Analysis of Delay Causes Using BIM

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Abstract: Delay in the field of the construction industry is an inevitable problem with the many project activities, which may have reached me thousands of activities related to the supply of materials and the adoption of engineering drawings, which may lead to bleeding the scope of work first and then disputes and most of them lead to arbitration and not satisfy the stakeholders, so it was necessary to review the literature for study and analysis Reasons for the delay, and analysis delay by linking them to new technology, which is the BIM, for the construction industry to study its delays impact on the life of the project and to protect stakeholders from losing the scope of work by dealing with it in a proactive way to avoid its impact on the causes of delay during construction. A literature review was conducted to compile a list of most delay causes firstly and degree impact of using BIM to analyze delay that was structured questionnaire. The resulting list of delay causes was selected to a questionnaire survey and application Model selected to take into consideration of the most important causes of delay, The overall results indicated that by using BIM technology during construction it reduces the effect of delay project and scope creep by Study project case, and review of effects BIM on delay causes it was established by literature and interviews. Results' analyses suggest that to significantly avoiding delay causes and its analysis a joint effort based on coordination with all parties and using BIM technology for delay analysis reports during the project life cycle, furthermore, the causes of project delay were discussed based most of the overall projects in the construction industry.

Introduction

Delays in the Construction Projects are the major source for a greater degree of risk and dissatisfaction stakeholder in relation to cause a delay. One way to minimize the effect of these delays during progress activities at the site is handling them through detailed reports of building elements during implementation in a proactive manner, to achieve project scope success. During the execution of a project, procedures for project control reports and delay analysis for any element in the project become indispensable tools to managers and other participants in the construction process and control the cash flow. These tools serve the dual purpose of recording the performance of projects that occur as well as giving managers an indication of the progress and delay analysis associated with a project. The task of project control systems is to give a fair indication of the existence and such problems and quantities of these problems. This research presents a building information modeling (BIM) based delay analysis. List of construction delay causes retrieved from literature. The feedback of construction experts was obtained through literature and questionnaire.

- A questionnaire survey was prepared. The questionnaire survey was distributed to one fifty construction experts who represent owners, consultants, and contractor's organizations.
- The research methodology is displayed to show how to application Analysis of Delay causes by using BIM to mitigation these delays. Afterward, a case study is presented to demonstrate for model how the proposed framework can be applied on and produce the required result.
- A Delay analysis report is generated showing actual and potential delays, their causes, evaluation, and recommendations to control their consequences.

One of the main objectives of delay analysis by using BIM is the establishment of a factual matrix and a chronology of the events which actually delayed the project's completion date, delays are a common occurrence in projects. When They arise, they need to be evaluated and analysis quickly and managed efficiently. However, the whole topic of delay analysis and various analytical Techniques available is one which provokes much debate and controversy, the effect of delay and disruption can be identified and assessed using several dissimilar techniques. Provided on these techniques. To minimize the effect of these delays are handling them in a proactive manner and view delays. The purpose of this research is to serve as a Practical, available, and easy to select the causes with analysis is one which provokes much debate and controversy due to the seemingly complex and sometimes conflicting guidance provided on these techniques. To minimize the effect of these delays is handling them in a proactive manner and view delays. The purpose of this research is to serve as a practical guide to control the process of delay during the project life cycle, Time for the performance of a project is usually a particularly important consideration for the consultant, owner, and the contractor. Often, the most troublesome construction delays involve failure to complete the work promptly. No assessing the impact of delay and method of analysis is sometimes a contentious issue. Delay analyses are a very effective way to save creep money and divert management resources from running to an effective one. Resolution by way of a mutually acceptable extension of time should be sought at the earliest opportunity to avoid the dispute stepping up to the next, more formal process. Including information available, time of analysis. The identification and assessment of delay entitlement can be difficult and time-consuming. When any degree of complexity is introduced to the mix, it can become particularly difficult for project staff who are often overworked dealing with site issues, project materials delivery, and submittals required, and who may also be untrained in forensic analysis or programming skills. This often manifests itself as a poor strike rate in achieving delay analysis during construction by contractors. When the employer's team lacks these skills and awareness, the risk is created by granting inadequate delay analysis to contractors. To be successful, a delay analysis according to causes of delay selected and Major issues with risk should adequately establish causation and liability and assist in demonstrating the extent of time- related damages or disruption costs experienced as a direct and indirect result of the delay events relied upon. The purpose of delay analysis is to satisfy the delay causes in such a way that it can be used to select the delay analysis and account for the resulting damages.

