

**An integrated framework of advanced technological  
solutions for better construction project delivery in UAE**

الإطار المتكامل للحلول التكنولوجية المتطورة لتحسين منظومة تسليم المشاريع  
الإنشائية في دولة الإمارات العربية المتحدة

by  
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of the requirements for the degree of  
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## Abstract

For years the construction sector has been keen to enhance its productivity and efficiency, besides many initiatives been proposed. The confusion lies on the selection of an appropriate innovation for better construction project delivery. Presently, a number of advanced construction tools, innovations, and methods are available that could be used to improve construction project delivery. Hence, this study aimed to examine how advanced technological tools and methods can be used to reduce the number of construction project delivery errors in United Arab Emirates (UAE) and propose an integrated framework that will comprise of advanced technological solutions for better delivery of construction projects in UAE.

As highlighted in this study, the proposed framework can be used by UAE practitioners to overcome current project delivery challenges. It is worth noting that low productivity and delay in UAE construction projects have been observed as main challenges. The factors that influences the construction project delivery were identified in the literature and a conceptual framework proposed. The conceptual framework comprises of key technologies, innovations, tools, methods, and materials that could positively impact the construction project delivery and to address the current challenges of UAE's construction projects.

The data was collected through quantitative research method. Professional construction practitioners in UAE were the participants of this study. The findings of the study suggest that there is a need for the integration of construction technologies in the UAE sector. Advanced technological solutions were used to formulate the proposed integrated framework, that could be used to enhance project delivery in UAE. The findings of the study further suggest that the framework could be used to by construction practitioners to address technological project delivery challenges in UAE.

**Keywords:** *Construction Technologies, Project delivery, Advanced construction technologies, Productivity, Project management, United Arab Emirates.*

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## الخلاصة

لطالما كان قطاع الانشاءات تواقا لسنوات من أجل تحسين الانتاجية والفاعلية من خلال مبادرات عديدة. يكمن الجدل في اختيار الأساليب الابتكارية الأنسب لتحسين منظومة تسليم المشاريع الإنشائية. حالياً تتوفر هنالك عدد من الابتكارات والأدوات المتطورة والطرق والأساليب والتي يمكن استخدامها لتطوير وتحسين آلية تسليم المشاريع الإنشائية. لذا، تهدف هذه الدراسة إلى فحص إمكانية استخدام هذه الطرق والأدوات لتقليل المشاكل والأخطاء الحادثة عند تسليم المشاريع الإنشائية في دولة الامارات العربية المتحدة، ويقدم البحث اقتراح إطار موحد يتكون من مجموعة من الحلول التكنولوجية الحديثة من أجل تحسين منظومة تسليم المشاريع الإنشائية في دولة الامارات العربية المتحدة.

كما تم تغطيته في الدراسة، يمكن استخدام الاطار المقترح من خلال الأشخاص الممارسين في دولة الإمارات للتغلب على التحديات الموجودة حالياً في تسليم المشاريع. من الجدير بالذكر أن الإنتاجية المنخفضة والتأخر في البرنامج الزمني هما التحديان الأبرزان كما تم تحديد العوامل المؤثرة في تسليم المشاريع الإنشائية في اطار الدراسة النظرية والاطار المفاهيمي المقترح. يتكون الاطار المفاهيمي من التكنولوجيا الأكثر أهمية والابتكارات والأدوات والطرق والمواد اللاتي قد تؤثر بشكل إيجابي على تسليم المشاريع الإنشائية، وفي نفس الوقت تعالج التحديات الحالية في قطاع الانشاءات في دولة الامارات العربية المتحدة.

تم جمع البيانات من خلال طرق البحث الكمي. شملت هذه الدراسة أشخاصاً محترفين في مجال الانشاءات في دولة الامارات العربية المتحدة. اكدت نتائج البحث عن حاجة قطاع الانشاءات في الامارات لدمج تكنولوجيا البناء الحديثة فيه حيث استخدمت الحلول التكنولوجية المتطورة في صياغة الاطار الموحد المقترح. اشارت نتائج الدراسة إلى ان الاطار الموحد المقترح قابل للتطبيق من قبل الممارسين في قطاع الانشاءات لمواجهة التحديات الراهنة.

*الكلمات المفتاحية: تكنولوجيا البناء، تسليم المشاريع، تكنولوجيا البناء المتطورة، الانتاجية، إدارة المشاريع، الإمارات العربية المتحدة.*

## **Dedication**

I dedicate this dissertation

To myself, the one whom I never appraised for all the hard works and accomplishments in life. I want to take time and thank him for all the paid hard works till now.

To my parent dad and mother, this is for you, thanks for your all supports and motivations. Without your encouragements and huge support, I wouldn't be able to reach to this level. Very grateful to have you all beside me.

To my brothers and sisters, this degree is for you all, thanks for all the motivations and supports during my studies.

---

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## List of Abbreviations

**2D** Two Dimensions

**3D** Three Dimensions

**AEC** Architecture, Engineering and Construction

**AIA** American Institute of Architects

**BIM** Building Information Modelling

**CAD** Computer-Aided Design

**D&B** Design and Build

**D&E** Design and engineering

**DBB** Design–Bid–Build

**DM** Dubai Municipality

**E-submission** Electronic submission

**GCC** Gulf Cooperation Council

**GDP** Gross domestic product

**MEP** Mechanical Electrical Plumbing

**O&M** Operation and Maintenance

**PDF** Portable Document File

**PMO** Project Management Office

**R&D** Research and Development

**RFI** Request for Information

**SPSS** Statistical Package for Social Science

**UAE** United Arab Emirates

**UK** United Kingdom

**US** United State *of America*

# **CHAPTER ONE: INTRODUCTION**

## **1.1 Research background**

Construction industry has been challenged over decades by various of problems. One of these obstacles which pulling back the industry from moving towards improvement, is traditional methods of work processes. Where it had very poor signal towards technology adoption till now in many regions, especially in UAE (Omar, 2015). The construction projects tend to be more complex over the years and this complexity is not only due to technical issues thus, many more challenges arose, such as, procurement and contractual complexity as well as supply chain management. Furthermore, nowadays construction projects' requirements are high in terms of sustainability, smart buildings and safety. In addition, the productivity rates have declined over the years in construction projects. The drop down in productivity shows the industry's failure in terms of managing the multiple team works, poor communication, lack of collaboration, stakeholder management, and not adopting the required technology at the right time based on the industry's need.

The improvement within the industry majorly associated with application of advance technology (Mitropoulos and Tatum, 2000). Although the technology adoption is crucial to help the industry to overcome its challenges, thus, it is possible to obtain through teamwork integration, productivity enhancements, quality improvements, cost reduction, stakeholders management, addressing the users' and clients' satisfaction, and enhance profitability. This will lead the industry to compete within the current market more effectively. Therefore, changes within the industry is vital to improve the project's delivery. According to Jernigan (2014), It is easy to improve the construction project delivery, the success factor is associated with the industry's management to rethink on the industry's strategy and best possible ways to improve the collaboration, and to consider that old methods are no longer helpful.

Architect, engineering, and construction (AEC) professionals and top experts believe that application of advanced technologies improves the overall project delivery. Such technologies like, BIM, Autonomous machinery, 3D printing, augmented reality, and etc. each of these innovations has significant positive impact on the overall project delivery. BIM is considered as a revolutionary technology, where it manages the projects very different. According to Azhar (2011), BIM changes the processes of project design, construction, and operation which moves the project towards a successful delivery.

Technology in construction projects mainly refers to the technical processes and methods that were used in constructing buildings. Technology became one of the significant aspects of construction industry as it moved the industry towards better overall performances. Furthermore, construction processes are the integration of materials, methods, equipment's into a form for use. Yet, unlike other industries such manufacturing, construction sector never completely standardized its processes especially in terms of application of technologies. BIM is considered as one of the innovations that alters highly positive the construction processes. Its root lies under the parametric modeling that was implemented in USA and Europe in 1980s. nevertheless, AEC sector commenced the use of BIM in 2000s for the construction projects. BIM were used worldwide for managing projects; therefore, it became the foremost center of attention of many international construction companies (Eastman et al. 2011).

Technologies have variety of benefits to the AEC organizations; however, it requires appropriate implementation. Such an appropriate implementation of technologies like BIM will enhance the quality and the productivity, reduction in project duration and costs, reduction in waste, responds accurately to the user's requirements, meeting the users and client's satisfaction, creates integrated teamwork's, and easing the overall construction processes (Sebastian 2011; Eastman et al. 2011; Azhar 2011).

Based on many reviewed literatures it can be concluded that BIM's benefits have been identified and considered as the main focus for the future of construction industry in the developed countries that all the construction firms must adopt. Therefore, BIM mandating happened in many countries such as; UK, USA, Norway, Germany, Finland, Australia, Hong Kong, and Singapore (Omar, 2015).

## **1.2 Construction industry background**

Construction industry has shaped the world by the iconic, mega structures, and tallest buildings in the world. Hence this sector receives a lot of criticism across the work in terms of low productivity (Khalfan and Anumba, 2000). The industry always was keen to increase the quality, sustainability, productivity, infrastructure value, and to lower the lifecycle costs, manage time and reworks by effective collaboration, information sharing, and communication among all the shareholders within the project (Nour, 2007). Many initiatives being introduced to the market in order to acquire the desired demand for continues development of the industry's operations, such as contemporary procurement methods, integrated project delivery, Advance technological innovations that can improve design and construction processes, such as 3D-CAD and modeling (Abubakar, 2014).

Building information Modelling (BIM) is considered one of such initiatives that pledged to lead desired improvements within the industry and enhance the existing processes of the operation in order to have successful project delivery. BIM creates a virtual environmental type of tasks, the accurate model of building is known as *Building information Model* that is able to support different phases of project such as design, procurement, fabrication or site construction, as well as for the facility management of the building which helps managers to have easy access to data after completion of the building (Azhar, 2011). BIM is able to improve the productivity by effective communication and collaboration between the shareholders from the commencement to completion of the project (Abubakar, 2014).

According to Eastman *et al.* (2011) many case studies present evidences that, BIM enhances the construction processes more effective and efficient. Yan and Damian (2010) asserted that despite the BIM challenges, its adoption in many developed countries such as USA, Australia, UK, Netherland, Singapore, Hong Kong, Finland, Norway, Denmark, had outstanding results.

Moreover, this research attempts to identify the factors of BIM adoption that might positively or negatively affect the industry and to explore the other construction technologies in UAE along with exploration of methods to address the challenges and benefits.

### **1.3 Research questions**

The exploration should have answered the below research questions:

- What are the current main challenges that construction sector faces in UAE?
- What is the key success factor of application of advance technologies in construction sector in UAE?
- What are the new advance technologies that can benefits construction sector to increase productivity, quality, cost effectiveness and positively impact the project duration?

### **1.4 Research aim**

The research aims to examine how advanced technological tools and methods can be used to reduce the number of construction project delivery errors in UAE and propose an integrated framework that will comprise of advanced technological solutions for better delivery of construction projects in UAE.

### **1.5 Research objectives**

- I. Examine current construction project delivery processes in UAE and propose areas of improvement.
- II. Determine the impact of traditional construction delivery tools and non-traditional tools (including BIM).
- III. Exploring new advance technological tools and systems including (BIM) which can be used for improvement of construction sector in UAE.
- IV. Identify new advance technological tools which can be used to enhance construction project delivery in UAE.
- V. Evaluate how construction practitioners can use BIM to manage information throughout the lifecycle of a construction project in UAE more efficiently and effectively
- VI. Propose an integrated framework that will comprise of advanced technological solutions for better delivery of construction projects in UAE.

### **1.6 Research process**

An exploratory review of literature was conducted on application of new technologies in construction sector in UAE. The review explored the current project deliveries and its overall processes methods. The review pointed out the gaps within the construction sector in UAE, and addressed the application of new technologies as a heal to those challenges. New tools and methods were explored and detailed their benefits and challenges to the construction sector. The research questions were derived from the literature review chapter, and then the research aim and objectives were verified. Furthermore, a suitable research method is being chose accordingly. And data were analyzed in the form of themes and by SPSS software. Later, an integrated framework comprises of advance methods and technologies for better project delivery were proposed, and the same were presented to the construction professionals for verification and validation.



## 1.7 Dissertation structure

This dissertation is divided into six various chapters. Where, the first chapter contain of introduction to the research paper. It begins with the research background and a brief background on construction industry. Further, it elaborates on research questions, aim and objectives.

The second chapter is the literature review where it discusses multiple opinions of many previous researchers on the topic of advance technology in association with construction project delivery. This chapter discusses the overview of construction industry in UAE and its performance in recent years. Moreover, the construction project delivery methods and its current challenges of the industry will be explained. In following the contemporary tools, methods, and innovations will be discussed in alignment with the current challenges and research objectives. This chapter also contains the new advance technologies tools be and materials that positively impact the project delivery. The international comparison of project delivery in relation to the advance technology will be elaborated. Also, advance technology adoption methods, and its implementation challenges within the construction projects are explored. Last but not least, conceptual framework is well detailed as the last part of this chapter where it provides the framework for the quantitative analysis. The framework also includes qualitative research data where factors are considered as variables to assist in data analysis.

The third chapter of this paper is research method, where, it explains strategy of research, data collection, sampling, scaling, ethics, pilot study, and data analysis. The analysis is considered to be in two categories, one into themes and second the same data is analyzed by SPSS software. Moreover, further explanation will be conducted on research limitation, verification, and validation.

The fourth chapter is data analysis and discussion. All the collected data will be discussed in the form of themes and the same data will be analyzed by SPSS software in order to check reliability and relationship between the variable. The data will be tested to create links between the factors derived from the literature and reality.

The fifth chapter presents a framework in alignment with research objectives on better delivery of construction projects. Further, the data were verified and validated by the professionals in construction market in UAE.

