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State of the art of the use of BIM for resolution of claims in construction projects

Estado del arte del uso de BIM para la resolución de demandas en proyectos de construcción

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Abstract

Multiple attributes make construction projects to be likely to face disputes during its execution, such as the nature of adversarial relationships between stakeholders, tight budgets, and the lack of incentives in contracts encouraging collaboration. Furthermore, the impact of claims will vary but is likely to have a negative impact on projects. Consequently, stakeholders have to manage the process of claim resolution. A challenge of this process is the understanding and clarity of the information used to resolve construction claims. A technology that has faced a steady growth in the construction industry is Building Information Modeling (BIM). The benefits of implementing BIM in construction projects are widely recognized such as automation of the quantity take-off estimation process, quick reaction to design changes, better visualization of the construction schedule, and design coordination. Nonetheless, limited studies have addressed how the existing benefits from implementing BIM can be used as a platform to facilitate the resolution of construction claims. This study explores and discusses the existing literature to identify the main benefits of implementing BIM in the resolution of construction claims. The aim is to assess what exists in the legal branch of implementing BIM in construction to suggest its use in this regard.

Keywords: *BIM, claims resolution, construction projects*

Resumen

Hay muchos atributos que hacen que los proyectos de construcción sean susceptibles de enfrentarse a disputas durante su ejecución, como la naturaleza de las relaciones adversas entre las partes interesadas, los presupuestos ajustados y la falta de incentivos en los contratos que fomenten la colaboración. Además, el impacto de las demandas variará, pero es probable que tenga un efecto negativo en los proyectos. Por consiguiente, las partes interesadas deben gestionar el proceso de resolución de demandas. Un desafío de este proceso es el entendimiento y la claridad de la información utilizada para resolver las demandas de construcción. Una tecnología que ha tenido un crecimiento constante en la industria de la construcción es el Modelado de información para la construcción (del inglés *Building Information Modeling*, BIM). Los beneficios de la implementación del BIM en los proyectos de construcción son ampliamente reconocidos, tales como la automatización del proceso de estimación del desglose y presupuesto de materiales, la rápida reacción a los cambios de diseño, la mejor visualización de la programación de construcción y la coordinación del diseño. No obstante, estudios limitados han abordado la forma en que los beneficios existentes de la implementación del BIM pueden utilizarse como plataforma para facilitar la resolución de las demandas de construcción. Este estudio explora y analiza la literatura existente para identificar los principales beneficios de la implementación del BIM en la resolución de demandas de construcción. El objetivo es evaluar lo que existe en la rama legal de la implementación del BIM en la construcción para sugerir su uso en este sentido.

Palabras clave: BIM, resolución de demandas, proyectos de construcción

1. Introduction

The global average value of disputes in the construction industry in 2017 was US$43.4 million, and the average length of those disputes was 14.8 months. (Global Construction Disputes Report, 2018) Interestingly, in North America, the average value of disputes is approximately half of the global average (i.e., 19 US$ million). (Global Construction Disputes Report, 2018). However, on average it takes longer to solve construction disputes in North America (i.e., 17.7 months) (Global Construction Disputes Report, 2018). These numbers are expected to increase in the coming years given the development of large and complex infrastructure projects in response to the expected urban growth of North American cities, and the maintenance and rehabilitation of aging infrastructure such as bridges, highways, and water networks (ASCE, 2017).

If the problem of reducing the cost and time to resolve disputes in the construction industry needs to be addressed, it becomes necessary to explore the causes that lead to such disputes. For example, in North America, the region in which this study is focused, errors and omission in the contract documents, failure to manage the contract appropriately, and failure from the owner/contractor/subcontractor to understand and/or comply with their contractual obligations have been identified as the three main causes of disputes in construction projects in 2017 (Global Construction Disputes Report, 2018). It is evident that the leading causes of disputes are related to problems in the communication and collaboration among the different stakeholders involved in construction projects (e.g., owner, design engineers, the prime contractor, and subcontractors). Therefore, is necessary to explore alternatives that assist in solving these problems in

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the construction industry such as new project delivery methods (e.g., Integrated Project Delivery), Building Information Modeling (BIM), or alternative dispute resolution methods (ADR).

