THE BARRIERS AND STRATEGIES OF IMPLEMENTING BIM IN SAUDI ARABIA

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ABSTRACT

Fundamentally a technology-driven concept, Building Information Modelling (BIM) fosters a more reliable and timely exchange of information among project stakeholders about all the different phases of a construction project. It has the potential to significantly impact the Saudi construction industry by dealing with issues pertaining to estimating, scheduling and design coordination. The advantages of implementing BIM include the visual coordination of the building systems such as Mechanical, Electrical, and Plumbing systems and it also identifies the possible conflicts between these. By detecting the conflicts, problems can be resolved before actual construction which in turn saves project time and cost. This article presents the preliminary results of an ongoing research. One of the objectives of this research is studying the barriers of BIM adoption and strategies for its greater implementation in Saudi Arabia. Primary data was collected by means of a questionnaire survey, where 342 people in total were approached to complete the questionnaire. Data was collected in full from 224 persons in Saudi Arabia signifying the response rate of 65%. The data was analysed by means of descriptive statistics. The results show that, the adoption of BIM has seen a slow but gradual upward trend within Saudi Arabia in recent years. However, the lack of knowledge of the BIM adoption process, lack of support from managers to accept changing current practices, and lack of practical standards and guidelines as well as the lack of attention by policy makers and the government were identified as some of the barriers to the adoption of BIM in Saudi Arabia. Nevertheless, a majority of the respondents are convinced that BIM delivers the benefits of savings in time and significant improvement in the final quality of buildings. The strategies suggested for implementing BIM fully in Saudi Arabia include an enabling legislation and a supportive regulatory environment, financial assistance by the government, more education for the actors involved and benchmarking against other countries.

Keywords: adoption, barriers, Building Information Modelling (BIM), questionnaire survey, Saudi Arabia, strategies.

1 INTRODUCTION

The Kingdom of Saudi Arabia has one of the largest and rapidly growing construction sectors in the Middle East region. Saudi Arabia's construction efforts are fuelled by current domestic need, to cater for the needs of a very young and rapidly growing population [1]. The revenues from oil has brought remarkable financial support to the Saudi Construction Industry [2], hence the financial flow and the size of the projects are comparable to the currently prevailing situation [3]. According to Al-Arabiya news the construction industry in Saudi Arabia is expected to go through a period of accelerated growth during the next 10–15 years, with a value of projects estimated at exceeding one trillion US dollars. With over $629 hundred billion already invested in energy, infrastructure, transportation, education, healthcare, and other very important economic sectors still remain, making the Kingdom a leading investment destination for construction work [4].

Nevertheless, the construction industry of Saudi Arabia is characterised by inefficiency, which stems from the lengthy process that spans the design stage to tendering, and finally, construction due to a range of factors such as increasing demands from construction clients and the use of conventional methods in construction engineering. In addition, it has been stated that most of the local Saudi construction companies have a lack of knowledge, management and experience in the project lifecycle [2], [5], which makes it difficult for them

to compete with the technologically more advanced international companies. Such inefficiency causes delays and time overruns as well as increasing construction project costs.

Fundamentally a technology driven concept, Building Information Modelling (BIM) aids to develop a virtual model or construction process of a building prior to its actual physical construction, for the purpose of minimizing uncertainty, improving safety, identifying collisions, and simulating and analysing potential environmental impacts. Traditional building design was largely reliant on 2D CAD drawings (plans, elevations, sections, etc.). BIM initiatively extends this to 3D (width, height and depth) and more, e.g. a fourth dimension of time and a fifth of cost [6]. BIM has the potential to promote greater efficiency as it encourages the integration of the roles of all project stakeholders and business structures and practices into a collaborative process that enables the reduction of waste and optimisation of efficiency through all phases of the construction project life cycle. The BIM model is also used for the maintenance and facility management of the building after completion [7].

