The Effect Of Building Information Modeling (BIM) On Construction Claims

Ahmed N. El Hawary, Ayman H. Nassar

Abstract: The complexity of construction projects is increasing by time all over the world. The higher the level of complexity in a construction project, the higher possibility problems may occur, which may have different negative effects on the project's time, cost, and quality. These problems could result into construction claims being made by one of the project's parties. Today, claims are a very common occurring issue in construction projects than any other previous time, and they are considered to be the most disruptive event of any project. Thus there has been always a great demand for finding new methods and techniques to minimize and prevent construction claims. Building Information Modeling (BIM) is a relative new technology that is widely getting accepted in the construction sector, which has been having a very important role on improving different areas of construction management in which claims are a part of. This paper researches the effect of utilizing Building Information Modeling technology in construction projects on reducing or avoiding the different causes of construction claims through a questionnaire survey that was developed. The developed survey also investigated the occurrence frequency of different claim causes, and there level of contribution in creating construction claims. The effect of BIM on reducing claims was also assessed considering the project's complexity level. The obtained results showed that using BIM technology in construction projects will have a very high effect on reducing certain construction claims causes, especially in large complicated projects. Thus decreasing the number of the construction claims occurring. However, it was also shown that some construction claims causes will not be reduced or prevented as a benefit of utilizing BIM technology in construction projects. All results of the questionnaire were validated through case study of two mega projects.

Keywords: Building Information Modeling, BIM, Construction Claims, Construction Projects

I. INTRODUCTION

The large increase in construction claims numbers made them a commonplace in most construction projects, and it is believed that by time the number of factors leading to the arise of claims will increase due to the increase in both size and complexity of construction projects (Parvin 2011). Construction claims include many different types, and could arise due to a wide range of reasons and causes. Although, claims preventing actions exists and are practiced in most projects, but it is impossible to avoid construction claims completely (Koc 2014). Therefore, researchers have been always working on studying and developing new methods that could minimize construction claims to the far extent. Building Information Modeling (BIM) is a relatively new approach, which is believed by many experts in the Architecture, Engineering, and Construction (AEC) sector, that it improves the overall efficiency of the construction industry and reduces the number of claims and disputes in construction projects (Gibbs et al. 2015). BIM had shown that its proper utilization can enhance construction quality, reduce the project's delivery time, and reduce construction claims (Udeaja et al. 2015). Using BIM will improve construction processes in terms of better analyses, easier exploration of more alternatives, fewer claims, and fewer budgets and schedule overruns (Eastman et al. 2011). Eastman et al. (2011) further stated that, the number of claims must be reduced with BIM because the design and construction processes will be more efficient.

Rajendran et al. (2014) agrees with these statements by mentioning that the BIM features will significantly help in speeding the construction process, reducing costs, and minimizes legal claims and disputes. Taghizadeh et al. (2015) discussed through there published paper different features and tools of BIM that could reduce claims in construction projects. Khoshnava et al. (2012) proved through their research that the potential of BIM in identifying and preventing errors and conflicts during different phases of the project, which will minimize the number of construction claims. Moreover, Gibss et al. (2012) stated that BIM reduces claims and disputes due to improved collaboration. They further stated that 4D (Time) and 5D (Cost) BIM appeared to provide assistance regarding delay claims. Furthermore, the research made by Rahman (2011) during his master thesis showed that BIM if used will improve the process of claim management, by acting as a very important tool for both claim identification and quantification. CSQ (2014) mentioned the reduction of claims as one of the advantages provided by BIM if utilized properly.

II. METHODOLOGY

The research methodology is the general strategy which provides a plan for how and what information must be collected, and how will the results be analyzed to achieve the main aims and objectives of the research. Thus the adopted research methodology of this research included the following stages:

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

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Fig.1 shows the exact research methodology adopted for this research.