During the last decades, the construction industry has seen how a variety of new technologies have been developed and implemented as an effort to improve the performance of construction projects overall. Perhaps one of the most promising technologies has been building information modeling (BIM) (Eastman et al., 2018). The use of BIM in the US has rapidly increased in recent years (Construction McGraw-Hill, 2012); this growth has been most likely driven by the US government requiring infrastructure related contracts to be BIM enabled (Construction McGraw-Hill, 2014). Nonetheless, the use of BIM in the legal context in construction has not followed the same trend (Ashcraft, 2008).

This study aims to focus on the study of the advantages and challenges of using BIM to manage claims and disputes in the construction industry. This study is motivated mainly by three factors: (1) the framework proposed by BIM of encouraging a better communication in an environment of collaboration among the different stakeholders, (2) the premise of providing better information leading toward better decision-making, and (3) the limited literature of implementing of BIM in the legal context of the construction industry. Exploring the use of BIM to resolve construction disputes is thought to be a viable and convenient alternative for the construction industry; however, challenges such as technology acceptance by stakeholders, and legality implications must be identified, assessed, and discussed in order to implement BIM in the context of construction claims and disputes.

2. Background research

Building Information Modeling (BIM) provides digital representations of the physical and functional aspects from buildings and facilities. As such, it provides shared knowledge for all the stakeholders in the project. Moreover, it is based on the premise of collaboration by the multiple stakeholders involved during the different stages of the lifecycle of a construction project (Azhar, 2011); (Eastman et al., 2018); (Gurevich et al., 2017). The use of BIM has multiple reported benefits, such as early involvement from stakeholders, design efficiency, 3D modeling and visualization, take-offs and estimating, 4D simulation, design coordination, increased quality of design and work execution (Ashcraft, 2008); (Eastman et al., 2018); (Gibbs et al., 2013); (Jobim et al., 2018). The diversity of BIM benefits is illustrated in (Figure 1), which shows the different project phases where BIM is traditionally implemented and the benefits in such phases.

Project stage			
Preconstruction	**Design**	**Construction and Fabrication**	**Post Construction**
Concept, Feasibility, and Design Benefits	Early and more accurate visualization	Use of design to fabricate components	Improves commissioning and handover of facilities
Increased Building Performance and Quality	Automatic correction when changes are made	Quick reaction to design changes	Better management and operation facilities
Improved Collaboration Using IPD	2D drawing automatic generation	Discover mistakes before construction starts	Integration with facility management
	Early collaboration among disciplines	Synchronization of design and construction planning	
	Automatic cost estimates	Synchronization of procurement with design and construction	

Figure 1. *BIM benefits during construction project stages, adapted from (Eastman et al., 2018)*

Furthermore, in (Figure 2) it can also be observed the level of influence on the project cost related to the implementation of BIM. The most common use of BIM has been concentrated in the design and construction stages of projects. However, more application has started to be implemented in other phases such as the feasibility analysis (e.g., Hollywood BIM), or during the operation and maintenance (e.g., BIM for facility management).

