Identification of Key Risks Impacting Project Completion Time in UAE's Building Projects- Towards Developing a BIM Solution

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Abstract

A construction project is subjected to unique complexities that increase the probability of risk occurrence and adversely impact the achievement of the project objectives. Studies have shown that risks should be managed as early as possible in the project's life cycle, especially during the design phase. In doing so, key challenges arise from the fact that modern design process is inherently iterative in nature. Thus, the management of information exchange forms the basis for achieving the desired project objectives. Many tools and methods have been developed to manage the information exchange in design projects. However, Building Information Modeling (BIM) is one of the most widely used phenomena in the UAE's high-rise building projects. Though the adoption improves the overall project delivery, its application in the risk management of these projects is not widespread. Hence, this research aims to contribute in developing a risk management framework for the BIM-enabled design by identifying the key design phase related risks impacting the time of the projects. An interviews were conducted and the preliminary results identified the top 10 risks impact the time of the projects in the UAE. Further, the paper mapped the identified most significant risks against its possible BIM based solutions.

Keywords
Risk Management, Design Phase, Building Information Modeling (BIM), Design-Bid-Build (DBB) Projects

1. Introduction

As associated with uncertainty, risk potentially appears when the outcomes are not as desired. The Project Management Body of Knowledge (PMBOK®) Guide defines project risk as "an uncertain event or condition that, if it occurs, has a positive or negative effect on the project's objectives" (PMI, 2017). Project objectives could be time, cost, quality, safety, environmental sustainability etc. (Zou & Zhang, 2009). Risk management is defined as a process to manage the risks in such a way that the management actions are to increase the probability and impact of positive events, and to decrease the probability and impact of negative events in the project (PMI, 2017). The risk management process has been divided into: risk identification and classification, risk analysis, risk response, and risk monitoring and controlling. The identified risks can be analyzed through two types; qualitative risks and quantitative risks, and risk response can be administered through five actions: accept, mitigate, transfer, avoid, and escalate (PMI, 2017).

In construction contexts, studies listed in Table 1 have classified risks based on their relation to the project objectives, project phases, or stakeholders.

Table 1. Classification of Risks in Construction Projects

Risk Classification		**References**
Risks vs. Project Objectives	Project cost overrun risks	(Kaming et al., 1997) (Chen et al., 2004)
	Project time delay risks	(Shen, 1997) (Mulholland & Christian, 1999)
	Project quality risks	(Tilly et al., 1997) (Lee et al., 2005)
	Project safety risks	(Abdelhamid & Everett , 2000) (Haslam, et al., 2005)
	Project environmental sustainability risks	(Chen , Li, & Wong, 2000) (Dione, Ruwanpura, & Hettiaratchi, 2005)
Risks vs. Project Stages	Conceptual (feasibility) phase	(Uher & Toakley, 1999)
	Design phase	(Chapman, 2001)
	Construction phase	(Abdou, 1996)
	Operation phase	(Zou & Zhang, Managing Risks in Construction Projects: Life Cycle and Stakeholder Perspectives, 2009)
Risks vs. Project Stakeholders	Client, contractor, consultant, material, labour, contract, contract relationship, and external factors.	(Sambasivan & Soon , 2007)
	Project, owner, contractor, consultant, design-team, materials, equipment, manpower (labour), and external factors.	(Assaf, Al-Khalil, & Al-Hazmi, 1995) (Assaf & Al-Hejji, 2006)

Construction projects encompass unique features that increase the probabilities of risk occurrence and consequently achieving the project objectives (Flanagan & Norman, 1993; Akintoye & MacLeod, 1997; Smith, 2003 in Zou, et al., 2009). These features are, but not limited to; (1) involvement of multiple stakeholders with different interests, these interests are interfaced with each other which complicates the communication and collaboration between the project stakeholders. (2) Construction projects encompass numerous interconnected phases; these phases are totally fragmented in some case which increase project risks (Hammad, et al., 2012).

