Investigating the use Building Information Modeling (BIM) in Managing Construction Claims[1]

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ABSTRACT

As the complexity of construction projects is increasing, possibilities for problems are growing, drawing negative impact on projects' cost, time and quality. Thus, triggering claims that are disruptive to projects, time consuming and costly. Building Information Modelling (BIM) holds huge potential in improving claim management practices. The main aim of this paper is to evaluate how and to what extent BIM can help avoiding and reducing claims in construction. The paper ran a literature review on recent research, industry reports, and other sources to see how they it identified claims, their sources and types. Also, the paper identified contemporary challenges in the claims field and the construction industry as whole. A framework of preventive effects and reactive actions to manage claims was identified. Then the paper established how each effect and action related to BIM's features can contribute to claims practically. The obtained results have shown that BIM outperforms traditional claim management practices in many aspects including identifying and analyzing claims, where the benefits are realized in time and cost savings, less change orders, less rework. Also, the information and knowledge management that BIM provides can improve many aspects of claim management.

Key Words - Building information modelling (BIM), Contracts, Claim Management, Dispute, Avoidance, Mitigation

INTRODUCTION

Disputes became an indivisible part of construction projects. As the complexity of construction projects increases, it became impartial to adopt emerging technologies, innovative techniques, new standards, contracting and delivery methods. With all this, the number of claims and

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disputes has increased significantly and the need to adopt effective methods and tools in dispute resolution processes became more prominent.

Building Information Modeling (BIM) is a powerful tool that has been changing construction projects and industry. For instance, BIM's visualization capabilities make it possible to communicating one standardized holistic image about the project[2]. Moreover, BIM gives stakeholders the ability to navigate in 3D models and run walkthroughs, giving a real feel of the project before its even started. Thus, building a match in the as-built model to client's expectations before construction takes place. BIM can keep different consultants' interpretations away from any deviation or misinterpretation[3]. Using BIM's database for sharing information, managing documents, communicating technical aspects can improve supporting, reviewing and managing claims. However, the maturity of BIM still is very limited in this area. This is emphasized through IP's (2002)[4] findings that verbal and written ineffective information exchange and poor communication between parties are the main cause and catalyst for majority of disputes and claims.

1. Value of claims

Arcadis[5] have mentioned in their 2017 report that the global average value of disputes was US$42.8 million with a global average length of 14 months. The highest claim value for 2017 was worth US$2B. Despite the slight decrease, the trends show that a spike can occur at any time as seen in table 1.

REGION	AVERAGE DISPUTE VALUES (US$ MILLIONS)						AVERAGE LENGTH OF DISPUTE (MONTHS)					
	2011	2012	2013	2014	2015	2016	2011	2012	2013	2014	2015	2016
North America	10.5	9	34.3	29.6	25	21	14.4	11.9	13.7	16.2	13.5	15.6
Asia	53.1	39.7	41.9	85.6	67	84	12.4	14.3	14	12	19.5	14.6
Middle East	112.5	65	40.9	76.7	82	56	9	14.6	13.9	15.1	15.2	13.7
UK	10.2	27	27.9	27	25	34	8.7	12.9	7.9	10	10.7	12
Continental Europe	35.1	25	27.5	38.3	25	19	11.7	6	6.5	18	18.5	14.1
GLOBAL AVERAGE	32.2	31.7	32.1	51	46	42.8	10.6	12.8	11.8	13.2	15.5	14

Table 1. Regional and global average value of disputes (Arcadis 2017)

2 Ministry of Business, Innovation and Employment, Building Performance, (2016) Productivity Benefits of BIM [online] Building and Construction Productivity Partnership
[3] Al Shami, K. (2016). Critical investigation of BIM implementation and its impact on project collaboration and communication in Jordan (Dissertation of Master of Science). Coventry University.
[4] Ip, S. (2002). An overview of construction claims: how they arise and how to avoid them. British Columbia.
[5] Arcadis. (2017). Contract Solutions: Avoiding the Same Pitfalls (pp. 1-30).

