Evaluation of using building information modelling in green building in Saudi Arabia construction contracts

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Abstract. Building Information Modelling (BIM) enables, faster development, real-time monitoring of project performance, clash detection, knowledge management, more effective and efficient operation and maintenance, and provide more reliable and timely exchange of information to support the decision-making process. Despite the worldwide adoption of BIM, its implementation is the Kingdom of Saudi Arabia is not mature, especially when it comes to green buildings. The goal of this research is to investigate the use of BIM in green buildings in KSA and provide insights on the factors that need to be considered for optimal attainment of BIM outcomes. First, BIM implementation is analyzed in international contracts such as FIDIC and NEC4. Second, the local implementation of BIM in KSA is investigated through analysing the public works contract and the contract of case study of a mega project. Finally, a survey was conducted to identify and rate the (1) obstacles, and (2) benefits of BIM implementation in green building in KSA. Among the significant results was the fact that the strongest barrier to BIM implementation is the lack of support from the management to accept changing the current practices, and the weakest barrier is actually the costs of BIM implementation. The findings shed the light on significant aspects (such as increasing awareness about BIM and fostering flexibility in managers) that will enable successful implementation of BIM in green buildings in KSA; which in turn will result in cost and schedule savings.

1. Introduction
The Kingdom Saudi Arabia (KSA) is heavily invested in construction projects, where the construction industry is one of the largest and fastest growing sectors [1]. According to the General Authority for Statistics (GASTAT) in 2019, the construction industry constituted around 5.5% of KSA’s gross domestic product (GDP), with a total spending of approximately SAR 163.56 billion with 4.6% growth rate [2]. These numbers demonstrate the significant construction development occurring all over the country and reflects the importance of the construction industry to KSA. However, since construction is a complex process that involve several parties, managing this process and coordinating between the different stakeholders and relevant parties poses significant challenges [3]. Without proper planning and utilization of the latest tools, projects face cost and schedule overruns. The effective adoption and implementation of Building Information Modelling (BIM) has shown great potential towards mitigating these challenges and improve the performance of construction industry [4].

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BIM is defined as a modelling technology and associated set of processes to produce, communicate, and analyze building models [5]. With BIM technology, one or more accurate virtual models of a building are constructed digitally with precise geometry and data needed to support the construction, fabrication, and procurement activities through which the building is realized, operated, and maintained [6]. Proper utilization of BIM means that it is not treated as just software, but also a process that can be capitalized on to collaborate and exchange the relevant information about the project with its stakeholders throughout the project life cycle. BIM enables, faster development, real-time monitoring of project performance, clash detection, knowledge management, more effective and efficient operation and maintenance, and provide more reliable and timely exchange of information to support the decision-making process [4]. In addition, it helps to enhance productivity and collaboration, increase efficiency, improved communication with stakeholders, and reduce project’s time and cost [7].

In a study conducted by Gerges M [8] to determine the current state of BIM adoption in the Middle East by exploring the extent of implementation of BIM among stakeholders in the construction industry; the results reveal that the status of adoption of BIM in the Middle East is not satisfactory. The study also confirmed that only 20% of construction companies implement BIM or participate in the BIM certification process in any capacity, while the remaining 80% do not implement it and do not participate in its certification process in any capacity [8]. Hassan [9] studied the BIM practices and barriers in the construction industry in the GCC. Hassan [9] also found evidence of a low implementation rate for BIM in construction projects in the GCC market and lack of awareness of BIM, unwillingness of stakeholders to accept changing current business practices. A study conducted by Al-Hammadi [10] regarding BIM technology awareness in KSA, more than half of respondents (67.3%) in their survey were unaware of BIM. Only (4.5%) of overall respondents were aware of BIM usage and used it in practice, while (16.59%) of respondents were aware but had not used BIM [10].