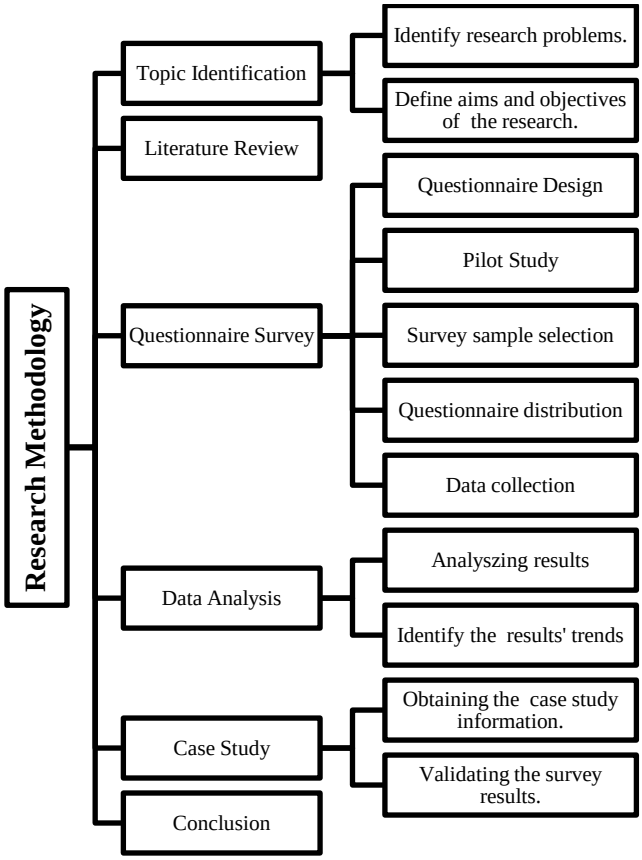

***Fig.1** Research Methodology.*

A. Topic Identification

Performing a literature review helped in identifying the main problem and aim of this research easily. This research had a main aim, which is to investigate and develop a clear understanding about whether utilizing BIM technology will have an effect on reducing/avoiding construction claims or not. To achieve this aim, four objectives were outlined which included:

1. Measuring the occurrence frequency level of the different construction claim causes.
2. Measuring the contribution level of the different construction claim cause on creating claims.
3. Assessing the effect of using BIM technology on reducing or avoiding different construction claims causes.
4. Assessing the effectiveness of BIM technology in reducing or avoiding claims, considering the project's complexity level.

B. Questionnaire Survey

Based on reviewing a large amount of previous researches and studies in detail regarding the different aspects of construction claims and Building Information Modeling (BIM) technology, a questionnaire was developed. The designed questionnaire avoided any complex or repeated questions and was formatted as closed ended questions, where respondents had to choose an answer from a series of choices for each question, to assure that the questionnaire is efficient and at the same time quick and easy to answer by all the respondents. The different developed questions aimed to satisfy the objectives of the research, by collecting all the required data and information to support the research results.

The developed questionnaire is divided into four parts as follows:

1. **Part 1:** General respondent/organization information
   This part was designed to gather information about the respondents and there working organizations or companies. The collected information included the respondent's name, working organization name, educational qualification, and years of experience.
2. **Part 2:** BIM awareness level. This part 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 a good level of experience and knowledge about BIM technology, thus increase the accuracy of the obtained results. To achieve this, respondents were to answer two groups of questions, where the first question assessed the participants' level of BIM knowledge and the second assessed the participants' level of working experience in BIM technology.
3. **Part 3:** Occurrence frequency and contribution level of construction claims causes. This section of the questionnaire consisted of two groups. The first was added to measure and examine the occurrence frequency of different construction claims causes, while the second one was to assess the contribution level of each claim cause in creating construction claims
4. **Part 4:** Effect of using BIM on reducing/avoiding construction claims. This section of the questionnaire was the most important part, as the included questions were used to assess the main aim of the research, which is to determine the effect of using BIM technology on reducing or preventing different types of construction claims. Two groups were designed to collect information in this part. The first group was developed to measure how effective is BIM in reducing or avoiding certain construction claims causes. While the second group was developed to assess the effectiveness of BIM in reducing or avoiding construction claims causes considering the project's complexity level.

