Assessment of Pakistani Construction Industry – Current Performance and the Way Forward. *Journal for the Advancement of Performance Information and Value, 1*(1), 51.
11. Ghaffarianhoseini, A., Tookey, J., Ghaffarianhoseini, A., Naismith, N., Azhar, S., Efimova, O., & Raahemifar, K. (2017). Building Information Modelling (BIM) uptake: Clear benefits, understanding its implementation, risks and challenges. *Renewable and Sustainable Energy Reviews, 75*, 1046-1053.
12. Infrastructure and Cities for Economic Development (ICED). (2018, 8 29). *Construction Sector Employment in Low-Income Countries: Size of the Sector*. Retrieved 5 22, 2021, from http://icedfacility.org/: http://icedfacility.org/wp-content/uploads/2018/08/ICED_Evidence_Construction-sector-employment-in-LICs-Size-of-the-sector.pdf
13. J. Yates, A. E. (2006). *Epstein, Avoiding and minimizing construction delay claim disputes in relational contracting.*
14. Keane, P. J., & Caletka, A. (2008). Delay Analysis in Construction Contracts.

15. Kongkoon Tochaiwat, A. C. (n.d.). Information System for Managing Employer's Construction Claims.

16. Kraatz, J. A., Hampson, K. D., & Sanchez, A. (2014, 09). R&D investment and impact in the global construction industry. *Buildings, 4*, 453-466.

17. L. Yoke-Lian, S. H.-L. (2012). *The assessment of applications for extension of time claims in Malaysian construction industry.* International Journal of Engineering and Technology.

18. Liu, Y., Sander, v. N., & Marcel, H. (2017). Understanding effects of BIM on collaborative design and. *International Journal of Project Management, 35*(4), 686-698.

19. M.Kumaraswamy, M., & EkambaramPalaneeswaran. (2008). An integrated decision support system for dealing with time extension entitlements.

20. Marzouk, M. O. (2008). *Using BIM to identify claims early in the construction industry: Case study.* Journal of Legal Affairs and Dispute Resolution in Engineering and Construction.

21. Masood, R., K., M.K.N., N., & A., R. (77). Is BIM Adoption Advantageous for Construction Industry of . *Procedia Engineering*, 229-238.

22. Murray, M., & Carmichael, S. (2007). Record keeping for contemporaneous delay analysis: a model for effective event management.

23. National Institute of Building Sciences. (n.d.). Terms and Definitions. *National BIM Standard - United States, 3*(1), 3-38.

24. Ren, Z., Anumba, C., & Ugwu, O. (2003). Multiagent system for construction claims negotiation .

25. Shahhosseini, V., & Hajarolasvadi, H. . (2018). *A conceptual framework for developing a BIM-enabled claim management system.*

26. Shami, K. A. (February 2018). Investigating the use Building Information Modeling (BIM) . *PM World.*

27. Trauner Jr., T. J. (2009). *Construction Delay: Understanding them clearly, analyzing them correctly* (Second ed.).

28. W. Vidogah, I. N. (1997). *Improving management of claims: contractors' perspective.*

29. Wahab, M. A., & Vogl, B. (2011, June). Trends of Productivity Growth in the Construction Industry across Europe, US and Japan. *Construction Management and Economics, 29*(6), 635-644.

30. Yoke-Lian, L., Hassim, S., Muniandy, R., & Mee-Ling, T. (2012). The Assessment of Applications for Extension of Time Claims in Malaysian Construction Industry.

31. Yusuwan, N. M., & Adnan, H. (n.d.). Issues Associated with Extension of Time (EoT) Claim in Malaysian Construction Industry. *Procedia Technology, 9*, 740-749.

32. Z. Ren, C. A. (2003). *Multiagent system for construction claims negotiation.*

33. Zolotova, J., Vatin, N., Tuchkevich, E., & Rechinsky, A. (2015). Autodesk Revit - Key To Successful Training Of Highly Qualified Civil Engineers. *Applied Mechanics and Materials*, 1617-1625. doi:10.4028/www.scientific.net/AMM.725-726.1617