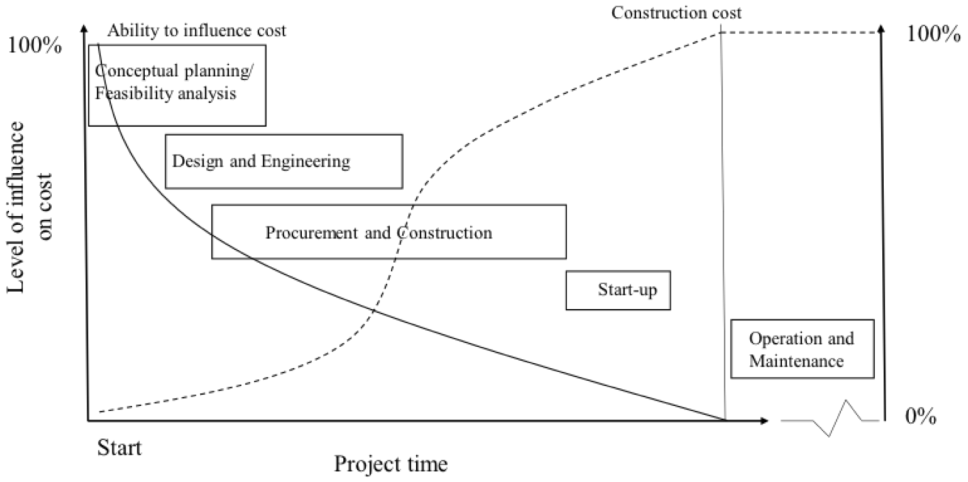

Figure 2. *Influence on overall project cost over the project lifecycle (Eastman et al., 2018)*

Although BIM has multiple benefits, it also faces challenges such as limited standardization of processes, data interoperability, and legal implications (Ashcraft, 2008); (Eastman et al., 2018). In recent years, documents to standardize the modeling process have been developed, and data interoperability has been improved facilitating the interaction of models among different vendors. However, the challenge posed by the legal implications of BIM has not seen improvements at the same pace, which is surprising given the adversarial relationships that are part of every day in most construction projects. For example, a study explored the different attributes used by construction companies to assess BIM benefits by compiling 18 published studies related to BIM (Won, 2014). As expected, the attributes of schedule and cost are the most frequently used with 67% and 56% respectively, then followed by requests for information, change orders, and return of investment each one with 28%. However, claims were at the bottom of the list only achieving 6%, thus emphasizing the low level of interaction between BIM and the resolution of construction claims.

It has been identified that there is a gap in studying the implementation of BIM in the legal context of construction projects (Ashcraft, 2008). Perhaps, in response to this claim made by Ashcraft in 2008, researchers began to explore the legal side of implementing BIM in the construction industry. Some benefits of implementing BIM that have been found include that the use of BIM on projects decreases the probabilities to have disputes between the parties involved in the project, because facilitates a collaborative environment among the project stakeholders, and increases the chances to eliminate design and schedule conflicts early in the project (Greenwald, 2012). Additional benefits of BIM include reducing potential causes of claims in construction projects such as design errors and uncertain estimated quantities related to the execution of the project; these benefits may often be observed during large and complicated construction projects (El Hawary and Nassar, 2015).

On the other hand, challenges of BIM application have been explored, for instance, (Hamdi and Leite, 2013) through a literature review and interviewing nineteen experts, studied the challenges of implementing BIM, focusing on the contractual challenges. These authors found relevant gaps in BIM implementation during phases of construction projects. Namely, between the design and construction stages, and between construction and post-delivery phase. These gaps are mainly due to interests' misalignment between stakeholders. However, from a contractual standpoint, these gaps are more than addressable by the stakeholders (Hamdi and Leite, 2013).

Another perspective to analyze the use of BIM in claim resolution in construction projects is Dispute Resolutions (DR). Existing literature has already recognized the need to explore the use of BIM in this context, and also some literature developed in recent years have explored the identification of the leading causes of claims using BIM and using 4D scheduling for claims. For example, (Gibbs et al., 2013) claimed that there is a gap in studying the interaction between BIM and the process of claim analysis. Furthermore, the authors highlighted the necessity to solve conflicts using a proactive approach to avoid future disputes, which is exactly the type of environment that provides BIM to construction projects.

(Charehzehi et al., 2017) studied the application of BIM in construction conflict management in the context of the Malaysian construction industry. Namely, proposed a framework in which the main causes of the conflicts among the client, contractor, and consultant are identified based on four dimensions (i.e., cost, time, quality, and documentation). Additionally, a variety of BIM applications or functions are assessed as the best alternatives to manage each type of conflict; the BIM functions explored included facility management, shop-drawing processes, 4D scheduling, automated cost estimation, structural analysis, clash detection, and 3D visualization. Finally, the study suggested that clash detection, 4D scheduling, 3D visualization, and structure analysis are the functions with the highest priorities to manage conflicts in construction projects. Interestingly, (Marzouk et al., 2018) took a step further and developed a BIM-based model to identify and evaluate construction claims. Interestingly, the result of the model is a claim report that shows actual and potential claims in the project, and the time delay due to existing claims.

