

Investigating the Usage Effectiveness of BIM in Engineering Consulting and Contracting Firms: A Case Study of Jeddah City, Saudi Arabia

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Abstract This investigates the effectiveness of Building Information Modeling (BIM) in engineering consulting and contracting firms in Jeddah City, to raise awareness and improve professional practices for a competitive advantage. The study adopts a descriptive research approach and utilizes a case study to analyze the current state of BIM usage in these firms. Data is collected through a survey targeting engineering consulting and contracting firms in Jeddah, Saudi Arabia, and analyzed using descriptive analysis. The survey results reveal several key findings, including a lack of client awareness, insufficient proficiency in BIM, and the need for a unique BIM implementation plan and framework. To address these issues, the authors propose a BIM framework to enhance the efficient use of BIM by engineering consulting and contracting firms. The paper also focuses on the awareness and challenges of implementing BIM in Jeddah engineering consulting and contracting firms. The findings of this study can assist policymakers in developing constructive strategies to overcome challenges and promote the widespread use of the BIM concept and technology in engineering consulting and contracting firms in Jeddah City. The paper also highlights the lack of investigative studies focusing on the introduction of new technologies to advance the construction sector in Jeddah City. Therefore, future work involves implementing the proposed framework, evaluating its effectiveness, and identifying areas for improvement.

Keywords: Building Information Modelling (BIM), engineering consulting and contracting firms, BIM dimensions, BIM effectiveness, adoption of BIM, Jeddah

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1. Introduction

This paper focuses on investigating the usage effectiveness of BIM in engineering consulting and contracting firms located in Jeddah City, Saudi Arabia. Construction is one of the largest industries in Saudi Arabia and plays an important role in sustaining economic growth and improving people's quality of life. The Kingdom's construction sector in 2023 is worth US\$65.58 billion, expected to increase by a CAGR of 2.75% to US\$75.12 billion in 2028, The Saudi Arabian construction market is currently pegged at the value of US\$64 billion and is expected to grow at a CAGR of 5.8% during the forecast period of 2019-2028. [1]. Therefore, the government has established its 2030 vision plan and encouraged all sectors to be creative, efficient, and environmentally responsible. A huge budget is dedicated to investments and incentives in construction projects. However, the Saudi Arabian construction industry still faces critical problems such as poor planning, delays in

project delivery, lack of communication, errors and changes in design, cash flow problems, and increased maintenance costs [2]. Further, major causes of claims in KSA are related to contractor payment delays from the owners' side. Financial difficulties challenge the contractors because most of them might not be able to inject the required money into a project if the owner delays or holds the contractor's payments unreasonably [3]. In 2017, the Ministry of Municipal and Rural Affairs reported that approximately 75% of public construction projects have exceeded their planned time and are delayed [4]. This project aims to investigate the usage effectiveness of BIM in engineering consulting and contracting firms in Jeddah City, raise awareness about BIM and improve professional practices in this field for competitive advantage. This paper's objectives are:

- (1). To clarify the usage effectiveness of BIM in class A engineering consulting and contracting firms,
- (2). To measure the effectiveness and key factors that obverse engineering consulting and contracting firms from using BIM effectively,
- (3). To develop a framework to ensure the effective

use of BIM in engineering consulting and contracting firms.

To achieve the objectives of the current study, the following method will be conducted:

- (1). To achieve the first objective of the current study:
Sort out the class A engineering consulting and contracting firms in Jeddah City utilizing a MOMRA database [5].
Determine the main and critical elements of BIM.
Determine the class A firms that utilize BIM using a coidentity field survey to identify engineering consulting and contracting firms that use BIM in Jeddah.
Utilize Google Forms to distribute surveys to all class A engineering consulting and contracting firms that use BIM.
- (2). To achieve the second objective of the current study:
Using a thought survey, identifying the gap in BIM application utilization remaining dimensions between the engineering consulting and contracting markets.
Identifying the gap in BIM application utilization between the engineering consulting and contracting markets.
Identifying the key factors that prevent engineering consulting and contracting firms from using BIM effectively.
- (3). To achieve the third objective of the current study, the following method will be conducted:
Development of a blueprint to guide engineering consulting and contracting firms in enhancing the efficient utilization of BIM.

2. Literature

Over the last decades, Building Information Modeling (BIM) has increased its relevance to construction project management to improve the construction projects' outputs and the integration between stakeholders. BIM is undoubtedly a tool used worldwide and has become practically a standard in construction project management. [6]. Most use of BIM around design problems, and lack of coordination in design resolves design problems, synchronization, building performance, and quality. BIM should provide a level of solution in terms of optimization design, but we can think about the ability of BIM in business management including project management, cost management, facilities management, etc. so the BIM modeling in terms of 4D, 5D, 6D, and 7D that's main cost, time, facility management, and sustainability will improve the performance of the project. [7]. Powerful visualization and higher-quality information when employing BIM result in early clash detection and lessen disputes among project team members [8]. Besides aiding in planning and construction processes to operate more efficiently, BIM allows project team members to preserve data for subsequent operations and maintenance tasks. In addition, it minimizes the time to discover relevant information as it is simpler to obtain softcopy data than conventional hardcopy.

2.1. BIM Dimensions

1D BIM: At its core, BIM is composed of data—zeros and ones. If those data are not reliable and up-to-date, trust erodes and the value of BIM diminishes. As data are generated and shared, they should be exchanged in machine-readable formats that align with established interoperability standards such as the International Organization for Standardization (ISO) and the National BIM Standard (NBIMS). These are voluntary, industry consensus standards and do not reflect Federal requirements. [9].

