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Identifying Building Information Modeling Potentials for Construction Dispute Avoidance and Resolutions

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Abstract
The time and cost invested in dispute avoidance and resolution are massive. Therefore, various studies on effective construction dispute avoidance and resolution have been conducted in the past. However, still many disputes related to time and quality of work have not been fixed to its true potential e.g., using adequate technologies. Building Information Modeling (BIM) assists project stakeholders to improve dispute avoidance and resolution in the planning, design, and construction stages. Therefore, identification of potential opportunities of BIM for efficient dispute avoidance and resolution in the construction industry and challenges faced for the adaptation of BIM for dispute avoidance and resolution are discussed in this paper which is related to design review, drawing generation, 3D Co-ordination, extraction of quantity take-off, record modeling, 4D or Phase Planning, and 5D or Site Operation Planning, etc. This paper mainly adopts a review-based methodology to identify the potential of BIM in this dimension of Dispute Avoidance and Resolution. It is learned from the review that the BIM-based approaches can support construction dispute avoidance and resolution. BIM models in a combination with some cloud-based services like primavera unifier can open a new way to deal with dispute avoidance and resolution.

Keywords
Building Information Modeling, Dispute Resolution, Dispute Avoidance, Technology.

1. Introduction
Due to the extensive number of activities involved in the projects of the construction industry claims, conflicts and disputes occur one after the other. Various studies have been conducted to highlight the causes of claims, conflicts, and disputes but still, these causes are the major causes because these causes are not avoided and resolved and adversely affect the relationship among the parties involved and also cause the loss of money and time. This is to the report published by the Hong Kong International Arbitration Center (HKIAC), which discovered that in the year 2000 the number of disputes increased 3 times in the previous decade. Hence, the ability to resolve disputes cannot be overemphasized. It should be part of the tool kit for experts, especially those in decision-making capability or management grades (Cheung et al., 2002).

Although various research studies have been conducted to resolve and improve the construction dispute resolution and minimization still various limitations in this field need attention to minimize and resolve construction disputes such as design change (Cakmak and Cakmak 2014), failure to understand the implication of instruction (Farooqui et al., 2012) delays (Sambasvan and Soon 2007), etc., are the reasons to increase the volume of construction disputes. Therefore, for effective dispute management and minimization, these issues must be answered. BIM models help in detecting causes of dispute and in evaluating these cases during dispute resolution processes. BIM made the claiming process easy by visualizing the activities and variations in these activities. Therefore, BIM can be used for claim preparation and verifying claims which are complex in nature and can also be used for claim presentation. The information required for claim preparation in BIM is accurate and can be easily available (Koc and Skaik 2014). BIM is a fully integrated and interoperable and centralized information database that carries realistic intelligent physical and performance data from all the participants throughout the lifecycle of the project.

Building information modeling (BIM) improves coordination among stakeholders through integrated building design which helps in avoiding design problems and changes (Cheng and Das 2014) and reduces the construction disputes occurrence. BIM-based properties like clash detection and design review in design validation reduce the number of design errors and rework which ultimately reduces the construction disputes. BIM uses that have positive impacts on construction dispute management and avoidance are identified through extensive literature review, which are (1) design review, (2) Drawing Generation (3) 3D coordination, (4) quantity take-off, (5) Record modeling, (6) phase planning (4D), and (7) site utilization planning (5D), etc.

2. Objectives

The objectives of the paper are as follows;

i. To highlight the potential opportunities of BIM for dispute avoidance and resolution in the construction industry.
ii. To highlight challenges for the adaptation of BIM in dispute avoidance and resolution.

3. Key Issues of Construction Disputes

Construction dispute occurs when the claims and disputes are not resolved timely and completely. Disputes are caused by the project team members due to many reasons but the ones are (a) failure due to inability to perform work duties effectively and in a well-timed manner, (b) failure to express themselves clearly, or (c) incompetence to realize the consequence of instructions (Farooqui et al.2012).