C. Pilot Study

After designing the questionnaire, a pilot study on the questionnaire was made in order to get valuable responses and to ensure that the questionnaire had no logical problems. The pilot study was held by distributing copies of the designed questionnaire to three experts having experience in the same field of the research to obtain their remarks on the questionnaire. The chosen three experts included one academic professor and another two experts working in different companies or firms that deal with BIM in their construction projects. Two experts didn't have comments, they stated in there feedback that the questionnaire was clear, well designed and well written. However, few small remarks were obtained from the third expert, which were reviewed by the

researchers before taking them into consideration. The questionnaire was then launched.

D. Survey Population Selection and Sample Size Calculation

The sample is a small proportion that acts as a representation for the total targeted population. The targeted research sample for this research study included all professionals who have a good knowledge and experience about BIM technology and have a working specialization related to the AEC industry (Civil Engineers, Architects, Electrical Engineers, Mechanical Engineers, etc.). Being almost impossible to calculate the exact number of the total targeted population, two experts working in the BIM field were asked to state an approximate number for the required research population. The first expert stated a range of 120,000 – 150,000, while the other stated a range of 150,000 – 200,000. Also for more accuracy and as an extra reference, the website (www.linkedin.com) was checked for the total number of people who stated BIM as one of their skills. At the time of the research, 250,000 claimed that BIM is one of their working skills. Thus, an average population was taken for the answer of the two experts and the number obtained from the mentioned website, which resulted in 200,000 as the targeted research population. Statistical equations were used to calculate the sample size required. Three different statistical equations were used and the equation resulting with the largest sample size was used.

Equation 1 – Cochran Formula

$$n = \frac{z^2 * p * q}{c^2}$$

Z = Z value, taken as 1.96 for 95% confidence level.
P = Percentage picking a choice, expressed as a decimal, taken as 0.5.
q = 1 – P.
C = margin of error, taken as 9% = 0.09.
N= Total population, taken as 200,000.
n = Sample size.

Applying the equation: $n = \frac{1.96^2 * 0.5 * (1-0.5)}{0.09^2} = 118$

Equation 2 – Slovin's Formula

$$n = \frac{N}{1 + N\,(c^2)}$$

C = margin of error, taken as 9% = 0.09.
N= Total population, taken as 200,000.
n = Sample size.

Applying the equation: $n = \frac{200000}{1 + 200000\ (0.09^2)} = 123$

Equation 3

$$n = \frac{(z^2 * p * q) + c^2}{c^2 + \frac{z^2 * p * q}{N}}$$

Z = Z value, taken as 1.96 for 95% confidence level.
P = Percentage picking a choice, expressed as a decimal, taken as 0.5.
q = 1 – P.
C = margin of error, taken as 9% = 0.09.
N= Total population, taken as 200,000.
n = Sample size.

Applying the equation: $n = \frac{(1.96^2 * 0.5 * 0.5) + 0.09^2}{0.09^2 + \frac{1.96^2 * 0.5 * 0.5}{200000}} = 119$

Thus the result of **Equation 2** = 123 was chosen to be the required sample size of this research study.

E. 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 claims causes are classified into different groups according to the identified trends of the results in each section of the questionnaire.

F. Case Study

After completing the analysis of the survey results it was crucial and very important to verify and validate these results. Thus it was chosen to obtain several case studies of projects where Building Information Modeling was utilized to check whether construction claims occurred at its normal levels or was it reduced and avoided as an effect of using BIM technology, and thus validate the results of the questionnaire survey.

III. Construction Claims Causes

As for the use of this research study, and based on the literature review made, fourteen different construction claims causes were selected to be used in designing the questionnaire to assess their occurrence frequency, their contribution level in causing claims and to assess the effect of BIM on reducing or avoiding claims causes, which is the main aim of the study.

	Construction Claims Causes
1.	Delays in work
2.	Variations in quantities
3.	Errors in design drawings and plans.
4.	Poor planning and scheduling.
5.	Poor coordination and communication between project participants.
6.	Changes in the scope of the project.
7.	Acceleration of Work.
8.	Slow decision making.
9.	Poor safety measures.
10.	Different site conditions
11.	Unexpected increase in material prices.
12.	Payments delay.
13.	Force majeure.
14.	Errors and defects in contract.