Risks shall be managed at early stage in project life cycle as concluded in previous studies (Y. Zou, et al., 2016a, 2016b; Sacks, et al., 2015; Dharmapalan et al., 2014; Kamardeen, 2010; Adafin, et al., 2016a, 2016b). It has been made evident that ignoring risk at design phase leads to future progress in the subsequent phases to negatively be affected. Furthermore, the success of project completion will adversely be affected as risks amplify with time flow (Wu, et al., 2014). P. Zou, et al.(2007) concluded that during the design and feasibility phases ‘variations by the client’ and ‘Project Funding Problems’ have the most impact on the time. Monazam, et al. (2016) explored the risks affecting the construction projects in Iran from the design perspective. They examined the impact of the 14 design-related risks on the successful of the construction project in Iran. The results revealed that “Design Changes by the Owner or other Non-Technical Stakeholders during the Construction” is the highest design-related risk affects the Iranian construction projects. Yang and Wei (2010) conducted a study to identify the causes of delay in the public construction projects in Taiwan during the planning and design phases. The study concluded that "changes in client’s requirement" is the main cause of delay in both planning and design phases. The study allocated the responsibility for the top five most significant causes to the client or planner/designer.

The implementation of risk management during the design stage faced by key challenges arise from the fact that modern design has numerous interdependent and knowledge intensive multidisciplinary tasks where the overall design process is inherently iterative in nature (Venkatachalam & Varghuese, 2013, 2010; Venkatachalam, et al., 2009). Thus, the management of information exchange forms the basis for achieving the desired project objectives during the design stage. Many tools and methods have been developed to manage the information exchange in the construction projects such as: Design Structure Matrix (DSM) (Venkatachalam, et al., 2009; Venkatachalam & Varghese, 2010, 2013), Multi Domain Mapping Method (MDM) (Lindemann, et al., 2008) and Building Information Modeling (BIM). However, these methods are not widely used except the BIM (Dossick & Neff, 2011; Grilo & Jardim-Goncalves, 2010; Porwal & Hewage, 2013).

Construction industry has benefited in many areas from the BIM, which has become a mandatory requirement in many countries (Abdalla, 2016). A natural consequence of this success led to investigating its capabilities in managing project's risks where communication forms the main context of the risk management framework (Y. Zou, et al., 2016a, 2016b). BIM is not just a tool, it is a data management platform that requires integration of technologies, people and processes (Oh, et al., 2015). BIM has been defined in different ways by different researchers nonetheless, all the definitions concentrate on a main concept of storing and managing various information produced throughout the project life cycle in an integral manner to use them in generating 3D Model, 4D time simulation, 5D cost budget, 6D facility management plan, 7D sustainable design and 8D safety management plan.

The progress BIM achieved to date increases the expectations that BIM would play a substantial role in facilitating risk management in the project lifecycle (Zou, et al., 2016a, 2016b). There are two research trends for the BIM-based risk management: (1) product-oriented trend and (2) process-oriented trend. In the product-oriented trend, BIM, on one hand, can be used as a systematic risk management tool and, on the other, can perform as a core data generator and platform to allow other BIM-related tools for further risk analysis. Moreover, BIM can be integrated with traditional risk management tools to increase their efficiency where there is nearly no study focusing on that integration (Zou, et al., 2016a & 2016b). In the process-oriented trend, the possibility of integrating BIM into the traditional workflow for risk management or develop a new implementation framework for BIM-based risk management has been investigated. However, only limited research has been found in this area and new investigation is still needed (Zou, et al., 2016a & 2016b).

There are different routes and methods in procuring construction projects according to agreement between the project's parties. Each of these procurement methods pose different shares of risk allocated to each project's party. The most common procurement methods are; design-build- build (DBB) and design-build (DB) methods. In the DBB projects, client usually appoints a consultant with a mandate to design and tender the project, and then the client appoints a contractor to execute the work (Hogg, 2007). This staged process leads to missing inputs during the construction where detailed information on time, cost, and quality would be provided later by the contractor. The lack of information at early stages of DBB projects constitutes a challenge in the risk management regarding time, cost and quality. Literature review revealed that during the design stage of DBB projects, the existing BIM-based risk management frameworks are effective in managing the risks associated with project stakeholder communication, feasibility of the design options, and design constructability (Wu, et al., 2014; Liu et al., 2014; Chui et al., 2011; Malvar & Likhitruangsilp, 2014). However, these frameworks are not effectively utilized to manage the time, cost and quality risks during the design stage of the DBB projects.