Effective adoption and use of BIM require appropriate contract design to fairly allocate the contracting parties rights and responsibilities. Therefore, it is important to evaluate the use of the BIM in Saudi construction contract and identify the key factors influencing its implementation also, to assess the needed adjustment of conventional contract provisions to achieve the desired level of BIM adoption. The goal of this research is to investigate the use of BIM in green buildings in KSA and provide insights on the factors that need to be considered for optimal attainment of BIM outcomes. To this end, the research answers the following questions:

1. How do international contracts deal with BIM in terms of provisions?
2. How do contracts in KSA deal with BIM?
3. What are the obstacles that stand in the way of proper BIM implementation in the Saudi market, and what is their importance rating?
4. What are the benefits of BIM associated with the Saudi market?

2. Methodology
To achieve the research goal and answer the abovementioned questions, the following methodology was developed and followed (also demonstrated in Figure 1):

Step 1: This step involves studying international contracts to investigate how BIM is incorporated in such contracts. The studied international contracts in this research are FIDIC and NEC4, due to their frequent use in international projects worldwide [11].

Step 2: This step involves studying how BIM is dealt with in Saudi contracts, mainly the Public Works Contract (PWC); which is the official contract used for public works projects in KSA. As for private projects, a case study of a project using BIM is selected and its contract is analysed based on clauses that discuss the use of BIM.
Step 3: A survey is developed, deployed to contract experts in KSA, and analyzed to determine the current obstacles that face proper implementation of BIM in green buildings in KSA.

Step 4: This final step is also based on the survey in step 3, but this time to determine the key benefits of BIM special to the Saudi green buildings construction market.

3. BIM in International Contracts

It is a common practice in the construction industry to use standard form of contracts. These contracts are usually developed by professionals of international/national authoritative bodies, government representatives and others. Typically, it is prescriptive and provides guidelines, conditions, directives, and suggestions for the overall contractual process. This part of the research presents a different standard forms of building contracts and elaborate on how each type of these contracts address BIM. Also, demonstrates the effectiveness of the related contract's clauses toward sufficient implementation of BIM.

Old versions of FIDIC contracts up to 1999 did not include anything related to BIM. As for the new version of FIDIC contracts published in 2017, Conditions of Contract for Construction (Red book), Conditions of Contract for EPC/Turnkey Projects (Silver book), and Conditions of Contract for Plant & Design Build (Yellow book) there are mentioning to BIM as in “Part B – Special Provisions” but not in the contract. The part included in the Special Provisions is basically advisory notes and guidelines to users of FIDIC contracts where the project is to include BIM, these guidelines do not provide specific provisions but only list the points to note.

Most standard forms contracts make only light reference to BIM within their documentation. NEC4 arguably goes the furthest. The NEC4 contracts published in 2017 included a new secondary option clause (Option X10) on “Information Modelling” that covers incorporation of building information modelling (BIM) into the contract. This option was not previously included within the NEC3 contract. Clauses under this option are covers the following aspects:

- Defined terms, some defined terms to be considered for Option X10.
- Collaboration, contractor collaborates with other Information Providers.
- Early warning, contractor and project manager give an early warning by notifying the other as soon as either becomes aware of any matter which could adversely affect the creation or the use of the information model.
- Information execution plan sets the detail process and requirements for the review and acceptance of the information execution plan it also covers the form in which project information to be submitted.
• **Compensation events.** If the information execution plan is altered by a compensation event, the contractor includes the alterations to the information execution plan in the quotation for the compensation event.

• **Use of the information model.** The client owns the information model and the contractor’s rights over project information except as stated otherwise in the information modelling requirements.

• **Liability.** Client’s liabilities, Contractor’s liabilities, and Contractor’s insurance for claims arising out of its faults in the project information provided.

Option X10 has been widely considered as a positive step, it sets out a clear basis for managing projects using BIM and should be helpful to contracting parties. However, if this Option is used then rights of the information model will be owned by the client unless the information model requirements say otherwise. This might be represented as a risk for the contractor.