Causes of Delay in Literature

Definition of Delay in most industry construction

In the study of David Arditi (2006) construction delay was defined as "Delays in construction can cause a number of changes in a project such as late completion, lost productivity, acceleration, increased costs, and contract termination." Delay was also defined as a "Time for performance of a project is usually a particularly important consideration for the owner and the contractor. Often, the most troublesome construction disputes involve delays and failure to complete the work in a timely manner" by Zaki M. Kraiem, (1987).

Methods of Delay Analysis

Capabilities of the methodology, and Time, funds, and effort allocated to the analysis. The paper reviews research studies that discuss various aspects of delay analysis methods how can use it methods for delay analysis and summarizes the advantages BIM of widely used delay analysis methods, including the as-planned vs. as-built, impact as-planned, collapsed as-built, and time impact analysis methods. The paper starts out with a brief description of the universally accepted delay analysis methods and discusses the issues involved in delay analysis after using BIM. A number of factors may influence the result of delay analysis like the time specified in contract clauses regardless of which delay analysis method is used, include concurrent delays that change during projects life cycle progress, float ownership, theories of the critical path, and scheduling software options.

SABAH ALKASS. 1995. The analysis itself is usually complex and can be aided by a computerized approach.

Nuhu Braimah 2013. The time for performance of a project is usually of the essence to the employer and the contractor. This has made it quite imperative for contracting parties to analyses project delays for purposes of making right decisions on potential time and/or cost.
There are four methods often mentioned in the construction literature that are professionally acceptable. They include (1) the as-planned vs. as-built schedule analysis method, (2) the impact as-planned schedule analysis method, (3) the collapsed as-built schedule analysis method, and (4) the time impact analysis method. They are sometimes referred.

The as-planned vs. as-built method is the observation of the difference between an as-planned schedule and an as built schedule. The method identifies the as-built critical activities, compares these activities with the activities on the as-planned schedule, assesses the impact of delays on the project, identifies the sequences which actually define the duration of the project, and determines the causation and responsibility of delays that impact project completion.

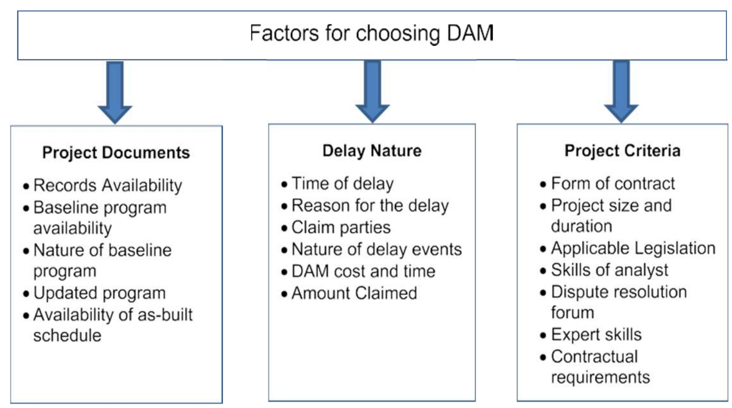
The impact as-planned method uses only an as-planned or baseline schedule for delay analysis. It is based on the theory that the earliest date by which a project is completed can be determined by adding the delays into the as-planned schedule. New activities that represent delays, disruptions, and suspensions are added to the as-planned schedule and are used to demonstrate the reason why the project was completed later than planned. Contractors who submit claims that involve A time extension, add only owner caused delays to the as-planned schedule in the appropriate sequence to document the total project delay caused by the Owner.

The collapsed as-built method is also referred to as the ‘‘but-for’’ schedule method. This analysis is popular in claim presentations because it is easily understood by triers of fact. SCL defines it as a method where the effects of delays are ‘‘subtracted’’ from an as-built schedule to determine what would have occurred but for those Events.