Moving away from the traditional 2D CAD program and the paper-based practices to BIM and the method of sharing a 3D environmental design has huge benefits. However, this will inevitably lead to significant changes on how construction projects will be undertaken and how the different professionals working on the project will be involved as there could be some barriers that may affect the implementation within the construction industry. Consequently, in light of the above this research is investigating why such a useful tool is not widely used in the Kingdom of Saudi Arabia, the barriers to this and the different strategies which can be implemented for the greater adoption of BIM. This article reports some of the findings of this research. The next section provides a literature review and is followed by the methodology employed in the research. The findings are then presented and discussed before the paper is concluded.

2 LITERATURE REVIEW

BIM is defined as the digital representation of the physical and functional characteristics of a construction project, which serves as a shared knowledge resource for information about a project forming a reliable basis for decisions during its life-cycle from inception onward [8]. In today's construction environment, investing on modern technologies is the prerequisite to improve competitiveness and economic status. Accordingly, BIM has recently been widely adopted within the global construction industry and it is a new term which has helped in reducing issues during the design process, operation and management of construction projects, increasing the performance of projects and the productivity of a team [9], as well as enhancing quality [10].

In fact, BIM is not just a tool or a solution [11], but rather value-creating collaboration, underpinned by 3D models and intelligent structured data [12]. An integrated digital model contains all the information about project, which is built by project participants and supports the interchange of data among them [13]. Even though BIM promise to generate benefits and overcome problems in the design, construction, and management of buildings, the barriers to its adoption specific to Saudi Arabia cannot be neglected. These can be typified in four categories [14]: *Legal problems* include the undefined responsibilities of data content in the models and the legal status of these models compared to other documents [15], [16], *Business problems* (concerned with the allocations of roles, responsibilities, and rewards, cost of implementation (software and training) lack of senior management support), *Human problems* (related to fear of changes to working culture and resistance to alterations in roles, ICT literacy), and *Technical problems* (related to the lack of training and project planning, the immaturity of software, particularly in terms of data exchange and interoperability) [15], [16].

In the last decade, there has been a significant growth within the Saudi Arabian construction sector which appears to be the second economic boom [3]. To a large extent, this growth is triggered by a number of mega-projects started by Saudi Government within housing, infrastructure, transportation and utilities sector, with project value exceeding one trillion US dollars. The Saudi construction industry has witnessed construction contract awards by the government to the tune of US$ 80,148 Million in 2011, which was expected to increase to US$82,541 Million by 2012 and US$86,098 Million in 2013 [17].

Nevertheless, the construction industry of Saudi Arabia is not progressing well in implementing effective management and achieving good organisational performance. This was clearly demonstrated by the number of projects suffering delay, which increased from 700 projects in 2009 to 3000 projects in 2013 [18]. The reasons for incomplete projects were the large number of projects being put on hold, with errors in the project design, and ineffective supervision of all the parties in the projects [18]. One main reason can be attributed to the lack of planning and design, and this lack of planning is caused by the weakness of the project team member's involvement in the project processes [19].

According to Falqi [20], the Saudi construction industry suffers from poor performance and faces some difficult challenges that have a negative impact on the performance of construction projects. Such as a study conducted recently by Alshehri [21] revealed that disputes concerning construction contracts, procurement and design change orders are considered to be one of the key causes of project conflict in architectural projects in Saudi Arabia. Abdul-Hadi et al. [22] had earlier identified these inefficiencies of the Saudi construction industry as a cause for concern and called for the Saudi construction industry to re-engineer itself to achieve simpler coordination and integration.