2. Types of claims

Understanding most common causes of construction disputes can help identify the best ways of preventing them. Claims are categorized into change claims and impact claims [6]. Change claims (51% of all claims) are those that occur due to formal changes from the client either onsite construction changes or design-related ones. Changes due to differing/adverse site condition, regulations and Acts of God are called impact changes (49% of all claims). They concluded that change claims were resolved more successfully than impact claims (58% vs. 21%).

3. Sources/Causes of claims

Researchers have addressed hundreds of claim sources, which can vary depending on many factors such as project type, complexity, region or country. Table 2 show most common claim sources shortlisted by many researchers.

	Hadikusumo and Tobgay (2015)[7]	Mohamed et al. (2014)[8]	El Hawary and Nassar (2016)[9]	Arditi and Pattanakitchamroon (2008)[10]
Differing/adverse site conditions	✓	✓	✓	✓
Delay from project participants (Payments, Material supply, etc.)	✓	✓	✓	✓
Changes/Incomplete in design, specifications and quantities	✓	✓	✓	✓
Force majeure	✓	✓	✓	✓
Omissions and/or ambiguous contract provisions	✓	✓	✓	
Communication nature among project team		✓	✓	

Table 2. Claim sources (by author)

[6] Bramble, B. B., D'Onofrio, M. F., & Stetson, J. B. (1990). Avoiding & resolving construction claims. RS Means Company.
[7] Hadikusumo, B. H., & Tobgay, S. (2015). Construction claim types and causes for a large-scale hydropower project in Bhutan. Journal of Construction in Developing Countries, 20(1), 49.
[8] H. Mohamed, H., H. Ibrahim, A., & A. Soliman, A. (2014). Reducing Construction Disputes through Effective Claims Management. American Journal of Civil Engineering and Architecture, 2(6), 186-196.
[9] El Hawary, A., & Nassar, A. (2016). The Effect of Building Information Modeling (BIM) On Construction Claims. International Journal of Scientific & Technology Research, 5(12), 25-33.
[10] Arditi, D., & Pattanakitchamroon, T. (2008). Analysis Methods in Time-Based Claims. Journal of Construction Engineering and Management, 134(4), 242-252.

4. Building information modelling (BIM)

Building Information Model (BIM) is defined as a data-rich three-dimensional model[11]. Where the data contained in the model forms a complete database which can be used and integrated with different tools and software for purposes such as scheduling, cost estimation, clash detection among different components and systems, energy consumption, scheduling, structural performance and many other uses. However, BIM is a process not a set of software programs. Furthermore, as it involves large group of stakeholders across project stages, it's considered an inclusive and collaborative platform that encourages organized mechanics of data-sharing.

Alongside the X, Y and Z geometrical dimensions in BIM's virtual environment, BIM's dimensions extend to three more dimensions that are time, cost and buildings life-cycle which represent the fourth, fifth and sixth dimensions respectively. According to Issa et al. (2009)[12] the project risk declines as the level of BIM in use progresses from 2D to 3D to 4D (schedule) to 5D (cost).

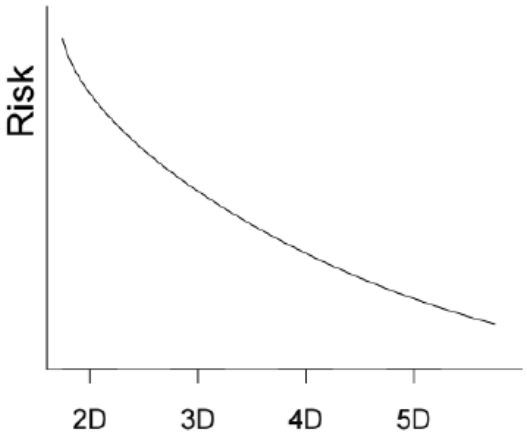

Figure 1: Relationship between risk and BIM level [11]

Therefore, using Detailed BIM models in projects with high budgets and/or risks would yield rewards by mitigating those risks. Refer to figure 1 to see the relationship between Risk and level of BIM used. Concisely, 4D BIM is a 3D model linked with a construction schedule that simulates the construction sequences with integrated dependencies of resources and processes. 5D BIM incorporates the costs of all elements with progression of schedule, and 6D BIM represents the construction lifecycle of the project[10].

METHODOLOGY

This research adopts a qualitative approach where four stages (Figure 2) were defined on what and how information is collected and how results are analysed to achieve the main aims and objectives of this paper.