2D BIM: Modeling a project in two dimensions is limited to a simple X-axis and Y-axis representation of project design and drawings. Planning is primarily conducted in two dimensions and relates constraints and objectives to the project specifications. 2D BIM, as the earliest form of construction model, allows fundamental planning activities to be performed faster and in a simpler format. However, in large and complex infrastructure projects, more elaboration is needed to ensure that cost-effective flawless plans and designs are generated and in place to support on-target construction project delivery. With the inclusion of more variables and constraints, detailed planning becomes more complicated and the need for visualizing the parameters arises [9].

3D BIM: Undertaking design and planning in a three-dimensional environment increases the clarity and rigor of the process. It entails the integration and visualization of graphical and non-graphical information ranging from space relationships and isometrics to estimated quantities [10]. Undertaking design and planning in a three-dimensional environment increases the clarity and rigor of the process. It entails the integration and visualization of graphical and non-graphical information ranging from space relationships and isometrics to estimated quantities [10]. Three-dimensional BIM is not the same as CAD 3D. Benefits of the 3D BIM dimension include complete transparency from the start due to fewer instances of rework and revisions, an improved 3D visualization of the entire project, streamlined communication and sharing of design expectations, and easier collaboration among numerous teams regardless of their area of expertise [11].

4D BIM: introduces the element of time into the 3D BIM model. It incorporates the construction sequencing and scheduling information, allowing stakeholders to visualize the project's progression over time. [12]. Four-dimensional BIM, which stands for four-dimensional building information modeling, is utilized for all planning-related tasks on construction sites [13]. Although 4D BIM is increasingly used in large-scale building and engineering projects, there have been a few positive results from its use in regular projects and it must be acknowledged that this technology is very new and needs to be adjusted to meet actual company needs [11].

5D BIM: This dimension of BIM incorporates cost estimates into 4D BIM to enable integrated cost planning and project budgeting. The budget software, scheduling software, and BIM 3D model interoperate seamlessly so that estimators can analyze capital and operating costs during the construction stages. This tool can be used

during the stages of infrastructure construction by keeping track of budget deviations from the baseline target. Elements of the 5D BIM should be capable of extracting and visualizing accurate cost-related information that can be shared among estimators, owners, investors, and contractors [14].

6D BIM: The 6D BIM optimizes energy consumption and reduces the long-term costs associated with running the facility and improves performance. This dimension of BIM significantly contributes to sustainability objectives and creating a green infrastructure by conserving energy in the infrastructure construction sector. Accurate prediction of energy construction requirements and upfront costs of projects gives insight into the entire costs of managing a facility, which helps designers adopt a long-term view of engineering specifications. The energy management tools simulate the energy behavior of a facility in the long run [15].

7D BIM: Further elaboration on the associated tools indicates that 7D BIM includes more lifecycle-related information necessary for achieving energy efficiency and sustainability throughout the lifecycle. Any information which is important for the operation and maintenance of the facility from design to demolition is integrated into 6D BIM to constitute 7D BIM. Seven benefits of 7D BIM include a streamlined building maintenance procedure for contractors and subcontractors, optimized asset and facility management from the design phase to demolition, a simpler and easier replacement of parts and repairs anytime during the entire life of a building, and lastly, simplified and easy maintenance process [11].

8D BIM: is focused on safety during the design and construction process. This dimension aims to prevent accidents and incidents by incorporating safety features into the design of a building from the outset. 8D BIM enables designers to conduct a thorough risk assessment of each design component of the facility they are designing. By doing so, potential hazards can be identified and eliminated before construction begins, resulting in a safer working environment for construction workers. [16].

9D BIM: The integration of lean construction requirements into 8D BIM forms the 9D BIM as a robust potential tool for more effective delivery and operation of a facility with the optimal use of resources and capital [17]. This dimension emphasizes the resource management techniques to improve the allocation and use of materials, labor, equipment, and tools during the facility's lifespan.

9D BIM analyzes all resources involved in the process of constructing and operating infrastructure.

10D BIM: The 10D BIM is another prospective dimension of the BIM system that aims to take advantage of industrialized construction and incorporates disaster management plans [17]. This dimension identifies and eliminates obstacles to productivity throughout the design, construction, and delivery of a facility. To improve the productivity level, this dimension encourages the use of drones and manufacturing machines. Artificial intelligence plays an important role in this domain to automate engineering planning and control procedures. This dimension has been introduced recently and its application is yet to be further explored and tested.

2.2. Practicability of BIM

The criteria for effective BIM implementation in Jeddah city were selected by studying the published works between 2017 and 2022. As presented in Table 1. The chosen aspects of this framework were the most mentioned aspects by several references, as presented in Table 1. Depending on the literature, some aspects (Experience, BIM project proportion, project types, and dimension uses) that were not studied extensively were also included in this study as insights for future works. The relevant studies are listed in Column II of Table 1. Finally, 5 aspects each with five levels were designated to evaluate the engineering consulting and contracting firms that implement BIM effectively in Jeddah city.

3. Methodology

A procedure for determining the technical facility's staff skills based on a variety of factors. These criteria have been created and divided into basic criteria and additional criteria Table 2. Their weights and limitations have been established following a dynamic process that is reasonable and appropriate given the market's characteristics.

3.1. The Final Rating Scores

The following procedure determines the establishment's ultimate categorization level based on the level of credit evaluation and technical evaluation Table 3 [5].

