CLAIMS AND DISPUTES RESOLUTION USING BIM TECHNOLOGY AND VDC PROCESS IN CONSTRUCTION CONTRACT RISK ANALYSIS

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ABSTRACT

Purpose - Building Information Modeling (BIM) technologies and Virtual Design and Construction (VDC) processes are becoming a driving force for advancing the design, construction and operation of buildings that may have the potential to reduce claims, disputes and litigation throughout the construction process. However, evidence shows that BIM isn't universally successful. To this end, this research aims to identify the most common BIM contractual risks (BCR).

Design/Methodology/approach - This research intends to go further into about 22 BIM Contractual Risks that have been identified from the literature review. A questionnaire survey was made to identify the risks occurrence rate, involved parties and solutions for highest faced risks based on number of participants and their years of experience. Result analysis was based on experience years for each participant's vs each risk's parameters.

Findings - The presented process mitigates the construction project participant's ability to complete the construction project under BIM collaborative environment and contracts isolation nature through the following: (1) identification and examination of about 22 BIM contractual risks, level of occurrence and solutions; (2) provide a BIM contractual framework that allows for defining each party's responsibility in BIM workflow.

Research Limitations – Due to diversity in construction project, BIM based projects require an additional drafting method to the contract and provide an understanding of each party's responsibility by analyzing legal implication of BIM adoption. In addition, local legislation can provide the support needed for BIM implementations.

Practical implications – Findings' implication suggests providing a legal understanding of BIM work flow through the investigation of BIM risks among construction project's parties and providing a contractual framework either in the BIM

execution plan BEP or in the employer information request EIR. The presented BIM framework mitigates the likelihood of these risks rising into disputes.

Originality/value – While there have been publications that investigate BIM contractual risks, they mainly provide guidelines of the risks and solutions. The following publication propose a thorough examination of BIM contractual risks, introduce a BIM framework based on industry's experts experience and the specification required in the contract, BIM execution plan regulation and legal background needed for BIM adaptation in a construction project.

Paper Type – Research Paper

Keywords: Building Information Modelling (BIM); Virtual Design and Construction (VDC); BIM Execution Plan (BEP); Employers Information Requirements (EIR); BIM Contractual Framework, BIM Contract, BIM contractual risk (BCR), Level of occurrence (LOC)

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1. INTRODUCTION

The use of BIM technology have proven to be a must in current construction projects especially with massive scale due to the shear amount of data(Sacks, Gurevich and Shrestha, 2016). Also, BIM has been used in many different industries which have shown what a great success this technology has become due its considered one of the effective techniques that help building in a virtual and collaborative working environment prior to physical construction (Charehzehi, 2015) which in turn is the result of the rise of miscommunication between project's parties no matter how well defined the virtual design and construction (VDC) process for the project(Jang *et al.*, 2019). BIM has been made mandatory for public sector projects in developed countries in recent years because if the past 10 years has been anything but an intensive discussion that BIM changed the architectural, engineering and construction (AEC) industry work practice especially architect and engineer who were affected by that change (Hijazi and Omar, 2017).

BIM has changed to a reality from being just a theory due to its ability to drive efficiencies, reduce costs and add long-term value to the development and management of built assets (D. Mosey, EL., 2016). BIM provides a close collaboration among project parties to visualize what is to be built in a simulated environment and identifying any potential design, construction or operational issues (Abd Jamil and Fathi, 2018). The use computer aided design tools will provide full sharing of model's information multidisciplinary integrated source of information technology that posts benefits in the construction industry which is the core of BIM (FIDIC, 2017) .In recent years, BIM is an encouraging development, technology and operation in the architecture, engineering, construction and owner-operated (AECO) industry due to its data-rich digital representation of building components as BIM technology brings better visualization (where architects can get design feedback from client) and in the construction level design stage, with BIM, detailing, specification and cost estimation can be easier than traditional 2D drawings (Liston EL. , 2011). The purpose of BIM is to add value to the construction industry, such as decreasing project cost, increasing quality productivity and reducing project implementation time (Eadie *et al.*, 2014). Over the past years, (BIM) has entered into another phase of maturity in countries that have been actively adopting and using BIM (Li *et al.*, 2019). The new challenge facing this adaptation is dealing with the legal issues

associated with BIM implementation (Chong EL., 2017). One of barriers to BIM implementation is the lack of contractual agreements which is caused by the fact that the majority of models do not contain all of the construction details needed for a project (Leon L. Foster, P.E., PMP, 2008; Ku and M.SC, 2011). Involving BIM & contracts presented to be challenging to put together because of BIM “collaborative” nature (Pandey EL ,2016). Also, BIM raises special legal and contractual issues that new contracting approach should be addressed (Abdirad, 2015). As a result, BIM is described as a technology both transformative and disruptive (Abd Jamil and Fathi, 2018).

BIM has become the potential risk to construction projects contracts because there is no legal status of electronic information and the electronic versions could not be filed (Kuiper and Holzer, 2013). That resulted in duplication of information gathering work and due to the nature of procurement, documentation and contracts; that also tend to isolate and insulate rather than support and collaborate, that's consider to be the opposite to the nature of BIM (McAdam, 2010; hooper and Widén, 2015).

BIM implementation necessitates developed a new context of technological, organizational, and procurement processes which raised special legal and contractual issues addressing new contracting approaches (Andre, 2011) so the motive for developing BIM standard forms of contract, as the conventional forms of agreement had not dealt with BIM implementation (Larson & Golden, 2007). As it was mentioned in the “strategy paper for the government construction client group” of 2011 in UK that suggested a recommendation for the legal and contractual for the BIM workflow to include a standard contract amendments in order to comply with (1) BIM protocols, (2) standardization of BIM protocols and (3) duties of both consultants and contractors under BIM platform of collaboration (BIM Task Group, 2011). “Those desiring to use BIM should anticipate spending a little more in a legal effort to draft and negotiate the risk-shifting contract provision that properly allocate risks to the party best able to manage them” (Barra, 2012).

The BIM approach, integrated into the parties contractual relationship, is a problem needing to be drafted into a new form of contracts due to the substantial nature of new changes that will arise from the adoption of BIM compared to traditional contracts (Ashcraft, 2008). This is especially the case at level 3 of the BIM maturity index in the UK, that requires a new form of contract to cover all different relationships between the parties involved in the project (Hasni, Ismail and Hashim, 2019). That being said, many construction personnel are still unaware of the existence of BIM standard form documents or protocol (Fan *et al.*, 2018). Thus, despite the fact that BIM itself is gaining momentum, the use of the standardized BIM protocols remains low and related works on BIM and legal issues were still at an exploratory stage due to limited empirical data across the architectural, engineering, construction, and facility management and operation (AECO) industries (Chong *et al.*, 2017). Contractual forms must support BIM workflows in an active way that enables teams to work better together with the product and project outcome in focus in order to advance toward integrated BIM (BIM maturity level) new procurement models (Widén el. , 2015).