1. Topic identification
2. Literature review
3. Data analysis

[11] Kensek, K. (2014) Building Information Modeling. New Jersey: Wiley
[12] Issa, R., Suermann, P. and Olbina, S. (2009) "Use of Building Information Models in Simulations". In Proceedings of the 2009 Winter Simulation Conference [online] held 2009. 2664-2671.

4. Conclusions

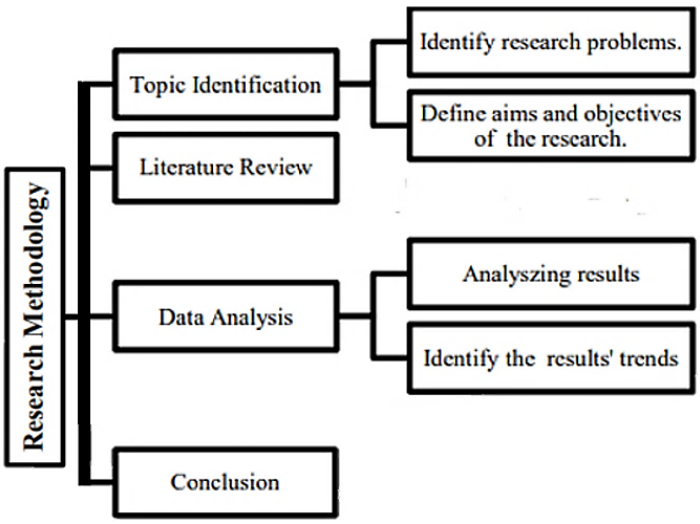

Figure 2: Research methodology (by author)

The qualitative side represents a good first step to uncover trends in both thoughts and performance about BIM Capabilities in helping avoiding/reducing construcyion claims, to reach deeper understanding and form a solid foundation to proceed with quantitative research afterwards. This is also due to the fact that BIM's implementation hasn't matured globally and due to the lack of established data and litriture in this topic.

The literature review was collected and developed from paper and electronic sources such as journals (i.e.: ProQuest, BusinessSource, ScienceDirect), conference proceedings (i.e.: IEEE Publications), contract document (AIA, NEC,…), reports (i.e.: Industry reports, company annual reports,…) and reliable news articles and websites.

Data analysis is critical to confirm that the aim and objectives of the research are realized. The data was analyzed, modelled and transformed to obtain results in form of written explanations and descriptions supported by charts, figures and tables for comprehensive discussions, conclusions and recommendations.

1. Problem Definition

The **main aim** of this paper is to identify how BIM technology can help avoiding/reducing construcion claims. To fullfil this aim the paper is going to answer the following questions:

- **How and to what extent BIM can help avoiding/reducing construcion claims?**
- **What are the currently encountered challenges in construction regarding claims, and how can BIM solve them?**

- **What are the limitations of BIM in reducing/avoiding project claims?**

2. Feasible Alternatives and Attributes:

To answer the questions above, a comparison between managing claims traditionally and managing claims with BIM is to be carried out. The comparison is to determine whether:

- BIM makes claim management more effective than traditional methods.
- BIM doesn't overperform and/or add value to traditional methods in claim management.

3. Development of the outcomes

3.1. Traditional ways in managing claims

Pursuing a claim using traditional methods requires generating information and providing documentation. This is challenging in complex projects, as most project documentation is carried out unsystematically and is poorly updated. Traditional claim procedures start with the claimant submitting a written notice within the allowed period after an event. Afterwards, the claimant is given a previously specified period of time to provide the required documentation to support this claim. Then, a comparison between planned situation and current situation is performed to find discrepancies that entitle the claimant for compensation. Traditional methods are costly and time consuming. Also, collecting documentations to support a claim can reduce the focus on controlling and managing the project.

