BIM ATTRIBUTES FOR ADDRESSING THE CAUSES OF DISPUTES IN CONSTRUCTION PROJECTS

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Abstract
Considerable concern has been expressed in recent years regarding the dramatic increase in conflicts and disputes in the construction industry in many countries including Australia. These conflicts and disputes resulted in a high cost to the industry both in terms of direct costs (lawyers, claims consultants, management time, delays to projects completions) and indirect costs (degeneration of working relationships, consequences of mistrust between participants and lack of teamwork). The nature of the construction disputes is complex, dynamic and multi-faceted. In addition, it is not only confined to disputes between the client and main contractor, but it occurs between the prime contractor, sub-contractors, consultants and designer. The alternative dispute resolution (ADR) is any procedure or combination of procedures, conducted in a controlled structured manner, which is entered into voluntarily by the parties to a dispute, as opposed to one using the other publicly in an open court. This research reviewed the literature to provide a comprehensive discussion and analysis on the root causes of disputes in the construction industry. The relationships between the parties involved in a construction project are also defined along with the potential of disputes in each relationship. Furthermore, the paper comprehensively explained how BIM could be used as an ADR in construction project phases including tender, engineering, procurement and construction.

Keywords: construction disputes and conflicts; alternative dispute resoultion; BIM.

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CAUSES OF DISPUTES IN A CONSTRUCTION PROJECT

To identify the types of disputes, this research identified the nature of relationships in the construction industry. According to Hallard (1987), the construction relationships can be categorised as Owner-Designer; Designer – Design Specialists, Owner – Prime Contractor, Prime Contractor – Subcontractors and Prime Contractor – Suppliers. Although in different types of contracts such as EPC, BOO, EPCM and DBFO, the relationships might differ slightly from the above. However, this categorisation stands correct for the majority of contracts in the construction industry. According to Halki principle, a dispute does not exist, until a claim has been submitted and rejected. So based on this definition, the primary cause of disputes are claims made by any parties involved in a construction contract. The claims can be made due to a broad variety of reasons (Otoo 2010; Yates 1998).

Building information modelling (BIM) can address the disputes in all phases and aspects of projects, including Tender, Engineering, Construction, and Procurement. A perspective on the roots and causes of disputes initiated in all these phases can lead us to a better understanding of the problem and how to address each of them using BIM. Table 1 lists the different causes of dispute and corresponding BIM feature to be implemented to eliminate the cause effectively.

Table 1 BIM capacities to eliminate causes of disputes in construction projects

Construction Phase	**Nature of Dispute**	**BIM Attribute**
Tender	Estimating Errors	More realistic BoQs and estimates by envisaging the project outcomes
	Unclear Scope of Work	The ability to visually determine a solid scope and division of work
	Potential Change Orders	The ability to check the fulfilment of the conceptual design by visualising the project's outcome
Engineering	Poor Design Quality	By building a virtual model of the buildings the omissions and deficiencies will be detected
	Lack of Constructability	By building a virtual model of the buildings, constructability issues will be prevented
	Disciplines Drawings Discrepancies	By building a virtual model of the buildings, the clashes will be discovered and tackled
Construction	Tasks Interdependency	A visual division of work and time dependencies of the activities in all disciplines
	Sequence of Activities	Modelling the entire project according to the basic activities derived from the preliminary design
	Machinery & Manpower Demand	Determining the most efficient demand by modelling the work environment and sequence of activities
	Safety	Identifies the potential hazards and proposes appropriate control measures
	Time Frame and Schedules	4D BIM anticipates the activities according to a visual model and assigns realistic time frame

	Payments to Contractors	Provides a solid evidence to specify the proper time for submitting and approving the invoices
Procurement	Materials Spec & Availability	Provides a procurement plan based on 4D BIM to determine the proper time for purchase and shipping
	Purchase & Delivery Time	Physically envisioning the project phases and extract accurate information for procurement

The remaining of this research elaborated the reciprocal relation between dispute causes and recognised BIM attributes in different phases of a construction project. As demonstrated in Table 1, the construction disputes are covered across four main project phases (tendering, engineering, construction and procurement). Additionally, Table 1 demonstrates the BIM attributes for each dispute. These phases and its disputes are explained as following.