The time impact method relies on the assumption that delay impacts to a project can be assessed by running a series of analyses on schedule updates. Time impact analysis is a procedure that uses CPM principles. It assesses delays_ effects on the project schedule by analyzing the schedule periodically, generally on a day-by-day basis. Window analysis, a variation of time impact analysis, uses weekly or monthly updates to perform the analysis. Delay events are inserted into the schedule and delay impacts are accumulated
Every time the schedule is recalculated.

Figure: 01 Factors for choosing delay analysis methods

Mohamed M. Marzouk 2018



Research Objectives and Scope

The primary objective of this paper is to analyze the delay relationships between delay causes and their impacts on time performance in projects by studying the BIM analysis to construction delays characterized by. Delay analysis in this paper is first developed at an activity level (over critical and non- critical activities) and then at a project level.

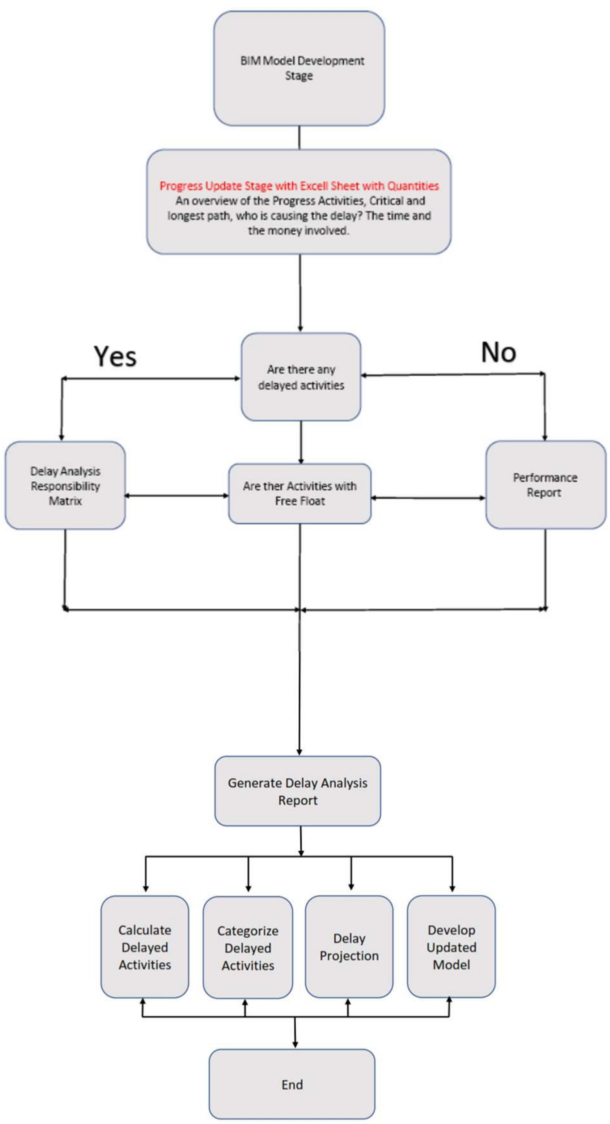
Research Methodology

These indicators in reports methodology proposal are aggregated to obtain information at the project level. From On-stakeholders data collection for this analysis was exhaustive and involved gathering a large amount of empirical evidence from the case study project.

The research methodology consisted of five stages, as follows:

- Topic Identification.
- Literature Review.
- Questionnaire Survey
- Data Analysis
- Case study (Result's Validation).
- Conclusions.

Figure.02 shows the exact research methodology adopted for this research.