3.2. Managing claims with BIM

Current claim management methods don't accommodate for the increasing complexity in construction where construction projects are becoming more information-intensive, with project teams being one of the most complicated forms of human organizations. BIM possesses high potential and capabilities when compared to traditional claim management methods. This paper aims to establish and differentiate between different levels of action that can be taken through BIM in the claim management process. considering claims as risks, this paper categorizes BIM's role into two main parts, Before and after claim occurrence. Prior to a claim occurrence, BIM can be used for prevention purposes. After claim occurrence, BIM can be used in a reactive manner to manage and resolve claims. Below are some of BIM features that hold potential significance in claim management and their area of implementation.

a. Visualization

The visualization in BIM allows for communicating one standardized holistic image of the project. This gives opportunity to compare the mock-up model to the client's expectations before construction commences, which keeps different consultants' interpretations away from

any misinterpretation and/or deviation. Thus, avoiding unnecessary change orders and minimizing risks of variation orders from the beginning of the project[13].

At level 2 BIM, it's possible to give exact details about the dimensions, size and shape of a particular building element. Which helps determining exact quantity take-offs of raw materials required with their all the associated costs[14]. By this, it's possible to reduce ex-gratia claims resulting from underestimations and avoid potential disputes.

b. 3D-Coordination and Clash Detection

BIM helps to identify drawing conflicts, missing information, and coordination issues that may otherwise result in change orders. The spatial coordination in BIM helps avoiding soft and hard clashes. Thus, preventing design errors and need for rework. Also, it mitigates later changes in design or specifications and their anticipated costs if they were faced at the planning phase or at later construction stages. According to AoCD Report[15] soft clash is when elements are too close to each other but refrain from overlapping or colliding, and hard clash is when two or more elements acquire the same place.

c. Optimized workflow and communication structure

Even with BIM being multi-dimensional and multi-functional, efficient communication and collaboration are vital amongst these functions. BIM processes combine and collaborate all concepts and elements of the project into one single model that includes all plans and designs, cost, time frame, materials used, and other aspects. This information on the model can be shared live among all users[16]. Thus, simplifying the traditional communication processes and pattern, as seen in figure 3.

[13] Hergunsel, M. (2011) Benefits of Building Information Modeling for Construction Managers and BIM Based Scheduling. Worcester Polytechnic Institute
[14] Avasatthi, B. (2017). Augmented Reality Empowered BIM Set to Change Construction Industry. The BIM Hub. Retrieved 30 November 2017
[15] AoCD, (2012) Clash Detection in BIM Modeling [online]
[1616] Goh, K., Goh, H., Toh, S. and Peniel Ang, S. (2014) "Enhancing Communication in Construction Industry through BIM". In Proceedings of the 11Th International Conference on Innovation & 85 Management [online] held 2014. Universiti Tun Hussein Onn Malaysia (UTHM), 313-324.

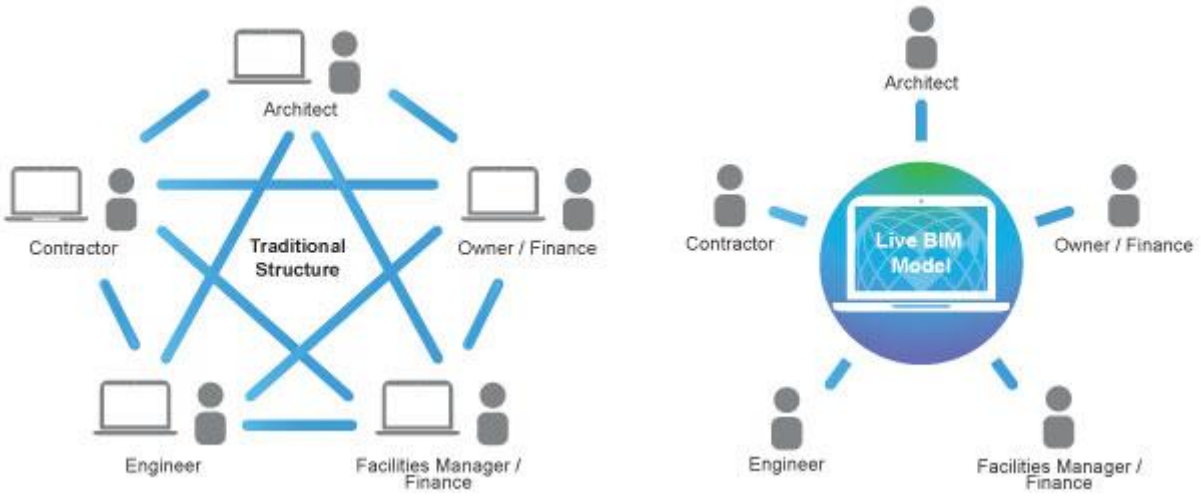

Figure 3: Traditional communication vs. communication through BIM (Model the Planet Corp 2016)[17]