The sixth chapter contains set of recommendations and future researches. These recommendations will be extracted from the data analysis and discussion. Also, this chapter will provide knowledge about the procedures and techniques on issues that need to be taken into deep consideration in future. All will be in association with the project delivery in relation with the technology applications.

Finally, the seventh chapter of this paper elaborates the conclusion of this research paper. This chapter points out the gained knowledge through the overall process of this paper. Including the literature review, survey, analysis, and discussion.

## **1.8 Framework**

An integrated framework was developed for better project delivery in UAE. The framework comprises the latest construction advanced innovations and technologies, tools, methods, and materials. Furthermore, the same has been presented among the construction professionals in order to validate and verify. The group of construction professionals have agreed to the proposed framework. The framework pointed out the key factors of advanced technologies as well as its adoptability and compatibility with other innovations and methods. The framework provides great understanding and awareness of all challenges and benefits throughout the implementation within construction projects.

## **CHAPTER TWO: LITERATURE REVIEW**

### **2.1 Introduction**

This chapter starts with an overview of construction sector in UAE. Key points such as current construction project delivery methods and its performance in UAE are discussed. Furthermore, the “advanced technologies” for construction projects have been elaborated in detail; its adoption processes, its benefits and as well as its challenges. The aim of this research is to determine the current gaps of the construction sector in UAE and propose a framework that includes appropriate advanced technologies for better project delivery in UAE.

### **2.2 Overview of the construction sector in UAE**

It has been noticed that in United Arab Emirates (UAE), Abu Dhabi and Dubai are the leading emirates in construction sector. The UAE economy is driven forward by government’s development strategies and vision. According to EC Harris (2013) Development and urbanizing of cites like Dubai and Abu Dhabi will be continued alongside of the young and fast-growing generation. Further demands are generated from the leisure sector in UAE as the country is considered center of tourist attraction in the region.

UAE represents diversity of cultures, knowledgeable government, easy process in regulation, top living standards and especially high rated of quality of life (Malkawi and Pillai, 2013). The fast expansion of UAE construction industry over years had led a win the Expo 2020 for Dubai. John (2018) stated that UAE is still leading the construction market in the Gulf Cooperation Market (GCC). Based on the survey findings by “Pinsent Masons’ GCC construction” that UAE construction sector had improvement over last two years by seven percent, furthermore, there are high expectations that UAE will run new projects in 2018 in order to maintain the top position in the lead-up to Expo 2020 (John, 2018).

According to ArabianBusiness (2013) there are many major projects that have shaped UAE as a remarkable country in the world and specifically in the region. Projects like Burj khalifa, Burj Al Arab, Palm Jumeirah, Sheikh Zayed Grand Mosque and Emirates towers are not only considered as iconic projects in UAE but reflected a positive image of the country to the world.

#### **2.2.1 Recent developments in the UAE construction sector**

In 1995, there were maximum of two buildings above the height of 150m in the middle east. The number of buildings increased dramatically, where in 2015, the number increased to 289, where 192 of those buildings were in UAE. The reputation of UAE was linked to the world-renowned palm Jumeirah and Dubai metro with the longest driverless train system in the world.

UAE’s biggest infrastructure project in the region will be Al Maktoum international airport expansion, with the US\$32 billion budget. UAE claims that this will be the biggest airport in the world with the capacity of 200 million passengers per year (Deloitte, 2015). Furthermore, there are a lot of ongoing and

upcoming considerable projects in UAE which will have a huge impact on moving the country toward the urbanization. Despite all the fast construction growth in the country, the firm is facing many challenges in terms of cost, quality, time, and adoption of technologies. Cultural diversity created a big impact on sub-challenges. From the above, it can be observed that the construction sector in UAE plays a significant role in the development of the country. One could also suggest that the US\$32 billion budget will lead to more projects being delivered in the next couple of the years. The next section will appraise the delivery tools that have been used in delivering construction projects in UAE.

### **2.2.2 Performance of the UAE construction sector**

United Arab Emirates (UAE) is a unity of seven states which is formed in 1971. UAE is well known country in its fast-economic growth and urbanization. Construction industry is the key player of the rapid developments. In mid 1990s, construction sector in UAE had a significant commencement. Gradually Improvements and developments pushed UAE construction sector to be dynamical center in Gulf Cooperation Council (GCC) area (Ahamed *et al.* 2011). According to Mehran (2016), construction projects in UAE are mostly working in a fast-track mode, the accelerated execution is based on the clients, developers, and government agencies requirements.

According to World Economic Forum (2015), the urban population is expected to reach up to billion 2045. If the current situation continues, then, a quarter of that population will live in slums. Therefore, a boost is required for housing in the urban areas. Author continues that shifting age of people has direct impact on construction sector. The need to build new houses for elderly people and it impact the labor supply in the market. The above-mentioned threat is considered less important than the past as new technologies arose and can be used in some tasks instead of human power. Yet the adoption of new technologies involved with highly skillful workers, and construction sector is contented with traditional system showed less interest to use any new technology, therefore, they will have difficulties to hire skillful talents.

The responsibility of construction firms is more beyond the delivery of each project; thus, the operation stage is impacted by the initial material selection which has direct impact on people's life building safety, environment and the durability that associated with cost over the lifecycle of the building. Lomite and Kare (2009) believe that, highly skilled workers and tools are required in order to select construction materials with less environmental impact.

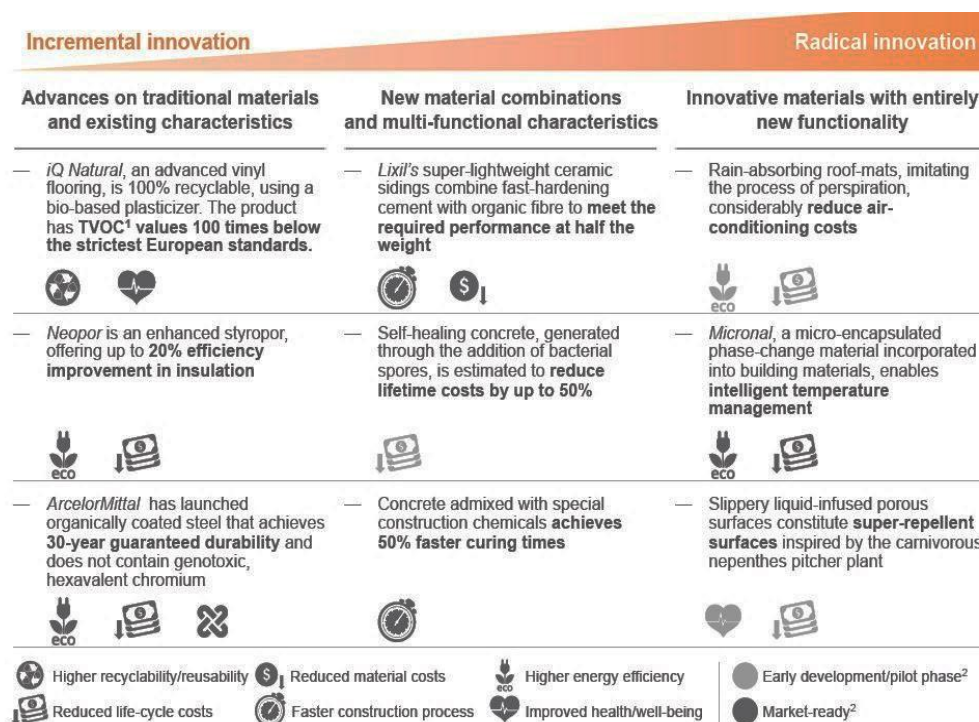


Figure 2.2.2.1 Advance materials selection based on its benefits  
(adopted from World Economic Forum 2015)

Figure 2.2.2.1 elaborates the selection of material based on its usage for high-efficiency, cost reduction, health improvements, reduction in life cycle cost, reusability, and faster construction processes.

The most powerful part of innovation is materials where around 70 per cent of innovation in products are derived from newly improved materials (European commission, 2014). Building material is significant to focus on, as it is one-third of the construction cost. In current era the new emerging building materials are many, from the progressive innovation of traditional materials with existing features, to the new combined materials with multi-function features, to perfectly new innovative materials with overall new features and functions.

### 2.2.2.1 Effect of construction sector on society

World Economic Forum (2015), claims that the business which continuously shaped the humankind's daily life is construction and most of the businesses are relying on construction. It provides the people accommodations, infrastructure, and creates an environment for people to live, work, and play. One of the biggest impacts on quality of our lives is the built environment (WEF, 2015). For instance, in Dubai, on average people spend 90 per cent of their time indoor,

so the health and well-being of people are impacted by the building's materials used for finishing. For countries like UAE having growth in construction industry, it is essential to examine the materials that being used in all buildings and verify to lower the impact those on people health.

#### **2.2.2.2 Effect of construction sector on Economy**

The estimates show that, construction industry growth on the upcoming years, where by 2025 the total revenues will be \$15 trillion (World Economic Forum, 2015). Currently construction industry recruited over 100 million people worldwide (Global Construction Perspectives, 2013). Construction industry has significant commerce dealings with other sectors as it serves all industries vertically. Furthermore, worldwide, the assets of 32 per cent belongs to residential houses from global construction volume, 32 per cent for transportation, energy and water infrastructures, 18 per cent for institutes and commercial buildings, 13 per cent for other industries such as (cement factories, automation manufacturers). For a country like UAE to have a sustainable growth, it is essential to adopt modern and efficient infrastructures. An extra 1 per cent investment of gross domestic product (GDP) to infrastructure construction will achieve an increase in GDP by 1.5 per cent after five years (International Monetary Fund, 2014).

#### **2.2.2.3 Effect of construction sector on Environment**

One of the biggest of raw material and resources consumer is construction industry by consuming about 50 per cent worldwide steel production. Every year over three billion tons of raw material is consumed by the global building product manufacturers (World Steel Association, 2015). Globally buildings are among 25 - 40 per cent of energy use, therefore, they play a key role on carbon dioxide release. World Economic Forum (2015), states that the focus must be on enhancing the total quality of construction and the material being used, in order to achieve a healthy indoor and outdoor environment and to move towards global sustainability and lowering the total cost.

From the above it can be concluded that construction industry has high impact on society, economy, and environment. Therefore, improvements in delivery of its projects are required in order to positively impact society, economy, and environment.

### **2.2.3 Key challenges of the UAE construction sector**

#### **2.2.3.1 Delays**

UAE had the fastest economic growth in the Middle East, leaders were always keen to develop the country and improve the people life positively. therefore, we have been witnessing of huge investments over the last four decades in construction industry in accordance to the leader's vision. Mega structure projects have been completed by different national and international contractors based on various contracts. Almost fifty percent of the projects in UAE have been delayed or suspended in 2002 (Faridi and El-Sayegh, 2006). According to Ahsan and Gunawan (2010), property investment in (2008) turned down to zero, prices dropped down by sixty percent. Therefore, developers had no choice to

suspend the projects. Delays in construction projects are mostly common in comparison to the other industries' projects (Gardezi *et al.*, 2014). Delays are occurring mostly in construction projects in UAE, professional and systematic techniques are required to manage the project scope. Construction firms mainly failing in analyzing delays which results unexpected events that requires urgent plans of rectification, the affect is on time, cost and quality of that project (Aziz, 2013). Delays are very challenging issues for construction project management and has to be studied well in advance (Brimah, 2013). Although UAE have the rapid growing city (Dubai) in the world in terms of urbanization, but challenges still not fading within the industry.

UAE construction sector had delays in many projects, thus based on many debates the unavailability of the project fund, or improper project's financing is the main cause of delay. Project delays are mainly classified based on its nature, cause and magnitude (Adel and Martin, 2009). Furthermore, many work environments generate delays and cost effect to the project such as: Bad planning, late decision makings, approvals delay, low productivities, mismanagement, cash flow issues, etc. (Rehman, 2015). project owner's late decision makings in all terms are the main concerns of all contractors for the project delays. Globally construction sector is considered as the main sector which has a high level of impact on economic of the country (AECOM, 2017). A construction project in order to be successful, required to be completed on time, within the budget, in accordance to the specification and shareholders' satisfaction. When a project fulfills the functionality and gained profit to the contractor with zero claim and it was "fit for purpose" is called successful project (Rehman, 2015). Sanvido *et al.* (1992) believes that when the project objectives are met, it is considered as successful. From the above it can be concluded that one of the main challenges of construction industry can be project delays, therefore, an integrated system combined with advance technologies to increase productivity is required in order to help the organizations to reduce delays of their projects.

#### **2.2.3.2 Lack of coordination and communication between stakeholders**

Malkat *et al.* (2009) highlight that complexity within the construction industry is increasing, vital coordination can maintain the best level of integration between the stakeholders. Peter (2005) says that, transparency, close interaction and communication with suppliers, vital information sharing, and being cooperative is the key to success of a project. All of these are now part of project management skills that need to manage the shareholders' relationship. Although, traditional method of time, cost, and quality isn't able to satisfy the shareholders' unique interests and demands. Furthermore, those criteria won't be enough to address the project success as shareholders influence is high in decision making at different stage of project lifecycle (Malkat *et al.*, 2009). Lack in information sharing and coordination within the project is critical to the success of the project delivery, therefore, this area is considered as a challenge to the success of the project and needs improvement and further developments.

#### **2.2.3.3 Project complexity**

Projects in UAE are increasing and mainly the government projects increase in the size of the construction that make it more complicated due to huge number

of participants such as; engineers, contractors, architects, authorities, suppliers, multiple clients with multi interests, suppliers, sub-contractors and others. Therefore, lack of a proper system of managing the coordination among the stakeholders will cause fragmentation between shareholders (Bryde *et al.*, 2013). In addition, there are separate companies working alongside that their schedule of activities need to be monitored as well as supply of the material to be managed in timely manner.