Although previously many research studies have been carried out for the construction dispute minimization and resolution, there are still many limitations that remained to be resolved. Several studies have been conducted to identify the causes of dispute but most of the researchers are failed to differentiate causes from the factors of dispute. Ilter (2012) differentiates both causes and factors of disputes and classified disputes into three categories (1) Extension of time (delay), (2) payments, and (3) Quality of work. This literature-based research centers on exploring the potential opportunities of BIM to resolve the delay and quality-related limitations in dispute resolution and minimization because limitations related to payments are almost the same as the limitations related to the extension of time (delay).

3.1 Extension of Time

Delay is considered the most important cause of the dispute in the construction industry. Construction delay is a universal evident reality not only in Pakistan but also faced by all the countries all over the globe. According to Assaf and Al-Hejji (2006). Extension of time-related limitations along with their groups is listed in Table 1.

Table 1. Extension of Time related Causes of Disputes

S. No	Phase	Extension of time-related Limitations	Limitation Group	References
DR01	Planning Design	contractor's inadequate planning and scheduling	09	(Sambasvan and Soon 2007)
DR02	Construction	contractor's poor site administration	09	(Khoshgoftar et al.2010)
DR03	Construction	mistakes during the construction stage	09	(Kumaraswamy and Chan 1998)
DR04	Planning Design Construction	Slow decision making	07	Chan and Kumaraswamy 1997)
DR05	Design Construction	too many change orders from owners	06	(Sweis et al.2008)
DR06	Construction	site condition	01	(Sambasvan and Soon 2007)
DR07	Design	Slow preparation and approval of drawings	02	(Faridi and El-Sayegh 2006)
DR08	Planning Construction	Poor estimation practices	09	(Al-Barrak1993)
DR09	Design	Poor design	01	(Al-Momani2000)
DR10	Construction	Labor supply	09	(Sambasvan and Soon 2007)

DR11	Construction	Shortage in material	09	(Sambasvan and Soon 2007)

3.2 Quality of Works

Meeting and exceeding the standards and specifications, constructing the projects in compliance with the construction drawings and design details, and the project meeting the local bylaws and codes set by the client is termed as the quality of work (Netscher 2015). Construction defects are one of the most common causes of dispute in the construction industry which puzzle the construction industry for years (Mades 2016). The quality of work-related causes of disputes is listed in Table 2.

3.3 Factors of Causes of Disputes

The extension of time-related and quality-related limitations in construction dispute resolution and minimization are categorized into nine groups. Out of nine groups here, only six groups discussed here are unclear contractual terms, adversarial approaches in handling conflicts, and unfamiliarity with local conditions that cannot be resolved and avoided through BIM utilization. The nine classified groups are as follows: (1) Variations (Muhammad et al.,2015), (2) Late instructions by the employer (3) Inadequate/incomplete specifications (Cakmak and Cakmak 2014), (4) Unclear contractual terms, (5) Adversarial approach in handling conflicts, (6) Unclear scope definition (Cakmak and Cakmak 2014), (7) poor communication (Cakmak and Cakmak 2014), (8) Unfamiliarity with local conditions (Al-Momani 2000) and (9) Technical adequacy of the contractor (Cakmak and Cakmak 2014).

Table 2. Quality of Work-related Causes of Disputes

S. No	Phase	Quality of work-related Limitations	Limitation Group	References
QR01	Planning Construction	Scattered criteria for quality control	01	(Chen and Luo 2014)
QR02	Planning Construction	Difficult to identify the responsibility of project participants	07	(Chen and Luo 2014)
QR03	Construction	The focus of quality control is on the final component	09	(Chen and Luo 2014)
QR04	Construction	Lack of proper contractor supervision of the work	09	(Mades 2016)
QR05	Design Construction	Design complexity	03	(Mades 2016)
QR06	Construction	Lack of control	09	(Erhorn 2015)
QR07	Construction	Failing to understand the specifications and standards	03	(Netscher 2015)
QR08	Planning	Inadequate planning	09	((Netscher 2015))