In regards to the use of 4D scheduling with BIM to manage claims in construction. (Coyne, 2008) argued that the use of 4D models allow effective analysis of the impact of delays on construction schedules, and as such, facilitates negotiations and dispute resolutions. However, the novelty and immaturity of 4D modeling at the time of the study would improve in the future and may become in a more accessible technology to perform delay-analyses. One decade later, (Guévremont and Hammad, 2018) explored the use of 4D scheduling as a tool to assess the impact of delays on the critical path of a construction project. The authors found that 4D BIM simulation provides better visualization and identification of delay events. Additionally, this approach generates a better environment for stakeholders to collaborate during the early stages of the project for claims mitigation.

3. Case study: Mortenson vs. Timberline 2009

Legal cases were also explored as part of the background research from this study. The purpose of this additional search is to look for a real example of the legal implication of implementing BIM during a construction project. A legal case was found in the literature that illustrates the claim for consequential damages suffered from a general contractor company after using a computer software related to BIM technology while preparing a bid for a construction project (M.A. Mortenson Co. v. y Timberline Software Corp., 1999). The general construction contractor M.A. Mortenson Company (Mortenson) purchased a licensed computer software from Timberline Software Corporation (Timberline). The problem was that Mortenson prepared a bid using the purchased software, and after the bid was awarded the company realized that the bid was $1.95 million lower than intended. Mortensen sued Timberline alleging the software was defective and claimed to be indemnified and recover the damages generated by the software failure. Finally, the Washington Supreme Court ruled in favor of Timberline, neglecting the claim made by Mortenson (M.A. Mortenson Co. v. and Timberline Software Corp., 1999).

The relevance of this legal case is that Mortenson Company was found to be responsible for the submitted bid prepared using the software purchased from Timberline regardless of software issues faced during the preparation of the bid. This case highlights an excellent example of the interaction between construction workers and software technologies, and the legal consequences of such interaction. The first impression after reading the abstract of the case is that the software company should be considered responsible from the lower bid submitted by Mortenson. However, after knowing that the software warned the users about a problem, and the users did not take into account such problem and continued preparing the bid with the software, it makes it clearer that the workers from the Mortenson company were also responsible from the lower bid submitted for the project. Notably, this case shows the relevance of having properly trained and competent workers that are able to use the computer software to facilitate their tasks but also can identify and acknowledge the severity and consequences of potential problems while using computer software.

4. Dispute resolution in construction

In order to discuss the benefits of implementing BIM to assist the resolution of claims, firsts is necessary to understand the process of resolving claims in the construction industry. The stakeholders that traditionally get involved during disputes in construction projects may include the owner, the design entity (A/E), the General Contractor (GC), and subcontractors. The traditional sequence to resolve disputes can be understood as a scaffold; stakeholders start with a very collaborative environment to resolve disputes (i.e., Partnering). However, if no agreement is reached the degree of hostility between the parties increases, in some cases even litigation is pursued, which is the most severe approach to resolve disputes in construction see (Figure 3).