This paper contributes in developing a risk management framework for the BIM enabled design process in UAE's high-rise building projects delivered under the design-bid-build (DBB) delivery method by identifying the key risks impacting the time of these projects.

2. Steps Solutions

Figure 1 shows the scope of this research paper:

- Design phase of construction projects
- Projects delivered under Design-Bid-Build delivery method
- Only Risk impacts on Time will be considered
- Only private projects will be considered
- The research concentrates on the high-rise building projects only
- The research is conducted in four cities in the United Arab Emirates; Abu Dhabi, Dubai, Sharjah and Ajman.

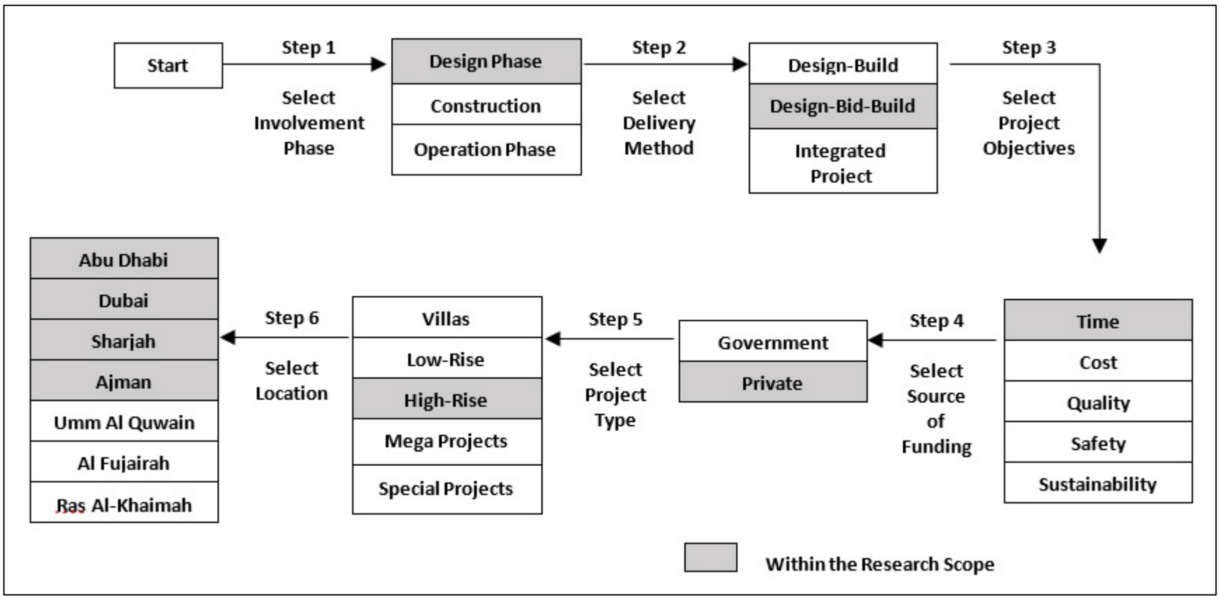

Figure 1. Research Scope

3. Data collection

3.1 List of Design Phase-Related Risks in DBB Process Impacting the Time of High-Rise Building Projects in the UAE

The collected data showing all the possible design-phase related risks affecting the time in the construction projects is presented in Table 2.