Table 1. Practicability of BIM

Criteria	Related literature	BIM-related factors	Levels
Human factors	Dao et al. (2020)[18], Hong et al. (2019)[19], Gamil and Rahman (2019)[20], Ayman et al. (2018)[21], Babatunde et al. (2020)[22], Chan et al. (2019a)[23], Saka et al. (2019)[24], Olawumi et al. (2018)[25], Ahmed (2018)[26], Gamil and Rahman (2019)[20], Hong et al. (2019)[19], Sholeh et al. (2020)[27], Babatunde et al. (2020)[28], Hatem et al. (2018)[29], Seyis (2019)[30], Oteng et al. (2018)[31]	Lack of BIM users on project Limited or no previous experience working with other companies on BIM projects. Lack of interoperability between BIM software used by team members Lack of trained professionals to handle the tools Social and habitual resistance to change	5 = above 15 years 4 = 10 to 15 years 3 = 5 to 10 years 2 = 2 to 5 years 1 = 0 to 2 years
BIM project proportion	(Pavol Mayer, 2021)[32]	Percentage of BIM projects out of all projects.	5 = 80 - 100% 4 = 60 - 80% 3 = 40 - 60% 2 = 20 - 40%

Criteria	Related literature	BIM-related factors	Levels
			1 = 0 - 20%
Project types	(Nguyen Tam et al. 2021); [33] (Yasser Al-Ashmori et al, 2019); [34] (Svetlana Olbina, Jonathan W. Elliott, 2019) [35]	The type of projects that the respondent companies deal with.	5 = 5 Project types 4 = 4 Project types 3 = 3 Project types 2 = 2 Project types 1 = 1 Project type
Dimensions Uses	Al-Ashmori et al. (2020a, 2020b), [36] Noor et al. (2018) [37], Olawumi and Chan (2019a) (2019b) [38,39], Van Tam et al. (2018), [40] Chan et al. (2019b)[39], Ibrahim et al. (2019)[41], Saka and Chan (2019) [42]; Yousif Zaia et al. (2022). [43]	Provided with 3D modeling/design Provided with 4D modeling/schedule of construction activities With 5D modeling/material take-off/ cost estimate Provided with 6D modeling/building sustainability, energy efficiency Provided with 7D modeling/facility management information	5 = use 2D&3D&4D&5D&6D and 7D 4 = use 2D&3D&4D&5D and 6D 3 = use 2D&3D&4D and 5D 2 = use 2D&3D and 4D 1 = use 2D and 3D
BIM tools	(Nguyen Toan et al., 2022); [44] (Mesároš, Smetanková and Mandíček, 2019) [13]; (Olsen and Taylor, 2017) [45]	Software that can help optimize the work of designing for architecture, construction, plant, civil, and MEP projects.	5 = use 5 more software 4 = use 5 software 3 = use 4 software 2 = use 3 software 1 = use 2 software

Evaluation level: 5 = very good, 4 = good, 3 = neutral, 2 = bad, 1= very bad is based on the survey results conducted by the researcher. Source: The Authors

Table 2. Additional criteria of technical assessment (MOMRA, 2023)

Criteria	Description	Number	Description
Basic criteria (80 points)	To be categorized as a minimum, the institution must fulfill these standards.	1	The proportion of employees in the enterprise who are engineers. (30 points)
		2	The proportion of employees at the facility who are technicians. (30 points)
		3	The average experience of engineers. (10 points)
		4	The average experience of technicians. (10 points)
Additional criteria (20 points)	The establishment can focus on improving these additional criteria to raise its grade.	1	The percentage of Saudis from the total employees in the enterprise (5 points)
		2	Out of the total number of employees at the facility, the proportion of engineers who are Saudis. (5 points)
		3	The percentage of the total employees at the facility are Saudi employees receiving high wages*. (5 points)
		4	The proportion of female Saudi employees within the overall workforce of the enterprise. (5 points)

Saudis with a monthly income of 10,000 riyals or more a social insurance number and who are employed by the establishment.

Table 3. Matrix for calculating the final score of the classification (MOMRA, 2023)

Financial evaluation	100-70	69-40	39-20	19-10	09-01
AAA	First Classification	Second Classification	Third Classification	Fourth Classification	Fifth Classification
AA+	First Classification	Second Classification	Third Classification	Fourth Classification	Fifth Classification
AA	First Classification	Second Classification	Third Classification	Fourth Classification	Fifth Classification
AA-	First Classification	Second Classification	Third Classification	Fourth Classification	Fifth Classification
A+	First Classification	Second Classification	Third Classification	Fourth Classification	Fifth Classification
A	First Classification	Second Classification	Third Classification	Fourth Classification	Fifth Classification
A-	First Classification	Second Classification	Third Classification	Fourth Classification	Fifth Classification
BBB+	First Classification	Second Classification	Third Classification	Fourth Classification	Fifth Classification
BBB	Second Classification	Third Classification	Fourth Classification	Fifth Classification	Fifth Classification
BBB-	Second Classification	Third Classification	Fourth Classification	Fifth Classification	Fifth Classification
BB+	Third Classification	Fourth Classification	Fifth Classification	Fifth Classification	Fifth Classification

Financial evaluation	100-70	69-40	39-20	19-10	09-01
BB	Third Classification	Fourth Classification	Fifth Classification	Fifth Classification	Fifth Classification
BB-	Third Classification	Fourth Classification	Fifth Classification	Fifth Classification	Fifth Classification
B+	Fourth Classification	Fifth Classification	Fifth Classification	Fifth Classification	Fifth Classification
B	Fourth Classification	Fifth Classification	Fifth Classification	Fifth Classification	Fifth Classification
B-	Fifth Classification	Fifth Classification	Fifth Classification	Fifth Classification	Fifth Classification
CCC+	Fifth Classification	Fifth Classification	Fifth Classification	Fifth Classification	Fifth Classification
CCC	Certified facility	Certified facility	Certified facility	Certified facility	Certified facility
CCC-	Certified facility	Certified facility	Certified facility	Certified facility	Certified facility
CC	Certified facility	Certified facility	Certified facility	Certified facility	Certified facility
C	Unclassifiable	Unclassifiable	Unclassifiable	Unclassifiable	Unclassifiable
D	Unclassifiable	Unclassifiable	Unclassifiable	Unclassifiable	Unclassifiable

3.2. Classification of Respondents and Firms

3.2.1. Respondents' Classification

Table 4. Demographics of the respondents (N = 24)