#### **2.2.3.4 Cultural diversity, quality management and cost overrun**

According to Dadfar and Gustavsson (1992), cultural diversity been a big challenge to overcome in construction sector in the Middle East, also, many projects suffer in terms of delays in schedule (Al-Kharashi and Skitmore, 2009). Y. Y. Ling *et al.* (2012) highlights that many projects fail to reach the satisfactory level of stakeholders as the project runs high in terms of cost and time. Author explains further that, insufficient control over cost and schedule causes many projects to undergo with cost overruns and delays. Quality management shall be based on some criteria to select a contractor. Such as financial capacity, experiences, current contract capacity, manpower, and resources. Plus, soft skill shall be also into consideration. In some incidences, the selection was not done based on merit (Y. Y. Ling *et al.*, 2012). Therefore, project might be stopped or postponed, such areas require improvements in order to deliver successful projects.

#### **2.2.3.5 Wastage in construction projects**

A prevention strategy shall be used for construction wastage reduction which will lead to profitability and also positively impact the environmental concerns (Ahankoob *et al.*, 2012). Consideration of wastage is vital in construction industry not only for efficiency but concerns are for green buildings and environmental issues. According to a report by environment agency Abu Dhabi (2010) stated that “*Municipal waste generation is more than (1.9) kg per capita per day compared to an OECD rate of (1.5) kg per capita per day, and expected to triple by 2030*”, therefore, as far that construction firms are producing more waste material during the building construction, one of the UAE’s goal set to reduce waste in construction sector and highlighted to achieve by 2030 “*enhanced value creation through optimized material flows and waste management*”. Wastage is considered one of the main challenges of construction industry, improvements in this area will lead to cost benefits and increase sustainability.

#### **2.2.3.6 Political and regulatory trends**

It’s been noticed that regulations have a high impact on construction and engineering firms in different aspects where it creates complexity, such impacts are on safety and health requirements, financial and labor rules, and environmental standards (KPMG International, 2011). New rules and regulations for the above-mentioned areas will have positively high impact on the operation stage. For example, rules to adopt energy conservation tools for the companies helps the industries to adopt more innovations which is also beneficial to the society and the environment (Setar, 2013).



This section identified the construction project delivery gaps and challenges, further the exploration of new technologies and advance methods shall address all these challenges.

## **2.3 Construction delivery process in UAE**

### **2.3.1 Construction delivery methods**

Currently, design bid build is considered as the traditional project delivery method where contractors are not in dealt with the design stage of the project. Owner usually assign a design professional for the job in order to deliver the contract and design phase (Turina *et al.*, 2008). Consultants require enough time to complete all the documentation and final estimations in order to call for tendering (Neighbour, 2000). Usually the period of assigning the architect till the selection of the contractor in order to start the work at site is considered several months (Hovet, 1994).

According to Tenah (1998), traditional systems mainly do not generate unified teams in order to share knowledge, ideas, experience and feedback. Client's requirements are not at most priority for the team members (Smith, 1998). Which results unsatisfactory of clients at the end (Markus, 1997). The architects and contractors believe that project delivery method has huge impact on better work progress and project success. Most of the current construction projects are very complex and requires new methods and advanced technologies.

Although currently construction market in UAE is trending in the middle east but, still the design bid build is the most preferable method of procurement. Asamoah (2012) the main reason is due to lack of companies that are capable of handling both design and construction processes. Turina *et al.* (2008) points out that, usually construction projects demands are not only according to cost, time, and quality but referred to project management, procurement and organization. Currently, clients are not satisfied with the traditional systems as the look for a method to meet their complex projects' needs (Turina *et al.*, 2008).

### **2.3.2 Contemporary project delivery methods**

Choosing a correct method of procurement is vital for better construction project delivery and has significant impact on time, quality and cost of the project. According to Turina *et al.* (2008), mostly construction projects are running in developed countries by implementing the integrated procurement system called "design and build". This is an alternative method of procurement to traditional, where client assign a party that is capable of design and construction at the same time. Single direct contact of clients and contractor minimized the misunderstandings and easier the procedures are considered the major advantages of this procurement method. Author believes that the design build has significant influence on better constructability in modern construction projects.

The integrated procurement system can be used by overlapping design and construction which will result improvement in communication between clients

and contractors. Moreover, unlike traditional procurement method the integrated method allows early involvement of contractors in the design and planning stages, and it has a significant impact on faster delivery of the project. Despite all the pros, difficulties of this method lie on client's commitment to a concept design at early stage and a comprehensive brief preparation of the project. Inadequate brief might result difficulties on tender's evaluation (Turina *et al.*, 2008).

From the above it can be concluded that most of the construction project delivery in UAE is by the traditional procurement method. Therefore, a need for a change towards better delivery of projects is required.

## **2.4 Construction delivery tools**

### **2.4.1 Traditional construction project delivery tools**

According to Spalek (2017) During the 1960's projects were independent with the long implementation process. The complexity level of projects was high which had direct effect on total cost of the projects. Therefore, the development of project management as a scientific discipline started since 1960's (Kerzner, 1987).

Accordingly, the key point was to create a detailed schedule of tasks and to follow up during the implementation process for each project (Spalek, 2017). However, managing projects this way is called traditional project management (Hebert and Deckro, 2011). By time as the number of projects increased new challenges arose, multi project environment created in many companies (Formentini and Romano, 2011). Project Management Office (PMO) was introduced to deal with such situations (Hobbs and Aubry, 2008). The role of PMOs were to improve industrial engineering, spread knowledge, and to support innovations but were unable to address all the challenges that the project faces (Spalek, 2017).

Despite the fact that methods were established well and developed over the years for traditional project management, it is being noticed that they are not able to address the new challenges that the organizations facing recently (Spalek, 2014d). Spalek (2017) stated that companies are highly interested in shortening the projects duration and cost-cutting tendencies by adopting new innovations. Moreover, as the projects are huge and dealing the expectations of heavy environment and stakeholders, therefore, traditional methods are not open to change enough for such challenges.

According to Jensson (2017), and Figure 2.4.1.1 clarify that, traditionally construction projects go through three phases:

- Design and engineering (D&E);
- Construction (C); and
- Operation and maintenance (O&M).

Succar (2009) stated that the flow of work for the above phases are linear. Based on the Figure 2.4.1.1, it is noticed that there are deficiencies of interoperability among the project lifecycle's phases (Dawson 2004).

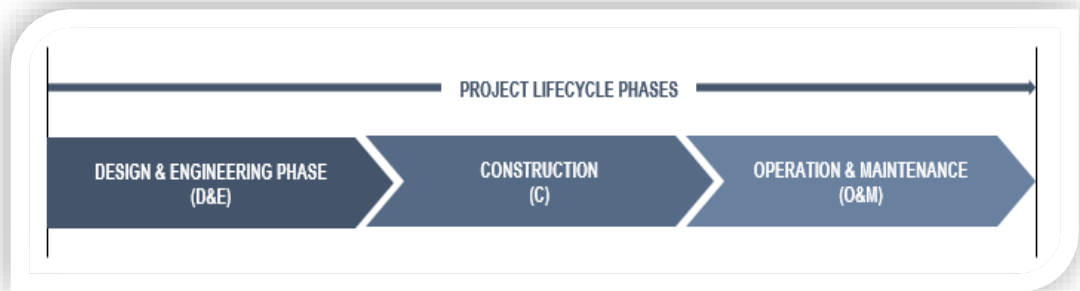


Figure 2.4.1.1: construction lifecycle phases  
(adopted from Jensson 2017)

From the above analysis, one could suggest that there is a need for the enhancement of construction tools that have been used in the UAE construction sector. Thus, this research intended to explore new advance technological tools and systems including (BIM) which can be used for improvement of construction projects in UAE.

#### 2.4.2 Non-traditional construction project delivery tools

In current days, we notice that changes in the world have been made very fast in all aspects, hereby, those changes push construction industry to move towards an effective transformation. Such transformation shall reduce the construction cost in order to have a wider society, use ecofriendly materials to have a sustainable environment, and enhancing economic development by reducing the infrastructure gaps (World Economic Forum, 2015). Whereas, there were tremendous developments in other industries over last decades to benefit the entire processes and brought innovation into products, engineering and construction firms did not adopt fully the latest new technologies. Lack of technology and innovation adoption fallen behind the construction sector from the race between other firms.

World Economic Forum (2015) clarifies that, this unsatisfactory result is due to some challenges:

- Resistant to change;
- Insufficient collaboration between contractors and suppliers;
- Recruitment of skillful employees; and
- Inadequate knowledge transfer.

The industry's potential is infinite, nevertheless, new advanced tools, digitalization's, innovations, new technologies and construction techniques have made it easier to improve the productivity and efficiency in construction projects, such as:

- Augmented reality;
- Drones;

- 3D scanning and printing;
- Building information modeling (BIM);
- Autonomous equipment's; and
- Advance building materials (Eco-Friendly).

Where most of the above have achieved the field level of maturity. Construction firms will enhance their productivities, project management, quality management, time management, and safety implementation by adopting the above-mentioned innovations. A serious commitment and effort for every firm is required to adopt new technologies in all aspects from operation, strategy and regulations (World Economic Forum, 2015).

The adoption of new technologies will have high impact on economic growth. Adoption is driven from a series of decisions on using new advance technologies, these decisions are mostly lying between uncertain benefits and new inventions and the cost associated with (Parente and Prescott, 1994). It is believed that adoption of new technologies was very slow by the architecture, engineering and construction (AEC) firms, as they tend to use the old model and process for years (Takim *et al.*, 2013). However, several new practical applications made it smoother for the technologies for better information sharing and outsourcing. Technology adoption is vital to maintain and enhance the quality of life. For example, Computer aid design (CAD) is used by the firms to create two- and three-dimensional models. According to Hassan (2012), Building information modeling (BIM) is also a new modeling system which is used to create six-dimensional models, it will improve the productivity and quality within the industry's work progresses.

#### **2.4.2.1 Material selection**

Moreover, project's life over than 30 years, the operation and maintenance costs are mostly as high as the initial cost of the project (World Economic Forum, 2015). Therefore, still the industry does not take into consideration to optimize the cost for life-cycle of materials. The reason behind this might be the conflicts on interests between parties (Developers, contractors, Asset owner) and also lack of knowledge about life-cycle of the materials used in the building. This is unsatisfactory situation for all clients (developers), the remedy would be a proper investment in a new system during design and documenting the material specification with the consideration on long term cycle performance of each material that are being used for the project, where it has a direct cost impact on operation and maintenance.

#### **2.4.2.2 Investment in information technology**

According to Underwood *et al.* (2012), for all organizations, delivering the projects more efficient is the main objective, therefore, information and communication technology is playing a vital role to the success of this goal. Alshaw, *et al* (2008) state that today, information communication technology became very significant among all the higher management businesses. There were huge investments in information technology over last two decades. According to a report by UK Office for National statistics e-Economy (2007), investment in information and technology is reached to 165 per cent to £ 34.9

million from 1992 till 2004. Moreover, innovations have grown by implication of knowledge sharing, where proper usage create community development and promotes equality. Underwood *et al.* (2012) clarified the significance of information communication technology base on innovations, which will enhance the productivity and bringing more competitive advantages to the industry.

Construction industry is considered as the largest wealth creator of Europe's economy with sixty percent of gross fix capital formation (European Commission, 2006). The firm is extremely relying on information and knowledge sharing; therefore, they should implement the information communication technology if they still aim to stay competitive (BERR, 2008). However, construction firm is ranked the second lowest in terms of information communication technology usage compared to other firms. According to a report by NCC (2009), construction sector's median value is 0.96 per cent, where 4.09 per cent belongs to the education sector. Example: A reduction in selection of building materials been made for a mid-size construction company's project, therefore, the need for familiarization with many component and errors decreased accordingly. The success behind the implementation of such processes are the company's wide software and tools. These tools will provide a lot of information and make them accessible at any time that the project members need to use. That is counted as a great support for scope, schedule and cost.

#### **2.4.2.3 Framework for managing construction projects**

Operation phase of construction project is mostly depending on expert employees or even instinct of the independent project manager. Although construction projects are complex and are identical, therefore, the "lesson learned" can be used for another project. These experiences shall be institutionalized by the construction firms in order to continuously be used for better project management. World Economic Forum (2015), emphasis that construction firms shall focus on the below steps for a better project management framework: Accumulate and integrate the project management data, this step requires advance project monitoring system and great reporting tool that enable project data collection continuously. Standardization the identification of best practices: this part consists of evaluation of each individual project's performance and to evolve a set of best practices of overall processes in order to comply with different type of projects. Implementation of the standardized best practices at project level is vital and it might require to educate project personnel to be effectively involved in the process and apply best practices mandatory.

#### **2.4.2.4 Stakeholders management**

Relationship management skills are vital for completion of successful project deliverables, by meeting the stakeholder's expectations throughout the project life-cycle (Cleland, 1999).

Nowadays, construction projects are involved with multiple-stakeholders, collaboration improvement and knowledge sharing among architect, contractor, subcontractors, material suppliers, etc. is very significant and complex (World Economic Forum, 2015). The method for stakeholder's management is consist of five sections:

- Identification;
- Prioritization;
- Visualization;
- Engaging; and
- Monitoring.

Therefore, a platform is required to transfer fast and accurate information among stakeholders in order to meet the project's needs. By using technology, implementing the above process will have a high impact on the project success. Stakeholder Circle™ is a software and set of methodology which is designed to obtain the above objectives (Walker, 2008).

In conclusion, we have identified the latest methods and theories that can lead to a successful construction project delivery; therefore, demand is for a complete integrated platform in order to combine and implement all the latest methods under one umbrella. BIM could one of the platforms that can help to apply all the latest tools, methods, and latest practices and it assures the high transparency of the work progress, lowest errors, high productivity, lowest possible cost, and most importantly to have easy access to 3D data during the operation phase of the project.