Table.1 *Construction claims causes.*

IV. Analysis and 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 141 participants completely answered the questionnaire. However, the answers of 11 respondents were totally omitted. Five responses were omitted due to having at least one unexpected answer, 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 130 responses were used for the analysis of the questionnaire results

1. Years of Experience

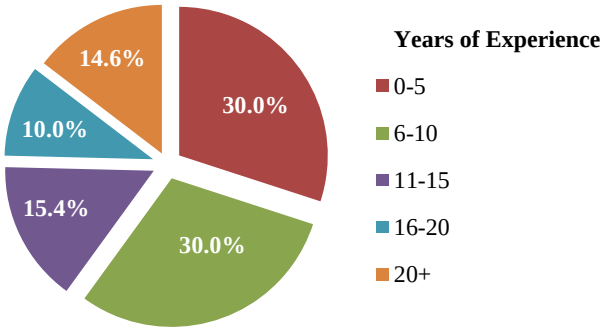

Fig.1 *Respondents years of experience percentages*

Majority of the respondents in this study had working experience between 0-5 years and 6-10 years with 30% each. Respondents with working experience ranging from 11-15 years and 16-20 years formed 15.4% and 10% respectively, while 14.6% of the respondents had working experience more than 20 years.

2. Type of Working Organization

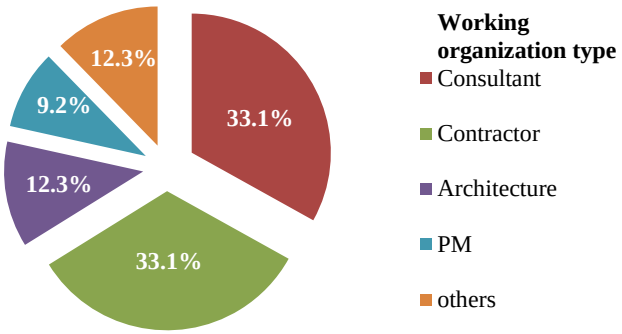

Fig.2 *Respondents working organization type percentages*

Regarding the respondents' working organization types majority of them work in a consultant or a contractor organization forming 33.1% each. 12.3% and 9.2% of the respondents works at an Architectural or Project Management organization respectively, while the rest of the respondents (12.3%) stated that they work in other different types of organizations than those mentioned above.

3. Current Working Positions

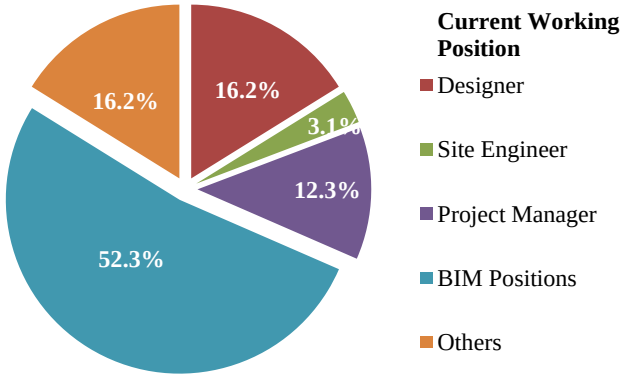

Fig.3 *Respondents current working positions percentages*

Results of respondents' current working positions showed that, Designers who participated in the questionnaire formed 16.2%, Site Engineers and Project Managers formed 3.1% and 12.3% respectively, while majority of the respondents (52.3%) work in positions related directly to BIM technology, for example BIM coordinator, BIM consultant, BIM manager, etc.. However, 16.2% of the participants work in other positions than those mentioned above.