In this study, an identification of the risks faces the adoption of BIM technology in a legal and contractual agreement is being examined to identify top BIM contractual risks (BCR). Such examination targets projects using BIM technology at any phase with factoring expertise of the industry's current BIM users and their years of experience. The input of the proposed examination involves the occurrence rate, parties responsible, suggested solution for each proposed risk. For that reason, defining a BIM contractual framework based on this research is important to allocate project parties' responsibility in a BIM work environment. After presenting general background information about legal and contractual risks facing the adoption

of BIM technology in the construction project in the next section, the proposed contractual framework is introduced and an analyzed survey to support the results.

2. LITERATURE REVIEW

Detailed review has been conducted to determine and study the existing publications relevant to the selected topic of research. To do so, the legal risks of BIM were studied initially using a total of 5 published research paper. Each research paper was studied in detail and based on this study a total of 22 contractual risks were identified and their description was constituted as shown in table.1. As presented in table 1. each BIM contractual risk has been investigated based on their reference of study and description. Thus, to fill the research objectives “the literature review” section focuses on reviewing the risks facing BIM adaptation.

Table 1 BIM contractual risks (BCR) in Details

Risk ID.	BIM contractual risk (BCR)	Description	References
BCR1	Intellectual property (IP)	Protection of intellectual property of design and input data	Olatunji (2011), Arensman and Ozbek (2012), Fan (2013), Manderson et al. (2015), and Alwash et al. (2017), (Abd Jamil and Fathi, 2018), (Jiang, Ma and Zhang, 2018), (Pandey, Shahbodaghlu and Burger, 2016), (Arshad <i>et al.</i> , 2019).
BCR2	Professional liability (PL)	Professional liability of shared information	Arensman and Ozbek (2012), Manderson et al. (2015), and Alwash et al. (2017), (USACE, 2012), (Abd Jamil and Fathi, 2018), (Jiang, Ma and Zhang, 2018), (Pandey, Shahbodaghlu and Burger, 2016), (Arshad <i>et al.</i> , 2019).
BCR3	Condition of contracts	Contract directs modeling deliverables and its sharing	Manderson et al. (2015) and Alwash et al. (2017), (Jiang, Ma and Zhang, 2018), (FIDIC, 2017), (Arshad <i>et al.</i> , 2019),.
BCR4	Data interoperability	When BIM files are exchanged, data loss may occur	Olatunji (2011), Bryde et al. (2013), Porwal and Hewage (2013), Won et al. (2013), and Chien et al. (2014), (Jiang, Ma and Zhang, 2018), (Pandey, Shahbodaghlu and Burger, 2016), (Abdirad, 2015), (Arshad <i>et al.</i> , 2019).
BCR5	Protocol, process and responsibilities	Development of communication structure between parties	Olatunji (2011), Arensman and Ozbek (2012), and Manderson et al. (2015), (Abd Jamil and Fathi, 2018), (Arshad <i>et al.</i> , 2019).
BCR6	Data security	Security against data corruption, theft or manipulation	Olatunji (2011) and Manderson et al. (2015), (Jiang, Ma and Zhang, 2018), (Abdirad, 2015), (Arshad <i>et al.</i> , 2019).
BCR7	Cost Compensation	Cost of model management and its reimbursement by stakeholders involved	Olatunji (2011), Arensman and Ozbek (2012), and Manderson et al. (2015), (Jiang, Ma and Zhang, 2018; Arshad <i>et al.</i> , 2019).
BCR8	Unclear BIM standard	Unclear BIM standards and contracts to operate	Azhar (2011), Arensman and Ozbek (2012), and Chien et al. (2014), (Arshad <i>et al.</i> , 2019).
BCR9	Standard of care and professional negligence.	Parties are appreciated to render professional services with reasonable judgment to prevent loss	Arensman and Ozbek (2012) and Alwash et al. (2017), (Abdirad, 2015; Pandey, Shahbodaghlu and Burger, 2016; Jiang, Ma and Zhang, 2018; Arshad <i>et al.</i> , 2019).

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BCR10	Admissibility of electronic-based documents	Admissibility of digital documents in court or local administration	Olatunji (2011) and Alwash et al. (2017),(Abdirad, 2015; FIDIC, 2017; Arshad <i>et al.</i> , 2019).
BCR11	Model management difficulties	As model is updated, more accurate data entry is required, which causes model management difficulties	Gu and London (2010), (Bay Area Headquarters Authority, 2012), Bryde et al. (2013), Porwal and Hewage (2013), Won et al. (2013), Chien et al. (2014), and Ozorhon and Karahan (2016), (Pandey, Shahbodaghloou and Burger, 2016; Jiang, Ma and Zhang, 2018; Arshad <i>et al.</i> , 2019),
BCR12	Legal validation of design	Vetting of design from local administration	Manderson et al. (2015) and Alwash et al. (2017) ,(Arshad <i>et al.</i> , 2019).
BCR13	Lack of software compatibility	Each firm is working with its typical software and hardware tools that cause compatibility issues	Bay Area Headquarters Authority, (2012), Luthra (2010), Azhar (2011), Migilinskas et al. (2013), Porwal and Hewage (2013), and Chien et al. (2014),(Arshad <i>et al.</i> , 2019).
BCR14	Legislation and judicial precedence	Legislation for BIM to operate	latunji (2011) and Manderson et al. (2015),(Pandey, Shahbodaghloou and Burger, 2016), (Arshad <i>et al.</i> , 2019).
BCR15	Scope and requirement	define clearly each participant's scope and the requirements of work at the Commencement of the project.	(FIDIC, 2017; Jiang, Ma and Zhang, 2018).
BCR16	Reliance	Parties may rely partially or completely on the model provided by designers which brings additional risks	(Jiang, Ma and Zhang, 2018), (Ozbek 2012; Kuiper and Holzer 2013)
BCR17	Insurance	Participants under conditions which involve the access of a third party and software crash, they need for additional policies for self-protection and to cover loss.	(Manderson, Jefferies and Brewer, 2015; Pandey, Shahbodaghloou and Burger, 2016; Jiang, Ma and Zhang, 2018)
BCR18	Spearin Doctrin	Contractors will not be liable for damages or losses arising from information, plans or specification provided by the employer.	(United States v. Spearin, 248 U.S. 132 (1918))(Pandey, Shahbodaghloou and Burger, 2016; Jiang, Ma and Zhang, 2018),.
BCR19	Experiencing data loss & dealing with database	Electronic Information must be protected from loss and actively preserved by the all parties and their counsel whenever Litigation is "anticipated".	(Zubulake v. UBS, 2004), (Pandey, Shahbodaghloou and Burger, 2016).
BCR20	Data misuse	Models should only be used for the purpose for which they are intended.	(Abdirad, 2015; Pandey, Shahbodaghloou and Burger, 2016).
BCR21	Risk allocation	risk allocation among the parties was not necessarily always clear	(Pandey, Shahbodaghloou and Burger, 2016).
BCR22	Right to delegate BIM related activities/ Right to transfer models to subcontractors/sub-consultants	For BIM Management, BIM Modeling, BIM Processing and Maintenance	(Abdirad, 2015), (Bay Area Headquarters Authority, 2012)