#### **2.4.2.5 BIM**

Arayici *et al.* (2012) claims that, BIM is alive more than twenty years, just only in recent years construction firms are aware of BIM advantages towards betterment of their project deliveries. The growth in BIM applications were extreme, it's a tool to design in (3D) three-dimensional, model analysis, clash detections, material selection, and to conceptualize the whole project (Weygant, 2011). The record shows that BIM started to develop in (1982) in Hungary (Graphisoft, 2013). Meantime, BIM products are mostly consumed in (US) United States of America as they are the greatest producer and the BIM knowledge is derived from US to other countries (Takim *et al.*, 2013). According to Howel and Batcheler (2005), countries like US, Finland, and Germany are still the top three in terms of using the BIM technology for their projects. Finland has known the leader in BIM implementation as they created the (Tekla and Vico) softwares (Khosrowshahi and Arayici, 2012). Author continues that, meanwhile other countries are having very good progress towards BIM implementation, countries such as: Singapore, South Korea, and Australia.

According to Penttilä (2006), building information modeling can be described as the combination of interactive policies, processes, and contemporary technologies where it creates diverse methods to control highly significant construction design and data conversion into a digital platform throughout the building lifecycle among the different stakeholders within the project. However, (AIA) American Institute of Architects (2007) describes BIM as “*Information use, reuse, and exchange with integrated 3D- 2D model-based technology, of which electronic documents are just a single component*”. Construction sector enhancing the profitability, cost, time management, and stakeholder's management by implementation of BIM to their projects. Azhar (2012) believes that is BIM is accepted as a vital and significant tool to enhance the construction processes and bring profitability.

Alenazi and Adamu (2017), highlight the BIM has huge impact on project success and reducing the delays during the design and construction phases. Further he suggests, that BIM is able to solve the multi-faced problems in relation to delays and cost over runs. First, it produces an advance design review system, design changes and errors are mostly affecting the cost and schedule of projects in construction. BIM will enhance the productivity in almost all delivery processes of construction, also it reduces the number of requests for information (RFI), design changes, team conflicts, and reconstruction. By using BIM, designers can easily modify and to make decision more accurately based on the given data, so on the efficiency and speed of the all process will be fast. Easy flow of data and information can be more value added.

Alenazi and Adamu (2017), highlighted the benefits of BIM for delay management in construction projects (Table 2.4.2.1):

*Table 2.4.2.1:*

*benefits of BIM on delay management, (Adopted from Alenazi and Adamu (2017), P828)*

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<b>B1:</b> Improve design quality and verify consistency to the design intent easily, which prevents expensive delays
<b>B2:</b> Earlier and more accurate visualisations of a design to the owner for better understanding of proposals
<b>B3:</b> Support decision making regarding the design
<b>B4:</b> Improve the design and installation of MEP services on any construction project systems as well as their coordination with other building systems
<b>B5:</b> Early quantity take-offs and cost estimating during the design stage with continuous updating as changes are made to the model.
<b>B6:</b> Improve understanding the sequence of construction activities and project duration
<b>B7:</b> Improve visualization of construction details
<b>B8:</b> Improve supply chain process
<b>B9:</b> Increase the ability to resolve requests for information (RFIs) in real time.
<b>B10:</b> Improve communication (information exchange among stakeholders)
<b>B11:</b> Reduce project duration and cost of construction
<b>B12:</b> More accurate scheduling and cost estimation
<b>B13:</b> Quick reaction to design changes (change orders facilitation)
<b>B14:</b> Clash detection (reduce clashes)

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Fourteen benefits of BIM on delay management is listed in table 2.4.2.1, where the top three benefits can be clash detection, improvements in communication, and Improve the design installation of MEP services. All fourteen benefits are vital and will lead to success of the project not only in terms of delay, but will positively impact the cost and quality of the project. BIM is vital as of a new advance and system for managing different type of construction projects.

Since long time construction industry faces problem such as miscoordination between design and construction. Project complexity will increase when there are lack of integration and communication between stakeholders (Naoum & Egbu 2015). BIM as a platform to bring all stakeholders to work together in a transparent system; these include contractor, client, architect, engineer, and other constitutions (Pcholakis 2010). Also, it does change the work processes in all disciplines. Mcauley *et al.* (2012) states that the changes by BIM will focus on improvement of the outcome in relation with quality, cost, and time. The main aim of BIM adoption is to improve the overall construction process from the feasibility study stage till facility management (Eastman *et al* 2011). This section of literature review represents the all aspect of BIM adoption, its impact on the project delivery methods and to examine to what extend the change will impact the project performance and productivity in all processes.

According to smith (2014) BIM made it easier for stakeholders to communicate between each other, and enhanced the quality of data provided to them for better decision making. Activities cycles timeframes are reduced and has direct impact in cost saving associated with, which result a good quality product delivery at every stage of the project.

Nowadays, construction industry mostly relying on integrated solutions for their project deliveries (AIA, 2007). Such solutions shall combine business-frameworks, people, systems, and professional practices into a single operation process that will produce effective knowledge to all shareholders in order to enhance the project delivery, increase the value to the clients, reduce waste, and to improve the efficiency of work in design and construction phases. BIM is a useful tool that is able to integrate the processes and the project teams, and also provides accurate and transparent data alongside an open technological platform for all stakeholders.

Regardless of the traditional methods of project management, clients should not be unaware of the construction problems anymore issues like; delay, cost overrun, schedule, and quality matters (Fernandes, 2013). Clients are now able to adjust their assumption and decide more accurately at every stage of the project as they are involved in design and construction processes. Using such tools will help the project team to decide better and that will improve the rework reduction, delay, and cost overruns. These tools were used prior BIM, and now integration with BIM will have great impact with outstanding result.

According to Romm (1994) in addition, the recent years demands are high for projects with more energy efficiency, hence, BIM is able to help clients in terms of environmental consideration issues by some applications that will impact their project deliveries. Table 2.4.2.2, shows the software's that is useful through development of BIM-linked to controlling performance.

*Table 2.4.2.2: Software's that could be used through BIM performance (Adopted from Tristan Gerrish et al, 2017, P221)*

Software	Function
IES-VE [54]	Modelling and simulation of building performance
Autodesk Revit [55]	Modelling and attribution of descriptive performance meta-data to objects & spaces within the BIM model
Autodesk Dynamo [56]	Attribution of simulated performance output to Autodesk Revit model Extraction of geometry and meta-data from Autodesk Revit into a lightweight data-interchange format (JSON)
Python (Pandas [57], Matplotlib [58], ipywidgets [59])	Extraction of data from BMS SQL Server Cleaning of extracted data Code interlinking JSON file with query-able performance data

Autodesk Revit is one of the BIM software that can be used by architects, landscape architects, structural engineers, MEP engineers, designers and contractors (Autodesk, 2019). Dynamo studio is a stand-alone programming environment that enables designers to create visual logic to explore parametric conceptual designs and automate tasks. IES Virtual Environment (VE) is an energy analysis and performance modeling software that provides a variety of custom modules designed to address different building performance workflows (Vectorworks.net, 2019). Pandas is a software library written for the Python programming language for data manipulation and analysis. In particular, it offers data structures and operations for manipulating numerical tables and time series.

Other than productivity and quality issues BIM is able to facilitate the wastage control in construction projects. Wastage in construction is a critical issue and



generally unsustainable in environmental terms, also, has cost related impacts (Ahankoob et al., 2012). BIM adoption helps to reduce the wastage and to delete the non-value adding activities. BIM as new technology provides a total paperless working platform and provides accurate information for better decision making which results a reduction in reworks and wastages. A conclusion made by Baldwin et al. (2008) that BIM creates a perfect platform to develop analysis of construction waste and implication design decision. In addition, BIM helps designers to evaluate the impact of design decision on the construction processes by virtual prototyping and 3D virtual modeling that can result very effective. In conclusion, BIM is an approach of advance systems and methods to reduce construction wastage during design, pre-construction, during construction, and operation phases.

In this section we have explored the BIM as of a new advance construction system that can help to improve the project progression that will lead to successful project delivery. And also, how to manage information sharing throughout the project lifecycle. Furthermore, the next section will identify and explore the new advance tools and their benefits to the construction projects.

### **2.4.3 Advance technological tools**

#### **2.4.3.1 3D Printing**

It is being expected that 3D printing's development to have significant domination on the construction sector. This new technology is able to produce the built shapes, where other methods are unable to do, gaining of 80 per cent productivity is assured for some applications and a huge waste reduction in all applications. Time frame for construction of elements within the building could reduce from weeks to hours and components customization will be at much lower cost (WEF, 2015).

Although, 3D print in construction firms are at premature level, and developments are expected to happen in future. Few issues preserve, including resolutions issues like; (Large scale printings are most likely to produce bulky and rough result). The constrain of standard 3D printers are by their sizes, but big printings are slow and cost high.

At the moment, application of 3D printing is mainly for low volume and more valued parts. Technological challenges, and economic cost of the printers are yet to be analyzed and experienced by construction firms. WEF (2015) asserted that, A UK based company achieved 75 per cent weight reduction and 40 per cent reduction in material by using 3D print models in compared to the old production methods for the similar projects.

#### **2.4.3.2 Semi-automated construction equipments**

Alenazi and Adamu (2017), stated that using automation equipment's for construction activities based on the critical path will be also very beneficial. Day by day construction processes are going to be more complex and mechanized, machineries have played a vitally strong role in productivity gain within the construction projects. machineries like bulldozer and excavator are to move large amount of earth soil easy and fast; underground engineering work is being done by drilling-rig, and pile-driver; concrete pump to make quick and easier the

pouring of concrete; and mobile crane to carry heavy loads. Meanwhile other industries like, automotive firm, have achieved the highest advance technological tools, and producing any type of machinery to ease the processes, but construction industry is still at low level of automation adoption. Thus, it needs to bring changes, however, new advance technologies developed in robotics that open up huge new possibilities (World Economic Forum, 2015). New advance technologies in digital platform like, (unnamed aerial vehicle, autonomous control system, low cost sensor, remote operation) could become important starter of innovation in construction equipment. Semi-automated equipment is able to carry out any task with complexity, though it just requires human control. Autonomous equipment performs by mix use of sophisticated digital tools and advance technology, for example drones, where it only requires human to monitor. Semi-autonomous equipment's have optimum potential along with multiple dimensions that reduce construction cost, shorter the project delivery by increasing the productivity; high accuracy and better quality which result fewer workmanship errors and safety improvements by pushing the labors out of danger zones.

Industries are able to step forward with value chain to increase the implementation of automation where necessary. The result of combined system of physical and digital will be satisfactory for all stakeholders. Example: a Japanese construction equipment manufacturer is working on development of a bulldozer consolidating many digital systems. Drone, 3D-scanner and stereo camera collect required data, that is transferred to the bulldozer; these equipment's are installed with intelligent machine control system that carries out the specified work independently. Therefore, grounding work at construction sites will be completed faster, less workers involved by monitoring and control of the human operators the entire process (World Economic Forum, 2015).

#### **2.4.3.3 Digitalization in construction**

The enhancement and deployment of digital technologies and processes that are linked to the construction industries' transformation. Innovation adoption will enhance new functionalities and the value chain from the design stage to the end of project lifecycle. WEF (2015), published that studies being conducted on digitalization that is able to produce cost savings of \$0.7 - \$1.2 trillion on non-residential projects within ten years on engineering and construction projects and \$0.3 – \$0.5 trillion in the operation stage. The main technologies that facilitate this transformation are listed in Figure 2.5.4.1 such as; Data analysis, BIM, virtual reality, 3D scanning, and mobile interface and augmented reality.

#### **2.4.3.4 Application of huge data and analytic**

Algorithms create new vision from the data platform that is available on construction projects, and on current resources during the operation stage. New system of simulation and virtual reality assist to find any clashes during the design phase and help to view a virtual building prior construction in the early design stage. Companies are able to have live and accurate communication by mobile connection and augmented reality which provide workers with additional on-site data and information. Example: Atkins (Engineering Consultancy Company) by using advance parametric design technique for detail design of water infrastructures, which produced twenty-two different design options on one day to their clients, this shows 95 per cent improvement design in terms of quality and accuracy in compared to traditional methods. 3D scanners are able

to make digital models of existing buildings, and also able to determine any deviations while construction work is in progress and enable deformation monitoring (World Economic Forum, 2015).

From the above it can be summarized that what are the new advanced tools that could be used to enhance construction projects progress and how the process is workable in order to benefit the construction industry.

## **2.5 International comparison of project delivery in relation with new technology**

### **2.5.1 United Kingdom**

According to cabinet office (2011) stated that, construction firms are challenged in cost reduction of the government projects by 15 to 20 percent by 2015. Succar (2009) stated that, at the time of financial crisis, the savings on construction projects required more than twenty percent, therefore, BIM is suggested as the best solution to improve the sharing data with fully integrated system throughout the multiple teams within the projects. It is believed that BIM has capacity to enhance productivity alongside the high efficiency gain by the advance modeling techniques that centralize the design information and develop the communication platform (Cabinet Office, 2011). Robson (2014) stated that in UK BIM adoption in construction sector is based on four levels: starts from zero level for design of two-dimensional, to intimately consolidated three-dimensional design modeling, cost and time at level three. BIS (2011), according to UK government requirement; all public projects shall be completed by using BIM level two by 2016. Project teams shall work in 3D modeling for design stage as per level two requirements. Sub-contractor companies produce eighty percent building costs in UK and their design concept has to be intertwined with main contractors' supply chain (Robson, 2014). In order to reduce cost by using BIM, sub-contractor's involvement in the process is a must. BIM adoption for the UK government seem the high priority as it is aligned with the government vision and upgrading the system is possible at any time soon in future.