Items	Categories	Frequency	Percentage (%)
Gender	Male	19	79.16
	Female	5	20.83
Education levels	Bachelor's degree	20	83.33
	Master's degree	3	12.50
	Doctor's degree	1	4.16
Work experience	0 to 2 years	10	41.66
	2 to 5 years	8	33.33
	5 to 10 years	5	20.83
	Above 10 years	1	4.16
Role in construction project	Project manager	5	20.83
	Site manager	3	12.50
	Site engineer	1	4.16
	Designer	8	33.33
	Architect	6	25.00
	Company manager	1	4.16

This part of the survey was established to classify respondents according to their gender, education levels, work experience, and role in construction projects as shown in Table 4. The gender of respondents was measured to be (79.16%) male and (20.83%) female. The qualifications of respondents were measured to be (83.33%), (12.5%), and (4.16%) for bachelor's degrees, master's degrees, and doctorate degrees. The table also shows that (41.66%) of the respondents have working experience of 0 to 2 years, which is the highest percentage. (33.33%) of the respondents have working experience of approximately 2 to 5 years, while (4.16%) of the respondents have above 10 years of working experience, which is the lowest. Furthermore, it can be observed from the collected data that (20.83%) of the respondents are project managers, (33.33%) are designers, (25.00%) are

architects, and (20.84%) are others. The others included site manager, site engineer, and company manager, which is the lowest percentage among the respondents.

3.2.2. Firms' Classification

A preliminary investigation into the number of engineering consulting and contracting firms in Jeddah was undertaken, and it revealed the existence of 5 classifications as well as the existence of an unclassified category of total number 753 for engineering consulting firms, 29 firms make up Class A, with a percentage 3.85% of total firms, and 802 for contracting firms, 17 firms make up Class A in Figure 1, with a percentage 2.11% of total firms [5].

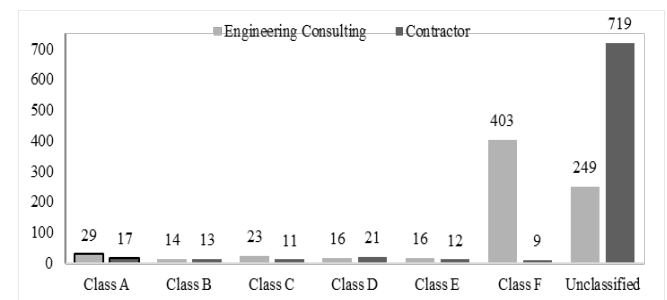


Figure 1. 'Number of Firms' use percentage of BIM application level

The survey team specifically class A engineering consulting and contracting firms effectively utilized the BIM. These firms were invited to participate in a comprehensive survey centered on the BIM. Until the survey closed 46 individuals visited the survey link and only 41 visitors completed answering the survey, while the other 5 visitors failed to answer the questions. So, the paper decides to eliminate uncompleted responses to ensure maximum consistency in the reported results. The survey response rate is 89.13% which is good enough to engage significance.

3.3. Personal and Organizational Information

This section consists of analyzing the general information regarding the features and characteristics of the study sample.

3.3.1. Firm Types

The respondents to this survey relate to the type of organizations shown in Figure 2 'Firm Types' use percentage of BIM application level Among the total of 41 responses, there were 26 (63.4%) respondents from engineering consulting firms, 15 (36.6%) from contracting firms. There were 15 out of 26 (57.69%) from engineering consulting using BIM, and 9 out of 15 (60.0%) from contracting using BIM.

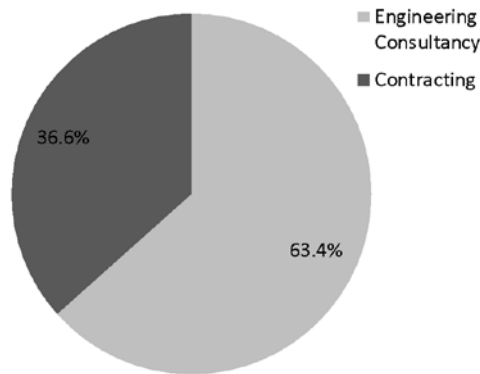


Figure 2. 'Firm Types' use percentage of BIM application level

3.3.2. Experience Firms

In this paper, professionals with many years of professional experience in the area were preferred. Therefore, considering experience: (6.7%) in engineering consulting and (0.0%) in contracting had above 10 years, and (40.0%) in engineering consulting and (44.4%) in contracting had between 0 to 2 years in Figure 3 below.

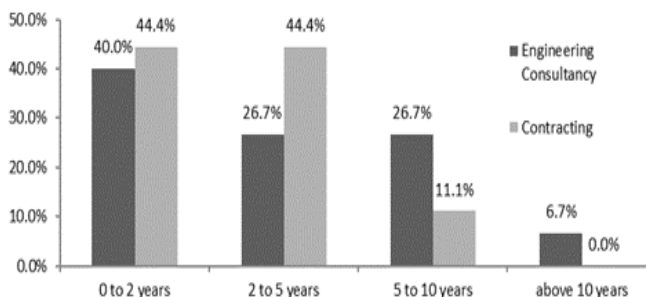


Figure 3. BIM Use Experience' use percentage of BIM application level

3.3.3. BIM Project Proportion

Answers on their number of new projects and the projects among those that used BIM. As shown in Figure 4, among the 41 responses, 24 provided the answers for their BIM project number and their total project number. (46.7%) of engineering consulting firms and (77.8%) of contracting firms claimed that between 0-25% of all their new projects implemented BIM. (33.3%) from engineering consulting firms and (11.1%) from contracting firms that between 25-50% of their projects had utilized BIM. There were 1 (6.7%) respondents who utilized BIM between 75-100% of their new projects. As shown in Figure 4, the BIM utilization of these companies is polarized. The company either uses BIM for most of its projects or uses BIM for a very limited proportion of their new projects.