Prior to its release there was a real fear that the NEC4 would follow the JCT 2016 and effectively say something akin to: “It’s BIM, you sort it out.” Thankfully, this has not been the case and the NEC4 sees the inclusion of a new secondary option which specifically deals with information modelling – Option X10. The mere existence of any such clause constitutes a significant step in the right direction in respect of both the industry’s use and its general understanding of what BIM is and how it should be used. But with it remains clear that standard forms of contract, including NEC4, have some way to go yet before they fully incorporate and utilize the use of BIM [12].

4. **BIM in Saudi Contracts**

The Public Works Contract (PWC) is the first and only endeavour for standardizing construction contracts in KSA [13]. The Saudi Ministry of Finance and National Economy introduced the PWC in the late nineteen eighty’s based on the FIDIC 1977 contract [14]. The majority of the PWC has not been changed since then. Some changes have been made in 2007, however the majority of the features related to risk allocation are still the same [14]. The application of BIM in Saudi Arabia has not been mandatory by the Saudi government and there is no clear clause mentioning BIM in the PWC and it has not been widely implemented by construction organizations [15]. Based on that, it is imperative to investigate the current and potential obstacles and benefits for the use of BIM technology in Saudi construction contacts.

A case study was chosen to provide a comprehensive understanding and evaluation of the use of BIM in Saudi Construction Contracts. As a mechanism for data eliciting, interviews were conducted with some of the BIM project participants in that case study. Open-ended questions were adopted in the interviews to give the respondents free space to answer and to give as much data as possible. The focus of interview questions was to determine the reason for choosing BIM, the advantages resulting from its use, conflicts concerned with BIM implementation and Improvements needed to use BIM in contracts.

The Public Investment Fund housing and commercial project in Al Madinah Al Munawara (its name changed later to Dar Alhijjra) is a mega project with an area of 1,600,000 square meters, located three kilometres southwest of Prophet Muhammad’s Mosque. The project is implemented in three phases, the first is infrastructure, the second is administrative office buildings, and the third is residential towers. We will focus on the second phase (administrative office buildings) in which the BIM method was used. The phase budget is 2,500,000,000 SR consist of 13 buildings. In this project the bidding documents were used and it was mentioned that all drawings and information provided by the contractor shall be made using BIM. Most of the interviewees agreed that the benefits from the application of BIM in the contract are great and contributes to reducing contract disputes and their recommendation to expand the application in construction contracts in Saudi Arabia and use of the latest versions such as (ISO19650).

To be exact, clause #25 in the case study’s contract explicitly mentioned “*The Contractor shall prepare accurate plans and drawings on the computer using BIM software packages that are compatible with*
what the Contractor received in the Tender documents, for all architectural, structural, mechanical, and electrical works; showing all visible and invisible works”.

5. Obstacles Facing BIM Implementation in Green Buildings in KSA

The data collected through the interviews in the case study constructed a base to conduct an online survey. An online survey was sent to construction participants in both private and public sectors. This survey was divided into two sections, the first section related to obstacles of implementing BIM in the contract while the second concentrated on the benefits of implementation Building Information Modelling (BIM) in Saudi construction contacts.

The participants in the survey have different academic backgrounds, 69.7% of the respondents have a bachelor’s degree in engineering, 21.2% have a master’s degree in civil engineering and 6.1% of the 33 responses had Ph.D. in civil engineering while 3% had other academic levels such as diploma in civil engineering. Most of the participants have a good experience level where 78.8% of respondents had more than 6 years’ experience which indicate reliability and credibility of the responses, 48.5% of the respondents of an experience from 6 to 10 years, 21.2%, 18.2% of an experience 0 to 5 and 11 to 15 respectively, and the respondents who had an experiences more than 16 years represent 12.1% of the participants in the survey.

The types of projects that have been executed by the survey participant in Saudi Arabia in which they have used BIM are: 27.3% implanted BIM for projects in public sectors, 18.2% implanted BIM for projects in private sectors, and 54.5% of the participants implanted BIM delivery method for both private and public sectors.