2.1 Risks Facing BIM Adaptation

The relationship between technology, the business of construction and law is dynamic, with developments in one continually driving changes in the others where BIM is one such technological development (El-adaway, Abotaleb and Eteifa, 2017). Facing the different variables and constraints that governs the use of BIM technology as a powerful tool in the construction industry; the risks of using BIM have emerged as part of the problem not the solution in some projects due to the lack of understanding on whom the liability and responsibility of the BIM model whether in design, construction and maintenance phase lay on (Klee, 2015). However, the difference between BIM collaborative nature that provide an environment sharing platform between project parties and contracts nature that tend to isolate and insulate rather than support and collaborate has been proven to be a perplexing difference (HKIUS, 2017).

Parties involved in the BIM process are required to sign a common legal document, which establishes the obligations of the parties, both technical and legal, for the modeling process (Greenwald, 2013). When it came to the enforceability of some regulations and terms with BIM integration within projects, there were problems emerging due to the lack of experience in dealing with BIM technology in a contractual based model (Abd Jamil and Fathi, 2018). This problem was that the result of the progress the construction industry face with working at level 3 BIM with exploiting the benefits of a fully collaborative single model environment toward achieving its goal by 2016 (Bew and Richards, 2008). The application of BIM as a working methodology is subject to a greater risk and uncertainty from several aspects which is due to BIM contractual and legal risks, and that BIM practices have yet to mature (Almarri, Aljarman and Boussabaine, 2019).

Despite the fact that BIM is not a set of contract conditions and it is a mechanism to provide an environment where all parties have access to information relevant to their role in the design and construction of a project (FIDIC, 2017), the need to re-craft existing contractual relationship to facilitate collaborative decision making any to equitably allocate responsibility among construction participants and for that to be achieved, we need to understand that the connection between commercial environment and contractual provisions (Klee, 2015). Also, the need to comprehend the resultant procedural & behavioral phenomena that can make BIM at odds with legal and commercial environment presented to be a must when dealing with BIM technology in a contractual framework (Hooper and Widén, 2015). Construction industry requires a quick and efficient conclusion in contracting stages because of repetitive contracting requirements for a large number of projects, time sensitive projects' feasibility, and economic realities in the market. In BIM, it's considered to be important because of new deliverables, building contracts, liabilities, risk management, and insurability need to be tackled (Oo, 2014).

The best definition of risks that best describe BIM is the condition, behavior or any other factor that increase liability, loss or any other negative occurrence/consequence that may emerge from BIM as a working method which presents risks involved with BIM as a consequence of uncertainty (Jiang, Ma and Zhang, 2018). The reason why this definition is best described BIM risks is because BIM and risks can't be statically measured or predicted as BIM risks are seen as consequences of uncertainty related to issues such as who owns the BIM library, data sharing/collaboration, BIM management, BIM content, emerging technologies and processes, etc. (Almarri, Aljarman and Boussabaine, 2019).

2.2 Evaluation of the Literature

While there are many attempts to capture the existing industry situation in terms of utilizing BIM Technology and VDC Process in the project's construction contract, this study, additionally, considers the different risks that may occur when implementing BIM as a mean in

which the construction project parties work through and the investigation of the industries expertise regarding BIM contractual risks that they faced while dealing with BIM based projects. To further study the industry situation, a questionnaire has been distributed to measure the risks that may facing the adaptation of BIM in the construction contracts.

3. PROPOSED METHOD

Figure 1 Methodology of research

Figure 1. represent the research methodology on which this research has been conducted which is as follows: 1) research objectives, 2) survey's questionnaire design, 3) collecting data, 4) data analysis. Firstly, an explanation for the research methodology employed in this study. Methods are explained in details to justify for their selection. Various types of research techniques were employed in this study and why these techniques were chosen, used and rationalized. The research techniques, literature, interviews, and content analysis are briefly explained during the research process.

Research objectives were defined and recognized throughout the research. First objective of the research was focused the identification of BIM contractual risks throughout a taxonomy of BIM technology used in many firms worldwide where BIM is implemented at any stages of the project. Quantified data, content analysis, conclusions were the result of the first objective based on utilizing categorization and frequency of the answers given on certain subjects. The second objective of the research was identifying the risk as a role that functions and has a responsibility that is represented in the forum of level of occurrence for each BIM contractual risk that challenge face-to-face the standardization concept of contracts. This objective was the result of examining the literature review and survey participant's responses who are BIM experts which in turn identified the critical success factor. The third and final objected is realized by recommending the best BIM contractual framework.

3.1 Survey's questionnaire design

Semi-structured in-depth survey questions with architects and BIM managers were conducted within 4 months. 'informed consent proforma' was distributed and general data protection regulation (GDPR) was taken under consideration to protect the rights and welfare of interviewees(Schwerin, 2018). The survey participants were briefed on the aims, objectives, and scope of the research. The first step in the survey was to obtain information about the survey participants so the questioned focused on previous experience of participants on BIM like how many years of experience did the participants had with BIM and to which Filed of industry does

the participants belong to (owner, contractor, consultant, project management). Secondly, providing the participants with the contractual risks facing the BIM adoption to choose from and those risks were chosen based on the literature review. Each risk will be faced with three possible answers (yes, no, not Sure). thirdly, each risk has been assigned an occurrence rate on a scale from 1 (least likely to take place) to 10 (very likely to take place). With that under consideration, we can determine what are the main focus of BCR to consider. Followed by identifying the effect of each risk on several parties in the construction process which in turn recognize the liability of every party involved. Each risk has the ability to affect more than one party in any construction project that adopts BIM. However, for the sake of the survey, we have assigned the main parties of the project the liabilities in question regarding BIM risk and the parties were (owner, contractor, consultant, project manager and/or other's (provide the participants own insight on the project)). Finally, every risk had a suggested solution based on the expert's opinion and what he/she experienced along their journey in the adaptation in BIM. For each risk a solution of three options is offered for the sake of the survey as in some research papers more than one solution was offered which may cause a variation in results which will increase this research's variables.