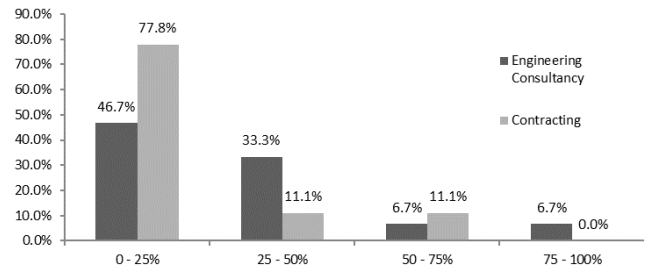


Figure 4. 'BIM project proportion' uses the percentage of BIM application level

3.3.4. Project Sectors

The results of the respondent work sector indicate in Figure 5 that (26.7%) from engineering consulting and (30.8%) from contracting firms work in the public sector only, (26.70%) from engineering consulting firms and (46.20%) from contracting work in the private sector only, and (46.70%) from engineering consulting firms and (23.10%) from contracting work in both (public and private).

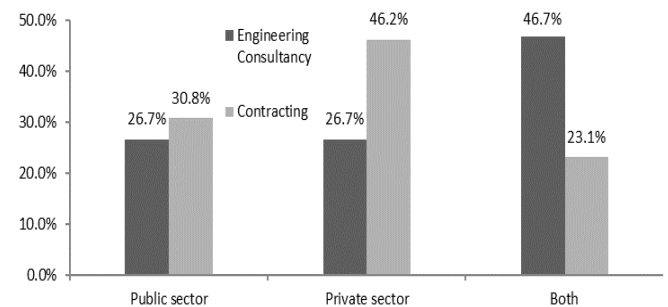


Figure 5. 'Sectors' use percentage of BIM application level

3.3.5. Project Types

The results of Project Types analysis indicate that (22.9%) in engineering consulting and (29.2%) in contracting using Project Types analysis for Commercial, and (5.70%) in engineering consulting and (4.20%) in contracting for Renovation. The results for this question are illustrated in Figure 6 below.

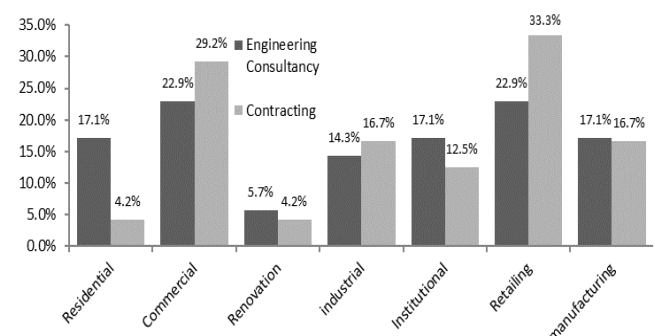


Figure 6. 'Project types' of use percentage of BIM application level

3.4. Implementation of BIM

This section aims to study most BIM solution software used and the difficulties that resist adoption of BIM. 2D drawing software.

3.4.1. 2D Drawing Software

The results of 2D drawing software analysis indicate that (62.5%) in engineering consulting (69.2%) in contracting using 2D drawing software analysis for AutoCAD, (8.30%) in engineering consulting, and (0.00%) in contracting for LibreCAD. The results for this question are illustrated in Figure 7 below.

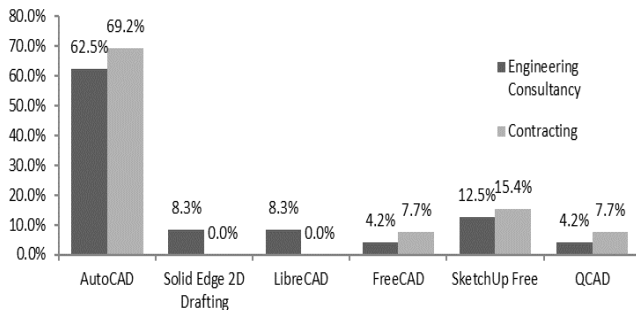


Figure 7. '2D drawing software' uses a percentage of BIM application level

3.4.2. 3D Modeling Tools

The results of 3D Modeling tools analysis indicate that (53.80%) in engineering consulting and (69.20%) in contracting using 3D Modeling tools analysis for Revit – Autodesk, and (3.80%) in engineering consulting and (0.00%) in contracting for Civil 3D Software. The results for this question are illustrated in Figure 8 below.

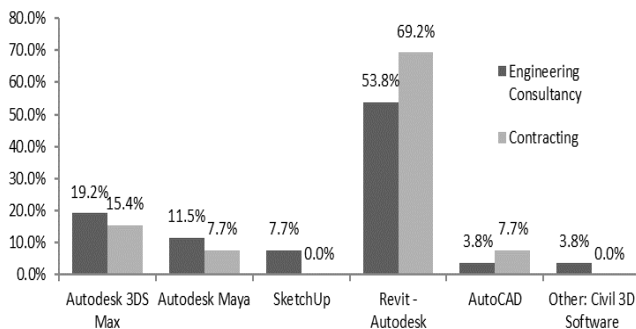


Figure 8. '3D modeling tools' use a percentage of BIM application level

3.4.3. 4D Planning Tools

The results of 4D planning tools analysis indicate that (45.5%) in engineering consulting and (66.7%) in contracting using 4D planning tools analysis for Navisworks, and (9.1%) in engineering consulting and (0.0%) in contracting for Vico Control. The results for this question are illustrated in Figure 9 below.

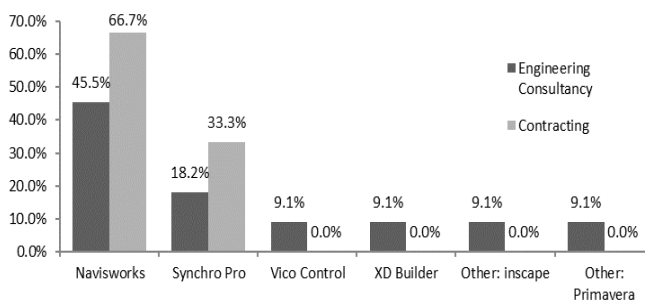


Figure 9. '4D planning tools' use a percentage of BIM application level

3.5. Technical Information about BIM

The focus of this section for the researcher will entail the technical concepts of the 5D, 6D and 7D. Therefore, they were detached from the previous dimensions. Also, the researcher will investigate how to get benefits from this integration in achieving project goals.