The participants in the survey cover the main parties in construction contracts that have private contract relation and another sub-parties in the projects. The majority of respondents were Contractors and Consultants, with percentages of 54.5% and 33.3%, respectively. 6.1% of survey respondents are projects owners who executed projects with BIM whiles 6.1% are of other parties as sub-contractors and suppliers and others.

Participants in this study were asked to evaluate the delivered obstacles in 5 points Likert scale where; 1 is strongly disagree, 2 disagree, 3 neutral, 4 agree, 5 Strongly agree. According to the responses that were obtained, 45.5% of the respondents evaluate the first BIM obstacle that states: The unawareness of BIM nature and give a value of 5 for this obstacle, on the other hand 48.5. 29% of respondents assess the second obstacle, Owners do not require the use of BIM with evaluation value of 5, the same evaluation with the following obstacles, as The hardness of authorities to adopt and support BIM, Lack of support from the management to accept changing the current practices, Lack of practical standers, guidelines, and specifications support BIM in the contract, Difficulties to find a contractor or designer who is familiar with BIM, Contract Provision does not support integration and Collaborative work among the project stakeholders, Lack of the arrangements of ownership and licensing of intellectual property rights in BIM models and their permitted uses, where 36.4%, 48.5%, 42.4%, 39.4%, 33.3%, 39.4%, 18.57% and 17.14% of respondents for the above, While 30.3% and 45.5% of respondents assess the obstacles The cost of using BIM is only feasible for large projects and BIM requires a completely new contractual approach than the conventional contracts and give a value of 4 for these obstacles as shown in Table 1.
Table 1. Obstacles Facing BIM Implementation in Green Buildings in KSA.

| Rating Power | 1 | 2 | 3 | 4 | 5 | Mean | Rank |
|--------------|---|---|---|---|---|------|------|
| Obstacles    |   | Percentages (%) |   |   |   |      |      |
| 1. The unawareness of BIM nature | 6.1 | 6.1 | 6.1 | 36.4 | 45.5 | 4.10 | 2    |
| 2. Owners do not require the use of BIM | 12.1 | 9.1 | 3 | 27.3 | 48.5 | 3.91 | 7    |
| 3. The hardness of authorities to adopt and support BIM | 9.1 | 9.1 | 24.2 | 21.4 | 36.4 | 3.68 | 9    |
| 4. Lack of support from the management to accept changing the current practices | 3 | 6.1 | 15.2 | 27.3 | 48.5 | 4.13 | 1    |
| 5. Lack of practical standards, guidelines, and specifications support BIM in the contract | 3 | 6.1 | 18.2 | 30.3 | 42.4 | 4.03 | 4    |
| 6. Difficulties to find a contractor or designer who is familiar with BIM | 6.1 | 6.1 | 18.2 | 30.3 | 39.4 | 3.91 | 6    |
| 7. The cost of using BIM is only feasible for large projects | 15.2 | 21.2 | 30.3 | 18.2 | 15.2 | 2.97 | 10   |
| 8. Contract Provision does not support integration and Collaborative work among the project stakeholders | 3 | 18.2 | 18.2 | 27.3 | 33.3 | 3.70 | 8    |
| 9. Lack of the arrangements of ownership and licensing of intellectual property rights in BIM models and their permitted uses | 3 | 3 | 24.2 | 30.3 | 39.4 | 4.00 | 5    |
| 10. BIM requires a completely new contractual approach than the conventional contracts | 0 | 3 | 18.2 | 45.5 | 33.3 | 4.09 | 3    |

The study results are emphasizing the BIM implementation obstacles acknowledged by Hassan [9] and Al-Hammadi [10], as can be observed from the survey responses unawareness of BIM nature and Lack of support from the management to accept changing the current practices are of the highest ranked BIM implementation obstacles which means that these obstacles are still hindering the implementation of BIM in construction projects in Saudi Arabia. Moreover, as stated by Al-Hammadi [15] the application of BIM in Saudi Arabia has not been mandatory by the Saudi government and there is no clear clause mentioning BIM in the public works contract and it has not been widely implemented by construction organizations, we can see in the survey responses that majority of the responses are strongly agreeing that BIM requires a completely new contractual approach than the conventional contracts and that Lack of practical standards, guidelines, and specifications support BIM in the contract is obstructing BIM implementation in Saudi Arabia.