Knowing that the responsibility of any part of the project no matter how small it is written in details in the contract document provided between the project's parties under mutual understanding. The final result is to reach to some sort of contractual framework that could define the variables and constrains in the BIM model in the Egyptian market and how this technology can be adopted throughout the legal validation of the model by the local administrative.

In most Researches, there are two strategies of research (quantitative and qualitative research) and in order to determine what type of research to be selected depends on the purpose of research, the type and availability of the information required.

The main focus of this research is on the BIM user's years of experience of the BIM experts in the AEC industry worldwide. Social science research techniques have been chosen because of the exploratory nature of this research and it is the appropriate approach when the amount of the knowledge about the topic is limited. The research techniques consist of literature review, expert interviews, and content analysis (Lee, Wong and Tong, 2014). The collected data are quantitative and qualitative method of research used for determining the impact and the identification, as previously shown in table 1., of BCR in the views of authors of selected research paper, a qualitative analysis was selected and for determining the appearance frequency (level of occurrences) and the affected parties of the contractual risks based on participant's experience.

3.2 Survey population analysis

Defining the main targeted population was selected based on the following step. The population consists of experts in the AEC Industry field, BIM coordination, virtual design and construction and BIM engineering. Numerous benchmarking was used for the selection of participants for the study. The participants were limited to (Architects, BIM managers, BIM coordinator, BIM specialist, BIM analyst, senior BIM engineer [structural, MEP, architect], junior BIM engineer (structural, MEP, architect), technical office engineer, revit content developer, contract engineer and BIM consultant...etc.) having more than one year of experiences on implementing BIM worldwide who interested to share their experience and knowledge. Those professionals had contributed their knowledge on AEC industry, build smart magazine, BIM essential guide for architectural and civil consultants. Invitations for participation in the research was emailed to potential participants and followed up with another e-mail on how Important taking Part in the survey is within 6 days after the Survey were disseminated. Positive responds were received

from this approach. The survey has been sent starting from march 2020 till July 2020. Since the number of targeted populations is almost unknown, LinkedIn (professional internet network) was used to asses in the process of estimating the population size. The population size has been predicted to approximately reach 500,000 individuals; field experts agreed on this size.

To the next step where the survey's questions are designed to be easily understood. Since the survey was designed to target entities around the globe, and the targeted sample was hard to be contacted due to its size, hence why LinkedIn was used to distribute the survey. Participants minimum number required to answer this research questionnaire is calculated by the following equation no. 1 (Israel, 1992; Aredah, Baraka and Khafif, 2019):

$$n = \frac{\frac{z^2 * p(1-p)}{e^2}}{1 + \frac{\frac{z^2 * p(1-p)}{e^2} - 1}{N}} \quad (1)$$

Where:

- (N) represent the population size, taken as 509,000 based on LinkedIn assessment
- (e) represent the margin of error as a percentage expressed as a decimal, taken 5.5%
- (z) represent the z-score, taken as 1.96 for 95% confidence level
- (p) represent population proportion, expressed as a decimal, taken as 0.5

By applying equation no.1 on this survey, the minimum number of participants is approximately 317.29 participants. The questionnaire has been distributed and sent to 2,074 individuals across the globe (15.3% response rate).

Adding on that, the relative importance index (RII), equation (2), is also used to rank the benefits and barriers of taking BCR when drafting a construction contract in the construction industry under consideration.

$$RII = \frac{\sum W}{A * N}$$

Where:

- (W) represent the weighting given to each element by the respondents. In this research, it ranges from 1 through 3 where 1 is the least significant and 3 is the highest significant.
- (e) represent the highest weight which is 3
- (N) the total number of respondents

The statistics equations helped to provide the survey with the quality insurance needed for the survey sample and provide a more reliable status to the study's findings.

4. RESULTS

The survey provided a new understanding of the risks facing BIM in case of claims or disputes by identifying the contractual risks most faced in the projects employing BIM.

4.1 Background Information Questions

Academic background for each participant question represents the highest level of education participant has completed and the field of any completed undergraduate college degrees to create statistics about education and the industry in total. Local, state, tribal, and federal agencies use education data to measure changes in education over time and evaluate the educational attainment of the workforce (Hasan, Adam and Midi, 2010). Based on the fig. 2, about 62% percent of BIM user's worldwide have a bachelor degree in science (BS.c) which include (civil, electrical, mechanical engineering and architects) followed by 29% percent of

participants whom obtain both master's and bachelor of science (M.Sc. & B.Sc.). Followed by 5% of BIM users with PhD degree in BIM. Also, the survey provided a clear understanding of whether a person needs an academic degree to be a BIM user as about 3 % of participants have no bachelor degree and became involved in BIM technology as a user's within their own trusted expertise based on diplomas that have been obtained on the use of BIM technology. Masters of business administration (MBA) holders may be involved in the BIM technology however most of them are in a management position.

Figure 2 Number of Academic Degrees Holders

Participant field's question shows different fields of AEC industry and to which party of the construction project every participant belongs to. From fig. 3, most BIM users fall into two major categories; consultant (designer) with a percentage of 41.5% and contractor with a percentage of 26.7% which indicates that BIM technology has become an important part of consultant work flow for a more easily design process and based on further analysis for the purposes of facility management after the construction stages comes to an end. However, BIM model is important for the contractor during the construction stage as the model provides the needed data and information that may take days for the contractor to get from the 2D Drawings (Lee, 2019). Then comes project management companies with a percentage of 12%. Followed by owners by a percentage of 26%. The new category is a BIM consultant office which is relatively new to the industry. The first BIM was presented general consultant offices (architecture, civil) provided those services. However, with the advancement this technology is facing, a need for a more specialized office in BIM offices has raised.

Figure 3 Participants Field of the Industry by Field in the industry

Participants were asked the question about total years of experience to understand the size and characteristics of different experience groups and to present other data by age. Also, to determine the significance of firms that typically had the most experience and which were thriving in terms of international collaboration (Ku and M.SC, 2011). There was an understanding that BIM technology is relatively new and experienced personal in such technology are engineers with an experience level between 5 to 10 years and a team of highly experienced site engineers provide them with their long-life experience in construction project guidance (Seyis, 2019). This understanding has in some way changed as now there are more engineer over 10 years of experience can provide the expertise needed. Fig. 4 represent the participant's years of experience in BIM as engineers over 10 years represents 39.6% where the percentage of engineers between 5 to 10 in experience represents 37.4% which isn't consider a huge gab but still a variance to be considered. Engineers under 5 years of experience represents about 22.9% which is due to the huge advancement of the software programs that made it easier to provide simpler understanding of what the BIM is about (Oo, 2014).