3.5.1. BIM-Cost Components (5D)

The results of BIM-Cost components analysis indicate that (26.7%) in engineering consulting and (33.3%) in contracting using Reduced Waste analysis for Reduced waste, and (13.3%) in engineering consulting and (0.0%) in contracting for Design Optimization. The results for this question are illustrated in Figure 10 below.

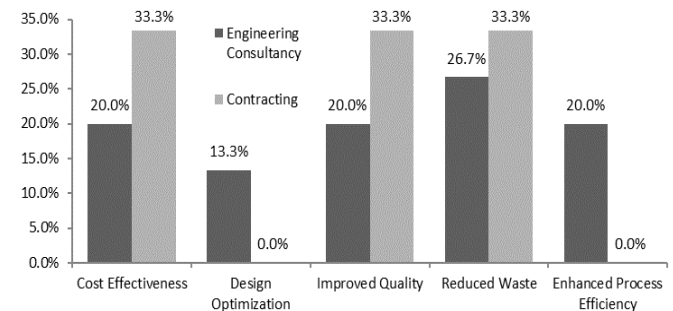


Figure 10. 'BIM-Cost components' use a percentage of BIM application level

3.5.2. BIM-sustainability Functionalities (6D)

The results of the functionality types of BIM-sustainability analysis indicate that (15.0%) in engineering consulting and (25.0%) in contracting using BIM-sustainable functional analysis for site analysis, and (8.0%) in engineering consulting and (0.0%) in contracting for LEED. The results for this question are illustrated in Figure 11 below.

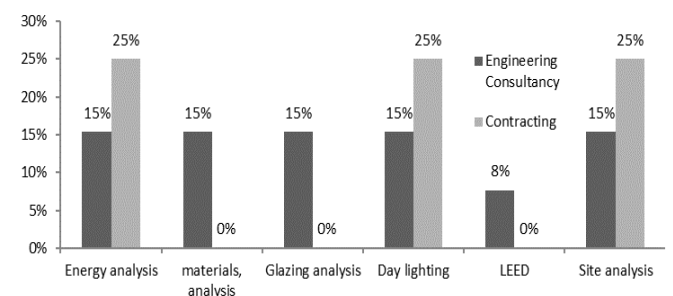


Figure 11. 'BIM-sustainability Functionalities' use percentage of BIM application level

3.5.3. Project Phases That Consider Maintainability (7D)

As shown in Figure 12, there were six effective responses as to whether maintainability was taken into consideration during the design and contracting phases. One (25.0%) of the engineering consulting firm and no one (0.0%) of the contracting firm indicated that they have somewhat considered maintainability in the design phases, whereas one (25.0%) of an engineering consulting firm and one (25.0%) contracting firms have had somewhat considered it in the construction phase, among them there

were two (50.0%) of the engineering consulting firms and 1 (50.0%) of the contracting firm that had considered maintainability in both the contracting and design phases.

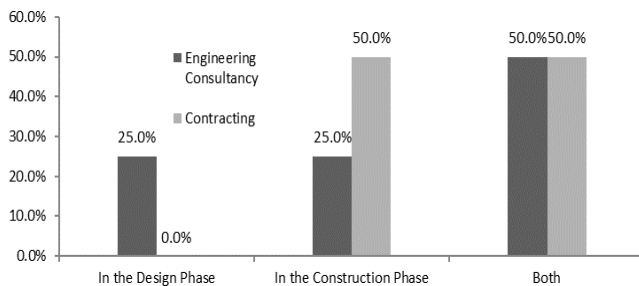


Figure 12. 'Project phases that consider maintainability' use percentage of BIM application level

3.6. Limitation BIM Utilization

As presented in Figure 13. The chosen aspects of this analysis were the most mentioned aspects by responses. The aspects (lack of qualified staff, no experience, we use it, and we'll take it step by step). The results of the analysis of the remaining dimensions indicate that (20.0%) in engineering consulting and (44.4%) in contracting was their answer "We'll take it step by step", and (26.7%) in engineering consulting and (22.2%) in contracting was their answer "No experience". We see that most of the engineering consulting and contracting firms in the city of Jeddah have the option of using BIM.

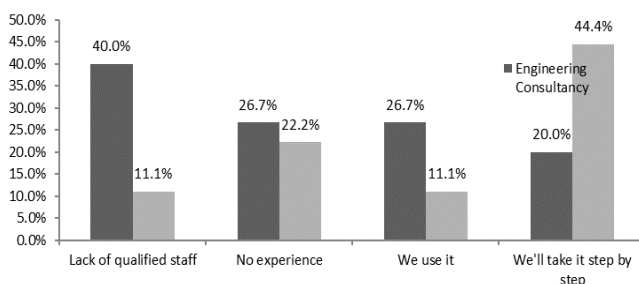


Figure 13. 'Limitation BIM utilization' uses the percentage of BIM application level

4. Discussion

This section examines the obstacles engineering consulting and contracting firms have while implementing BIM and looks at several aspects of the problem. There is a significant gap in the utilization of Building Information Modelling (BIM) between the engineering consulting and contracting markets, with firms being slower to adopt the technology. Several key factors, such as lack of training, cost, and resistance to change, prevent engineering consulting and contracting firms from fully utilizing BIM.