### **2.5.2 Globally**

Building information modeling as of the new advanced technology is now widely used in many countries as a trending technology to help the construction firms in all phases, such as; initiation, design, construction and operation (Wong et.al. 2009). Users are able to create a visual simulation of their own project prior to the start of construction phase. Nevertheless, BIM's complexity in processes require special trainings and skillful workers. To implement BIM, skillful workers from different engineering field shall work together to run and monitor this complex system.

According to Won *et al.* (2013) countries like UK and US mandated BIM, other countries are still working on adoption and implementation processes (Mehran, 2016). Reports elaborates that BIM adoption increased in US by fifty four percent in years between 2007 till 2012 (Lee, 2014). BIM adoption reached around thirty six percent in European countries in 2010 and UK had increase of BIM adoption by twenty six percent (Mehran, 2016). In Middle East BIM is being used around ten percent in construction projects. in Europe, some

countries which considered as leaders in BIM like; Sweden, Norway, Denmark and Finland. BIM publications around the world are increasing in terms of theory and processes. BIM awareness is very high in UK construction sector. And government support is required in relation to BIM awareness and that's what UK government does. Cost waste reduction is the main objective of UK government followed by mandating the BIM in 2016. Mehran (2016) mentioned that BIM's visualization is used over seventy percent in USA's construction projects. Moreover, generally BIM is being used for design stage of each project all over the world. E-submission of BIM was mandated in Singapore in 2008 by government by two main organizations (Building Construction Authority and Real Estate). Singapore is the first Asian country that use BIM and became the only country that demand the E-submission of BIM (Khaemlani, 2013). BIM handbook with title of "BIM As Changer" was presented in 2014 as a guidance towards BIM implementation in New Zealand and Australia.

### 2.5.3 UAE

According to Mehran (2014), In the last twenty-five years the economy of United Arab Emirates has dramatically increased with significant boom in construction sector. Yet the UAE construction sector is facing many challenges such as delays and cost over runs. Not long ago, Dubai Municipality (DM) for the first time in UAE history issued circular in relation to the BIM adoption. After UK, mandating BIM for public sector projects by 2016, DM also mandated BIM in (May-2014) for building more than 40 stories or more than 300,000 SQF and government projects.

UAE is well known country in its fast-economic growth and urbanization. Construction industry plays a vital role in urban developments in UAE. In mid 1990s, construction sector in UAE had a significant commencement. Gradually Improvements and developments pushed UAE construction sector to be dynamical center in Gulf Cooperation Council (GCC) area (Ahamed *et al.* 2011). According to Mehran (2016), construction projects in UAE are mostly working in a fast-track mode, the accelerated execution is based on the clients, developers, and government agencies requirements. Motaleb *et al.* (2014), believe that construction projects in UAE are unique and the high-risk level create vast challenges during the process. Projects in UAE being rated high with risk, fragmentation, competition, and also technical challenges. World's unique projects are completed in UAE such Burj khalifa, the world's tallest building that was handover in 2010, Burj Al Arab, the world's seven-star hotel and the third tallest hotel building in the world. Although construction sector plays a vital role in country's economy, still there are serious challenges that need to be addressed. Delays are occurring on most of the projects, and when it happens on mega structure and infrastructure projects which has direct effect on economy of the country as well on the industry. The world financial crisis which happened in May 2007, affected construction industry in UAE, which resulted in slow progress of the projects but the industry continued to build. Mehran (2016), stated that, the property boom in GCC countries was with sixty percent of UAE contribution and forty seven percent alone Dubai. Construction industry need a change and upgrade in order to increase the productivity around the world, so, governments, development organizations, and engineering & construction research centers around the world have identified the ineffectiveness that affect the construction industry daily, therefore, some government recommended and

some mandated the BIM adoption as a tool to improve the productivity. AEC industry's professionals used BIM as a framework in the Middle East (Mehran, 2016). As mentioned above that UAE mandated BIM on certain specific projects, despite the slow adoption progress UAE have completed some projects such as: Louvre Museum, Guggenheim, and Midfield Terminal in Abu Dhabi. According to a report published online by Mepmiddleeast (2019) stated that a UAE-based Engineering Contracting company has adopted BIM on their projects (Rawda and Una) and based on their weekly progress report that shows, currently, they are 3.2 per cent ahead of schedule and within the budget.

#### **2.5.4 Comparison of project delivery practices identified**

According to WEF (2015), Productivity improvement in construction industry in most countries were sadly so poor over the last five decades in comparison to other industries. Refer to Figure 2.7.1 for labors productivity in US. New technologies and tools being introduced by time to the market, but the adoption progress was very slow-going. Despite all the advantages of new technologies the question lies on why construction industry has such an unremarkable record? The related causes are many and different. Lack of innovation and delayed adoption. The vital vein of the industry is research and development (R&D) it is applicable to all industries; however, the advantages are long term and cost associated with it rises at current moment. This believe is ill-suited to the construction business where the industry's operation is affected so, there are less care and attention to (R&D) in compared to other industries. According M. Beck (2015), *"by overviewing the construction projects today, I cannot observe major difference in work execution in compared to 50 years ago"*.

New technologies emerging to transform and reshape the engineering and construction industry by contemporary innovations and revolutionary construction techniques. Work efficiency and productivity will be at utmost growth. It is mainly the industry's responsibility to adopt the new technologies in substitute to the traditional operational methods. Other industries like automotive have gone through many changes by adopting new advance technologies and their digital transformation is now underway (WEF, 2015). Construction firms have to decide and take a serious action. Despite all the challenges of technology adoption, the industry shall take action in several areas (WEF, 2015). Figure 2.5.4.1 shows an extensive approach outlined for industry transformation.

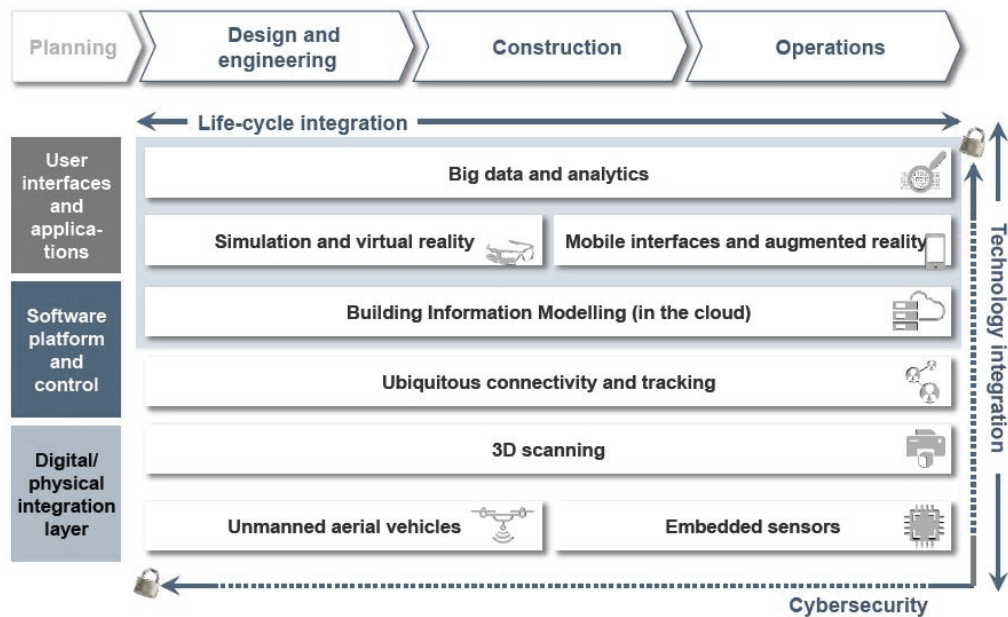


Figure 2.5.4.1: Technology Adoption based on the construction phases (adopted from World Economic Forum 2015)

Figure 2.5.4.1 elaborates that during the phases such as; design and engineering, construction, and operation different innovations can be adopted that will facilitate project performance. WEF (2015) stated that, firstly, individual organizations' initiatives are significant for the transformation – adopting new technologies and methods, latest business models, innovations, concentration to the corporate culture and organization, and so on. Actions by an individual is not sufficient for the transformation, yet, in such a complex and horizontal industry: challenges to be addressed in a collective manner – the industry as a whole is responsible, and has to create new ways of collaboration or to enhance the existing methods. Lastly, governments play a vital role in the transformation and their role as a regulator shall be transparent and active in this regard. Figure 2.5.4.2 clarifies of the industry's transformation framework. Construction industry's poor worldwide standard arrangement results low productivity gain in compared to a modernized industry that could bring vast advantages.

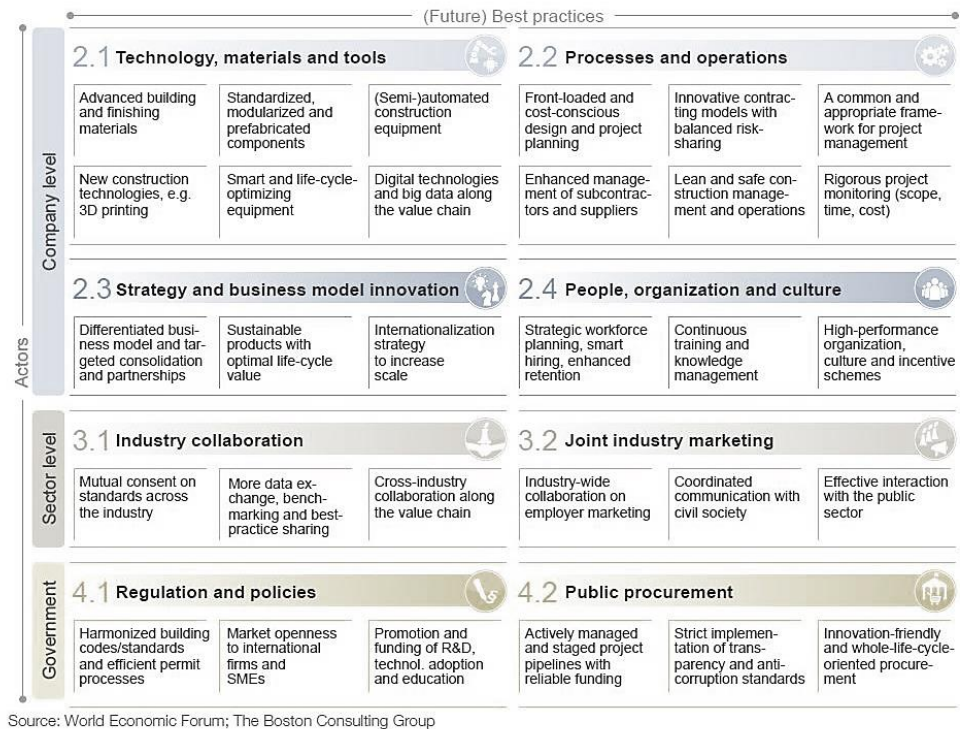


Figure 2.5.4.2: contemporary construction practices  
(Adopted from world economic forum 2015)

Main actors of contemporary construction project and the best future practices are elaborated in the Figure 2.5.4.2, therefore, commitments and encouragements of many active participant in the industry is required for the future of construction projects – people who trust and have confident in a modern engineering and construction that will benefit all (M. Beck, 2015). According to Figure 2.5.4.2, it presents that at the company level; technology, advance material and tools, contemporary processes and operations, business strategies, and people culture are significant parts of successful project delivery, also, industry collaboration and marketing at sector level, and regulation & policies and public procurement at government level.

To sum up, a need has been concluded from the literature review for a change in order to move forward towards better projects' delivery, this section compared the traditional construction methods to contemporary and evaluated the current construction practice that can enhance the project progress throughout its lifecycle. Further the challenges of new technology adoption in construction projects will be discussed in the next chapter.

## 2.6 Key challenges of adoption of new technologies in UAE identified

The adoption of any new technology has positive and negative impacts on the project. The effect might be more to the shareholders and their benefits. As an example of new technology, we aim to elaborate BIM adoption challenges. Regardless of the BIM's benefits realization within the industries, construction sector still did not utilize it aggressively (Takim, 2013). It is been notice that UK construction firms are not very interested in BIM adoption as the implementation progress is slow (Khosrowshahi and

Arayici, (2012). Possibilities lies on hardship in BIM implementation, project's cost overrun on adoption of BIM, comprehensive trainings, and most of the users still prefer to use 2D-CAD instead of BIM. BIM's Drivers, barriers, and adoption process were documented in the literature. Experts defined these challenges in different categories. There are some specific barriers for BIM, while the rest are general challenges to the innovation (Fox and Hietanen, 2006). According to Eastman et al. (2011) BIM adoption barriers are divided into two main categories:

- i. Process barriers to the business (related to legal and organizational issues are included);
- ii. Technology barrier (Technical: related to readiness and application processes).

Ayarici *et al.* (2009) defined primary challenges of BIM adoption based on a survey conducted in UK; the unfamiliarity of the construction companies with the BIM adoption, unwillingness to train staff or create new opportunities to implement, lack of solid proof on BIM's benefits, and also high cost of software and trainings. Uniformly, another survey conducted by RICS (2011) stated the probable barriers of BIM in UK; shortage of client's demand for BIM adoption, deficiency of guidelines and standards, lack of IT infrastructure, deficiency in contract conditions and amendments, and insufficient trainings, this survey was conducted among the construction engineers. Abubakar *et al.* (2014), presented a survey on BIMs adoption barriers which was conducted between the professional groups in Texas, USA; shortage in experienced partners, contract and legal issues, standardization issues, long duration for learning and high cost of implementation.