3.3.1 Variation

It is important to make the design accurately (DR09) to eliminate one of the main causes of construction disputes, which is variation in the design. BIM automatically reviews the geometry, spatial relationships, clearances, and other dimensional and object-oriented criteria and then determines whether the proposed design fulfills predefined user-generated instructions (Estman et al. 2018). Design reviews through BIM models help in understanding the design complexity (QR05). Change in site conditions (DR06) also causes variations which may ultimately result in disputes. BIM assists in developing a 3D model of the existing conditions for a site amenity on a site, or a specific area within an amenity (Pennstate 2010).

3.3.2 Late Instructions by The Employer

One of the causes of disputes in the construction industry is late instructions from the employer (Faridi and El-Sayegh 2006) during the design phase in the AEC industry which results in slow preparation and approvals (DRO7). BIM

models help the owner to take quick, definitive, and well-informed decisions as compared to traditional drawings (Azhar 2011) because the accurate geometrical representation of the parts of a building in an integrated data environment is a vital benefit of BIM (Innovation 2007).

3.3.3 Inadequate/Incomplete Specifications

To avoid and resolve dispute specifications and standards must be understandable (QR07) for the participants because poor specifications is an important source of design-related dispute in the construction industry (Jahren and Dammeier 1990; Cakmak and Cakmak 2014) which results in too many changes Orders from the owner (DR05) which ultimately results in mistakes during the construction stage (DR03) and adversely affects the contractor's site planning and scheduling (DR01). Poor design (DR09) and poor planning for quality (QR08) are also results of inadequate specifications.

3.3.4 Unclear Scope Definition

well-defined and managed scope leads to delivering a quality product at an agreed cost and within stated schedules to the participants. Lack of clear understanding or describing the project and scope are the main contributing factors for unsuccessful project (Mirza et al. 2013) Usually contractor makes mistakes during the construction process (DR03) which causes disputes between the participants, which is a result of unclear scope definition (Cakmak and cakCakmak14). Through BIM Scopes of work can be easily isolated and defined (Azhar et al. 2008).

3.3.5 Poor Communication

In construction projects, Various parties are involved and these possess different skills and try to become self-sufficient. But it is proved that for a successful alliance communication is critical (Chengli et al.2001). Improper planning (QR08) (DR01), and poor design (DR09) are causing disputes in the construction industry which are results of poor communication among the participants (Gamil and Rahman 2018). It is often difficult and time-consuming to extract, interpret and communicate complex design information from drawings and documents. Advance visualization skills like 4D planning have the remarkable potential to increase the ability to communicate and interpretation of team members (Dawood and Sikka 2008). BIM is a powerful schedule tool for phasing, coordinating, and communicating planned work (Keymmell 2007).

3.3.6 Technical Adequacy of the Contractor

Accidents, inadequate planning, or miscommunication between the parties cause mistakes during the construction which impact the progress of the project (Sambasivan and Soon 2007). Lack of control (QR06), lack of contractor's planning (DR01), contractor's poor site management (DR02), and mistakes during the construction (DR03) are the causes of disputes which occur due to the technical inadequacy of the contractor.

Poor site administration, inadequate planning, and construction methods are the conflicting issues of contractor firms. Lack of a well-organizational structure and lack of proper procurement schedules are also some of the issues of contracting firms. BIM technology is a very effective solution for these issues because the 3D attributes of BIM assist contractor firms to observe the construction of building in a simulated environment which assists them to improve planning and construction methods and improvising site management. Exploration of the project phasing and construction sequence in ensuring proper consumption of timeline for completion which is assisted by the 4D feature of BIM. Automatic quantity take-offs and cost estimates in BIM enable contractor firms at the design stage. A comprehensive procurement schedule can be achieved and be able to plan their procurement according to the construction phase of the project well before its actual stage of execution if the contractor firm properly implements BIM.