Table 2. Design Phase-Related Risks in the DBB Process Impacting the Time of High-Rise Building Projects in the UAE

#	ID	Design Phase-Related Risks in the DBB Process	Category
1	ICD	Interference by the Client in the design process	Client
2	CIV	Client initiated variations/ Client requests changes in the design	
3	DRD	Delay in reviewing and approving design by Client	
4	UCR	Unrealistic Client initial requirements/ Unreasonably high expectations from Client	
5	JOP	Joint ownership of project	
6	UCD	Unrealistic contract duration imposed by Client/ Pressure to deliver design on an accelerated schedule	
7	DPP	Delay in progress payments by the client	
8	FCC	Financial constraints faced by the Client	
9	DPS	Design process suspended by the Client	
10	NSE	New stakeholder emerge and requests changes	
11	CEU	Change in the End User	
12	MCR	Misunderstanding of Client requirements	Consultant
13	DPD	Delay in preparation drawings	
14	AMD	Ambiguities and mistakes in drawings and specifications	
15	PIQ	Poor implementation of Quality Control and Quality Assurance (QC/QA)	
16	PCC	Poor communication between consultant and other project parties	
17	PCD	Poor coordination between design disciplines	
18	IDC	Insufficient data collection and survey before design	
19	IDC	Impractical design /the constructability issues not studied well during the design phase	
20	MID	Mistakes in the design	
21	DMP	Difficulty in measuring progress during design development	
22	ITR	Insufficient time to review tender documents submitted by Contractor	

#	ID	Design Phase-Related Risks in the DBB Process	Category
23	MIB	Mistakes and discrepancies in the itemized BOQ prepared by Consultant	
24	SMS	Shortage in the materials specified by Consultant or the materials required approval from Authorities	
25	RCF	Reduction in the Consultant fees	
26	CSC	Consultant is changed by the Client	
27	TSA	Time Spent by the Consultant in Approval process	Authorities Approval
28	CRL	Changes in regulations and laws	
29	UGC	Unforeseen ground conditions (such as: unexpected geotechnical or groundwater issues, underground utilities lines,..)	Other
30	ADU	As-built drawings for the existing structures are not available	
31	SIF	Slow information flow between project team	
32	DCE	Deficiencies or inaccuracy in cost estimation	
33	DPS	Deficiencies in planning and scheduling of the project	
34	IOS	Inappropriate overall organizational structure of the companies linked to the project	
35	APM	Absence of professional project management	
36	MCD	Mistakes & discrepancies in contract documents	
37	LDP	Legal disputes between various parties in the Project	

3.2 Identification of the key design-phase related risks in DBB Process impacting the time of high-rise building projects in the UAE

Face-to-face interviews were conducted with clients, engineering consultants, and project management consultancies in order to rank the risks collected from the previous studies identifying the top 10 risks affecting the time of the high-rise DBB building projects in the UAE.

Stratified sampling technique is adopted to identify the sample participants from each emirate in the United Arab Emirates; Abu Dhabi, Dubai, Sharjah, Ajman, Umm AlQwain, Ras AlKhaimah, AlFujirah. Stratified sample number was calculated based on the number of companies eligible to work in high-rise buildings in each emirate. The data were collected from the municipality and economic department in each emirate as shown in Table 3. The targeted sample was 30 respondents. The calculation of the stratified sample is shown in Table 4. Random and snowball sampling approach was adopted to identify each participant to this study. The sample taken from each emirate is shown in Table 5.

The methodology was selected for the following reasons: (1) increase the data level of confidence by insuring that all respondents have received the same level of understanding, (2) investigate the root causes of the highest ranked risks, and (3) investigate the possibility to have more risks other than the collected from the literature review. The interview was structured into three parts. The first section seeks general information about the respondent's background and insure that the response fulfills the criteria of the scope of the research. The second part intend to collect information about delays in the high-rise building projects in the UAE, and the involvement of each project's parties in such delays. In addition, it provides information about the role that design phase plays in risk management process. The third part of the interview tend to collect the list shown in Table 2 and questions the respondent to rank the impact of each risk on time. The respondents were also asked to rank the impact of the risk and the likelihood of occurrences. A five-point scale proposed by Zou, et al. (2009) was used for ranking. The assessment of Impact was based on the scale of: 1= very low (0-10%), 2= low (10-30%), 3= moderate (30-50%), 4= high (50-70%), 5= very high (70-100%), and the assessment of likelihood of occurrence was based on the scale of: 1= very unlikely (0-10%), 2= unlikely (10-30%), 3= moderate (30-50%), 4= likely (50-70%), 5= very likely (70-100%)