International Studies

Several articles have discussed causes of delay and effect of BIM in construction projects in numerous manners: some studies identified the main causes of delay in several countries and various project types, while other studies discussed the delay analysis methods and the proposed ways to mitigate it. Nine studies were incorporated in this study to compile a list of delay causes. The study of David-John Gibbs, (2013) was carried out to determine the causes of delay in the construction and the potential to exploit aspects of BIM in UK. The next study was by Essa Alenazi, Zulfikar Adamu (2017) which investigated the educe delays in construction projects through building information modelling (BIM) in- KSA, Ayman Hamdy Nassar (2016) the effect of utilizing Building Information Modeling technology in construction projects on reducing or avoiding the different causes of construction claims in Egypt, Mohamed M. Marzouk (2018) One way to minimize the effect of these claims is handling them in a proactive manner; this allows the project parties to foresee the potential claims and take necessary measures to avoid them in Egypt, Pablo González1; Vicente González (2016) analyzes delay causes in activities that were not completed as scheduled. The paper contributes to a methodology to examine the qualitative (delay causes) and quantitative (time performance) dimensions of the delay issue in USA, Zaki M. Kraiem (1987) presents a tool to aid in analysis of delay claims. The procedure set forth will handle delays and accelerations and will help in determination of the as-adjusted schedule in USA, Thailand. Ahmed et al. (2003) carried out a study to identify the major causes of delays in building construc- tion in Florida, then allocated the responsibilities and types of delays for each cause. Regarding commercial construction projects, Choudhury and Phatak (2004) studied the causes that affect time overrun, Djoen San Santoso (1987) analyzes the delay factors in road construction projects in Cambodia and their effects on project time, cost in Thailand.

It was noted that the Mohamed Marzouk1. (2018) the study has Using BIM to Identify Claims Early in the Construction Industry, and was not study being within using BIM to Delay Analysis. Therefore, the causes stated in the Mohamed Marzouk1. (2018) study were considered as datum, while Ayman Hamdy Nassar causes in the other studies were compared against it to build a more comprehensive list of delay Analysis, Moreover, Assaf et al. (1995) had grouped the delay causes into nine major groups: financing, materials, contractual relationships, changes, government relations, manpower, scheduling and control, equip- ment, and environment. It was decided to use the same technics by BIM while changing the "Methodology by programming" description to be "Analysis of Delay" to give a wider view of the analysis of delay causes shown in other studies. The compiled list analysis of delay causes contained a total of causes and are available in the Appendix.

Expert Interviews

The main objective of these interviews was to deliver a list Analysis for delay causes, this was achieved by two additional inter- views that confirmed the outcomes of the Questionnaire and reflected saturation. A varied sample was sought that included experts from contracting, consulting, and academic backgrounds, each with a minimum experience of 15 years in construction and excellent knowledge of project management.

Finally, the main causes of delay discussed, were com- pared to the list obtained in this research and no additional causes could be identified. The format of the interviews was semi structured to have set questions and allow probing when necessary. The factors com- piled from the literature review.

Table 1. Distribution of Survey Participants

Participant organization	Participant position						Total
	Project/ Manager	Designer	BIM Position	Site engineer	Other	Coordinator	
Contractor	10	2	1	4	11	2	30
30Consultant	5	2	0	2	2	1	12
Owner	2	2	0	1	1	—	6
Total	17	6	2	7	14	3	50

Questionnaire and Degree of Importance Calculation

A questionnaire survey was conducted to quantitatively confirm the list of causes obtained from the Literature, Interviews and identify the most important causes of delay. The questionnaire was divided into two parts: Part 1—participant's personal information (e.g., contact information, age, position, and experience, Working by BIM?, are you used BIM before to prove Delays in your project?); and Part 2—project information (e.g., measurement of the importance of the causes of delay). The 49 causes of delay were grouped ac- cording to responsibility (contractor, consultant, owner, and com-

Results Analysis

Analysis of Overall Results

To provide a degree of importance for each delay cause, an im- portance index was calculated, in a manner similar to that in Assaf et al. (1995), as shown in Eq. (1)

$$I = \sum_{i=1}^{4} \frac{a_i \times x_i}{3} \qquad (1)$$

where I=importance index; a_i=weight of the ith response; x_i = frequency of the ith response; and i = response category index.