4.1. The Gap in BIM Utilization Between the Architectural and Construction Markets

The researcher identifies the obstacles that prevent engineering consulting and contracting firms from effectively implementing BIM projects. The results of

obstacles of the consultant's analysis indicate that (46.2%) are having obstacles with contractors in Miscommunication, and (15.4%) in cost and budget issues. The results for this question are illustrated in Figure 14 below.

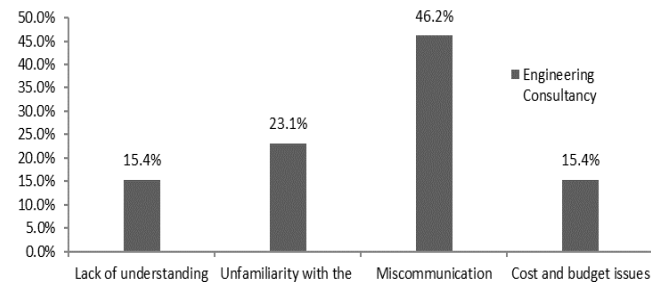


Figure 14. 'Obstacles of engineering consultancy' uses a percentage of BIM application level

The results of obstacles of contractor's analysis indicate that (70.0%) are having obstacles with consultants in miscommunication, and (10.0%) in Data Transfer. The results for this question are illustrated in Figure 15 below.

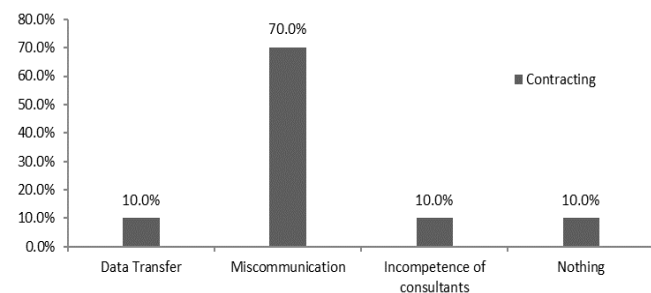


Figure 15. 'Obstacles of contractors' use percentage of BIM application level

4.2. The Key Factors That Prevent Firms from Using BIM

The researcher found that the issue of experience, which accounts for (50.0%) for engineering consulting and (50.0%) for contracting of the reasons why engineering consulting and contracting don't use BIM, is the most important one. The results for this question are illustrated in Figure 16 below.

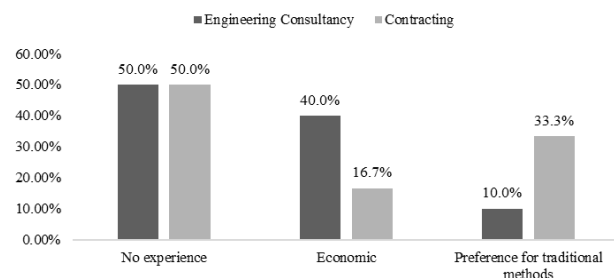


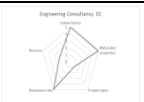
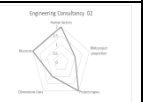
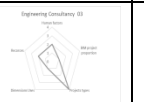
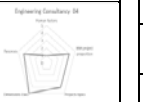
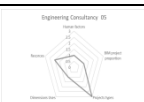
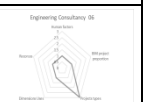
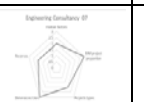
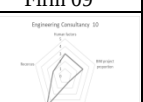
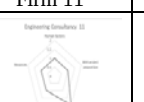
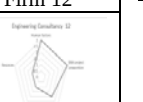
Figure 16. 'Factors that prevent using BIM' use percentage of BIM application level

4.3. Calculate the Standard Weight

The researcher will give a weight for personal qualification of responses out of 5 as shown in Table 1.

The first question describes how engineering consulting firms are rated per the criteria. The evaluation of engineering consulting firms in terms of how efficiently BIM is used in the city of Jeddah is shown in Table 5.

Table 5. Engineering consulting firms' weighted scores in terms of BIM implementation in Jeddah City

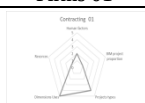
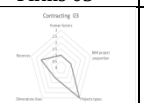
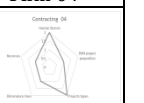
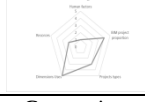
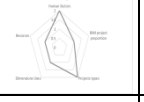
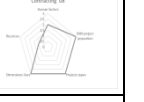
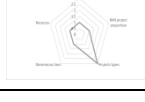
Engineering Consulting Firm 01	Engineering Consulting Firm 02	Engineering Consulting Firm 03	Engineering Consulting Firm 04
			
Engineering Consulting Firm 05	Engineering Consulting Firm 06	Engineering Consulting Firm 07	Engineering Consulting Firm 08
			
Engineering Consulting Firm 09	Engineering Consulting Firm 09	Engineering Consulting Firm 11	Engineering Consulting Firm 12
			
Engineering Consulting Firm 13	Engineering Consulting Firm 14	Engineering Consulting Firm 15	
			

The second question expresses how contracting firms are rated. The evaluation of contracting firms in terms of how efficiently BIM is used in the city of Jeddah is shown in Table 6.

The researcher used the radar chart to show how the BIM average is used in the city of Jeddah, noting that the engineering consulting firms' average is 2.19 out of 5 degrees, while the contracting firm's average is 1.80 out of 5 degrees. Therefore, the conclusion that each of the variances in the assessment criteria were favorable. The final degree of appraisal was bad (2.19) in engineering consulting firms and (1.80) in contracting firms as shown in Figure 17. average of firms ranking in terms of BIM implementation in Jeddah City. This is referring to the need for BIM application on construction projects for

engineering consulting and contracting firms in the city of Jeddah to be improved.