A pilot study was conducted with 20 respondents. The distribution of the respondents is presented in Figure 2. All the comments provided by the respondents in the interview were analyzed. All the variables proposed by the respondents were studied and implemented as required. The new risks suggested by the respondents were studied, and some of them were considered as root causes for the existing risks.

The interviews were conducted as elaborated above. 27 questionnaires were completed. The distribution of the respondents is shown Figure 3 and Figure 4.

Table 3. Population *(Number of Companies Eligible to work in High-Rise Building Projects)*

Emirate	Engineering Consultancies	Project Management Consultancies	Total Number of Companies
Dubai	193	27	220
Ajman	5	0	5
Sharjah	96	8	104
Abu Dhabi	273	17	290
		Total	619

Table 4. Stratified Sampling Calculations

Emirate (Strata)	Strata Sample Size	Division of Strata Sample		
		Engineering Consultancies	Project Management Consultancies	Total Number of Companies
Dubai	10.7	9.4	1.1	10.5
Ajman	0.2	0.2	0.0	0.2
Sharjah	5.0	4.7	0.4	5.0
Abu Dhabi	14.1	13.2	0.8	14.0
			Total	29.7

Table 5. Adopted Stratified Sampling in the Present Research

Emirate (Strata)	Strata Sample Size (number of companies)		
	Engineering Consultancies	Project Management Consultancies	Total Number of Companies
Abu Dhabi	7	4	11
Dubai	9	1	10
Sharjah	5	0	5
Ajman	1	0	1
		Total	27

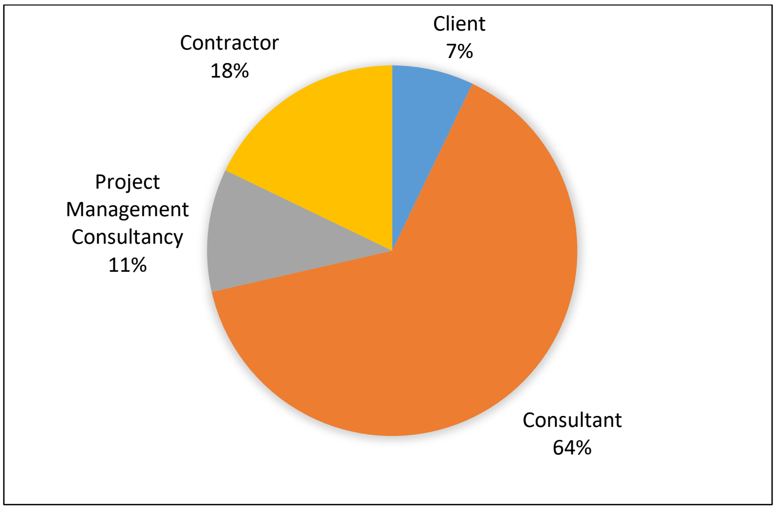

Figure 2. Distribution of Respondents per profession (Pilot Study)