BIDDING PHASE

Generally, when the feasibility studies, preliminary design and basic design are completed, the client starts bidding for the project. At this stage, a holistic perspective of the project has not been developed yet. This immaturity can lead to multiple disputes later on during the construction phase.

Estimating Errors

Preparation of Bill of Quantities (BoQ) and subsequent estimating is the cornerstone of every construction project. Errors at this stage potentially lead to unrealistic tendering by a potential contractor. Many of the change orders issued by the clients are caused by the lack of an adequate understanding of the needs and requirements of the projects at bidding stage. Therefore, clients need to have a means to enable them to envisage the outcome of the project. A means which can also play as a reliable source for extracting BoQs and estimates. Given the attributes and features of BIM like dimensioning the structures to the precision required in the calls for tenders (Koppinen, Tiina, Skanska Oy, Finland; Kiviniemi, Arto (2008). It can conveniently play such an important role.

Unclear Scope of Work

A construction project is comprised of a broad variety of activities which may differ from one project to another. At the bidding stage of the project, having a thorough perspective on all these activities is almost impossible, and many of them emerge at the construction phase. On the other hand, contractors plan on the activities which are assigned to them by the terms of the contract and are extremely unwilling to take one step further than it is specified in the scope of work defined at the beginning of the project unless with an addendum ensuring the extra payments. This problem occurs more prominently, especially when multiple contractors are engaged in a project. Ambiguity in the project's scope is a root for disputes between the client and contractors. This can lead to severe disputes during the construction phase and put the entire project on hold until a proper settlement is reached, which may take months to be agreed by all parties. BIM provides all the parties involved in a construction contract the ability to visually determine a solid scope of work to prevent all time-consuming disagreements regarding the division of fronts and works (Azhar, Nadeem, Y N Mok, & H Y Leung, 2008).

Potential change orders

Change orders are another problem causing disputes which is a result of lack of proper perspective on the project by the Client. BIM enables the project leadership to virtually construct a building before setting up the construction site. The scope of a project undertaken by each contractor can be visually illustrated at the bidding stage. This can also enable the client to make sure that the outcome of the construction phase can fulfil the conceptual design to prevent any change orders during the construction phase.

ENGINEERING PHASE

Generally, it is during the construction phase of the projects where design defects are detected. The problems initiated in the Engineering phase of the project are mainly a) Poor design, b) constructability issues and c) Discrepancies in details provided to different teams.

Poor design quality

Design drawings are generally incomplete, and they are not explicit. Very often design documents have inconsistencies, errors, ambiguities, and omissions, or lack clarity in presentation. These problems, when detected during the construction phase are referred to the client through Request for Information (RFI) or Design Team Query (DTQ), issued by the contractor. Due to paper works and formalities, the simplest enquiry takes a few days to be responded by the Engineering team of the client or the consultant. Regarding everyday costs of a construction site, borne by the contractor, before submitting the queries or during the waiting period for a response, the Engineering teams of the contractor, located at site try to figure out the problems on their own to prevent further delays. In this manner, all the efforts of the contractor's Engineering teams, instead of being assigned to meet the milestones of the projects and advancing the construction activities, will be wasted on identifying, reporting and following up correspondences related to a poor design quality, a problem which could be prevented mostly at the Engineering phase of the project, if the drawings produced are used initially to build a virtual model of the buildings. In this manner, many of the ambiguities will be discovered, and associated with future disputes will be prevented. BIM enables the Engineering teams on both sides of the contract to do this productive practice (Linderoth et al. 2014).

Lack of constructability

An important proportion of the problems detected during the construction phase is due to the lack of constructability of the design. This is a more serious problem than the latter. Because issues with constructability are not kinds of problem which can be resolved by the Engineering teams at the site. Accordingly, significant delays are expected when issues regarding constructability are raised. Due to the nature of this problem, reassessing the design and redesigning some structural elements will be inevitable, during which the associated working fronts at the site will be frozen until a proper remedial plan is prepared. The constructability issue can also be tackled by the tools BIM provides for the design team, in the same manner, that it prevents a poor design quality (Hijazi, W., Alkass P, S., Tarek, & Zayed, T. (2009).