To elaborate more, in relation to legal issues; BIM data ownership is considered a serious risk to the industry (Azhar, 2011). BIM data shall be protected through copyright laws and legal right's channel. The question is who will own BIMs data? There is no direct answer to the question, thus, the unique answer is depending on the project participant's demands. Rosenberg (2007), claims that in order to avoid controversies over the copyright issues, the solution lies on settling the contractual documents ownership rights and responsibilities. One more contractual issue is who is responsible to monitor the data entry into the model. Azhar (2011) believes that it is a big risk to take the responsibility of data controlling during any update made by participants and to check the accuracy of details. Due to multiple stakeholders' involvements the coordination of submittals in an integrated form is very difficult, for instance many subcontractors may not use the same software as main contractor is using for scheduling, therefore, main contractor has to create a new submittal that is compatible with the building information model (Azhar, 2011). Therefore, cost associated with the admin work will rise as new cost to the project, the responsibility of data accuracy and coordination of costs and schedules must be addressed in advance in the agreement or contract (Thompson and Miner, 2007).

Azhar (2011) having an integrated and collaborative project delivery contract will be the most effective method to deal with those risks, where all the risks are shared among the stakeholders. Author continues that according to an exhibition by American Institute of Architects on BIM to assist the project participants in order to define their BIM development plan for integrated project delivery. The participants are able to define the model management arrangements, as well as authorship, ownership, and level of development requirements at different phases of the project.



Furthermore, the successful transition of BIM is mainly played by the BIM drivers as stated in the Figure 2.5.4.2. Government supports by legislations, clients' interests, software availability, professional bodies commitments, and collaborative procurement methods all together play a vital role in succession of BIM adoption by the industry. BIM is identified as an advance technology that will enhance the project delivery; therefore, application of such technologies has risk that this section elaborated the possible risks and how to reduce the risk. Furthermore, the next chapter will explain the technology adoption criteria and key points to consider prior adopting a new technology.

## **2.7 Technology adoption Factors**

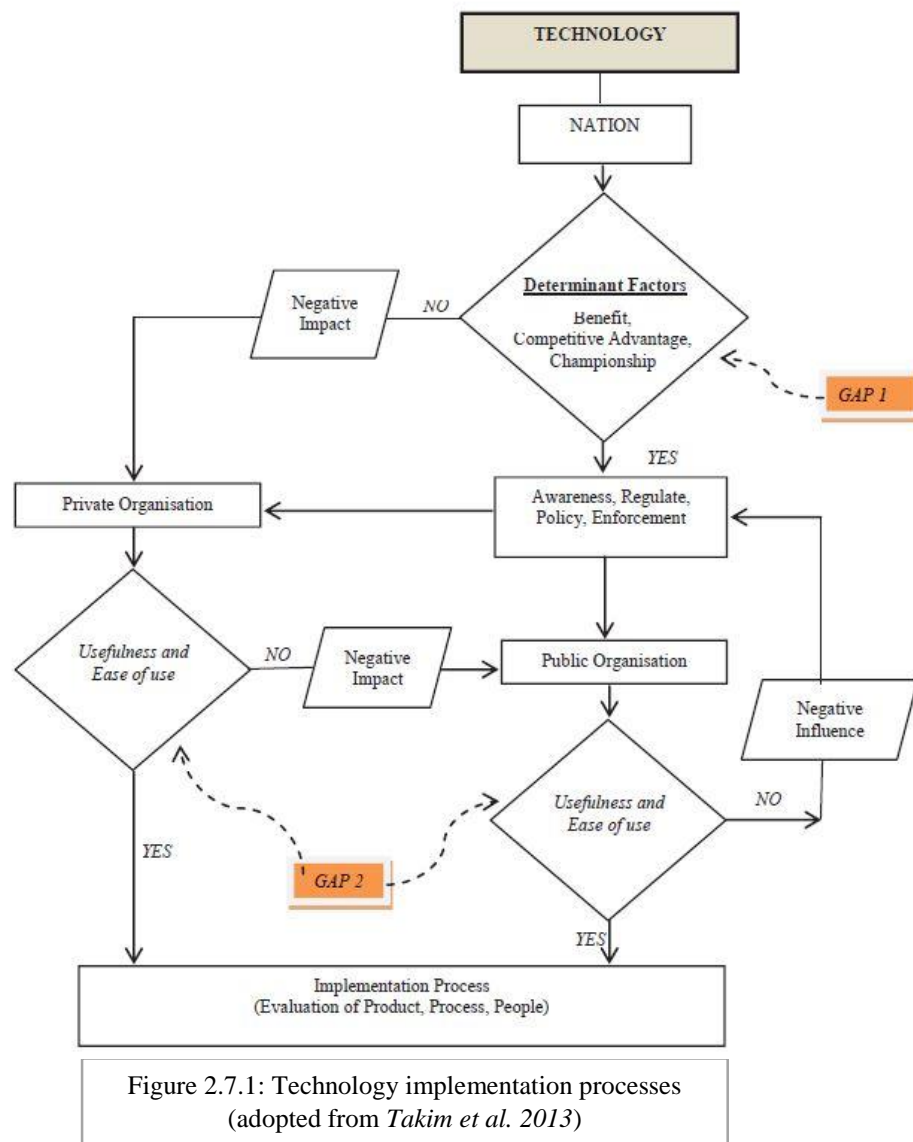
Technology acceptance factors: There are three well known factors that shall be considered during technology adoption process:

### **2.7.1 Adoption of technology**

Organizations mostly decide to accept a new technology unofficially in order to study overall aspect of that. Abukhzam and Lee (2010), stated that decision of technology adoption always will be based on benefits and economic advantages by the local and international organizations. The advantages will be from policies, regulations and standards from the industry. Suebin and Gerdri (2009) believe that due to complexity of technology processes trainings and supports are inevitable and must be taken into account for better technology adoption.

### **2.7.2 Influencer factors of technology adoption**

According to Majid et. al (2011), when new trends and technologies are being introduced to people in the market, a set of factors will impact their decisions about the mechanism and when to accept the technology. Suebin and Gerdri (2009) believe that, the decisions are based on their imagination about new technology throughout a communication, but harassed about the future changes. The entire acceptance of new technology is a process which starts with recognition and realization and go through many stages that will result a productive and functionable implementation. The influencing factors on decision making on technology adoption are awareness, evaluation, acceptance, learning and application (BTC, 2005). Awareness means the knowledge and information acquired by users about the technology's advantages and aim to explore further; analyzing the functionality, effectiveness and challenges in adoption of the technology by users is called evaluation; acceptance is when the users tend to decide either adopt or not the technology; learning phase is when users improve the capability and knowledge of technology usage in perfectly effective manner; and lastly application is when users effectively apply the technology to the business and accept the adoption. According to Davis (1989) Technology Acceptance Theory (TAM) on employee's imagination on technology effectiveness and easy use of adoption factors and it is reflected in Figure 2.7.1.



### 2.7.3 Factors Mediating Technology Implementation

According to Takim *et al.* (2013) Based on several studies, it is believed that complexity of technology adoption is very high. Gu and London (2010) stated that, in order to start the study, acceptance and determination to adopt, willingness of the organization in relation to its products, processes, and people is desired to pursue. Product subjects to a selected system's complexity and capability based on the user's requirements; process refers to the need to recheck the current work system and processes that demand alter; and people presents users and higher management involvements, awareness's, adequate trainings and supports. Khosrowshahi and Arayici (2012) stated that, in every company there are available mediation factors on technologies implementation. The intimate process of new technologies and its adoption is presented in Figure 2.2.2.1 along with the application in construction industry. There is a need of evaluation of technology's total benefits when it is rapidly growing and being introduced to the nation. It might never attract them if no benefits and positivity found at the national level. Meantime, regulations, policies, and awareness's plans will be emerged when whole processes of development and management is in favor of the nation.

Takim *et al.* (2013) stated that private and public sectors tend to adopt new technologies based on many advantages and easy implementation processes. On the other hand, when no benefits or advantages obtained by private sectors, unfavorable impacts will be on public sectors which will affect the awareness program, policies and regulations of the contemporary technologies. Author continues that, Figure 2.7.1, presents three significant factors in relation to Gap 2: by using BIM the transparency of project to all stakeholders will increase and it leads to better decision making with huge risk reduction; data accuracy and continuity throughout the project lifecycle; and to provide vital information to business agility. BIM implementation is applicable to public and private projects in different stages such as planning, design, construction, delivery and operations.

## **2.8 Conceptual framework**

UAE have been always keen to increase the number of their projects aligned with the country vision, therefore, an increase in local construction companies happened in the region. This led to complete as many projects as possible. The truth lies on what method of construction the industry is using was not satisfactory at this era where the technology hiking to the better development of project deliveries. It has been discovered in the literature review that there are many factors that challenge the current situation of construction projects in UAE. This study aims to fill the gap derived from the literature. It is assumed to highlight some factors that causes the current challenges within the industry and being the reason for unsuccessful project deliveries. Thus, this paper provides solid solutions with detail by the help of data analysis, framework proposal, and set of recommendations.

Detailed literature has been provided on understanding of current gaps in construction sector in UAE and also the use of technologies for better construction project deliveries on worldwide projects. Comprehensive details have been provided on contemporary construction tools, and methods that enhance the construction project delivery. The conceptual framework made of the key points derived from the literature that are aligned with the research objectives. Mainly the two parts are extracted; construction project deliver and construction advance technologies. Factors generated from the literature as subcategories for the construction project delivery and advance technologies. Therefore, these features are variables which shaped the conceptual framework as shown in figure 2.8.1. these variables will be generated in a form of questionnaire and the data will be analyzed through Statistical Package for Social Science (SPSS) software and with further discussions.

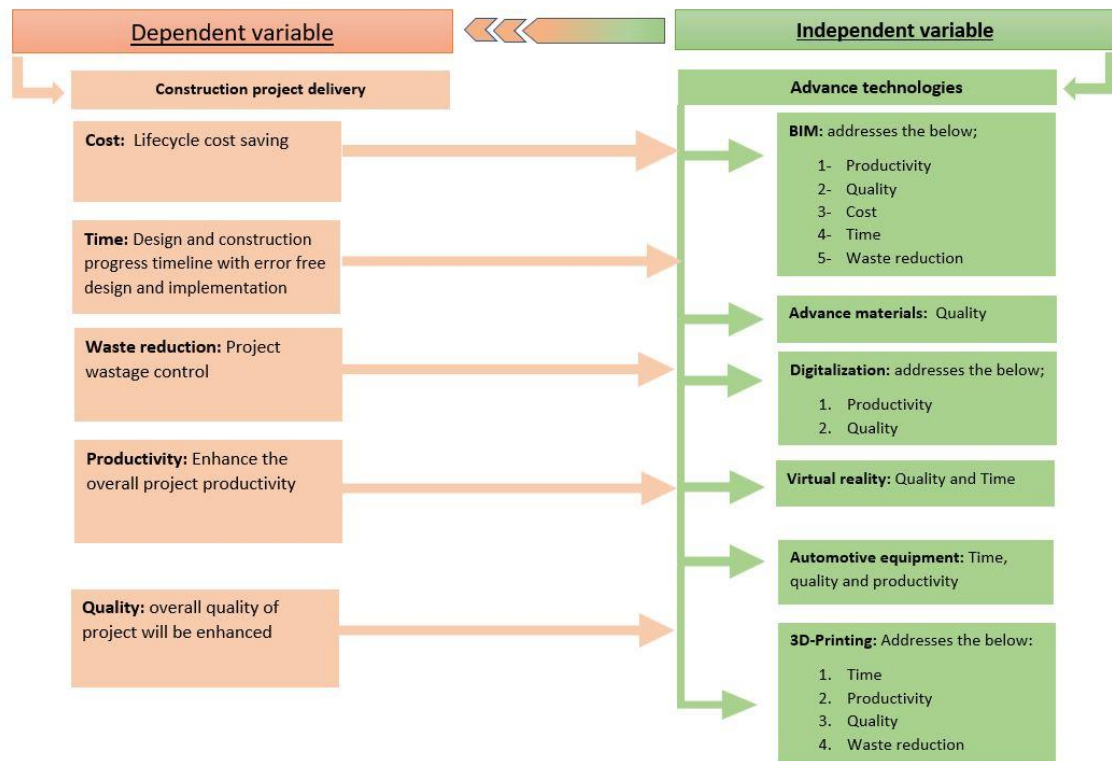


Figure 2.8.1: Conceptual Framework

## 2.9 Chapter summary

From the above literature in relation to the adoption of advance technologies in construction projects the below gaps were identified:

- How construction project delivery processes in UAE can be enhanced – **Objective 1:** “*Examine current construction project delivery processes in UAE and propose areas of improvement*” should desire this gap in the literature.
- How construction project deliveries can benefit from traditional and non-traditional methods - **Objective 2:** “*Determine the impact of traditional construction delivery tools and non-traditional tools (including BIM)*” and **Objective 3:** “*Exploring new advance technological tools and systems including (BIM) which can be used for improvement of construction sector in UAE*” shall support this gap in the literature.
- What are the new tools to increase the productivity and efficiency of construction project delivery - **Objective 4:** “*Identify new advance technological tools which can be used to enhance construction project delivery in UAE*” shall desire this gap in the literature.

- What is the influence of information sharing on succession of project delivery - **Objective 5:** “*Evaluate how construction practitioners can use BIM to manage information throughout the lifecycle of a construction project in UAE more efficiently and effectively*” should desire this gap in the literature.
- How a combined method of advanced construction tools, systems and new technologies can improve the project delivery - **Objective 5:** “*Propose an integrated framework that will comprise of advanced technological solutions for better delivery of construction projects in UAE*” should fulfil this gap in the literature.

The above objectives of this research are supporting the literature gaps that are identified. The next chapter of this research will be a detailed of research method along with complete analysis.