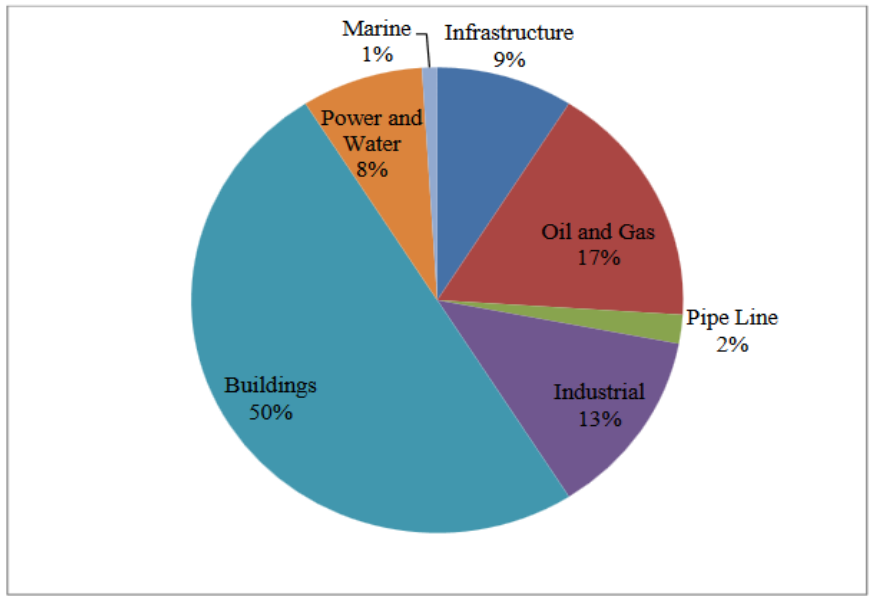

Figure 1: Saudi construction industry budget by sector (US$ million).

Since BIM simulates the construction project in a virtual environment. It can be viewed as a virtual process that involves all aspects, disciplines, and systems of a facility within a single, virtual model, allowing all design team members to collaborate more effectively than using traditional processes [23]. Due to the powerful data-based modelling, visualization, analysis and simulation capabilities of BIM, it has the potential to significantly impact the Saudi construction industry by dealing with issues pertaining to estimating, scheduling and design coordination. The advantages of implementing BIM is the visual coordination of the building systems such as Mechanical, Electrical, and Plumbing systems and it also identifies the possible conflicts between these [24]. By detecting the conflicts, problems can be resolved before actual construction which in turn saves project time and cost [25], [26]. The benefits of adopting BIM has encouraged many developed countries such as (UK, USA, Singapore, Norway, Denmark, Finland, Hong Kong, South Korea, Netherlands) to make or in process of making use of BIM mandatory as part of public procurement process [27]. Yet, in terms of level of technological advancement the construction industry of Saudi Arabia has lagged behind in BIM adoption and implementation owing to the numerous barriers it is faced with.

As a result, the reluctance of a large part of the industry in adopting innovative ideas such as BIM, hinders the progress of the construction industry in Saudi Arabia. Benefits accrued from adopting BIM could be translated into gains in many spheres, such as economy but they are often not well understood or accepted within the Saudi Arabian construction industry. Hence it is imperative that appropriate strategies are put in place to develop the capacity of Saudi construction workforce with regards to BIM.

3 RESEARCH METHODOLOGY

As BIM is still an emerging technology as far as the Saudi Arabian construction industry is concerned, not many construction organizations have undertaken this technology due to the many barriers they face in the adoption of BIM [28]. For this reason, the effort was made to find out the barriers and the strategies for BIM adoption in the Saudi Arabian construction industry amongst construction professionals such as Contractors, Builders, Site Engineers, Design Engineers and Project Managers; by conducting a questionnaire survey for which questions were drafted covering major aspects of the barriers and the strategies for BIM adoption.

The questionnaire survey was posted on the Internet using a web based platform. Construction professionals in Saudi Arabia were then asked to complete the on-line survey. In addition to this the questionnaire survey was also distributed personally by hand to the live construction projects where site visits were reachable and accessible. Thus, a number of the completed surveys were returned back by post. A total of 342 people were approached for data and 224 fully completed questionnaires were obtained, representing a response rate of 65%. This is a strong response rate for the target audience and is statistically significant. A five-point Likert scale was mostly used in the questionnaire, as advocated by Wong et al., [29]. EXCEL was used to collate the data collected while SPSS was used to conduct the descriptive statistics analysis.

4 DATA ANALYSIS AND DISCUSSION

Nine questions were asked from the respondents to quantify the barriers to BIM adoption in the Construction Industry of Saudi Arabia. The responses to the questions were measured on a five-point Likert scale as follows – strongly disagree, disagree, neutral, agree and strongly agree. The responses were obtained and the percentages of sample obtained are shown in Table 1 below.

Table 1: Response percentages regarding the barriers to BIM adoption in the Saudi Arabian construction industry.