Figure 4 Participant's total years of experience

We can summarize the participant's background information in table. 2 representing participant's academic background total years of experience in the field and participants filed of work in the AEC industry in both participant's number (No.) and percentage (%).

Table 2 Participant's background information

Choices	No.	%
Qualifications		
BIM Diploma	8	3%
B.Sc.	196	62%
M.Sc.	93	29%
MBA	4	1%
PhD	15	5%
PhD Candidate	2	1%
Field in the industry		
Academic and Research	5	1.6%
Aviation	1	0.3%
BIM Consultant	21	6.6%
Construction Contract Specialist	2	0.6%
Consultant (Designer)	132	41.5%
Contractor	85	26.7%
Facility management	6	1.9%
Owner (client)	26	8.2%
Petroleum Engineer	1	0.3%
Project Manager (PM)	38	11.9%
Solution Sales Consultant-Enterprise CDE	1	0.3%
Years of experience		
Less than 5 yrs. of EXP.	73	23.0%
Between 5 to 10 yrs. of EXP.	119	37.4%
More than 10 yrs. Of EXP.	126	39.6%

BIM as a technology when emerged there was no much collage degree at the time that can provide an understanding of how to prepare the upcoming graduates to be on or how this technology has come from. Knowing the education level of the participants will make us measure how the BIM community have come (bachelor of science (B.Sc.), master of science (M.Sc.), doctor of philosophy (Ph.D.) and other's).

4.2 BIM Contractual Risks (BCR) questions

Reliance on information technology is associated with risks and one forum of this technology is BIM technology that has become part of the construction industry in order to add value to the construction projects such as decreasing project costs, increasing quality, productivity and reducing project implementation time depending on the model level of details however, over the years BIM applications is subjected to greater risks and uncertainty from several aspects as a working methodology (WINFIELD and ROCK, 2018). The reason for such uncertainty is because of the legal and contractual risks of BIM that is considered to have yet to mature.

Figure 5 BIM contractual risks (BCR) vs number of participant's

The participants were asked to select the BIM contractual risks that represent a barrier towards BIM adaptation in construction contracts. Data collected from the questionnaire survey is given in Fig. 5 and, in which the highest risks can be identified based on participants' input. The results revealed (from approximately 318 participant's) that the heights BIM contractual risks which have a higher level of participant's input agreeing are (BCR5) Protocol, process and responsibilities (221, 69%), (BCR3) Condition of contracts (210, 66%), (BCR4) Data interoperability (206, 65%), (BCR8) Unclear BIM standard (204, 64%), (BCR2) Professional liability (PL) (203, 64%), (BCR15) Scope and requirement (195, 61%), (BCR1) Intellectual property (IP) (193, 61%), (BCR11) Model management difficulties (185, 58%), (BCR22) Right to delegate BIM related activities/, Right to transfer models to subcontractors/sub-consultants (182, 57%), (BCR20) Data misuse (175, 55%). Top of the risks that have a high probability of facing the construction project parties while adopting BIM model has been identified as (BCR5) protocol, process and responsibilities, (BCR4) Data interoperability, (BCR3) condition of contracts, (BCR8) unclear BIM standard, and (BCR2) professional liability (PL). Participant's agreed on the importance of defining protocol, process and responsibilities as well as data interoperability between construction project parties. The least risks faced while using BIM are (BCR18) Spearin Doctrine, (BCR17) Insurance and (BCR6) Data security are found with low interest or satisfaction to the participant's as the complex projects most participants are working on, till now there is many international standards that define BIM protocol, process, responsibilities, standard and clauses none of whom can represent to be the most effective or can cover all BIM contractual risks. The mentioned was agreed by the respondents about the important of defining the needed protocols and standards for example in India contractors always feel insecure when BIM consultants are being hired by the owner because they have to

work accordingly the BIM consultant's model and if the contractor didn't, then whenever a conflict arises consultants point out contractor mistakes and the contractor shall make the required compensation, either cost or money, that is needed for the project.

BIM emerging risks have come to light when BIM task group of 2011 in UK didn't explicitly categories BIM risks or suggest a statements (contracts) for measuring the occurrence of such risks despite that their report (published in 2011) outlined a very detailed strategy & benefits for the use of BIM. As a result of such problem, the BIM task group in 2015, UK national standard body BS, industry and academic organizations embarked on the development of several standards to facilitate BIM adoption like (BIM Task Group, 2011).

Every risk faces the participants are considered. BIM contractual risks have an occurrence rate depending on how many times the participants face such risk during day-to-day work activity. For the sake of this survey, the occurrence level question has been designed from 1 through to 10 as which categorize the risks into five groups; [1] (10-9) frequent, [2] (8-7) probable, [3] (6-5) occasional, [4] (4-3) remote and [5] (2-1) extremely unlikely. Fig. 6 illustrate the mentioned occurrence rate for each risk according to participant's input in the questionnaire. Respondents in such though to widen the perspective of research when dealing with BIM technology beyond the 3D representation. Looking at the BIM model can't be limited on the Revit model whereas in practice, the construction parties deal with an information model which extends beyond 3D and related information. Asset information is progressive through planning, design, construction, certification, handover and operation. Fortunately, by the common use of BIM we have reduced the potential for the future digitally engineered profession but a development of the way AEC industry individuals dealing with the BIM technology and the contractual work frame of a construction contract has been proven to be a necessity.

Figure 6 Occurrence level for BIM contractual risks

Total years of experience in the construction industry has a huge impact on the AEC industry. Now that BIM technology has become a great part of the construction project, BIM experts experience also has an effect on the survey. Based on fig. 7, different participant's category was observed in the survey and according to the total years of experience each participant has in the field. A value was assigned based on each party influence on the industry. So, less than five years of experience can affect (points of influence POF) the industry be a numerical value of 1 as it represents individuals in an entry level positions. between 5 to 10 years of experience will affect the industry by 2 as it represents individuals in an intermediate level position. More than 10 years of experience will be 3 as it represents individuals in a managerial level positions as shown in table 3. This research highlighted that this numbers represents each category weight on which we can take the factor of years of experience under consideration and we can add its influence to the analysis. Commonly, years of experience in the AEC industry has a huge impact on the industry itself and the reality exists today that professional services and means and methods are becoming more integrated and harder to separate (Leon L. Foster, P.E., PMP, 2008). BIM essentially accelerates this trend. A basic understanding of the difference between contractual risk facing BIM and general contractual risk is helpful at this point in time.