Discrepancies between the drawings for different disciplines

Each engineering discipline team at the site have specific timetables and defined milestones to meet. So the first result of any clash between the drawings for different disciplines, before referring it back to the designers is a conflict between the engineering

teams at the site. The best case scenario for such clashes is that they are discovered by the contractor's engineering teams before entering the construction phase at the corresponding work front. However, in most cases, the worst case scenario happens, in which one discipline proceeds with the activities as per their drawings and then when another discipline is handed over the front to start their works, the discrepancies are discovered. In the latter case, a rework is due, which includes dismantling or demolition, the nightmares of any contractor.

The matter of clashes between the disciplines is harsher than the other problems in the engineering phase. It is not discovered until the engineers from different disciplines sit together to asses and compare the drawings which belong to the same work front. This practice is conducted in many construction sites with proper management. However, the time and energy of the teams are wasted this way, to deal with a problem which could be prevented in the first place. Another aspect of severity of this problem is that when it is referred to the designers, it takes a long time to process and redesign, during which the contractor has no other alternative but to wait for a practical response by the designer (Tan 2010).

CONSTRUCTION PHASE

Most of the disputes and clashes emerge in the construction phase. Whereas they are initiated in other phases, such as tender and engineering. Claims and disputes are inherent parts of everyday life in every construction site, and without settling them in a proper timeframe, the project fails to meet the milestones planned in the project's schedule. To deal with these everyday disputes, a great deal of time and effort of the management and engineering teams are wasted. The precious time and efforts which are to be assigned to what they are meant for in a construction project; leading engineering and labour teams, investigating resources, preparation of invoices and bill of quantities, supervision, making registers and records of the activities, planning for the activities, preparing reports, anticipating and applying for required permits, etc.

The majority of disputes during the construction phase are initiated during the design phase of the project and caused by deficiencies in the drawings and engineering documents. However, the disputes during the construction phase are not only confined to the engineering documents are elaborated below.

Tasks Interdependency

At the beginning of every construction project under proper management, there is a liaison meeting among the participating engineering teams from different disciplines. These meetings are held to found a structure and system for the disciplines to interact during the project, and to prevent any possible clash among them. During the first stages of the project, this liaison is more crucial. Executing earthworks and foundations need continuous communication among the disciplines since they include most of the substructure of mechanical and electrical works. Without a proper communication at this stage, reworks and demolitions will be inevitable.

Before starting up the project, the interdependency of the activities within a discipline and also in conjunction with other disciplines is to be defined and determined. The best way to illustrate such interdependency is using BIM which provides us with a visual division of work and time dependencies of the activities in all engineering disciplines. The clashes caused by unclear interdependencies not only lead to costly reworks or demolition, but also can cause degeneration of professional relationships between the engineering teams at the site. Lack of a clear interdependency plan makes the engineering team like isolated islands proceeding with their working schedules.

Sequence of Activities

One of the crucial pieces of knowledge to make a good construction manager is to know the sequence of construction activities. Then putting the activities in an organised work breakdown structure, and determining the prerequisites of every single activity, and implementing a system on the construction site to monitor and supervise the activities to be undertaken according to the pre-defined sequence. Defining a proper sequence is more important when it comes to interdisciplinary activities. Generally, for this purpose, a construction manager will have a few meetings with the engineers from different disciplines to define the sequence and prepare a Work Breakdown Structure, concurrently with site set up and mobilisation.

At the beginning of every project, due to lack of a thorough perspective of the outcome, and only relying on the general knowledge acquired by experience and previous jobs, the unique characteristics of projects are neglected. Consequently, the sequence of activities might not cover all the activities, especially the ones with higher complexities. In case of lack of a profoundly defined sequence of activities, a construction site will suffer demolitions and reworks, as well as degeneration of relationships between the engineering teams as a result of these clashes. Even without a complete set of project drawings, BIM can model the entire project according to the necessary activities derived from the preliminary design. By visualising the project outcomes at each stage, the engineering teams will be able to predict the activities at each stage and have a more reliable resource to define the sequence of activities (Strafaci, 2008).

Disagreements over Machinery and Manpower Demand

Dealing with disagreements between clients and contractors is a daily routine in every construction site. Although some disputes can be settled by referring to the terms of contract or law, but not every dispute is addressed in those references. These disputes are raised by the different points of views of the client and contractor's representatives at the site. One of the most common of these disputes is the disagreements over the manpower demand by each activity.