B. Respondents BIM Knowledge Level

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 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:

1. BIM Awareness Level

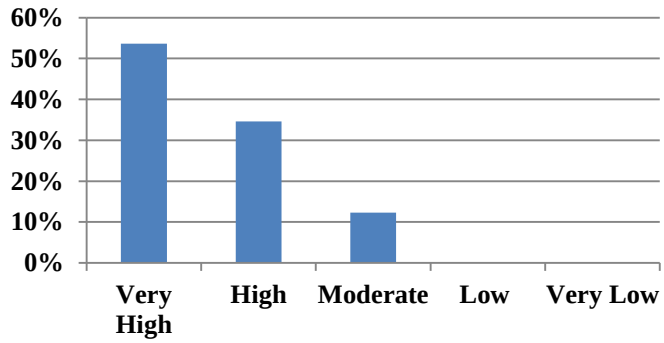

Fig.4 *Respondents BIM awareness level percentages*

Respondents to this question were requested to choose the level of awareness and knowledge they have about BIM technology, according to given rating choices that started from very high awareness level and up to very low awareness level. Results were that 53.6% and 34.6% of the participants have very high and high BIM awareness level respectively. While 12.3% stated that they have moderate level of knowledge and awareness about BIM technology and 0 respondents mentioned neither low nor very low BIM awareness.

2. BIM Experience Level

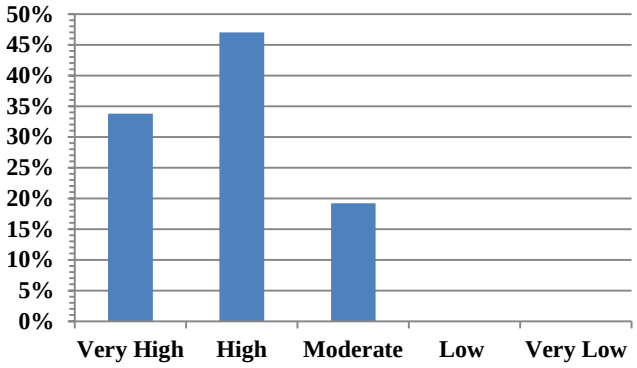

Fig.5 *Respondents BIM experience level percentages*

This question required respondents to choose their degree of experience using BIM technology in different construction projects. Majority of the respondents (47%) claimed to have a high experience in using BIM technology, which was also a very important goal to achieve to increase the results accuracy. 33.8% of the respondents had very high experience using BIM technology, which is considered also a high percentage, and 19.2% stated to have moderate BIM experience. While no respondents have low or very low experience using BIM.

C. Claims causes occurrence frequency

Respondents to this question were to rate the occurrence frequency of the fourteen different construction claims causes, starting from very frequently occurring to never occurring. Looking at the results of this section, it was clearly noticeable that the 14 causes of construction claims could be categorized into 3 different groups according to the trend in the analyzed results. The first group would be the "High occurrence frequency" group, which consist of all the claim causes that had majority of respondents choosing very frequent and frequent choices. The second group would be "Medium occurrence frequency" group which consist of all the claim causes that had majority of the respondents choosing medium occurrence frequency choice. The third group would be "Low occurrence frequency" group which consist of all the claim causes that had majority of the respondents choosing rare and never choices. The following Table.2 presents the 14 causes of claims divided into the 3 groups mentioned above, along with the majority percentage of each cause.

High occurrence frequency	**Majority Percentage**
Delays in work.	75%
Variation in quantities.	53%
Errors in design drawings and plans.	58%
Poor coordination and communication between project participants.	49%
Medium occurrence frequency	
Poor planning and scheduling.	50%
Changes in the scope of the project.	53%
Acceleration of work.	50%
Slow decision making.	57%
Different site conditions.	46%
Payments delay.	44%
Errors and defects in contract.	58%
Low occurrence frequency	
Poor safety measures.	48%
Unexpected increase in material prices.	44%
Force Majeure.	78%

Table.2 *Construction claims causes categorized by occurrence frequency level.*

D. Claims' causes contribution level.

Respondents to this question were requested to give a rating to each one of the fourteen construction claims causes, considering the contribution level of each cause in creating construction claims. The ratings started from very high contributing and up to very low contributing. Reviewing this section's results it was clearly figured that the 14 causes of construction claims could be categorized into 3 different groups according to the contribution level of each cause in creating construction claims. The first group would be the "High contribution level" group, which include all the construction claims causes that had majority of respondents choosing very high contributing and high contributing choices. The second group would be the "Medium contribution level" group which include all the construction claims causes that had majority of respondents choosing medium contributing choice. The third group would be the "Low contribution level" group that includes all the construction claims causes that had majority of respondents choosing low contributing and very low contributing choices. Table.3 shown below presents the 14 causes of construction claims divided into the 3 groups mentioned above, along with the majority percentage of each cause.