Effective and efficient use of BIM helps achieving project collaboration among team members. Thus, it prevents information delivery problems in terms of content, clarity and time. This is required on both the preventive side of claims and on the claim aftermath.

d. BIM based E-procurement

As 2D-paper drawings and e-procurement are non-fully automated, time consuming and can cause many problems. Research established that BIM has solved this by automating and integrating all processes. BIM-based e-procurement aids in reducing the time and effort related to information management activities with heavy administrative and contractual procedures and documentation, as the model would serve as an effective repository to all this information and for all project stakeholders[18]. Accordingly, BIM E-Procurement can help providing accurate quantity take-offs from early stages of the project, reducing uncertainty in costs and contract ambiguity.

e. Prefabrication

By using BIM, contractors can build prefabricated elements with higher quality and less cost compared to their non-fabricated counterparts[19]. BIM's potential in this area is hugely realized in the facts that this feature can reduce rework and change orders, since it can build elements

[17] Model the Planet, (2016) Traditional vs. BIM Communication Pattern
[18] Costa, A. and Grilo, A. (2015) "BIM-Based E-Procurement: An Innovative Approach to Construction E-Procurement". The Scientific World Journal [online] 2015, 1-15.
[19] Ebrahimi, H. and Akhbari, H. (2015) "Construction of Management and Sustainable Construction in the Engineering by Building Information Modeling". International Journal of Materials Engineering [online] 5 (3), 64-75.

that are fit-for-purpose, when and as needed. Also, it's an effective method to avoid delays from resulting from time spent to find suitable elements or late material supply.

f. BIM's Geospatial technology

Geospatial technology encompasses the use of equipment in measuring, analysis and visualization of earth's features. This technology is widely spread in military use, but less common in commercial construction. It involves systems as GIS (geographical information systems), GPS (global positioning systems), and RS (remote sensing).

Navigant's 2016 report[20] states that the integration of Geospatial technology with BIM provides access to accurate and real-time data and information about site, which improves planning, design and construction process. Thus, resulting in a decrease in claims of differing site conditions, changes and delays. Refer to table 3 for a summary of the features and their preventive impact on claims.

Feature	Effect on potential claims (preventive action)
Visualization	• Minimizes risk of change orders. • Reduces potential for ex-gratia claims (Contractor underestimates quantity/cost of materials).
3D-Coordination and Clash Detection	• Reduces changes in design and/or specifications due to errors.
Optimized workflow and communication structure	• Prevents information delivery problems in terms of content, clarity and time. • Reduces potential changes in design, specifications, contracts…
BIM based E-procurement	• Reducing uncertainty in costs and contract ambiguity.
Prefabrication	• Reduces rework and change orders • Helps avoiding delay claims
BIM's Geospatial technology	• Reduces claims of differing site conditions, changes and delays.

Table 3. BIM's Features and their impact on potential claims (by author)

After claim occurrence, BIM plays a different role, where it can be used to support and/or examine claims. In case of a claim, BIM models can be used to find discrepancies in specifications, costs or time which helps examining and/or demonstrating the causation, entitlement and quantification of a claim. The key point here is that BIM provides well-structured information with time and cost progression, and forms a more efficient and inclusive documentation tool.

[20] Navigant. (2017). The potential impact on project management and construction claims (pp. 1-28). Navigant.

To stipulate the effects of BIM before and after claim occurrence, table 4 describes the different effects/actions of BIM in claim management.