For determining the workforce demand for each activity, clients and contractors might consider different criteria. For the client's representatives at site, the primary concern is for the project to meet its milestones without any delays, and not to fall behind the schedule. Whereas the contractors, other than the schedule, need to take into account some other criteria as well such as payments dates, overhead costs of machinery and manpower, prediction of peaks and hiatuses of activities, in order to leverage the limited budget and resources at their disposal so as to achieve the target profit they set at the beginning of the project. These two points of views cause constant disagreements over the adequacy of the plants and manpower to cover the ongoing construction activity. Since such a matter is not and cannot be addressed in a contract, it remains one of the most unsettled argument in construction sites. The client's representative (which in most cases is the Construction Manager) insists on increasing the quantity of plants and manpower, whereas the contractors resist to do so.

General rules and estimates made based on the magnitude of working front's dimensions or the volumes of materials can never be applied to this case. Such disagreements can only be resolved if a system is defined to precisely determine the required plants and manpower demand for each activity specifically for each project. BIM by considering the sequence of activities and modelling working environment, and also taking into account the timeframe of the project and important milestones of the schedule, can determine to the most efficient quantity of plants and manpower to undertake any activity at each stage of the construction process (Tulke and Hanff, 2007).

Disputes over Payments to the Contractors

Scheduled payments to the contractors and the disputes over the proper milestones for the payments to be made are basic elements in every construction project. Timely mannered payments, due to inconsistencies in the payment amounts and also not efficiently covering costs and expenses are not contractors' favourite method. Time-dependent payments are not in favour of the clients either. In this manner, at the end of each period (mostly monthly), the contractors prepare and submit their invoices to the client's representatives. These invoices include the bill of quantities and unit prices for each activity. The client will assess the invoices in a reasonable amount of time, and if the activities and quantities are approved, the payments will be made. Preparation of invoices, especially in large projects is a very time-consuming activity. Besides, a contractor might have had a large expense at the beginning of a period and needs to wait to the end the period to submit the invoice and get reimbursed. From the client perspective, in a timely based invoice system, a contractor is more likely to assign higher priorities to the activities which gain more profit, instead of the project's important milestones. Padding out the invoices by the contractors is also another likely problem caused by this method.

This is why a WBS based payment system is more favourable to all parties involved in a construction contract. The payments will be made at the milestones defined based on the physical progress of the project. Similarly, the payments are made based on the progress percentage of the project, and these percentages are defined by finishing a particular activity or a building. The definition of completion of activity might not be as clear as it seems in some cases. Especially when an activity involves several independent activities. This is where a dispute may occur at the time of payment. The best resolution for such a dispute will be a 3-dimensional model, in which all payments milestones are defined and illustrated visually. BIM will provide substantial evidence for both contractors and clients to specify the proper time to respectively submit and approve an invoice for payment (Hergunsel, 2011).

Disputes over Safety

Around 12600 workers' compensation claims are accepted from the construction industry each year in Australia, for injuries and diseases involving one or more weeks off work. In the construction industry, this equates to 35 serious claims each day. In 2012–13 the construction industry had the 4th highest incidence rate of serious claims per 1000 employees and fifth highest fatality rate per 100 000 workers in 2013–14 (Safe work Australia, 2017).

This brings safety to one of the highest priorities in every construction site. There are incessant arguments at construction sites over the adequacy of control measures undertaken by the contractors, and also providing sufficient supervision for implementing the control measures. The supervisions are conducted through the Health and Safety Environment (HSE) agents by constant patrols throughout the site. The points of views and methods of implementing safety control measures might differ from one agent to another. Besides, construction managers, regarding a higher level of legal accountability, tend to be stricter than the HSE agents and keep overseeing the safety-related activities. The HSE procedure for the project does not go deep into the specific details of the activities. They mostly discuss the proposed safety control measures for different construction activities in a general form. This leaves the door open for interpretation by the parties engaged in setting safety policies, and here is where disputes over safety emerge in construction sites.

One of the capabilities of BIM is to specify safety hazards associated with each activity at the site during construction (Zhang et al. 2013). BIM also proposes

corresponding control measures for the hazards. This can provide the construction managers with a reliable reference when it comes to disputes over the adequacy of the safety control measures and how to implement and supervise them on site.