6. Benefits of BIM Implementation in Green Buildings in KSA

In this part, the experts were asked to evaluate the delivered benefits of BIM in green buildings of KSA in 5 points Likert scale where; 1 is strongly disagree, 2 disagree, 3 neutral, 4 agree, 5 Strongly agree. According to the responses, 51.5% of the respondents evaluate the first benefit of implementation BIM that states: Minimum project time schedule and give a value of 5 for this benefit, the same evaluation with the following benefits, as Minimum overall project cost, Highly design and construction quality, Minimum change order, Reducing contractor and designer dispute. Reducing project risks, more reliable and timely exchange of information among project stakeholders, where 54.5%, 69.7%, 51.5%, 51.5%, 48.5%, 54.5%, as shown in Table 2. It can be seen that the survey responses are aligned with the interviewee feedback about the benefits of the BIM application in the construction contract to reduce contract disputes and on the importance to expand the application in construction contracts in Saudi Arabia to improve design and construction quality and mitigate the project time and cost.
### Table 2. Benefits of BIM Implementation in Green Buildings in KSA.

| Benefits                                                   | 1 | 2 | 3 | 4 | 5 | Mean | Rank |
|------------------------------------------------------------|---|---|---|---|---|------|------|
| 1. Minimum project time schedule                           | 0 | 3 | 12.1 | 33.3 | 51.5 | 4.33 | 5    |
| 2. Minimum overall project cost                            | 0 | 3 | 12.1 | 30.3 | 54.5 | 4.36 | 3    |
| 3. Highly design and construction quality                   | 0 | 3 | 6.1  | 21.2 | 69.7 | 4.58 | 1    |
| 4. Minimum change order                                     | 3 | 3 | 21.2 | 21.2 | 51.5 | 4.15 | 7    |
| 5. Reducing contractor and designer dispute                 | 0 | 6.1| 6.1  | 36.4 | 51.5 | 4.34 | 4    |
| 6. Reducing project risks                                   | 0 | 6.1| 9.1  | 36.4 | 48.5 | 4.28 | 6    |
| 7. More reliable and timely exchange of information among project stakeholders | 0 | 3 | 6.1  | 36.4 | 54.5 | 4.42 | 2    |

### 7. Conclusion

Building information modelling has proved its capabilities in reducing project risks and overall cost and improve the quality and performance of the design and construction process. The research showed that the standard forms contracts vary in their effectiveness and level of depth to address BIM, and that standard forms of contract have some way to go before they fully incorporate and utilize the use of BIM.

BIM application in green buildings in Saudi Arabia’s construction project is evolving. However, application of BIM is not mandatory by the Saudi government even for the large projects, usually it is used based on the request by the owner. Also, there are no certain authority responsible for regulating the usage of BIM in the construction projects. The public works contract needs to be developed to keep pace with the advancement in technology and it should adopt the concept of green buildings.

Considering the data analysis conducted for this paper we can observe that one of the strongest barriers to BIM implementation is the lack of support from the management to accept changing the current practices, and the weakest barrier is actually the costs of BIM implementation. Therefore, there is much effort is needed in raising the awareness and knowledge about the significant of BIM implementation, as this would support in resolving many of the identified obstacles. Also, developing a national policy, specification, guidelines and implementing the specification considered to be a key aspect of supporting BIM adaptation in green buildings in KSA.

Effective implementation of BIM in green buildings required new contract provisions that directly or indirectly mandate a collaborative working through BIM and mutual agreement to act in good faith, as working in isolation and shifting the risk to the other party will be a complication toward successful implementation. Moreover, Incorporating BIM in construction project and with proper contract provisions would contribute greatly to reducing contract disputes. Therefore, BIM must be adopted and enforced by the government for public and private project at least for the large projects.
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