	Strongly disagree	*Disagree*	*Neutral*	*Agree*	*Strongly agree*
BIM is not required by clients. Clients do not request the use of BIM software in developing architectural and engineering designs and analysis.	3%	15%	20%	40%	22%
There is no (legal) practice guide to support the use of BIM in Saudi Arabia. No legal backing as to who owns the model and how the model will be exchanged among the team member.	1%	3%	30%	47%	20%
BIM is not required by team members such as architects and engineers. Team members do not request the use of BIM to develop a project design model or to extract information.	4%	16%	26%	44%	10%
BIM software are too expensive. Software prices are too high to the extent that only mega firms can afford their user license.	3%	11%	30%	35%	21%
BIM is difficult to learn. It takes time to learn all the tools in BIM and it is difficult to understand its functions.	6%	28%	24%	35%	8%
The non-availability of a parametric library hinders the uptake of BIM. Parametric object library that will enhance easier development of models using local building standard codes is not available in Saudi Arabia.	3%	8%	27%	48%	14%
It takes a longer time to develop a BIM model. More time is spent in developing a BIM model compared with just using 2D CAD.	4%	15%	34%	38%	8%
There is a lack of competent staff in Saudi Arabia to operate the BIM software. Majority of the available personnel are not conversant with BIM, and those who are competent, are not easy to reach and are very expensive to hire or employ.	1%	6%	16%	49%	28%
BIM does not add much value to our organization. BIM is not believed to add value to the work done by our organization.	23%	39%	21%	14%	3%

Nevertheless, breaking down the analysis down further into the sub-categories of strongly disagree and disagree' to establish the links between questions for the barriers to BIM adoption in Saudi Arabia as corresponding to the comprehensive literature review conducted as part of this on-going research. The respondents who selected the strongly disagree and disagree categories are not in high percentage but nevertheless for the purpose of this research it is important to ascertain who they are.

The respondents who selected strongly disagree and disagree for BIM is not required by clients have a Bachelor degree as their highest form of education qualification, along with work experience ranging between 1 and 20 years. Most of the respondents who selected strongly disagree and disagree are working as consultants and contractors whilst engineers are the highest number of respondents who selected strongly disagree. For disagree the highest number of respondents are engineers and project managers respectively with experience of working on small, medium and mega projects in both public and private sectors. All the respondents who selected strongly disagree have not attended any training sessions and from the respondents who selected disagree only one respondent had attended any training sessions also they have not developed any project using BIM within their organizations. The fact that the majority of these respondents are consultants, contractors, project managers and engineers who have hardly attended any BIM training sessions nor have developed any projects using BIM. Thus, here it can be concluded that low BIM training is a barrier to BIM adoption in Saudi Arabia.

Subsequently the respondents who selected strongly disagree and disagree for There is no (legal) practice guide to support the use of BIM in Saudi Arabia have a Master's degree as their highest form of education qualification, along with work experience ranging between 1 and 5 years. Most of the respondents who selected strongly disagree and disagree are working as consultants and contractors. Whilst engineers are the highest number of respondents who selected disagree. All respondents have experience of working on small, and medium projects only in both public and private sectors. All the respondents who selected disagree have not attended any training sessions apart from only two respondents had attended any training sessions also half of the respondents have developed between 1 and 5 projects using BIM within their organizations. Here it can be observed that the lack of governmental legislation, rules and regulation hinder the adoption of BIM as there is no point of legal reference to abide by. Thus, here it can be concluded that no low BIM training as well as no BIM legislation is a barrier to BIM adoption.

Furthermore, the respondents who selected strongly disagree and disagree for BIM software are too expensive are educated to university level. The respondents who selected strongly disagree have a Master's degree, whereas the respondents who selected disagree have a Bachelor degree as their highest form of education qualification. All respondents have wide ranging work experience between 1 and 10 years. Most of the respondents who selected strongly disagree and disagree are working as contractors and consultants respectively. Whilst engineers are the highest number of respondents who selected strongly disagree. For disagree the highest number of respondents are project managers and architects. The respondents who selected strongly disagree have worked mainly in the public sector only. Whereas the respondents who selected disagree have worked in both public and private sectors. All respondents have experience of working on mega projects. None of the respondents had attended any BIM training sessions however the respondents who selected strongly disagree have developed between 1 and 5 projects using BIM within their organization. From the respondents who selected disagree none had developed any project using BIM within their organizations. The fact that the majority of these respondents are consultant, contractors, project managers, engineers and architects who have not attended any BIM training sessions or have developed minimal projects using BIM. Thus, here it can be concluded that low BIM training and knowledge is a barrier to BIM adoption.