## **CHAPTER THREE: RESEARCH METHOD**

### **3.1 Introduction**

This chapter explains the methodology and the study approach. As the research approach is quantitative, further, the sampling method, questionnaire tool and ethical points were explained as shown in figure 3.1.1. Moreover, an exploration on how the study meet the validity and reliability requirements.

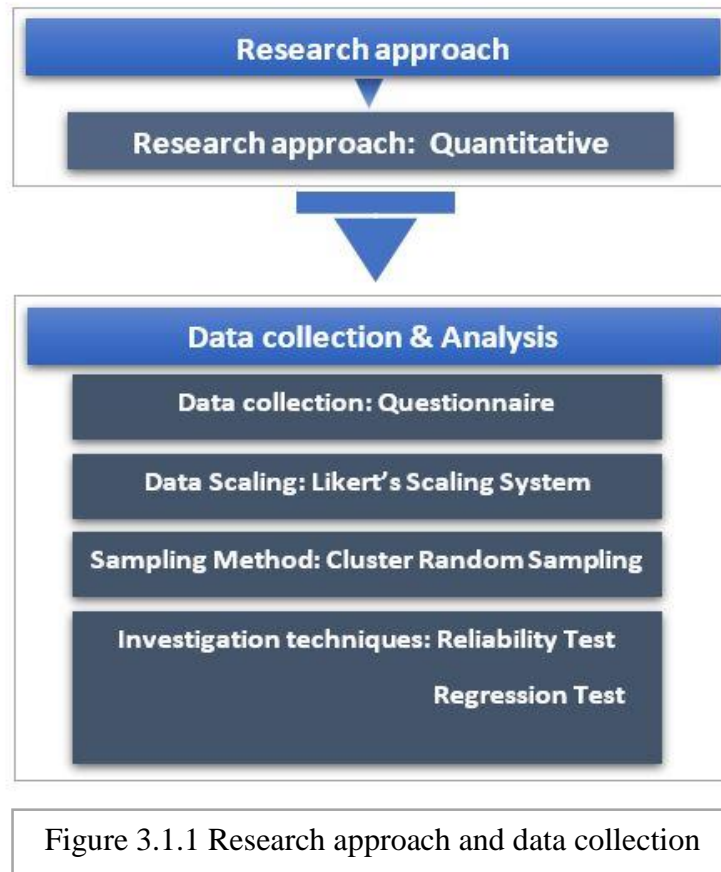


Figure 3.1.1 Research approach and data collection

### **3.2 Research background**

The research was conducted in the United Arab Emirates, with more focus on Dubai construction market. In specific in this research all construction projects were considered as large complex projects. The research participants were mostly engineers of both professions; consultants and contractors, and clients. The followings section will explore the research strategy and data collection and sampling.

### **3.3 Overview of qualitative and quantitative research methods**

Researchers find data usually in two main types, qualitative and quantitative data. Qualitative data mostly deals with quality, therefore, descriptive words used to introduce data appearance, color, texture, and other qualities (Anastasia, 2017). Furthermore, qualitative data' nature is more descriptive rather than numerical. These data are gained through observation, contrasting the quantitative data, that are measurable. Quantitative data are dealing with quantities and numbers where measuring them is possible for users. The quantitative data is more reliable and objective based on statistics that can be

generated by data analyzing. To sum up, the main difference between the qualitative and quantitative methods is their flexibility. Quantitative methods are comparatively inflexible. This inflexibility creates meaningful comparison of responses among the contributors and study sites. Nevertheless, in depth understanding of the related questions, and the perfect way to implore them, and to create the best range for responses. The main objective of having quantitative research approach for this study is to have clear results through the objective data. Based on numerical analysis of quantitative approach it has been easier to predict and expand data. Furthermore, the targeted areas of study are professionals dealing in construction sector in UAE and collecting their perception in relation with technology adoption is considered vital for this study. Analysis of such data will draw a good picture of current and future construction sector in UAE. Moreover, the next section will elaborate on the research strategy for this study.

### **3.4 Research strategy for this study**

This study represents non-experimental quantitative approach that utilized a survey as a research instrument. The survey was distributed online to the participants working or has influence in construction projects in UAE. The survey online link was distributed between the participants through the email, and other social media networks. The questions were easy to understand for the readers and addressed the key points that had a huge impact on the analysis.

### **3.5 Ethics and pilot study**

The participation in this survey was based on the willingness. The online survey link was shared with the concerned person, and he/she had the right to decide in order to participate or not. All the information's of the participants were kept confidential and the collected data will be used only for academic research purposes. The questions are made simple and easy to understand. Questions and answers addressed the main objectives throughout the survey. Also, all the questions and answers length were taken into deep consideration, therefore, answers and questions were short and understandable. This led the survey questions to consume much less time of the participants. Respondents were able to check the overall questions and answers prior to start the survey, so, they could have their own time management.

### **3.6 Data collection methods and scaling**

For this study online questionnaire was used as data collection method, questionnaire survey was sent to respondents residing in UAE via e-mail and other social networks. Participants mainly consisted of three groups; clients, contractors, and consultants. Online questionnaire was found to be the fastest and easiest way of data collection. Variables can be reflected directly on the questions that will lead in transparent data analysis without the need for rephrasing. The questionnaire was made in such a manner to avoid confusions in response rates as well as timely reduced to answer with stress-free in reading the questions. The questionnaire was classified into two categories; first category aims to collect general information of the participants such as organization, position in the company, work experience, years of involvement in managing

construction projects. Second category presents ordinal questions related to advance technologies, its application in construction projects and its impact on project delivery. The responsive method designed in the Liker's psychometric scaling system (five-points scale) where the participants were given an opportunity to highlight their level of disagreement or agreement on the statement. In order to ease the scaling of the responses, they were designed in highest scale as 'strongly agree' and the lowest scale as 'strongly disagree'. The first five questions were designed as demographic and the rest eleven questions were related to application of advance technology and the project delivery.

### 3.7 Sampling strategy

Cluster random sampling method was selected for this study as the specific group of samples in a region was targeted to enact the research of the study. The aimed sample groups were clients, contractors, and engineers residing in UAE. Project owners and client's representatives were considered from the client's group. Similarly, project engineers, BIM modelers, project managers, and other technical staffs are the sample groups from consultant's and contractor's zones. Any main influencer who was part of the main project, decision maker, and had knowledge in construction field as well as application of advance technology within the same field could be the sample frame of this study. Moreover, the sample's required size for this study was 30 to 50 and the gained response were 45.

### 3.8 Data analysis

SPSS is one the data analyzing software that currently being used by many researchers. Collected data from the distributed questionnaires are being analyzed by SPSS. Under the analysis section, the reliability and regression tests were applied on the data.

Basically, reliability test was conducted in order to identify if the scale is reliable which involved the advance technologies and methods (independent variables), such as; Cronbach's alpha that helps in verification of factors that are fit for study. Also, the variables' internal consistency check could be done by Cronbach's alpha ( $\alpha$ ). The sum of scales was considered as total score as the overall reliability coefficient for the set of items in the survey. The reliable score for ( $\alpha$ ) should be above the 0.7, the higher the score, the higher the reliability is considered. Values lower than 0.7 was considered undesirable and shall be eliminated by using the command of 'if item deleted' in the software and test will be rerun.

Moreover, regression test was conducted to check the relation of a single variable on multiple variables. This can be used to test the influence of the advance technologies on one of the single project delivery factors. Regression test was also called a prediction modeling technique that is able to testify the relation between the independent (predictor) and dependent variable (target). Also, it was used to measure the strength of influence of multiple independent variables on a single dependent variable. The coefficient for correlation ( $r_2$ ) identifies the proportionality of the variation of the independent variables. The independent variable's impact on the dependent will be revealed. For instance, if the ( $r_2$ ) value was 0.45, the conclusion will be drawn that dependent variable was 45 per cent affected by the independent variable. The below points are assumed in these tests;



- Linear relationship;
- Every variable is independent to each other;
- Variable's data have equal variances; and
- Variables are distributed equally.

Hence, the tests' findings have been critically discussed and reflected in the format of guidelines in order to skip the time related concerns and to help all the personnel working within the construction sector to run successful projects.

### **3.9 Research limitations**

All researches have their own limitation based on the region and area of the research. During this research paper the researcher had difficulties to convince owners companies' such as consultancy and contractors, where they are considered the main decision makers in application of new technologies within their own organization. Most of them were reachable as they were out for business trips and many had ignored or did not check their mail box to participate.

Moreover, inadequate experts who has experience in dealing with technologies and innovations such as BIM within their organization on construction projects was also considered as another challenge for the researcher. It was so difficult to find such experts as mentioned above, as the number of companies are so less to use latest technologies for their projects. Despite these limitations the researcher targeted the experienced engineers, and other professionals that has key influences on construction projects. The contributors are discussed in detail in the chapter five.

### **3.10 Verification and validation**

Focus group participants are considered for this study in order to provide their opinions on the presented proposed framework for better project delivery by using the latest advanced technologies, methods, tools and innovations, and materials. Moreover, the verification and validation objectives and processes are described within the chapter five. Furthermore, the results of the data being discussed in section 5.5 in chapter five.

### **3.11 Chapter summary**

This chapter discussed the variant methods of analysis on the outcomes and data. The sampling method, ethics and pilot study were elaborated. Software SPSS have been used for the derived data and further the analysis was followed in form of themes. Furthermore, a focus group participants' views were tested on the proposed framework. The framework is presented along the outcomes in chapter five.

## **CHAPTER FOUR: DATA ANALYSIS AND DISCUSSION**

### **4.1 Introduction**

This chapter include the analysis of quantitative data obtained from the research participants in relation with the application of advance technology on better construction project delivery in UAE. This chapter commence with brief explanation of participants understandings on current situation of construction market and the level of advancement in terms of technology in UAE. Further, the five key themes emerged from the analysis and followed by a brief explanation of tests result that was conducted by using Statistical Package for Social Science (SPSS) software.

### **4.2 Data analysis**

Construction project deliveries have been discussed deeply in chapter 2 in association with application of advance technologies. The knowledge gained from the chapter 2 helped to develop the theoretical framework that represent all aspects that needs to be analyzed. The previous chapter elaborated all tests and types of analysis that needs to be conducted on the findings from the literature. Based on the final result from the analysis, a framework of advance technology as set of recommendation was proposed on real construction projects for future use.

Furthermore, SPSS software was used to perform the proposed tests on the collected data. The collected data relies on the current professionals working within the construction firms in UAE, where their responds reflect the current status of the construction sector and level of adopted technology. Sampling method as cluster was used that include variant participants that has direct influence on the construction progress within the organization. Last but not least, the questionnaire delivered to the participant via online portals along with clear statement of introduction on the purpose of the survey and its significance.

### **4.3 Definition of advance technology on better project delivery**

As summarized in figure 4.3.1, 100 percent of the participants agreed that application of advance technology has a huge impact on better project delivery in UAE.

1. Application of advanced technologies are very significant to improve delivery of construction projects.

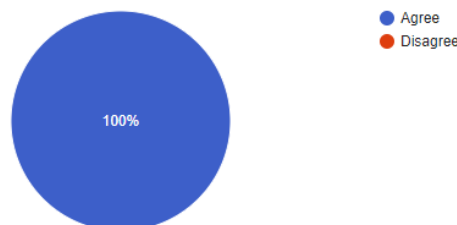


Figure 4.3.1 Application of advance technology

The result emphasize that participants have gained enough knowledge on advance technology that are usable for construction projects.

# 4.4 Participant experience

As shown in figure 4.4.1, participants' level of experience in relation to management of construction projects differed greatly. Most of the participants had a twelve-years' experience of management of construction projects, which suggest they were involved in both processes of modern and traditional construction practices therefore, their opinion for this research is vital.

5. How many years of experience do you have in construction projects management?

53 responses

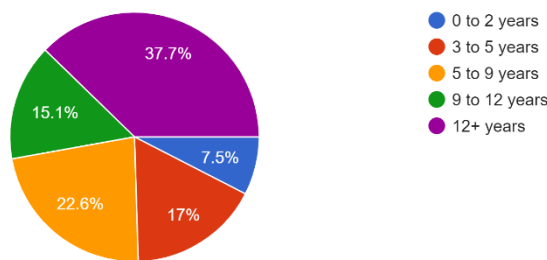


Figure 4.4.1 Years of experience

Figure 4.4.2 shows that participants involved in this study came from variant of fields that had direct impact or link to the construction projects. Most of the involved in this study mainly came from construction and engineering sector, which entailed contractors, consultants, and engineers. Furthermore, the clients and client's

2. In what sector does the main aspect of your business activities fall under?

54 responses

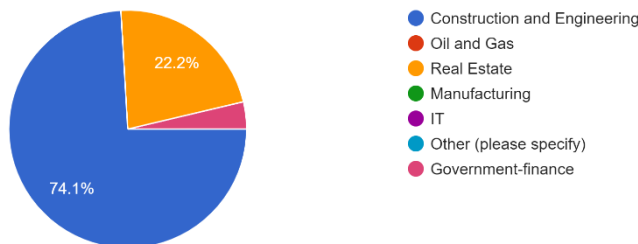


Figure 4.4.2 Aspect of business activities

representative were under the real estate section that is in the second ranking of participants. This result is aligned with the research goal as to have the most contributors in this survey from client, contractor, and consultant.

## 4.5 Job position analysis

The participants' job variety was very important to the data qualification gained in the quantitative research, elaborating the diverse opinion of experts within the construction sector. Figure 4.5.1 illustrates the percentage of the participants with variant in their job positions where consultants' and contractors' engineers contribute the most. The concern of this research was to achieve the participants from the variety of involved firms into the construction project which will validate the findings and delete the bias. The contractor, consultant, and client were the goals and the minimum are responses are achieved.