4. Identification of Potential BIM Uses for Construction Dispute Minimization and Resolution

A list of BIM uses that can be used in construction dispute avoidance and resolution is identified in this study. They are existing condition, Quantity take-offs, phase planning (4D Simulation), Site Analysis, Design Authoring, Design Reviews, Drawing Generation, Code Validation, Site Utilization planning, 3D coordination (Clash Detection), Field/Manage Tracking, and Record Modeling as shown in Table 3.

BIM-based existing is a procedure in which a 3D model for existing conditions for a site, facilities on a site, or a specific area within a facility is developed by the team members. For proper material procurement, many BIM

software applications have a built-in feature for Bill of Material (Sabol 2008) BIM increases the accuracy in increase to 3% and time will be saved by as much as 80%(Olson and Taylor 2017). Phase Planning (4D Simulation) assists in construction sequencing and space requirements for a building site and its management. To determine the most optimal site location for the construction project site Analysis is a prevailing tool in BIM. The translation of the building design which provides true collaboration among the stakeholders and provides better control and quality control of design, cost and schedule can be done with BIM-based Design Authoring. Design Reviews deliver their feedback to validate various design constraints which can be done in an immersive lab with a Computer-Assisted virtual environment (CAVE)which assists in a well-organized shorten design review consequently resulting in improved communication and coordination among the project stakeholders for better decision making.

BIM models can be used to ensure proper alignment and facilitate automatically which helps out project team mitigate potential project site conflicts effectively with collision control tools a significant step forward in the preparation and distribution of a coordinated design data (Hooper and Ekholm 2010) This will assist in avoiding disputes before they arise which saves the time and for dispute resolution also saves relationships of participants involved in the process of design. Drawing Generation by using BIM is the procedure of generation itself which include representation, design progress, construction, and shop drawings. By using BIM different views (plan, section, elevation, and details) can be quickly generated and automatically update drawing sets based on the changes in the model. BIM-based site utilization planning can be linked with the construction activity schedule to deliver space and sequencing prerequisites. In this process critical space and time conflicts are quickly identified and the time required for the site utilization planning is avoided. Construction system design will decrease the language barriers because it assists in designing and examining the construction of a complex building system. During the construction, commissioning, and handover process Field Manage applications such as web-based applications, cloud computing, pad, smartphones, tablets are used to manage, track, task, and report on quality, safety, documents, and connected to Building Information Modeling (BIM), this process optimizes first work and reduces revisions, with proper communications manage work effectively and with no faults. To aid 3D design coordination and future modeling for renovation BIM assists in record modeling. Record modeling covers the information associated with architectural, structural, and MEP components and can be used throughout the lifecycle of the project.

Table 3. BIM Uses and their Potential Effects in Dispute Avoidance and Resolutions

S. No	Phase	BIM Use	Potential Effect
BU01	Planning	Existing Conditions	Yes
BU 02		Cost Estimation	Yes
BU 03		Phase Planning	Yes
BU 04		Site Analysis	Yes
BU 05		Programming	No
BU 06	Design	Existing Conditions	Yes
BU 07		Design Authoring	Yes
BU 08		Design Reviews	Yes
BU 09		Drawing Generation	Yes
BU 10		Engineering Analysis	No
BU 11		Energy Analysis	No
BU 12		Lighting Analysis	No
BU 13		Sustainability Evaluation	No
BU 14		Code Validation	Yes
BU 15	Construction	Phase Planning	Yes
BU 16		Cost Estimation	Yes
BU 17		Existing Condition	Yes
BU 18		Cost Estimation	Yes
BU 19		Phase Planning	Yes
BU 20		Site Utilization Planning	Yes
BU 21		3D Coordination	Yes
BU 22		Construction System Design	Yes
BU 23		Digital Fabrication	No
BU 24		3D control and Planning	No
BU 25	Operation	Field/Manage Tracking	Yes
BU 26		Record Modeling	Yes
BU 27		Record Modeling	Yes
BU 28		Building Maintenance Schedule	No
BU 29		Build System Analysis	No
BU 30		Asset Management	No
BU 31		Space Manage and Track	No
BU 32		Disaster Planning	No