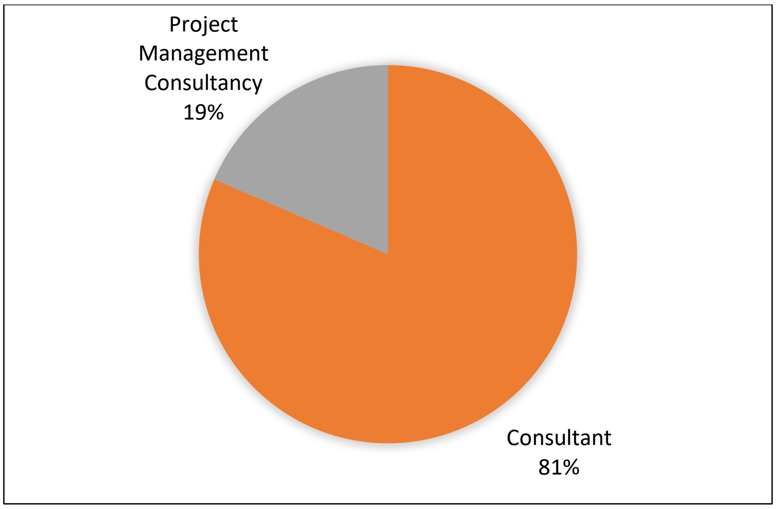

Figure 3. Distribution of Respondents per profession (Interviews)

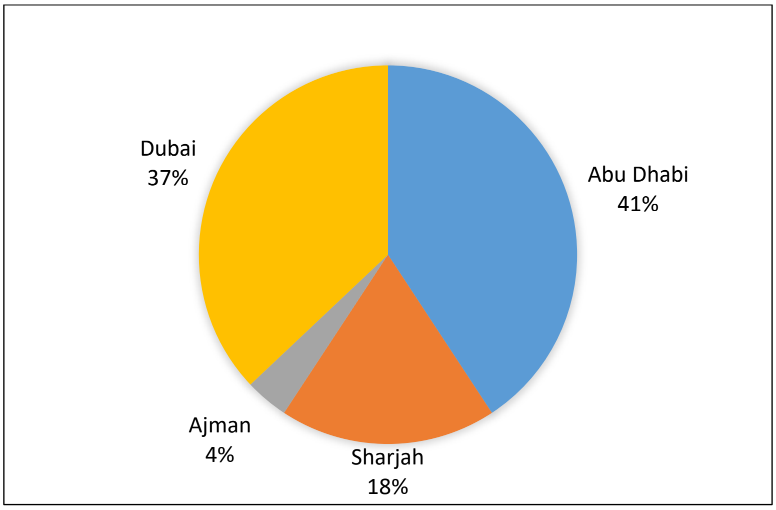

Figure 4. Distribution of Respondents per Emirate (Interviews)

4. Data Analysis

The results included two categories of measures, 1. the likelihood of occurrence of each risk and 2. its level of impact on time. Based on the above mentioned two measures, the significance index for each risk is assessed by each respondent was calculated through Equation (1) as adopted by Zou, et al., (2009).

$$r_{ij}^{k} = \alpha_{ij}\beta_{ij} \text{ ....(1)}$$

where r_{ij}^{k}= significance index assessed by respondent j for the impact of risk i on project objective k; i = ordinal number of risk, i ∈ (1, m); m = total number of risks; k = ordinal number of project objective, k ∈ (1, 5); j = ordinal number of valid feedback to risk i, j ∈ (1, n); = total number of valid feedbacks to risk i; α_{ij}=likelihood occurrence of risk i , assessed by respondent j; β_{ij}= level of consequence of risk i on project objective k, assessed by respondent j.ₙThe average score for each risk considering its significance on a project objective was calculated through Equation (2) (Zou, et al., 2009) .

This average score is called the risk significance index score and was used to rank all risks.

$$\text{Risk Significance Index Score} = R_i^k = \frac{1}{n}\sum_{j=1}^{n} \alpha_{ij}\,\beta_{ij} \text{................(2)}$$

All risks are ranked in accordance with their risk significance index score as shown in Figure 6. The highest ranked risks are presented in Figure 5.