Successively the respondents who selected strongly disagree and disagree for the non-availability of a parametric library hinders the uptake of BIM have a Bachelor degree as their highest form of education qualification. All respondents have wide ranging work experience of between 1 and 10 years. Most of the respondents who selected strongly

disagree are working as contractors and consultants. Whereas the respondents who selected disagree are working as consultants. Whilst engineers are the highest number of respondents who selected both strongly disagree and disagree. The respondents have experience of working on small, medium and mega projects in both public and private sectors. None of the respondents had attended any BIM training sessions. However, the respondents who selected strongly disagree have developed no projects using BIM, whilst the respondents who selected disagree developed between 1 and 5 projects using BIM within their organizations. The fact that the majority of these respondents are contractors, consultants and engineers who have not attended any BIM training sessions or have developed minimal projects using BIM. Thus, here it can be concluded that low BIM training and knowledge as well as poor implementation is a barrier to BIM adoption.

Yet again the respondents who selected strongly disagree and disagree for There is a lack of competent staff in Saudi Arabia to operate the BIM software all have a Bachelor degree as their highest form of education qualification. All the respondents have wide ranging work experience between 1 and 15 years. Most of the respondents who selected strongly disagree and disagree are working as consultants. Whilst engineers are the highest number of respondents who selected strongly disagree and disagree. The respondents have experience of working on mega projects in both public and private sectors. None of the respondents had attended any BIM training sessions nor have they developed any projects using BIM within their organization. The fact that the majority of these respondents are consultants and engineers who have not attended any BIM training sessions nor have developed any projects using BIM. Thus, here it can be concluded that low BIM training and knowledge is a barrier to BIM adoption.

Here the respondents who have drawn attention to several barriers being faced by the construction organizations of Saudi Arabia in adopting BIM such as: there is not enough demand from clients, lack of BIM training, lack of governmental legislation, interoperability and functionality issues due to poor implementation, the lack of BIM users within the Saudi construction industry, cost of hardware and software, and lack of BIM expertise. Undeniably, these issues could have a negative impact on the implementation of BIM adoption [30] within the Saudi construction industry.

The assessments of the respondents were not unanimous, as some fewer respondents rated constructs in the neutral, ‘disagree’ and strongly disagree categories. In this regard, it can be observed that the respondents who rated strongly disagree and disagree are not homogenous; their construction backgrounds including level of education and work experience in the construction industry of Saudi Arabia is wide ranging. However, the majority of these respondents have either not attended any BIM training sessions or have only attended a few training sessions. Also, the majority of them have not developed any projects using BIM. The few respondents who have developed projects using BIM have done so on only between 1 and 5 projects. This may suggest that they still have a lot to learn or that they have been working with traditional methods for so long that they need to professionally develop themselves to bring them up to date with innovative new working methods in the construction industry of Saudi Arabia. There is also some ratio of respondents who were neutral, maybe because they were not familiar with the BIM or they do not know the advantages or disadvantages of BIM.

Henceforth another ten questions were asked from the respondents in order to evaluate the implementation strategies for BIM adoption in the Construction Industry of Saudi Arabia. The responses were obtained and the percentages of sample obtained are shown in Table 2.

Table 2: Strategies to implement BIM in the Saudi Arabian construction industry.