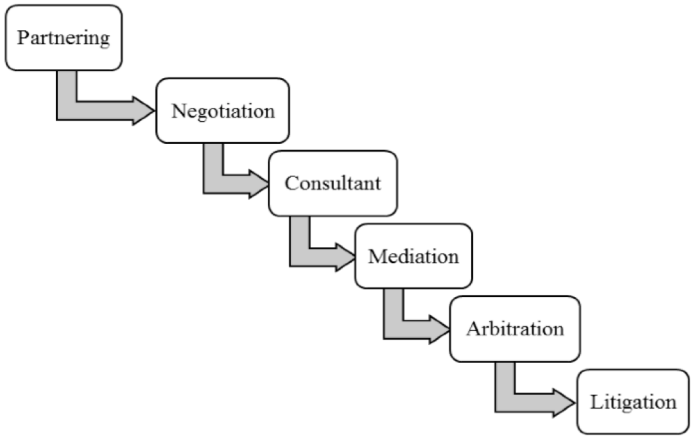

Figure 3. *Dispute resolution phases (Cheung et al., 2000)*

In the construction industry, partnering can be developed during projects. However, due to the short-term relationships (i.e., the project), the confrontational nature of relationships in construction, and the lack of incentives in contractual documents to cooperate, is difficult to observe sustained collaboration in construction projects. Nonetheless, the project delivery method that has better captured this concept is the Integrated Project Delivery (IPD). IPD involves all stakeholders from the conception of the project, share incentives and risks to finish the project according to expected costs, schedule, quality, and safety requirements. Although this project delivery method has increased its implementation in the construction industry during recent years (Fischer et al., 2017), is still mostly related to highly complex projects such as healthcare facilities. The process of negotiation is still voluntarily by all the parts involved in the construction project, and it also requires a level of commitment from all the participants to resolve the existing problems. If not taken seriously following written resolutions, it may not be as successful as expected. The process of hiring a qualified third party (i.e., expert or consultant) to provide his/her opinion on the likely outcome if the case went to a trial. As such, the parties may use the opinion of the expert to encourage the settlement of the dispute out of court.

Mediation and arbitration are perhaps the most common ways to resolve disputes in construction since both avoid going to court, and the process is managed by a third party (i.e., mediator or arbitrator) and, which in many cases is an expensive and time-consuming process for the parties (Clough et al., 2005); (Menassa and Peña, 2007). The main difference between mediation and arbitration is the level of control of the outcome from the parties. In mediation, all the parties voluntarily meet with a third party mediator and attempt to resolve the problems and disputes, then the decision made by the mediator of how to resolve the conflict is a highly suggested solution, however, is not binding or mandatory to accept the proposed solution (Clough et al., 2005). On the contrary, during an arbitration, once the parties submit all the information related to the conflict to the arbitrator, the solution made by the arbitrator is binding. Therefore, all the parties must accept the resolution made by the arbitrator (Clough et al., 2005). Finally, the last phase of this sequence is litigation. In general, construction companies do not follow this path, unless a one party has very strong arguments and wants to make a precedent in the law (Tazelaar and Snijders, 2010). The main point to avoid litigation from construction companies is that the decisions related to conflict resolutions are made by a judge or a jury that in the majority of the cases lack of construction expertise. As such, judges and juries may not be fully aware of the consequences of their decisions.

5. Bim - the path to facilitate dispute resolutions in construction?

As it has been discussed in this study, BIM provides multiple benefits for the construction industry, namely throughout the multiple phases of a construction project lifecycle see (Figure 1) – (Figure 2). Moreover, there is extensive literature supporting such benefits (Ashcraft, 2008); (Eastman et al., 2018); (Won, 2014). Notably, in the context of benefits of implementing BIM to resolve construction claims the existing literature is much more limited. For instance, (Table 1) summarizes the main findings identified in the literature prepared for this study.

Table 1. *Summary of the benefits of implementing BIM for Dispute Resolutions*

Authors	***Main findings***	***Reason provided***
Greenwald (2012)	*Increases the chances to eliminate design and schedule conflicts early in the project.*	*BIM supports a collaborative environment using formal documentation.*
El Hawary and Nassar (2015)	*Reduce potential causes of claims.*	*Reduce uncertainty related to quantity estimations.*
Charehzehi et al. (2017)	*BIM framework to control conflict causes using Clash detection, 4D scheduling, and 3D visualization.*	*Best BIM functionalities to manage claims.*
Coyne (2008); Guévremont and Hammad (2018)	*4D Modeling to resolve delay claims.*	*Better visualization and identification of delays.*
Hamdi and Leite (2013)	*Gaps were found during the implementation of BIM between design and construction stages. However, these gaps can be addressed from a contractual standpoint.*	*Existing misalignment between stakeholders.*