	Effect/ Action	Description	Mechanism through BIM	
Effect on potential claims	Mitigate	Proactively minimizing the impact and/or probability of claim occurrence	• BIM features help reducing changes in design, specifications and contractual terms due to errors or miscommunication. • Reduces uncertainties in costs.	Preventive
	Avoid	Total elimination of the probability and/or effect of a claim	• BIM features help eliminating changes in design, specifications and contractual terms due to errors or miscommunication.	
Action after claim occurrence	Identify	Timely and proactive follow-up of developing problems that make a potential claim or dispute.	• Visualization, 3D-Coordination and Clash Detection can help find scope creep. • Cost and time progression can identify discrepancies.	Reactive
	Examine	Establishing legal and factual grounds to support or establish defenses to claims	• compare planned vs actual construction. • 4D & 5D BIM cost and time analysis and quantification of claims. • Faster accessibility to data and reports and takes less time for analysis.	
	Document	Collecting hard facts to support a claim. This shall include the right time and amount of information provided to the right party in a timely manner.	• Single repository cloud storage • Daily update of activities and progress done manually and through technologies. • Automation of report making • Able to update progress visually in 4D & 5D models.	
	Present	A clear and solid demonstration of harm caused by action or inaction of the respondent party.	• Producing reports of cost, man-hours, time, delay analysis… • Automates report generation and provides rich communication through visuals.	

Table 4. Effects/actions of BIM in claim management (by author)

4. Selection of criteria

At this stage, after both traditional and BIM-aided claim management were explained and analyzed. They are going to be compared side-by-side to assess the effectiveness of BIM in improving and adding value to claim management processes.

In order to realize which of these two alternatives is more effective and whether BIM adds value, the following comparison criteria have been selected:

- **Data collection, record making/keeping, reporting,** to assess which method is more effective in managing claims in terms of creating and maintaining documentations and reports to have better accessibility, availability, speed of data collection and speed of information generation.

- **Automation of processes,** to assess which method brings more benefits from the use of computerization and IT tools.

- **Timeliness,** to analyze which method consumes more time at different stages of claim management.

- **Cost (man hours),** to analyze which methods requires more staff to handle identifying, examining and documenting claims. The amount of staff needed is directly proportional with man hours and its accrued costs.

- **Communication quality to gather required information,** to evaluate each method's quality of communication in terms of clarity and content which. As these factors affect many aspects of claim management, such as timeliness, costs and even the outcomes, where ineffective claim documentation can lead to loss of compensation entitlement.

- **Simplicity/ease-of-use,** to see which method is easier to use by professionals in terms of time, and amount of personnel needed.

- **Level of expertise required,** to see which method requires more expertise to manage claims.

- **Reliability,** to check which method performs better and more effectively.

- **Trustability,** to check which method is perceived by construction professionals as better and more effective.

In table 5, these criteria are assessed using disjunctive reasoning method. This would help in ranking criteria according to their importance.

	Data collection, record making/keeping, reporting	Automation of processes	Timeliness	Cost (manhours)	Communication quality to gather required information	Simplicity/ease-of-use	Level of expertise required	Reliability	Trustability	Ordinal Ranking
Data collection, record making/keeping, reporting		1	1	1	1	1	1	0	1	7
Automation of processes	0		0	0	0	0	1	0	0	1
Timeliness	0	1		1	0	1	0	0	1	4
Cost (manhours)	0	1	0		0	1	0	0	1	3
Communication quality to gather required information	0	1	1	1		1	1	0	1	6
Simplicity/ease-of-use	0	1	0	0	0		1	0	0	2
Level of expertise required	0	0	1	1	0	0		0	1	3
Reliability	1	1	1	1	1	1	1		1	8
Trustability	0	1	0	0	0	1	0	0		2

Table 5. Ranking BIM's features according to their importance in claims management (by author)

In table 5, reliability was ranked the highest, proving that end results are the most important. data collection, record making/keeping, reporting and communication quality were also high rankings, this explains how inevitable it is to have efficient communication, data collection, documentation and reporting to manage claims effectively. Timeliness and cost were important but not as the former ones, since they are triggered by the performance of the higher ranked criteria. Trustablility was ranked low as individual perceptions are less critical when compared to real performance and reliability.

FINDINGS

1. *Analysis and comparison of the alternatives*

After assessing and ranking the importance of each criteria, to further support the results, additive weighting technique is applied to find out whether BIM outperforms or improves traditional claim management techniques, refer to table 6.