	Strongly disagree	*Disagree*	*Neutral*	*Agree*	*Strongly agree*
The importance of BIM should be further promoted with construction clients in KSA. Service providers should embark on mass organization of workshops, seminars and symposia on BIM.	1%	2%	13%	41%	43%
The use of BIM should be regulated. The Saudi Government should introduce a policy that will encourage, and subsequently oblige, construction organizations and professionals to use BIM for all designs.	2%	3%	10%	44%	42%
The training of construction staff on using BIM is needed now. In house training and short courses regarding BIM should be encouraged by all Saudi construction organizations.	0%	2%	10%	44%	44%
BIM should be introduced in the curricula of Saudi Arabian universities. Compulsory teaching of BIM in both Undergraduate and Postgraduate courses of Architecture and Construction Management.	0%	3%	9%	42%	47%
More efforts are needed to make BIM inter-operable. Development of local parametric library embedded in a national BIM server.	0%	2%	7%	53%	38%
Adopting BIM will give Saudi construction organizations an added value.	0%	0%	10%	45%	45%
The changes needed by Saudi organizations in order to adopt BIM are too problematic.	1%	8%	41%	31%	18%
The Saudi Government specifically and actively provides support to encourage the adoption of BIM by construction organizations.	2%	6%	19%	46%	26%
The Saudi Government specifically provides financial subsidy to promote the adoption of BIM by construction organizations.	3%	7%	20%	47%	23%
A law is needed to compel practitioners to use BIM.	4%	7%	23%	36%	30%

According to the analysed survey data for implementation strategies for BIM adoption in Saudi Arabia it was found that the respondents who selected strongly disagree and disagree with the strategy. The importance of BIM should be further promoted with construction clients in KSA have a Master's degree as their highest form of education qualification. The respondents have work experience ranging between 1 and 5 years. Most of the respondents are working as consultants. Whilst planning team members are the highest number of respondents who selected strongly disagree and disagree. Having experience of working on small and medium projects having worked in the public and private sectors respectively. The respondents had attended between 1 and 2 BIM training sessions amongst them and have developed between 1 and 5 projects using BIM within their organization. The fact that the majority of these respondents are consultants and planning team members, who have attended very few BIM training sessions and have only developed a few projects using BIM. Thus, here again it can be concluded that low BIM training is equal to low knowledge of strategies to BIM adoption.

Following on the respondents who selected strongly disagree and disagree for the strategy. The use of BIM should be regulated have quite diverse backgrounds. The respondents who selected strongly disagree have Bachelors, Master's and PhD degrees respectively. Whereas the respondents who selected disagree only have a college education as their highest form of education qualification. All respondents have wide ranging work experience of between 1 and 25 years. All of the respondents who selected strongly disagree and disagree are working as consultants. Whilst architects, directors and engineers are the highest number of respondents who selected strongly disagree. For disagree the highest number of respondents are planning team members. The respondents have experience of working on small, medium and large projects having worked in both public and private sectors. None of the respondents who strongly disagree had attended any BIM training sessions however the respondents who selected disagree had attended between 0 and 4 BIM training sessions amongst them respectively. The respondents who selected strongly disagree have developed between 1 and 5 projects using BIM within their organization. From the respondents who selected disagree none had developed any project using BIM within their organizations. The fact that the majority of these respondents are consultants architects, directors, engineers and planning team members, who have attended very few BIM training sessions and have developed only a small number of projects using BIM. Thus, here again it can be concluded that low BIM training is equal to low knowledge of strategies to BIM adoption.

Subsequently the respondents who selected strongly disagree for the training of construction staff on using BIM is needed now, the respondents have a Master's degree as their highest form of education qualification. The respondents have work experience ranging between 1 and 5 years. Most of the respondents are working as consultants. Whilst planning team members, project manager, engineer and lecturer are the highest number of respondents who selected strongly disagree. The respondents have worked in the public sector having experience of working on small, medium and large projects. The respondents had attended between 0 and 4 BIM training sessions amongst them and have developed between 1 and 5 projects using BIM within their organization. The fact that the majority of these respondents are planning team members, project manager, engineer and lecturers who have attended very few BIM training sessions and have only developed a few projects using BIM. Thus, here again it can be concluded that low BIM training is equal to low knowledge of strategies to BIM adoption.