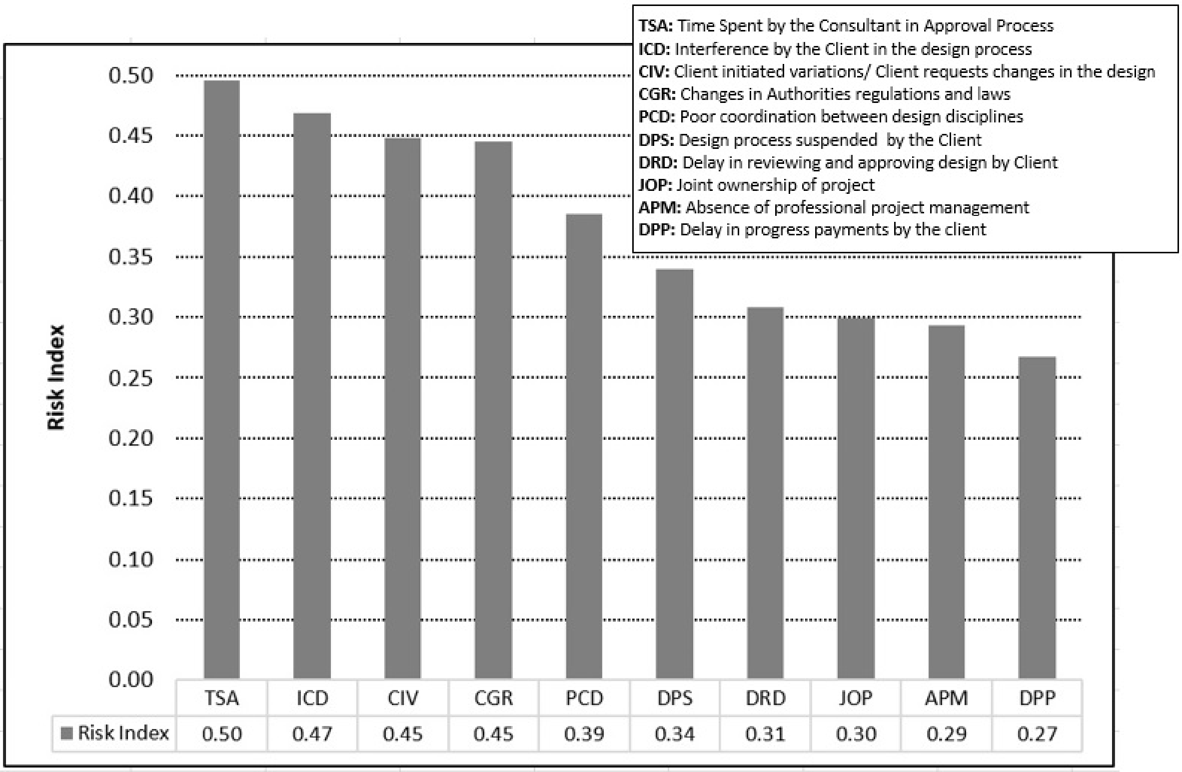

Figure 5. Key design phase-related risks in DBB process affecting the time of high-rise building projects in the UAE