Table 3 Participant's years of experience (POF)

Experience Category	No.	POF
less than five years of experience	126	462
between 5 to 10 years of experience	119	182
More than 10 years of experience	73	73
TOTAL	318	717

The survey has shown that BIM has a contractual risk somehow different from contractual risks and there is a slightly different in experience effect on BIM risk with each additional years of experience added to the individual experience. For example, participant's with less than five years of experience choose BCR that can affect data status in a construction-based environment like (BCR19) experiencing data loss & dealing with database, (BCR6) data security and (BCR22) right to delegate BIM related activities/ Right to transfer models to subcontractors/sub-consultants. Mentioned risks are more commonly related to how the process when dealing with each party responsibility to do the job entitled to a construction party however, participant's with a greater experience than 10 years are more concerned with risks that may affect the parties way of work with other construction parties like (BCR4) data interoperability, (BCR5) protocol, process and responsibilities & (BCR2) professional liability (PL). The reason for that, based on respondents, if the project will use the BIM technology as requested by the owner or advised by the consultant thus there should be a contract between the consultant (BIM manger) and the contractor about the criteria of the work flow (in which the owner will be just a guest member in the contract). The presented understanding gives an advantage to the owner as a spectator each construction parties rather than participating. On that note, the owner becomes a part of the process without being in the process which will result in an observed gap when a claim or a dispute arises especially contractor to owner claims in which the owner will have the advantage.

Figure 7 Participant's years of experience (POF)

4.3 BIM contractual risks (BCR) solutions

The solution for every BIM contractual risk can provide a wider understanding of the preliminary contractual framework for BIM based contract. According to participants input analysis, the most suitable solution for risks facing every contractual risk was identified and if any participant has another solution that may be used as a new recommendation for research in the future. After analyzing the heights 10 risks facing BIM adaptation in contract with respect to both number of participant's and participant's total years of experience. Followed by identifying the highest contractual risks that BIM user's face when using BIM among project parties based on participant's total years of experience, we found that there are 12 contractual risks that represent the heights BIM contractual risks as shown in table 4.

Mostly there is a BIM/data appendix in the construction contract, made by the owner and the contractor/designer expand/elaborate on this in the execution plan (Construction Industry Council, 2018). There are no standardized BIM contract addenda have been developed without the use of some sort of protocol for information exchange that include software, security, and electronic transmission as well as control of the BIM model in order to define and assign liability (Greenwald, 2013). As with protocol, process and responsibilities the questionnaire shows that about 129 (58.37%) believe that BIM protocol prescribe how BIM service providers should use BIM in a way that deliver the project parties value and mandate that the protocol application be in the construction contract followed by 78 (35.29%) and 75 (33.94%) who think that the BIM execution plan is prepared by the consultant and provided in the contract as a part of the condition of contract and the BIM execution plan is prepared by the consultant and provided in the contract as a part of the appendix of the contract documents respectively. BIM execution plan is a developing document completed at each stage by each lead participant. Furthermore, Owner can only give high level guidelines; his representative should develop BIM related plans as the owner of the project which is the most logic and common understanding (The American Institute of Architects, 2014). About 131 (22.38%) of total of 210 participant's

think that the Contract should define the roles and scopes of works for all parties involved in the project followed by 119 (20.67%) participants' who think that contract should define the BIM's goals and quality checks for different stages of development with a slightly small difference in participants' opinion between (whether the contract should provide the BIM execution plan prepared by consultant (84 (14%)) participants') or the owner (82 (13.57%) participants').

Table 4 Participant's years of experience (POF)

Rank	BIM contractual risk (BCR)	No.	POF
1	(BCR5) Protocol, process and responsibilities	221	499
2	(BCR3) Condition of contracts	210	478
3	(BCR4) Data interoperability	206	479
4	(BCR8) Unclear BIM standard	204	455
5	(BCR2) Professional liability (PL)	203	473
6	(BCR15) Scope and requirement	195	415
7	(BCR1) Intellectual property (IP)	193	434
8	(BCR11) Model management difficulties	185	385
9	(BCR22) Right to delegate BIM related activities/ Right to transfer models to subcontractors/sub-consultants	182	283
10	(BCR20) Data misuse	175	366
11	(BCR6) Data security	118	445
12	(BCR7) Cost Compensation	168	383

The international alliance for interoperability (IAI) known as "buildingSMART" has developed industry foundation classes (IFCs) as a neutral and open specification for building information models. Several applications support IFC today and the number continues to grow (NIMBS Committee, 2007). For that reason, (BCR4) data interoperability risk solution based on this research suggests that 137 (66.5%) of participants believe that file format should be specified in the BIM execution plan and about 101 (49.03%) of participants believe that File format should be developed to be common between all project parties which disagree with the 74 (35.92%) of participants of total of 206 participant's opinion of making the consultant as the developer of the design model the provider the common data format to work on. Follow the ISO 19650 standards guidance for BIM procurement shows that employer's information requirements (EIR) with BIM execution plan (BEP) responses provide the needed platform for information exchange where the BIM execution plan is prepared by the contracting parties and describes how the demands from the BIM protocol will be delivered.

Standardized process and procedures for BIM became a must not a requirement as (Sacks *et al.*, 2018) stated that BIM standards are driving the recognition that all building model exchanges need to have a use case specification, if they are to be relied upon. Also, because direct exchanges have been developed, debugged, and maintained by the two companies

involved, they are typically robust for the versions of the software for which they were designed, and the use case functionality intended. For that reason a solution for (BCR8) unclear BIM standard based on participant's input shows that from the 204 participant's about 131 (64.22%) see that project parties agree on a specific standard which is added to contract document and about 103 (50.49%) of participant's believe that the adoption of an international BIM standard is the best serve the project parties' experience and knowledge. Finally, about 67 (32.84%) believe that the consultant as the developer of the model is responsible for assigning those standards. ISO 19650 state that everything else is obsolete now.

Seeking to share project parties' design information through a common file format in a BIM collaboration platform aims to enable other project participants to combine the data with their own data to produce a federated BIM model. For example, when the architect delegates the design obligations to different party in the construction project, a risk may arise unless the contractors to whom the design has been delegated to have professional liability insurance in place when the exchange is performed. Otherwise, any defective design claims could seek restitution from the architect's professional liability insurance policy (Pandey, Shahbodaghlou and Burger, 2016). (BCR2) Professional liability risk solution based on this research suggest that about 142 (69.95%) participants of total of 193 participants believe that each party is responsible for their own inputs and about 74 (36.45%) participants support the hypothesis that the consultant is responsible for the BIM model data. Followed by 64 (31.53%) of participants supports the consultant is responsible for the design contributions of others. Lead consultant may have coordination responsibilities.