A response of "very important" was given a weight of re- sponse 3, "important" was given a weight of 2, "somewhat im- portant" was given a weight of 1, and "not important" a weight of

0. For example, if 100 responses were received of which for a certain delay cause: 20 responded by "very important"; 65 re- sponded by "important," ten responded by "somewhat important," and five responded by "not important," then the importance index for this delay cause would be calculated as shown in Eq. (2)

Data analysis

Data analysis involved analyzing all the data collected from the responses of the questionnaire survey, to achieve the required results of this research study. The results are presented in the form of written explanation and description, percentages, tables, and charts. Graphical representations are used because they have the ability to make the results better understandable and clearer. Also, for better demonstration and presentation of the results, the construction delay causes are classified into different groups according to the identified trends of the results in each section of the questionnaire.

$$I = \frac{20*3+ 65*2+ 10*1+ 5*0}{3} = 66.67 \qquad (2)$$

The importance indices were calculated for all delay causes and the delay causes were ranked accordingly. Table 2 shows the ranked delay causes, and their corresponding importance index. The most important causes identified by the survey, and based on overall results, were: Delay in approving shop drawings and sample materials

In order to identify how project delay analysis , it is important to identify the responsible party. Therefore, the respon- sibility of the delay causes is illustrated in the responsibility col- umn of Table 2. Within the ten most important causes, three of the causes were under the contractor's responsibility, three under the owner's responsibility, three under common responsibility, and only one cause under the consultant's responsibility. It can be concluded that the most important delay causes have mixed re- sponsibility, and no single party is responsible for delay.

Table 2. Importance Index for Overall Results

Rank	Delay cause	Importance Index	Responsibility
1	Delay in approving shop drawings and sample materials	26.67	Consultant
2	Delay in material delivery	26.67	Common
3	Unavailability of utilities in site or Delay in providing services from utilities such as (water, etc.)	26.67	Common
4	Weather effect (hot, rain, etc.)	26.67	Common
5	Payments Delay	25.00	Owner
6	Variation orders/changes of scope by owner during construction	25.00	Owner
7	Late in revising and approving design documents by owner	25.00	Owner
8	Quality assurance/control	25.00	Consultant
9	Unclear and inadequate details in drawings	25.00	Consultant
10	Mistakes and discrepancies in design documents	25.00	Consultant
11	Difficulties in financing project by contractor	25.00	Contractor
12	Poor site management and supervision	25.00	Contractor
13	Delay in preparation of shop drawings and material samples	25.00	Contractor
14	Changes in material types and specifications during construction	25.00	Common
15	Shortage of labors	25.00	Common
16	Unqualified workforce	25.00	Common
17	Low productivity level of labors	25.00	Common
18	Traffic control and restriction at job site	25.00	Common
19	Slow permit by government/municipality	25.00	Common
20	Slow decision making	23.33	Owner
21	Delay in finance and payments of completed work by owner	23.33	Owner
22	Inadequate experience of consultant	23.33	Consultant
23	Delays in sub-contractors work	23.33	Contractor
24	Poor in technical engineer	23.33	Contractor
25	Shortage of construction materials in market	23.33	Common
26	Equipment availability and failure	23.33	Common
27	Changes in government regulations and laws	23.33	Common
28	Delay in performing final inspection and certification by a third party	23.33	Common
29	Lack of communication between the parties	23.33	Common
30	Fluctuations in cost/ currency	23.33	Common
31	Suspension of work	21.67	Owner
32	Unrealistic contract duration	21.67	Owner
33	Ineffective delay penalties	21.67	Owner
34	Inadequate contractor experience	21.67	Contractor
35	Ineffective planning and scheduling of project	21.67	Contractor
36	Rework due to errors during construction	21.67	Contractor
37	Problem with neighbors	21.67	Common
38	Force Majeure as war, revolution, riot, strike, and earthquake, etc.	21.67	Common
39	Effects of subsurface conditions (e.g., soil, high water table, etc.)	16.00	Common
40	Type of project bidding and award (negotiation, lowest bidder)	14.00	Owner
41	Delay in site mobilization	14.00	Contractor
42	Environmental restrictions	14.00	Common
43	Delay to furnish and deliver the site to the contractor	13.00	Owner
44	Owner interference	13.00	Owner
45	Accident during construction	13.00	Common

Analysis of Results

This section presents the results of the research which is obtained from the data analysis of the questionnaire survey done. The results are divided into four sections according to the four different sections of the designed questionnaire.