			Claim management with BIM		Traditional claim management	
Criteria	**Ordinal Ranking**	**Normalized Weight (A)**	**(B)**	**(A) x (B)**	**(C)**	**(A) x (C)**
Data collection, record making/keeping, reporting	8	0.18	1	0.18	0.33	0.06
Automation of processes	1	0.02	1	0.02	0.33	0.01
Timeliness	6	0.13	0.67	0.09	0.33	0.04
Cost (manhours)	5	0.11	0.67	0.07	0.33	0.04
Communication quality to gather required information	7	0.16	0.67	0.10	0.67	0.10
Simplicity/ease-of-use	2	0.04	0.33	0.01	0.33	0.01
Level of expertise required	4	0.09	0.67	0.06	0.33	0.03
Reliability	9	0.20	0.67	0.13	0.67	0.13
Trustability	3	0.07	0	0.00	1	0.07
	45	**1**	**SUM**	**0.68**	**SUM**	**0.50**

Table 6. Comparing traditional claim management against BIM-aided claim management (by author)

From the analysis above, BIM has the higher score overperforming traditional claim management methods in data and information management, communication quality and timeliness. This is well reflecting in cost reductions compared to traditional methods. Both methods scored equally in the reliability criteria despite the performance gap, this is explained by the lack of interest and experience in using BIM for claim management. This is noticeably highlighted where traditional methods scored higher in trustability.

2. ***Selection of the preferred alternative***

Based on the literature review, disjunctive method and the additive weighting analyses, it's apparent that BIM underlies many potential benefits and capabilities in claim management. Where is performed better in five out of nine criteria, was equal in three criteria, and fell back in the trustabililty criteria only as it hasn't been widely implemented and its full benefits haven't been understood yet.

3. ***Performance monitoring and post evaluation of result***

- To achieve all awaited outcomes from BIM, it should be implemented the right way, incorporating best standards and practices. True and mature implementation of BIM

requires a mature working culture, mitigation for risks and performance shortcomings, capability and willingness to undergo learning curve that is time consuming and costly.

- Utilization of BIM in claim management requires using 4D/5D BIM, which are one of the highest edge-cutting technology advancements. Thus, requiring true planning for the use and management of BIM processes, with allocating budget, planning of resources, risks and all other aspects. Concisely, immature and ineffective use of BIM can cause claims by itself.

- These is a direct proportionality between the benefits of BIM in claim management and the size and complexity of the construction project, where the benefits of BIM exceed its costs

CONCLUSIONS

This paper has assessed the use of BIM in claims management compared to the traditional methods, to establish the effect of BIM on avoiding and/or reducing construction claims. To fulfil the aim of this research, the following research questions were answered.

- **How and to what extent BIM can help avoiding/reducing construcion claims?**

BIM utilization in construction projects has great imact on reducing and/or avoiding construction claims. The paper aimed to define a framework of preventive effects and reactive actions to claims. This mechanism helps safeguarding projects against claims and in case of their occurrence, it helps supporting, establishing defenses and managing claims more effeciently. Also, the paper summarised some of BIM's features and how the can impact claims.

- **What are the currently encountered challenges in construction regarding claims, and how can BIM solve them?**

The paper has reviewed the regional and global trends of dispute value and length, then it has identified most common types of claims and their causes from previous research. These initial facts underlined the economocal and social implications of construcion claims. In the analysis part, the paper pointed out how BIM improves data and information managemet, cuts costs and reduces time taken to manage claims. Critically the paper has adressed breifly how BIM solves major problems and challenges in claim management, including:

- inaccessibility to needed supporting documents.
- unavailability of records, ineffective record keeping, inaccurate information.
- Poor communication in data collection and gathering to analyze a claim.
- Deficiency of time to manage and prepare claims.

- Lack of computerization, automation, knowledge management for establishing and maintaining lessons learned.

- **What are the limitations of BIM in reducing/avoiding project claims?**

After discussing its key benefits, its recognized that BIM technology is very attractive and holds high potential. Nonetheless, at its current state of prevalence, BIM has many weaknesses. Whereas adopting BIM is time consuming, costly, might require restructuring of the organization, training employees and acquiring expensive hardware and software packages (Al Shami 2016).

On the social side, with the lack of common standards and regulations, BIM often fails in cross-organizational and cross-cultural collaboration, where different standards and cultures might intersect but don't integrate, creating communication gaps and malfunctions. The key takeaway is that underperforming BIM can be a cause of claims rather that a solution to claims.

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