5. Challenges in Adopting and Implementing BIM in Construction Industry

Adaptation of BIM is slow, however, the industry gaining its benefits of improving constructability, fewer requests for information because of its property of visualization approaches, minimizing cost estimation time and conflicts, and improved coordination between stakeholders (Azhar 2011). BIM is not just a technology but it is also involved in developing new present approaches and methods of construction. Malaysian construction industry facing adaptation issues because of the absence of National standards and procedures and government interests which results in the resistance from people. Companies are trying to cut resistance from people by developing new business hierarchies and by introducing new roles and responsibilities to facilitate people and organizations (Bin Zakaria et al. 2013).

The full benefits of BIM use can be achieved when the BIM is in common practice in the Architect, Engineering, and Construction (AEC) industry. Issues posing difficulty for a small company to adopt indicated by respondents in the different surveys conducted for the adoption of BIM in the industry are interoperability, high cost, too large folder sizes, and use of diverse discipline model software. Top grade management is not supported and a lack of clearly assigned responsibilities for the BIM is also among the concerns which are indicated by respondents (Liu et al., 2010).

6. Conclusions and Discussion

Construction dispute resolution and minimization is a global issue. Many countries opted for different policies and approaches to avoid or resolve disputes. The chief key causes of disputes in the construction industry are variations, late instruction by the employer, ambiguous specifications, uncertain scope definition, poor communication and technical adequacy of the contractor have not been completely resolved yet. Technological advancements in the

construction industry such as BIM can effectively handle these problems to minimize and resolve construction disputes throughout the project lifecycle from the planning stage to the operation phase. Therefore, the objective of this paper is focused on the identification of potential opportunities for BIM to effectively resolve and minimize construction disputes.

This paper identified 10 extension of time-related limitations and 8 qualities of work-related limitations, and 13 BIM uses that assists in dispute avoidance and resolution through an extensive literature review. The BIM uses include existing site conditions, cost estimation (Quality take-offs), Phase planning (4D simulation), Site Analysis, Design Authoring, Design Reviews, Drawing Generation, Code validation, Site Utilization planning, 3D coordination (Clash detection), construction system design (Virtual mockup), field/manage tracking and record making. Using BIM claimants and other stakeholders can minimize the documents such as bill of quantities logs, time, and cost schedule which will not only assist in better record-making but it will also help in dispute avoidance and dispute resolution process. All the documents will be stored in a single BIM model instead of keeping them individually. BIM also helps in clash detection, site utilization, and better coordination which ultimately minimize the chances of disputes. 3D coordination using clash detection feature in BIM in different models assists in removing systems conflicts earlier to construction. 3D Coordination through BIM also coordinates building project, visualize construction, make accurate as-built drawings, and reduce RFI'S as compared traditional method.

The end of this paper identified the challenges in a way of adapting and implementing of BIM in dispute resolution and minimization. The challenges include the unavailability of national standards for the adaptation of BIM. Challenges faced by the companies during the adoption of BIM are Lack of demand for BIM from the employer, a Steep learning curve to build, habits of 2D drafting practices, and Lack of availability of skilled BIM manpower knowing implementing BIM, Lack of Technical Skill, and Managing Risks through BIM.

BIM can provide better opportunities for dispute avoidance and resolution when used in combination with some other technologies such as web-based services such as primavera Unifier. And this area needs further efforts to explore the benefits of these services in a combination of BIM for dispute avoidance and resolution.

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