A. Respondents Profiles

A total of 50 participants completely answered the questionnaire, e.g. stating that Force Majeure occurs very frequently or answering that using BIM technology has a very low effect on reducing errors in design drawings and plans. While the other 6 responses were omitted due to that their respondents stated that they have a low or very low experience or awareness about BIM technology. Thus 50 responses were used for the analysis of the questionnaire results.

1. Years of Experience

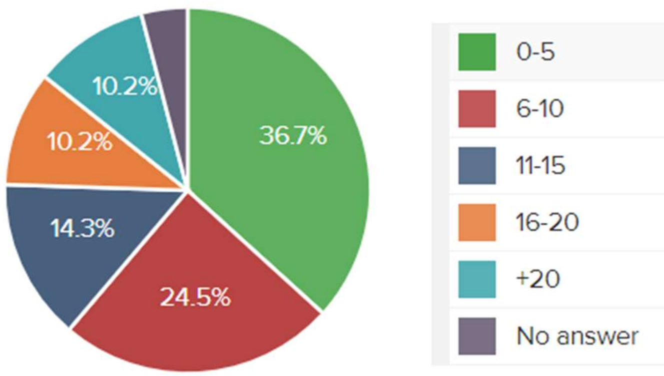


Fig.1 *Respondents years of experience percentages*

Majority of the respondents in this study had working experience between 0-5 years and 6-10 years with 36.7% each. Respondents with working experience ranging from 11-15 years and 16-20 years formed 14.30% and 10.20% respectively, while 10.20% of the respondents had working experience more than 20 years.

2. Type of Working Organization

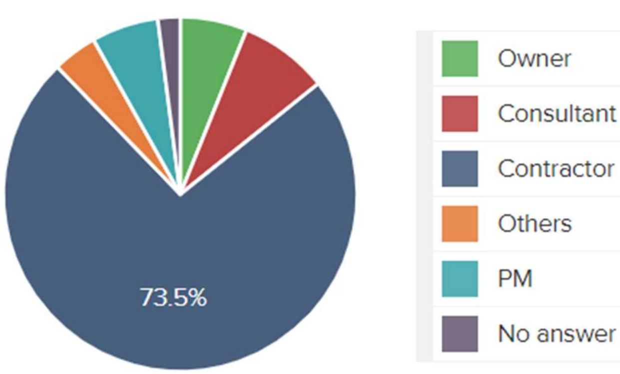


Fig.2 *Respondents working organization type percentages*

Regarding the respondents' working organization types majority of them work in a consultant or a contractor organization forming 81.70% each. 6.10% and 4.10% of the respondents works at an Owner or Project Manager organization respectively, while the rest of the respondents (8.10%) stated that they work in other different types of organizations than those mentioned above.

3. Current Working Positions

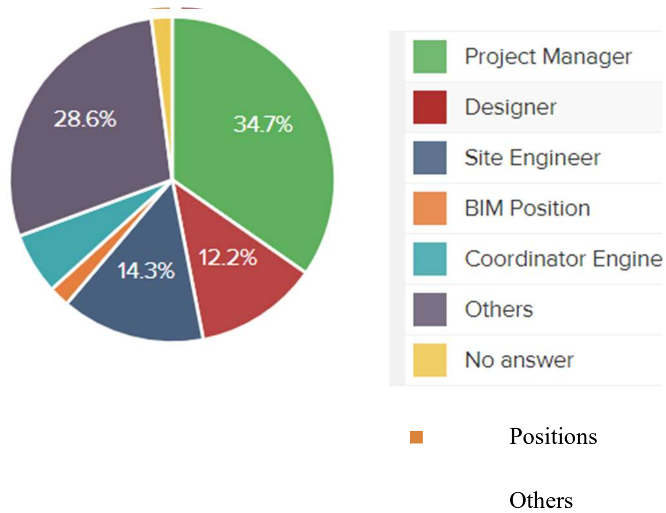


Fig.3 *Respondents current working positions percentages*

Results of respondents' current working positions showed that, Project Managers who participated in the questionnaire formed 34.70%, Designers and Site Engineers formed 12.20% and 14.3% respectively, while majority of the respondents (8.10%) work in positions related directly to BIM technology, for example BIM coordinator, BIM consultant, BIM manager, etc.. However, 30.60% of the participants work in other positions than those mentioned above.