High contribution level	**Majority Percentage**
Delays in work	75%
Variation in quantities	72%
Errors in design drawings and plans	78%
Poor planning and scheduling	46%
Poor coordination and communication between project participants	60%
Changes in the scope of the project	75%
Acceleration of work	54%
Different site conditions	51%
Payments delay	63%
Medium contribution level	
Slow decision making	52%
Unexpected increase in material prices	45%
Errors and defects in contract	52%
Low contribution level	
Poor safety measures	56%
Force Majeure	53%

Table.3 *Construction claims causes categorized by contribution level*

E. BIM and Construction Claims

This part was the most important section of the questionnaire, which is to examine and understand whether using BIM technology has an effect on reducing or avoiding construction claims in construction projects or not. Two questions were designed on this matter. The first question respondents were to rate the effectiveness of BIM technology on reducing or avoiding each of the fourteen construction claims causes. While in the second question they were asked to rate the effectiveness of BIM in reducing claims considering the

project's complexity level. Results of both questions are presented and discusses in the following paragraphs.

1. Effect of BIM on construction claims

Participants in this question based on their knowledge and experience were requested to rate the effect of BIM technology on reducing or avoiding each of the 14 construction claims causes 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 reducing or avoiding certain claim causes, while some other causes of construction claims 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 14 different causes of construction claims 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 14 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**
Delays in work	66%
Variation in quantities	90%
Errors in design drawings and plans	95%
Poor planning and scheduling	79%
Poor coordination and communication between project participant	96%
Moderately effected by BIM	
Changes in the scope of the project	46%
Acceleration of work	51%
Slow decision making	44%
Lowly effected by BIM	
Poor safety measures	60%
Different site conditions	75%
Unexpected increase in material prices	95%
Payments delay	56%
Force Majeure	95%
Errors and defects in contract	73%

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

2. BIM effect on construction claims considering the project complexity

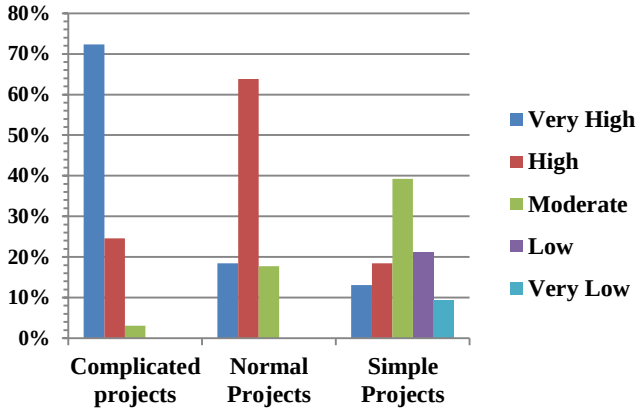

Fig.6 *Effect of BIM on claims considering project complexity level percentage results*

It was very important also to understand, whether using BIM is more effective in reducing or avoiding claims in large complex projects than that in small simple projects, or it is that using BIM would reduce claims in all types of projects by the same size or degree. Thus participants were asked to rate the effectiveness of BIM technology in reducing claims 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 reducing claims in complicated large projects than that on normal or simple projects. Also normal projects are better affected by BIM technology on reducing claims 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.

V. Case Study

Upon the completion of the questionnaire survey results analysis, a very important step to be done was to verify and validate these results. Hence, it was chosen to obtain information about several projects where Building Information Modeling was utilized to check whether construction claims occurred at its normal levels or was it reduced and avoided as an effect of using BIM technology, and thus validate the

results of the questionnaire survey. To accomplish this step, a case study form was developed which consisted of questions designed to collect all the required information and data about the project. The required information mainly consisted of project description, information about BIM utilization in the project, and information about claims that occurred in the project. The case study form was then distributed among different firms and companies working in the construction field in Egypt, where the research was conducted. However, it was found out that there are very few projects in Egypt where BIM is utilized which is currently under the design phase, thus doesn't satisfy our research requirements. This was due to BIM being a technology that is recently introduced to the Egyptian construction market and thus not widely spread among the construction firms. Hence, many firms outside Egypt were contacted, especially in the gulf area region, where BIM technology is utilized at higher levels. This resulted in obtaining two case studies that will be discussed in detail in the following paragraphs.