Table 6. Contracting firms' weighted score in terms of BIM implementation in Jeddah City

Contracting Firms 01	Contracting Firms 02	Contracting Firms 03	Contracting Firm 04
			
Contracting Firm 05	Contracting Firm 06	Contracting Firm 07	Contracting Firm 08
			
Contracting Firm 09			
			

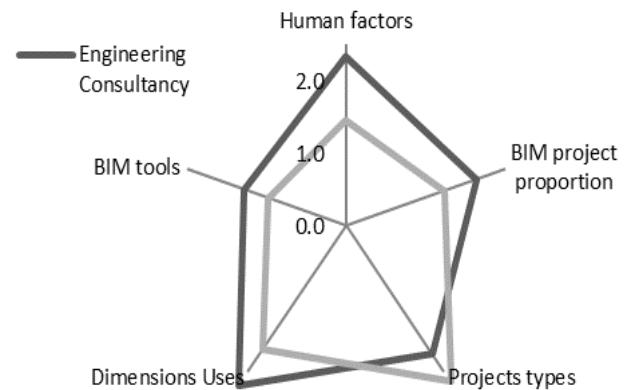


Figure 17. Radar chart for average of firms ranking in terms of BIM implementation in Jeddah City

5. Recommendations

An analysis of the obstacles encountered by engineering consulting and contracting firms led to the development of a framework to guide firms in enhancing the efficient utilization of BIM in these sectors within the city of Jeddah. The details of this plan are presented in Table 7.

Table 7. The framework for engineering consulting and contracting firms

Criteria	Engineering Consulting Firms	Contracting Firms
Human factors	BIM Training: Train team in BIM to improve skills and keep up with software developments. Collaborate with Experts: Partner with experienced firms to learn BIM best practices and enhance workflows.	BIM Education: Educate team on BIM to stay updated and improve construction processes. Learn from Experts: Collaborate with experienced firms to optimize workflows with contracting and gain valuable insights for projects.
BIM project proportion	Standardize BIM: Establish consistent workflows to improve efficiency and reduce errors/conflicts in design. Partner with Experts: Collaborate with BIM consultants to identify improvement opportunities and implement best practices for optimized workflows.	Standardize BIM: Establish standardized processes to enhance efficiency and minimize errors/conflicts in contracting. Partner with Experts: Collaborate with BIM experts to identify areas for improvement and implement best practices for optimized contracting workflows.
Project types	Employee Training: Invest in training to enhance diversity and skills of employees. Collaborate with Diverse Clients: Engage with clients from diverse industries and geographies for varied perspectives in projects.	Employee Training: Invest in training to promote diversity and enhance employee expertise in the construction site. Collaborate with Diverse Clients: Partner with clients from different backgrounds to bring diverse perspectives and approaches to implementation projects.

Criteria	Engineering Consulting Firms	Contracting Firms
Dimensions Uses	BIM Software Training: Train staff in latest BIM software for enhanced multidimensional work. Stay Updated: Encourage engineering consulting firms using BIM to keep up with software releases for maximum project benefits.	BIM Software Training: Provide staff with training in the latest BIM software for multidimensional contracting work. Stay Updated: Encourage contracting firms using BIM to stay current with software releases to optimize project outcomes.
BIM tools	Employee Training: Train in BIM and software for improved skills to design projects Stay Updated: revision with latest software releases for BIM use optimization	Employee Training: Train in BIM and software for enhanced expertise for construction projects. Stay Updated: Stay current with software releases for optimal BIM utilization to help in contracting.

Table 8 provides detailed information and recommendations of this framework. It presents practical advice and concrete measures that government entities in Jeddah City can implement to improve the adoption of BIM, increase operational efficiency, and achieve successful projects in collaboration with Secretariats and municipalities.

Table 8. The framework for government sectors

Criteria	Government sectors
Human factors	Invest in BIM training and education for staff to manage infrastructure assets more effectively. Collaborate with more experienced firms to gain insights into BIM best practices and improve procurement and contracting processes.
BIM project proportion	Standardize BIM workflows and processes to improve efficiency and reduce errors/conflicts in infrastructure asset management. Partner with BIM experts or consultants to identify opportunities for improvement and implement best practices for optimized BIM workflows and processes in infrastructure management.
Project types	Invest in employee training to improve diversity in infrastructure asset management and increase the skills and expertise of staff. Collaborate with diverse stakeholders from various industries and geographies to gain insights into different perspectives and approaches to increase diversity in infrastructure projects.
Dimensions Uses	Provide staff with training in the latest BIM software to improve skills and expertise in infrastructure asset management. Invest in updated BIM software that supports multi-dimensional modeling and visualization to accommodate more dimensions in infrastructure projects.
BIM tools	Implement comprehensive training to enhance government employees' BIM and software skills for project design, covering principles, techniques, and practical application. Establish a process to regularly review and adopt the latest BIM software updates, including new features and optimization techniques. This ensures employees stay updated and optimize BIM utilization, leading to improved project design outcomes.

6. Conclusions

This paper surveyed Jeddah, Saudi Arabia to explore the usage of BIM in engineering consulting and contracting firms. The study objectives were achieved by (1) clarifying the usage effectiveness of BIM in class A engineering consulting and contracting firms, (2) measuring the effectiveness and key factors that hinder engineering consulting and contracting firms from using BIM effectively, and (3) developing a framework to ensure the effective use of BIM in engineering consulting and contracting firms. The main aim is to investigate the

usage effectiveness of BIM in engineering consulting and contracting firms in Jeddah, raise awareness about BIM and improve professional practices in this field for competitive advantage. For this paper, a survey characterized by specific questions was chosen as the data collection instrument and the interviews were carried out in person. The survey results indicated that the final degree among firms was bad, primarily due to a lack of awareness among clients, insufficient proficiency in BIM, and the absence of a comprehensive BIM implementation plan and framework. The authors suggested a BIM framework to enhance the efficient use of BIM by engineering consulting and contracting firms. The future work includes implementing the proposed framework, evaluating its effectiveness, and identifying areas for improvement. The study aims to enhance education, research, and professional practice in Jeddah City.

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