The owner may engage a project manager or architect to advise. However, depending on the building type and use case the client may want the data for FM (Facility management). To define owner's (client's) need a clear scope and requirements of work are the basis for tender, and furthermore are vital proof for subsequent variation, management and claims where the employer and inspector also rely on this to inspect whether the physical construction is qualified with the objective (Ashcraft, 2008). According to the survey data, from 195 participants that agree on (BCR15) scope and requirement risk about 113 (57.95%) believe that scope and requirement of the BIM model is specified by the owner (client) and about 75 (34.46%) participants believe that scope and requirement of the BIM model is specified by project's party's needs. Finally, about 60 (30.77%) participants believe that Scope and requirement of the BIM model is specified by the consultant and Scope and requirement of the BIM model is specified by the minimum requirement to adopt BIM technology in the construction process. AEC industry participants deals with an information model not a BIM model as each participant will require different information to carry out their tasks ultimately the information model becomes the asset information model.

For the perpetuity the BIM model to take place, "Licensing for use" is required to be issued for the contractor and owner to obtain IP licensing for almost all aspects of the project and indemnity insurance: the contract requires any party of the project to take responsibility for any claims for breaches of IP data provided for the contract (Abd Jamil and Fathi, 2018). The protection of intellectual property (BCR1) is crucial for project stakeholders to identify and define in any event that requires consideration to regulate the ownership of IP and the BIM model in the Early stages of the project till IFC drawing it's the sole responsibility of the consultant. That being said, about 87 (45.08%) participants of total of 193 participant's believe that the consultant as the developer of the model owns the Intellectual property rights of the model and about 85 (44.04%) participants support such hypothesis providing the owner, the perpetuity right "Licensing-for-use" after the project being finalized and handed over to the owner. In most countries, the party that creates the model holds ownership of its copyright, unless the party is retained by another to create a work for hire, and then the party that hired the

modeler owns the model. Moreover, a trend has emerged that master rights should be with client, while the intellectual/design rights with consultants.

A greater barrier is related to model management and work process because integrating multiple disciplines requires multiuser access to the model which require technical expertise, establishment of protocols to manage updates and edits of the model, and establishing a network and server to store and access the model (Sacks, Gurevich and Shrestha, 2016). When faced with (BCR11) model management difficulties risk the questionnaire shows that from 185 participants about 104 (56.22%) of participant's believe that under the project parties' mutual agreement, the BIM Execution plan will be prepared followed by 103 (55.68%) participants believe that BIM manager is responsible for managing the model and 53 (28.65%) believe that BIM manager is responsible for managing the model. The role of BIM coordinator should be further more investigated.

On huge scale project with BIM platform, the main contractor may require to delegates the works to subcontractor where the need for a contractual framework for BIM contract should be included where the responsibility of the BIM model is delegated to the subcontractor (Leon L. Foster, P.E., PMP, 2008). Participants input facing a new risk (BCR22) right to delegate BIM related activities/ right to transfer models to subcontractors/sub-consultants from 245 participants about 98 believe that the delegation is done by providing all the needed information for the party to work with and the delegated data must be used under the needed purpose of the delegation. Followed by 93 participants believe delegation of BIM information requires great care information should be NON_EDITABLE as it passes through the process see ISO 19650.

As discussed before, BIM technology is built on information sharing among project parties. However, the information provided need to have some sort of "framework of sharing" between parties to define which parties have access to what type of information. If no clarity on status of deliverables, model status and information available for sharing is defined in the contract, confusion, error, communication fiasco and data misuse risk will take place (Widén et al., 2015). Models should only be used for the purpose for which they are intended. When a model made for one purpose is used for another, currency, adequacy and tolerances become a concern (Ashcraft, 2008). From analysis the questionnaire input, from 175 participants about 114 (65.14%) think that models should only be used for the purpose for which they are intended and about 107 (61.14%) think models should be used under the uses stated in the contact.

Based on (Arshad *et al.*, 2019), a well-protected network servers with the A/E responsible of the security of project data and superseded file in most BIM based project today shall be saved and it's logs shall be maintained. With that being already mentioned in the literature, the analysis of the questionnaire showed that about 112 (56.85%) believe that all project data should be saved on a network server which is well protected and about 107 (54.31%) believe that BIM execution plan will provide the necessary mechanism for the safety of the data. Finally, about 76 (38.58%) believe that Logs for each file shall be maintained.

The fee structure in some projects is already changing to reflect the value of decisions made during schematic design and the decreased effort required for producing construction documents. The change in distribution of effort also makes assumptions about delivery method and contracting (Eastman *et al.*, 2011). Based on participant's input, we can see that from 168 participants about 83 (49.4%) agree that The BIM technology cost is considered to be an additional cost added to the provider of such technology in the forum of cost compensation that the Owner (Client) bears it and about 49 (29.17%) believe that the BIM technology cost is considered to be an additional cost added to the provider of such technology in the forum of cost compensation that contractor bears it. Finally, about 44 (26.19%) believe that The BIM

technology cost is considered to be an additional cost added to the provider of such technology in the forum of cost compensation that the consultant bears it.

As per participant input in the survey, table 5. lists the critical BIM contractual risk solutions for each risk.

Table 5 BIM contractual risks (BCR) solutions

No.	Proposed solution	Participant's
BCR5 Protocol, process and responsibilities	- BIM protocol prescribe how BIM service providers should use BIM in a way that deliver the project parties value and mandate that the protocol application be in the construction contract.	<u>129(58.37%)</u>
	- The BIM manager is assigned by:	
	- Owner	64(28.96%)
	- Consultant	62(28.05%)
	- The BIM Execution Plan is prepared by the consultant and provided in the contract as a:	
	- Contract Conditions	78(35.29%)
BCR3 Condition of contracts OR	- Appendix part of the contract Documents	75(33.94%)
	- BIM deliverables shall be broken down in the BIM Execution plan by:	
	- The Owner.	81(38.57%)
	- The consultant.	<u>84(40%)</u>
	- Contractor	82(39.02%)
	- Apply best practices.	50(23.81%)
BCR4 Data interoperability	- Contract should define:	
	- the roles and scopes of works for all parties involved in the project	<u>131(62.38%)</u>
	- the BIM's goals and quality checks for different stages of development	119(56.67%)
	- Apply best practices.	50(23.81%)
	- File format should be developed to be common between all project parties.	101(49.03%)
BCR8 Unclear BIM standard	- File format should be specified in the BIM execution plan.	<u>137(66.5%)</u>
	- The consultant as the developer of the design model should provide the common data format to work on	74(35.92%)
	- Apply best practice.	53(25.73%)
	- Project parties agree on a specific standard which is added to contract document.	<u>131(64.22%)</u>
	- The consultant as the developer of the model is responsible for assigning those standards.	67(32.84%)
BCR2 Professional liability (PL)	- Adopted an international BIM standard that best serve the project parties' experience and knowledge.	103(50.49%)
	- Apply best practice.	44(21.57%)
	- The consultant is responsible for the BIM model data.	74(36.54%)
	- The consultant is responsible for the design contributions of others.	64(31.53%)
BCR15 Scope and requirement	- Each party is responsible for their own inputs.	<u>142(69.95%)</u>
	- Apply best practices.	41(20.2%)
	- Scope and requirement of the BIM model is specified by:	
	- The Owner.	
	- The consultant.	<u>113(57.95%)</u>
	- According to project parties' needs.	60(30.77%)
	- Minimum requirement to adopt BIM technology in the construction process.	75(38.46%)
	- Apply best practice.	60(30.77%)
		33(16.92%)