Successively the respondents who selected disagree for More efforts are needed to make BIM inter-operable, have a bachelor's degree as their highest form of education qualification. They have vast range of work experience of between 1 and 25 years. The respondents are

working as contractors, consultants and client representatives. Whilst directors, civil engineer and engineer are the highest number of respondents who selected disagree. The respondents have worked in both the public and private sectors having experience of working on mega projects. The respondents have not attended any BIM training sessions but have developed between 0 and 20 projects amongst them using BIM within their organization. The fact that the majority of these respondents are consultants, client representatives, directors, civil engineer and engineer who have attended very few BIM training sessions and have developed several projects using BIM. Thus, here again it can be concluded that low BIM training is equal to low knowledge of strategies to BIM adoption.

Lastly the respondents who selected A law is needed to compel practitioners to use BIM, are educated to university level. The respondents who selected strongly disagree have a Master's degree, whereas the respondents who selected disagree have a Bachelor degree as their highest form of education qualification. All respondents have wide ranging work experience between 6 and 15 years. All of the respondents are working as consultants. Whilst engineers are the highest number of respondents who selected strongly disagree and disagree. Whereas all the respondents have worked in both public and private sectors. All respondents have experience of working on small, medium and large projects. None of the respondents had attended any BIM training sessions however the respondents who selected strongly disagree have developed between 1 and 5 projects using BIM within their organization. From the respondents who selected disagree none had developed any project using BIM within their organizations. The fact that the majority of these respondents are consultant and engineers who have not attended any BIM training sessions or have developed minimal projects using BIM. Thus, here again it can be concluded that low BIM training is equal to low knowledge of strategies to BIM adoption.

As a result, these finding shows that a knowledge-gap along with a lack of BIM expertise's exists regarding the awareness of strategies for BIM adoption amongst professional such as consultant, project managers, and engineers, planning team members and even directors within the construction industry of the Kingdom of Saudi Arabia. Consequently, the findings of this research shown here in the form of the above tables demonstrate that the majority of respondents comprehend the barriers against the adoption of BIM by construction organizations in the Kingdom of Saudi Arabia. The respondents also acknowledge that the suggested BIM adoption strategies are useful and beneficial as very few respondents of the survey find them impractical and ineffective.

5 CONCLUSION

From the analysis of survey data, it was found that the respondents consider factors such as the lack of BIM training, lack of governmental legislation, interoperability and functionality issues due to poor implementation, cost of software, the lack of demand and lack of BIM expertise within the Saudi construction industry to be barriers being faced in adopting BIM. This can be attributed to the fact that several survey respondents have few or no training regarding BIM as they have not updated themselves with any professional development regarding BIM nor have they attended any BIM training sessions or developed any projects using BIM. This low BIM training finding shows that a knowledge-gap exists regarding BIM adoption within the construction industry of the Kingdom of Saudi Arabia.

BIM is one of the most visible aspects of a deep and fundamental change that is rapidly transforming the global construction industry. It is the platform that brings about collaboration between project stakeholders and improvement of project outcomes. The growing worldwide adoption and implementation of BIM for its powerful data-based

modelling, visualization, analysis and simulation capabilities represents a paradigm shift to an integrated digital information infrastructure that will ultimately revolutionize almost all aspects of the construction industry.

The research being carried out has so far shown that the successful implementation of BIM in Saudi Arabia requires a top–down strategy that facilitates the smooth flow of information. As the main challenges of adopting and implementing BIM include costs and training, it demands appropriate planning, patience and the full commitment of all stakeholders to embrace the prerequisite culture of open collaboration and trust at all levels of operation. The successful implementation of BIM for construction in Saudi Arabia will call for an abandonment of previous methodologies characterised by the physical movement of paper-based designs and written communication from government officials to more electronic communication via a standard platform.

Time constraints are a major consideration in the implementation phase of projects as all actions should be executed within the limits of contract lest additional costs are incurred. This phase also encompasses changes in personnel. The transition to using BIM in projects depicts a major move away from CAD workflow platforms which requires the reorganisation of employees and changes in their roles. Critical to the successful implementation of BIM is the training of staff. This is in light of the new concepts introduced by BIM in comparison to a conventional CAD workflow. The training entails preparing the users with knowledge and capacity to facilitate smooth information flow to and from the BIM database. Moreover, according to Becerik-Gerber and Rice [31], training employees is a critical issue for successfully implementing BIM.

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