Disputes over Time Frames and Schedules

At the tender stage of projects, based on the existing limited information, client demands that contractors must submit an appropriate work schedule according to the time frame set by the client. Especially in large and complex projects, contractors fail to foresee all the activities and consider every single of them while preparing the schedule. These unrealistic schedules due to lack of sufficient information and a holistic perspective of the project will be a constant subject of disputes in a construction project. These disputes not only impair the contractors financially not to fulfil the basic schedule according to the terms of the contract, but also leads to wasting hours of engineering and management manpower to discuss and argue over rescheduling the project, and especially in long terms projects, this rescheduling can occur several times during the construction phase. 4D BIM, anticipating all the activities according to a reliable visual model of the project, and assigning a realistic schedule for each activity, is a trustable means to overcome or mitigate the disputes over time schedules (Tulke and Hanff, 2007).

PROCUREMENT PHASE

Acquiring required materials, equipment and machinery with a reasonable price and at appropriate times is a crucial concern for every project manager. Without a proper procurement, the efforts of manpower in a construction site will go to waste. Making decisions on hiring or purchasing the required machinery is also a fundamental aspect of a procurement manager's job, which is not obtainable without reliable sources of information and a realistic time frame. Procurement phase of a construction project is very likely to be susceptible to disputes of its own.

Purchase and Delivery Time

A procurement manager is bounded by several factors for acquiring the needed goods; storage facilities on site, available funds and budgets, and a time frame dictated by the requirements of the construction activities. A right time to make a purchase is also subject to market fluctuations, primarily when the item being purchased (e.g. steel) is affected by international price fluctuations. In countries with weaker or unstable economies, inflation rates kick in to be a very influential factor when it comes to procurement. So one can assume that adding the pressures by the client to the factors above, can complete the ingredients for a dispute over the proper time to submit a purchase order. Shipment and delivery time can drastically differ from one item to another and manage a smooth procurement process requires constant planning, foreseeing the circumstances of market and experience. On the other hand, client's representatives on site always concern about any probable delays in items shipment and delivery. Therefore, they keep insisting on putting purchase orders at the earliest time possible.

A comprehensive procurement plan at the early stages of a project can benefit all parties involved and prevent potential disputes over the proper time for ordering materials and equipment. This procurement plan can be achieved by physically envisioning the project phases and being able to extract accurate information in terms of procurement. BIM is the tool we have available for this important purpose (Sacks, Treckmann, & Rozenfeld, 2009).

Disputes over Specifications and Material Availability

The design team at the engineering phase of the project, generally take the liberty of putting an ideal selection of materials, ideally in compliance with their design and also the equipment which are dictated by the client regardless of their availability at the procurement phase and the time of purchase. The problem is more likely to occur in the international project when the parties involved are located in different countries. Especially the design team, complying with their native standards and availability of the material in the local market, might merely neglect the fact that construction standards in different countries may suggest different specifications for the structural elements, such as steel grades and profiles. The problem does not materialise until the procurement unit prepares and submits a purchase order for the mentioned materials. The contractor fails to obtain the required material and is obliged to propose substitute materials. Apart from the massive paperwork to get the approval of the client and then redesigning the structural elements based on the substitute materials, the construction process may face delays due to this problem, and claims will be made by the contractor, blaming the design team as the culpable party for the delays. Substituting materials during the construction phase may also result in reworks at some fronts to make it compatible with the new materials (Gill et al. 2015).

A procurement plan, based on a 4D BIM will include required information on the material and their shipping and delivery time (Azhar, 2011). The information can be extracted from the BIM model at the design stage and will prevent costly and time-consuming clashes and disputes over the availability of the required material for construction.

SUMMARY

The construction industry is fraught with common disputes among involved parties. The disputes may evolve from a minor disagreement which takes minutes to resolve to complicated conflicts which have the potential to jeopardise the projects in multiple aspects. Construction disputes cause delays, which is considered as an essential root for loss of resources as well as project overruns. The disputes also contribute to the financial loss, degeneration of relationships between the parties, and time-consuming arguments which make the potentials of the engineering and management teams of all parties to go to waste. According to the extensive literature review conducted in this paper, BIM enables the project management to overcome the potential problems caused by common disputes within a construction project phases. Implementing a BIM unit, as an independent party involved in a construction project, functioning as a bonding agent for the engineering teams of contractors and consultants is proposed, which can significantly contribute to dispute resolution. The nature and type of interaction between the BIM unit and other parties is the material for research papers published in the field. It is evident that conducting interviews with industry professionals would validate the literature review findings of this paper.

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