A. New Jahraa Hospital project

1. Project description

The New Jahraa hospital project is located in Jahraa city in Kuwait. The project which is owned by the Amiri Dewan (Governmental association), and is estimated to cost 1 Billion dollars ($) started at 2013 and is estimated to be completed by the start of 2018. Mohammed Abdel-Muhsen Al-Kharafi was awarded the contracting of the project and Pan Arab Consulting Engineers (PACE) was selected to be the project's consultant. The project includes:

1. Main Hospital Building BUA = 440220 m2
2. Dental Clinic BUA = 45180 m2
3. Regional Health Administration BUA = 8573 m2
4. Central Utility Plant BUA = 38707 m2
5. Car Parking 1 BUA = 121302 m2
6. Car Parking 2 BUA = 71660 m2

Fig.7 *New Jahraa Hospital, Kuwait*

2. BIM utilization in the project

A BIM 3D model was developed for this project, mainly using Autodesk's Revit and Navisworks software. The model was mainly used to develop the entire project's design drawing free from errors, clashes, or mistakes. The model is also kept up-to-date to run regular constructability analyses, which allows detecting and resolving conflicts among structural, architectural and MEP elements. Different parts of the model were produced by different developers, where TRO developed the Architectural part of the model, DNA developed the Façade part of the model, NDEC developed the structural part of the model, and iTech developed the MEP part of the model.

Figure 8 shows an example of the clashes and errors that were detected due to developing the BIM model and were resolved before the construction starts. The figure shows a clash between drainage pipes and a beam, which was solved by changing the toilet layout architecturally to shift the drainage pipe away from the beam.

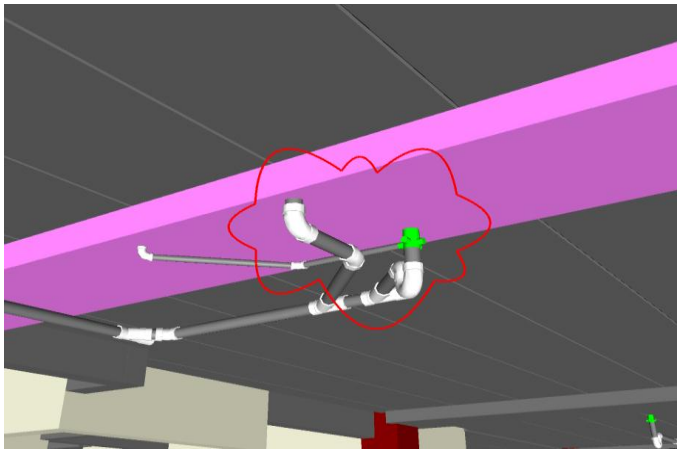

Fig.8 *Clash detected between drainage pipes and a beam*

3. BIM effect on claims

According to the information obtained about this project, it was stated that no problems occurred due to errors or mistakes in design drawing, poor coordination between the different participants in the project, poor planning and scheduling, or changes in the scope of the project. Thus no claims at all were proposed due to any of the previously mentioned problems, which is an effect of using BIM technology in this project.

4. Survey Results Validation

Looking at the previous section, it could be easily figured out that the information presented in the previous section clearly validates the results of the questionnaire survey. As it was stated by the survey results that using BIM has a high effect on reducing or avoiding claims caused by poor coordination between the different participants in the project, poor planning and scheduling, or due to errors in design drawings and plans, which exactly occurred in the case of this project. It was also stated by the survey results that Building Information Modeling has its best effect on reducing construction claims in case of large complicated projects, which also applies on this case study project.