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BCR1 Intellectual property (IP)	- The consultant as the developer of the model owns the Intellectual property rights of the model.	<u>87(45.08%)</u>
	- The owner of the project is the owner of any input by the consultant.	81(41.97%)
	- providing the owner, the perpetuity right "Licensing-for-use" after the project being finalized and handed over to the owner.	85(44.04%)
	- Apply best practice.	52(26.94%)
	- Every party owns the IP of their own input.	77(39.9%)
BCR11 Model management difficulties	- Under the project parties' mutual agreement, the BIM Execution plan will be prepared.	<u>104(56.22%)</u>
	- BIM manager is responsible for managing the model.	103(55.68%)
	- The consultant is responsible for managing the model.	53(28.65%)
	- Apply best practice.	42(22.7%)
BCR22 Right to delegate BIM related activities/ Right to transfer models to subcontractors/s ub-consultants	- The delegation of the BIM model should be under a new drafted contract between the BIM provider and the delegated party.	93(51.1%)
	- The delegation is done by providing all the needed information for the party to work with and the delegated data must be used under the needed purpose of the delegation.	<u>98(53.85%)</u>
	- Apply best practice.	54(29.67%)
BCR20 Data misuse	- Models should only be used for the purpose for which they are intended.	<u>114(65.41%)</u>
	- Models should be used under the uses stated in the contact.	107(61.14%)
	- Apply best practice.	42(24%)

5. PROPOSED CONTRACTUAL FRAMEWORK

Using collected data from literature review and based on questionnaire output, a BIM contractual framework is proposed. Three-dimensional information is proposed in this framework in the form of published contracts, survey response, and custom contract manuscripts to provide the information triangulation. Shown fig. 8.

Figure 8 BIM Contractual Framework

6. DISCUSSION

Contractual presence of BIM in a contract is yet to be investigated to the full extent of application due to the difference between BIM collaborative nature and contracts isolation and separation nature. However, with the advancement of the AEC industry to the current state, BIM has entered a new stage of development which seem limiting to the BIM application ,at first, but with further investigation and identification of BIM barriers in this perspective may help in defining this limits, as highlighted by (Pandey, Shahbodaghlou and Burger, 2016; Sacks, Gurevich and Shrestha, 2016; Almarri, Aljarman and Boussabaine, 2019; Arshad *et al.*, 2019). Previous researches provided identified BIM legal risks based, some more than others, and stated the solution for each risk based on previous research. This research went future into the forming a questionnaire that define in its structures the following; (1) participants background information (2) identifying BIM contractual risks, (4) level of occurrences for each risk, (5) affected parties by each risk where a proposed contractual framework was proposed, (6) solution for each BIM contractual risks based on years of experience for each participant. All the parameters in this questionnaire were obtained and then the questionnaire where designed upon previous researches conclusion.

7. CONCLUSION

Asset information is progressive through planning, design, construction, certification, handover and operation. Fortunately, by the common use of BIM the potential for the future digitally engineered profession have increased but BIM technology application in mega projects, with the needed level of details, have resulted in the rise of BIM contractual risks. The aim of this research is to investigate the contractual risks facing BIM technology and the other variables affecting them (level of occurrence, parties involved, participant's years of experience) followed by a solution for each risk. All solution will help provide a preliminary contractual framework on which BIM technology can have a smooth sailing through the life span of the contractual process that serves as a key finding in the development, as a checkpoint and as a mechanism to integrate knowledge, including many underlying factors. A very detailed review has been conducted to the highlighted literature review of the legal implication of BIM with projects legal strategies. As a result, this study has examined about 22 legal risks and found that top 10 contractual risks facing BIM adaptation are as follow: (1) (BCR5) protocol, process and responsibilities [221 (499 (69.5%) POF)], (2) (BCR4) data interoperability [206 (479 (66.8%) POF)], (3) (BCR3) condition of contracts [210 (478 (66.8%) POF)], (4) (BCR2) professional liability (PL) [203 (473 (65.9%) POF)], (5) (BCR8) unclear BIM standard [204, (455 (63.4%) POF)], (6) (BCR6) data security [118, (445 (62%) POF)], (7) (BCR15) scope and requirement [195, (439 (61.2%) POF)], (8) (BCR1) intellectual property (IP) [193, (434 (60.5%) POF)], (9) (BCR11) model management difficulties [185, (415 (57.8%) POF)], (10) (BCR20) data misuse [175, (390 (54.3%) POF)] based on number of participants, point of influence value and percentile. After careful investigation of several BIM protocol and standards with the results of this study, a proposed framework for a BIM has been concluded and presented. Findings has provided a wide understanding of the major risks facing BIM contractually and the proposed contractual framework has defined the major construction party's role in the BIM work environment to be addressed by assigning each risk to the concerned parties. BIM clouded framework will provide an easy and smooth implementation of BIM while becoming a part of a contractual agreement, BIM execution plan or BIM protocol. Furthermore, this study provides each parties responsibility to every proposed risk by highlighting the occurrence level of every contractual risk. This particular study represents a contribution to; (1) the identification of BIM contractual risks based on AEC industry participant population and years of experience, (2) providing a solution in the form of a contractual framework in the direction of a standardizing

a contractual system for implementing BIM technology, and (3) identifying the risk as a role that functions and has a responsibility in the forum of representing level of occurrence for each BIM contractual risk that challenge face-to-face the standardization concept of contracts.

LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

BIM technology was believed that it's far away from understanding its legalities in the near future. However, it's not as there has been a breakthrough in the AEC industry that have shed the light on such risks. In the light of recommendation, this research point is rich in its details and accountabilities in any construction project. Furthermore, research in such topic is highly recommended towards adding up the general standards that are currently followed in using BIM technology and also the flaws that are still persistent that hinders the further use of the same to the next level. Also, adding up the general standards that are currently followed in using BIM technology and also the flaws that are still persistent that hinders the further use of the same to the next level. Additional research in the design and build contracts is recommended where the contractor bears most of the risks. Further investigation into the development of a BIM contractual framework for the best implementation in BIM. The contract in forms of Employer's information request (EIR) then BIM execution plan (BEP) should be further investigated to the who, when and how will produce the info.

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