As can be seen in (Table 1) BIM benefits such as collaboration, 4D scheduling, and visualization have been identified as actual benefits to resolve disputes in construction projects. Perhaps these benefits from BIM were the most intuitive to validate in the context of resolving construction disputes. A collaborative environment during a construction project by nature facilitates the resolution of any problem of conflict between the parties involved, thus, limiting the occurrence of conflicts escalation from a single problem to a dispute. Furthermore, a collaborative environment encourages parties to address any problem or conflict as early as it may appear on the project. As such, taking into account what is shown in (Figure 2), the early the parties may address any potential dispute, the more influence the parties will have on the impact of such disputes over the cost of the project. Regarding the benefits of 4D scheduling, as discussed by (Kang et al., 2007), 3D visualization and 4D scheduling led to detect logical errors in the construction processed more frequently, faster, and making fewer mistakes. As such, is reasonable to assume that these benefits may provide valuable assistance to the stakeholders in resolving construction disputes.

Although some BIM benefits have been identified as having a positive impact on construction dispute resolutions, the research in this regard is still far behind other aspects of implementing BIM. Therefore, more research is still necessary in this regard, for example, expanding the quantification of these benefits according to the different type of construction projects such as industrial projects, commercial, housing, or infrastructure projects.

On the other hand, multiple benefits that are typically recognized from implementing BIM have not been explored yet in the context of disputes in construction projects, for instance, a quick reaction to design changes and improved collaboration using IPD (Eastman et al., 2018). Regarding these unexplored benefits, there are some challenges to assess their impacts on dispute resolutions that need to be overcome before. For instance, having a quick reaction to design changes using BIM is likely to minimize potential problems and disputes from such changes. Being able to react appropriately to changes, decreases the chances to have conflicts between the parties. Therefore, it may be difficult to find construction projects with quick design changes response and at the same time involved in a construction dispute. Similarly, regarding the implementation of IPD to encourage collaboration among the different parties in the project by nature may minimize the possibilities of having conflicts and disputes in a project. In the future when the industry of construction becomes more familiar with the implementation of IPD, future research should study construction projects using IPD and BIM to confirm whether implementing these frameworks together, in fact, minimizes—if not eliminates, the disputes in construction projects.

Given the uniqueness of construction projects as one of the main characteristics of the construction industry, is not realistic nor practical to assume that only one approach (e.g., BIM) will resolve all the problems and claims for different types of projects, and no one can expect that. However, what can be stated is that implementing BIM in construction projects requires a collaborative environment, improves the visualization of building elements and processes throughout project execution, reduces the uncertainty of quantities estimated in the project. As such, all these characteristics positively influence and facilitate at some extent construction

disputes resolution. Future research should be focused on classifying which characteristics have the most impact on resolving disputes, quantifying those impacts, and explore effective ways in which these high impact attributes of BIM can be successfully implemented in construction projects.

6. Conclusions

This study explores the existing literature regarding BIM benefits on construction projects, namely identified benefits of BIM in the context of disputes in construction projects. As such, different benefits were identified for instance encouraging a collaboration environment, visualization, and reducing uncertainty related to quantity estimation. However, when compared with the widely recognized benefits of BIM (Eastman et al., 2018), is clear that research on BIM and disputes in construction projects is well far behind. The study then discusses potential reasons to explain why the current state of BIM research for disputes in construction projects, challenges to overcome the current limitation, and suggest ideas for future research.

The principal findings from this study are first that the implementation of BIM to resolve disputes in construction projects is a relatively unexplored field, which should be explored in future years given the increased expansion of BIM implementation in the industry. Second, the early the implementation of BIM during a project and in a construction dispute process the better, in theory, BIM promotes a fully collaborative environment where disputes should not exist, however, the nature of construction many times encourages problems between the parties. Therefore, from a practical standpoint, if disputes can be minimized and problems can be solved as soon as they appear in a project, the implementation of BIM should be considered successful. Finally, the most attractive framework to be combined with BIM seems to be IPD. The collaborative nature of these two approaches makes them complement each other perfectly. However, currently, IPD is mostly applied to very complex projects such as health care facilities. A more common implementation of these approach in a more regular basis in the construction industry may lead to further studies confirming or expanding the benefits of implementing BIM and IPD.

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