4. Respondents Delay Causes and BIM Knowledge

This section of the questionnaire was very important to make sure that participants who take part in the questionnaire survey and whose responses will be part of the analyzed results must have good experience and awareness about Delay causes and BIM technology, thus increase the accuracy of the obtained results and give the research results great trust. To achieve this, respondents were to answer two questions as follows.

Effect of BIM on construction Delay analysis

Participants in this question based on their knowledge and experience were requested to rate the effect of BIM technology on delay analysis each of the highly Importance construction causes of delay mentioned before in the previous section. The ratings choices given started from very high effect and up to very low effect.

Looking at the analyzed results of this section, it was easily noticed that using BIM technology in a certain project will have a high or moderate effect on acceleration certain delay analysis, while some other causes of construction delays will not be reduced or avoided if BIM was utilized, or will be reduced at a very low level. So for better presentation and understanding of the results, the 10 different causes of construction delays could be categorized into 3 groups according to the effect of BIM on each cause. Causes that majority of respondents stated that BIM will have a very high or high effect on reducing or avoiding them, will be grouped at the ―Highly effected by BIM‖ group. While causes that majority of respondents stated that BIM will have a moderate effect on reducing or avoiding them, will be grouped at the ―Moderately effected by BIM‖ group. Construction claims causes that majority of respondents stated that BIM have a low or very low effect on reducing or avoiding them, will be grouped at the ― Lowly effected by BIM‖ group. Results in Table.4, presents the 10 causes of construction claims divided and categorized into the 3 groups mentioned above, along with the majority percentage of each cause.

Highly effected by BIM	**Majority Percentage**
Delay in approving shop drawings and sample materials	66%
Variation orders/changes of scope by owner during construction	90%
Unclear and inadequate details in drawings	95%
Poor planning and scheduling	79%
Delay in preparation of shop drawings and material samples	96%
Moderately effected by BIM	
Delay in material delivery	46%
Unrealistic contract duration	51%
Type of project bidding and award (negotiation, lowest bidder)	44%
Lowly effected by BIM	
Accident during construction	60%
Inadequate experience of consultant	75%
Unexpected increase in material prices	95%
Payments delay	56%
Force Majeure	95%
Low productivity level of labors	73%

Table.4 *Construction claims causes categorized by BIM effect*

It was very important also to understand, whether using BIM is more effective in Acceleration of delay analysis in large complex projects than that in small simple projects, or it is that using BIM would reduce causes of delay in all types of projects by the same size or degree. Thus participants were asked to rate the effectiveness of BIM technology in reducing causes of delay on complicated projects, normal projects, and simple projects according to given rating choices, that started from very high effect and up to very low effect. Respondents' results of this part stated that BIM technology has a better effect on acceleration of delay analysis and reducing causes of delay in complicated large projects than that on normal or simple projects.

Also normal projects are better affected by BIM technology on delay analysis than simple projects. This could be better understood looking at the percentage of responses to each choice. As for complicated projects 72% forming majority of the respondents stated a very high effect and 25% stated a high effect. While moderate effect was chosen by 3% of the participants only, and no responses were received at all regarding low or very low effect. Results percentages for normal projects showed that BIM also have a high effect on reducing claims in normal projects, but with a less degree than that in complicated large projects, as very high effect choice was chosen by 18%, while 64% chose high effect option. 18% of the participants also stated that BIM reduces claims at a moderate level in normal projects, while zero respondents chose low or very low effect choices. Results further stated that utilizing BIM reduces claims in simple projects too, but at a moderate level, as majority of the respondents (40%) stated that, unlike large complex project. However, 20% and 9% of the participants chose low and very low effect choices respectively, while very high and high effect choices were chosen only by 13% and 18% of the respondents respectively.

I. Case Study