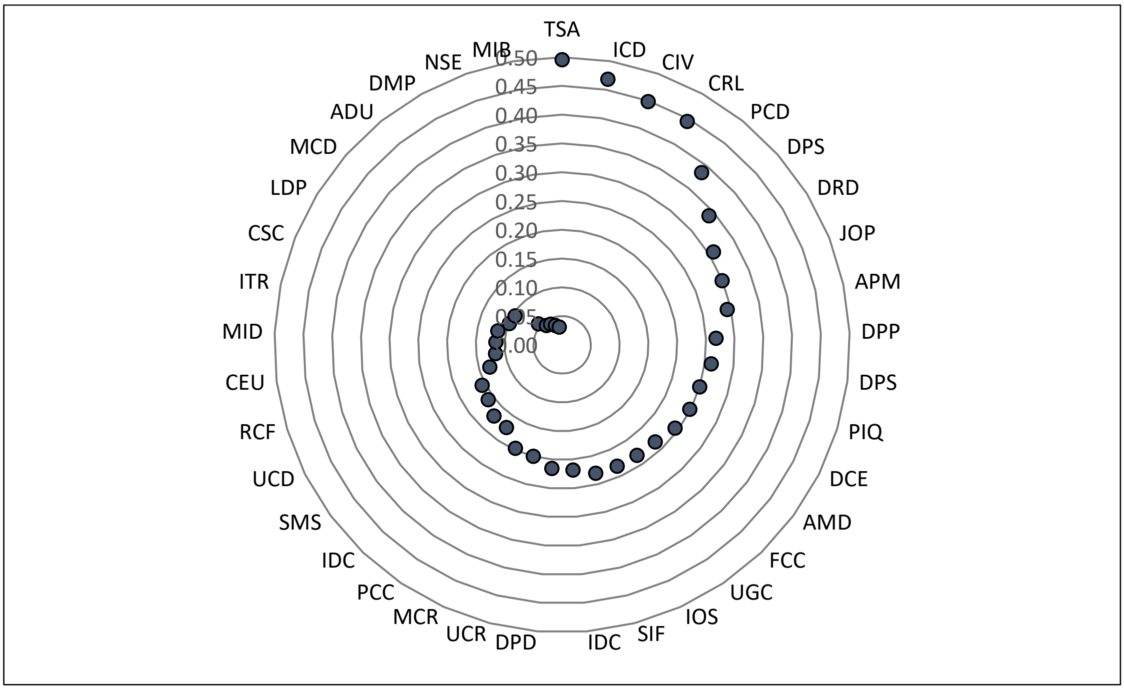

Figure 6. Risk Significance Index Score for the Design Phase-Related Risks in the DBB Process Impacting the Time of High-Rise Building Projects in the UAE

5. Results Discussion and Conclusion

The preliminary results presented in Figure 5 and Figure 6 showed that the “Time spent by the consultant in Approval Procedures” is the main design-phase related risk causing a delay in DBB high-rise building projects. Further interviews were conducted with authorities including the municipality, civil defence and services authorities to identify the root causes of this delay. The preliminary results from the interviews showed that the poor implementation of QA/QC system by the consultant, discrepancies in the drawings, mistakes in design and drawings, and poor implementation of new regulations are the main root causes of delay in approving process.

The results further showed that the client is responsible for most of the key causes of delays. The interference of the client in the design process and the change orders given by the client significantly impact the time of the project during the design phase. The interviews with professionals showed that the impact would be amplified when these risks occur during construction phase. The preliminary investigations showed that root causes of these risks are attributed to the fact that clients are not able to visualise the project or explain their own requirements.

Consultants as well are contributing to delays. The results showed that poor coordination between the design disciplines is one of the key risks causing delay during the design phase, and significantly delaying the project during the construction stage. The study found that the traditional tools such as; superimposing drawings in AutoCAD, regular meetings between the design disciplines, and hiring design coordinator to coordinate between the disciplines are normally used to coordinate the drawings between the design disciplines. However, the risk remains exist and contributes to delays.

The root causes of high ranked risks mentioned above were further studied and a solution approach is proposed through a BIM based solutions as indicated in Table 6. A expert opinion on the mapped solution approach were triangulated through a literature. The investigations on the possible BIM based solution approach show that it can effectively manage the design phase related risks impacting the completion time of DBB high rise building projects in UAE.

Table 6 BIM Solutions for High Ranked Identified Risks

Design Phase - related Risks	Root Causes of Risks	BIM Solutions
TSA: Time Spent by the Consultant in Approval Process	Poor Implementation of QA/QC System by the Consultant Discrepancies in the drawings Mistakes in design and drawings Poor implementation of new regulations	BIM-QA/QC, Clash Detection Software
CGR: Changes in Authorities regulations and laws		
ICD: Interference by the Client in the design process	Clients are not able to visualize the project or explain their own requirements	BIM Design Authoring Software, Cost Estimation, Site Analysis, Programing, BIM Code validation, Space Management and Tracking
CIV: Client initiated variations/ Client requests changes in the design		
PCD: Poor coordination between design disciplines	Traditional tools are used in coordination between the design disciplines such as; superimposing drawings in AutoCAD, regular meetings between the design disciplines, and hiring design coordinator	Design Collaboration Platform and Clash Detection Software

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