B. Taif Municipality Headquarter project

1. Project description

The Taif Municipality Headquarter project is located in Taif city in the Kingdom of Saudi Arabia (KSA). The project is owned by the Taif municipality (Governmental association), and is estimated to cost 150 million Riyal (KSA currency). Zuhair Fayes and associates (ZFP), and Saudi Benladin were both selected to be the project's consultant and contractor respectively. The unique design of the building was made to reflect the city's culture and environment, and to make the

building one of the most important city's landmarks. The project has a site area of about 47,000 m2 and a total built up area of more than 68,000 m2. The project includes:

1. Office building BUA = 36000 m2
2. Mosque BUA = 2000 m2
3. Underground car park BUA = 30000 m2

Fig.9 *Taif Municipality Headquarter project, KSA*

4. BIM utilization in the project

For the sake of this project, a BIM 3D model was developed, mainly using Autodesk's Revit software. The main purpose of the model was to create the entire construction documents, including the project's design drawings that free from any errors, or clashes. Apart from that the model was used as a graphical representation, it was also use to produce all the project's BOQ and cost estimations. The BIM model of this project was developed by Zuhair Fayes and associates (ZFP).

5. BIM effect on claims

The acquired information about this project stated that no problems at all occurred due to errors in any of the design drawings or plans, changes in the project's scope, poor coordination between project's participants, or due to any variation in quantities. Thus as an effect of utilizing BIM technology in this project no claims at all occurred due to any of the previously mentioned problems.

6. Survey Results Validation

According to the information available in the previous section, it is clearly figured out that the questionnaire survey results are validated. That's because the questionnaire results stated that construction claims caused as a result of errors in design drawings and plans, poor coordination between project participants or due to variations in quantities are reduced and avoided at a high level in case BIM technology was utilized in the project, which occurred exactly in this case study project. Moreover, considering that this project is a complicated large project and that BIM had a considerably high effect on reducing claims in this project, this clearly validates the result of the questionnaire survey which stated that BIM has a high effect on reducing or avoiding claims in the cases of large complex projects.

VI. CONCLUSION

Construction projects are becoming more complex by time and as the complexity of projects increase, the problems that may lead to construction claims also increase. Construction claims became a very common act that occurs in almost every construction project and is considered to be a very disruptive event due to its negative effect on time, cost and quality of the project. Hence, it is always important to find new solutions and methods to minimize and prevent construction claims. Building Information Modeling (BIM) being a relative new technology that is widely getting accepted in the construction sector, is believed to have a lot of benefits in improving different areas of construction management in which claims are a part of. This research was mainly aimed to study the effect of using Building Information Modeling technology in construction projects on reducing or preventing the different causes of construction claims through a questionnaire survey that was developed based on a detailed literature review. Fourteen different construction claims causes were selected. The questionnaire survey investigated the occurrence frequency of these different claim causes, and there level of contribution in creating construction claims. The questionnaire also fulfilled the main aim of the study by assessing the effect of BIM on reducing these construction claims causes. The effect of BIM on reducing or avoiding construction claims was also assessed considering the project's complexity level. The results of the study were analyzed to get out to the final conclusion. The acquired results stated that utilizing BIM technology in construction projects will have a very high effect on reducing certain construction claims causes, like errors in design drawings and variation in quantities as 95% and 90% of the respondents stated that respectively. Thus the amount of the occurring claims in construction projects would be reduced. Also certain causes of construction claims were shown by the results to be reduced at a moderate level when BIM technology is used, for example changes in project's scope and acceleration of work as majority of the results forming 46% and 51% stated that respectively. However, it was also figured that some construction claims causes will not be reduced or prevented as a benefit of using BIM technology in construction projects or will be reduced at a very low degree. An example of these causes is, different site conditions and unexpected increase in material prices, as 75% and 95% respectively forming majority of the results of the study, stated that these causes of construction claims are lowly reduced or avoided by BIM. Furthermore, results of this research also showed that utilizing BIM has a higher and better effect on reducing construction claims in case of large complicated projects than that in normal and simple projects, as 72% of the study results, stated a very high effect of BIM on reducing claims in complicated projects, while in case of normal and simple projects 18% and 13% of the results respectively chose the very high effect choice. As a final step for this research, information about two different mega projects where BIM technology was used was obtained as case studies. The effect of utilizing BIM on reducing construction claims in these projects was studied, which validated and verified all the results of the research work.

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