### 3. What is your current role?

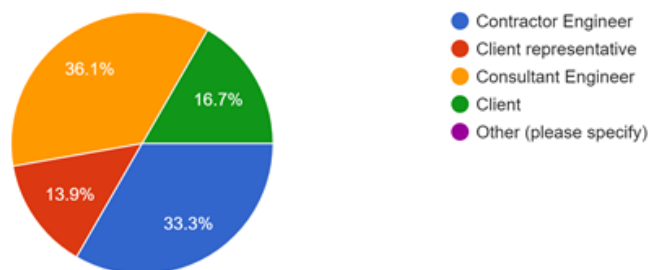


Figure 4.5.1 Current role

Figure 4.5.2 reflect the results, obtained from the analysis of the participants' job position.

### 4. How long have you worked within your sector?

51 responses

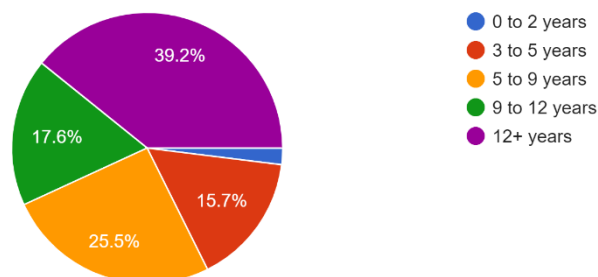


Figure 4.5.2 Number of years worked in the sector

The result shows that the highest percentage among the participants have worked more than 12 years within their sectors nearly to 40 percent of total contributors within this survey. This represents that most of those participants are at senior level or managerial level. Their response could be very significant for the further section's analysis. The overall outcome of this job position analysis elaborated that from all the related

construction sectors, high level of managerial-related job positions till the mid-level job position have been participated in this research.

## 4.6 Application of advanced technologies in the construction industry

The survey questions except demographic, have been assessed the participants' level of understanding in regards to advance technology and the current situation of construction industry in UAE. As per figure 4.3.1 that clarifies the level of effectiveness of application of advance technologies in construction projects. In conclusion, the knowledge of participants in regards to the new technologies were rated high as 100 percent of the participants agreed that application of advance technologies will lead to better project delivery. The results of all the questions are detailed as themes aligned with the objectives of the research.

### 4.6.1 Theme 1: Current project delivery processes in UAE

Prior to discuss about the tools that can enhance the project delivery in UAE, participants been asked to give their opinion on the current situation of construction industry on the level of advancement in terms of using the latest technologies within their projects. The figure 4.6.1.3 shows that 10 percent of the participants believe that construction industry is “not advance” at all while 20 percent believe that it is “slightly advance”.

6. How advanced do you find the construction industry in UAE with the latest trends such as BIM, advanced mat...f the size or nature of the projects)

53 responses

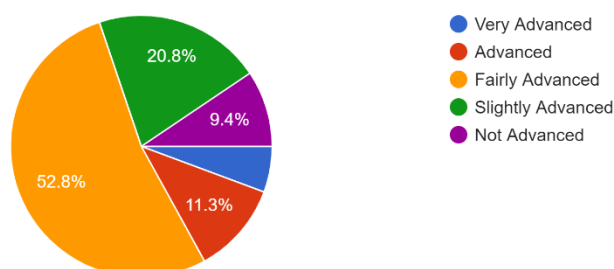


Figure 4.6.1.3 Advancement of construction sector in UAE

Figure 4.6.1.3 reveals that majority of the participants with 59 percent think that, construction sector in UAE is fairly advance. Only 5 per cent of the participants think that construction sector in UAE is “very advanced” and 11 percent believe that the sector is “advanced” in terms of using the latest technologies. From the above result in figure 4.6.1.3 it is clear that construction industry is not as advance as it needs to be. Therefore, it requires further advancement in terms of adoption of new trends to enhance the overall project deliveries.

The result gained from the figures 4.3.1 and 4.5.2 shown that participants were highly experienced within their firms along with high level of understanding from the current construction market situation and application of contemporary technology. The result from figure 4.6.1.1 can be drawn that current project deliveries in UAE is mainly by use of traditional project delivery methods.

7. Based on your experience, how many percent of construction companies in UAE still using the traditional construction methods for their projects?

54 responses

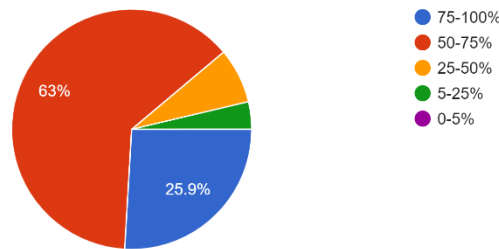


Figure 4.6.1.1 Utilization of traditional methods

Moreover, 34 respondents with the 63 per cent over all rating think that, 50 to 75 per cent of the companies in UAE still using the traditional systems for their project deliveries. On the other hand, 14 respondents with the 26 per cent over all ratings believe that, 75 to 100 per cent of construction companies in UAE still following the traditional project delivery methods. A minority of the participants with only eleven percent overall rating indicated that construction companies in UAE following traditional project delivery methods by 5 to 50 percent. Therefore, none of the participants believe that project delivery in UAE is in the range of 0 to 5 per cent. The literature chapter widely explained the traditional construction methods, therefore, current challenges of construction projects in UAE were asked from the participants as shown in figure 4.6.1.2.

The current projects delivery method is ranked highest as traditional system by the participants of the questionnaire survey. Therefore, current challenges were asked to rank from 0 to 4 as shown in table 4.6.1.1. The factors were delays, quality issues, cost overruns, regulatory issues, low productivity.

Table: 4.6.1.1: Current construction challenges in UAE

Factors	Rank from 0 to 4 (0 = lowest and 4 = Highest)				
	0	1	2	3	4
Delays	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Quality issues	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cost overruns	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Regulatory issues	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Low productivities	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

The result illustrated in figure 4.6.1.2 most of the participants believe that currently construction market is suffering a lot with project delays and cost overruns where 38 respondents ranked “Very High” cost overruns and delays as top challenges for UAE construction companies. Quality issues with 32, low productivity with 30 and regulatory issues with 29 “Very High” ratings took the 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> place. These challenges were determined and proposal of the improvement will be discussed in the Theme 2.

From the above analysis, one could suggest that there is a need for the enhancement of construction tools that have been used in the UAE construction sector.

9. Which of the below challenges occur the most in construction projects in UAE? please rate (0=very low, 4=very high).

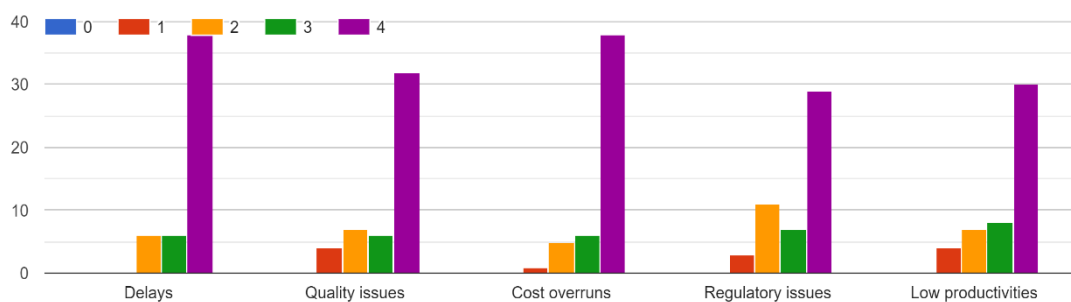


Figure 4.6.1.2 Challenges of construction projects

#### 4.6.2 Theme 2: Impact of traditional construction delivery tools and non-traditional tools

The traditional construction methods and tools were explained in the literature, therefore key points derived from the literature was asked from the survey questionnaire participants as shown in figure 4.6.2.1.

8. To what extent you agree with this term: Traditional construction methods are no longer capable to deliver complex projects on time, environmentally acceptable, at lowest possible cost, high quality, and to have easy and safe operation processes along with client's satisfaction.

51 responses

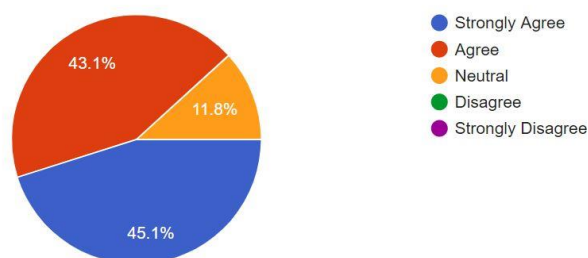


Figure 4.6.2.1 Application of traditional construction method

Respondents believed that (see figure 4.6.1.1), most of the construction projects are currently running by non-contemporary methods which leads to face multiple challenges as stated in figure 4.6.1.2. Participants were asked about the workability of traditional methods in current market situation in UAE whether these methods are capable to deliver projects (mostly complex projects) successful. Level of agreement of the participants were questioned on the statement below;

*“To what extent you agree with this term: Traditional construction methods are no longer capable to deliver complex projects on time, environmentally acceptable, at lowest possible cost, high quality, and to have easy and safe operation processes along with client's satisfaction”.*

The result surprisingly shows that, none of the participants were disagree nor strongly agree with the above-mentioned term. Thus, 23 numbers of participants strongly agreed with the terms in following 22 agreed and only 6 had neutral

14. Which of the following innovations has the most significant impact on enhancing the overall construction project's productivity?

52 responses

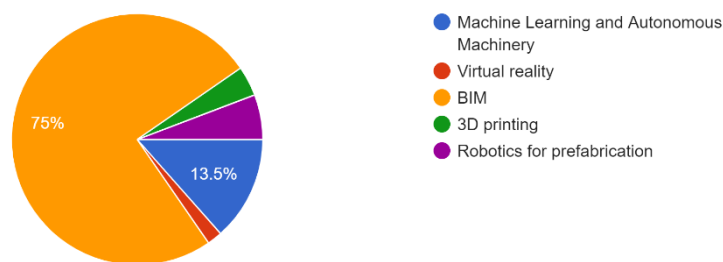


Figure 4.6.2.2 Impact of innovation

opinion. As explained also in the overview of construction projects in UAE in section 2.2 that, most of the projects in UAE are high rise and complex, therefore, a need to address all the challenges stated in figure 4.6.1.2 is required. Moreover, participants were asked on factors that has high positive impact on project delivery in UAE. The figure 4.6.2.2 illustrated that application of BIM has the highest impact to address the overall project delivery. 39 number of participants (75%) think that using BIM is highly significant to enhance construction project's overall productivity on the other hand only 7 numbers of participant think that machine learning and autonomous machinery could improve the overall construction productivity.

From the above results the conclusion can be drawn that it is not only BIM that can benefit construction sector, meanwhile emerging other technologies will significantly increase the overall project delivery. Furthermore, participants believe that virtual reality, 3D printing, and robotics has less impact on construction project delivery. This result shows that there is inadequate knowledge of these innovation within the construction practitioners. Meanwhile the literature elaborated the



benefits of the above-mentioned innovations in detail as for example the virtual reality has significant impact in design stage that could satisfy clients on having a proper reality image of their projects in advance. This could mean that some of the participants did not understand what are the benefits of these innovations to the construction project delivery. Even though the majority of the participants have agreed with the term mentioned in figure 4.3.1.

#### 4.6.3 Theme 3: Advance technological tools and systems including (BIM)

Construction practitioners were willing to share knowledge and information throughout the work progress. But since the digitalization tools were being used very less at construction site it made it very difficult for them to transfer information in order to reduce mistakes, reworks, and RFIs. Which leads to a huge cost overrun. Questionnaire participants were asked to rate from not important to extremely important the accurate information sharing and its success factor on better project delivery. The figure 4.6.3.1 shows that majority of the participants 64% believed that, accurate information sharing is extremely important to the success of the project delivery. While 36% believed that transparent and correct information sharing is important to the success of the project delivery. The outcomes illustrate that none of the participants believe that, accurate information sharing across the project lifecycle is less important or fairly important or not important.

12. How important you consider accurate information sharing across the project lifecycle in succession to the project delivery?

52 responses

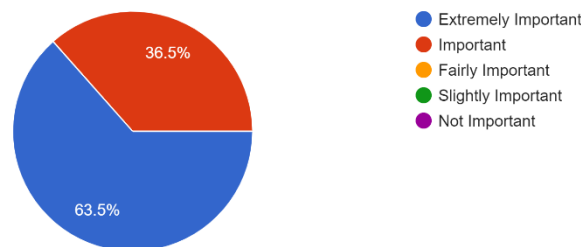


Figure 4.6.3.1 Information sharing

It is being explained in detail in the literature review section that sharing information accurately requires a reliable platform. Digitalization and using software's such as BIM will help the project to have a sustainable platform for the use of transferring the information. The result from the figure 4.6.3.1 elaborates that questionnaire participants understood very well the significance of information sharing between the project stakeholders throughout the lifecycle of the project. Russell D (1999) stated that, *"building on the rapid advances of computer supported systems and information technology in general, the power and benefits of documenting and integrating all of the project life cycle phases became more evident and more important"*.

A proper documentation within the project lifecycle enables the shareholders to apply system thinking and to create, plan, and manage the project in all stages.

As part of the advancement of construction projects, the materials that being used in such projects should be also advanced in all aspects such as, sustainability, health related issues, cost savings, durability, and etc. Therefore, according to figure 4.6.3.1 participants were asked to show their level of agreement on the usage of advance material and its significance within construction projects in UAE. Still the industry does not take into consideration to optimize the cost for life-cycle of materials in UAE. The results from figure 4.6.3.1 reveal that most of the survey participants (93%), believe that construction companies in UAE shall use advance material for their projects.

11. To what extent do you agree that construction companies in UAE shall use advanced materials for better quality of their project delivery that is capable to; reduce the life cycle cost, high recyclability, high energy efficiency, and improved health wellbeing.

53 responses

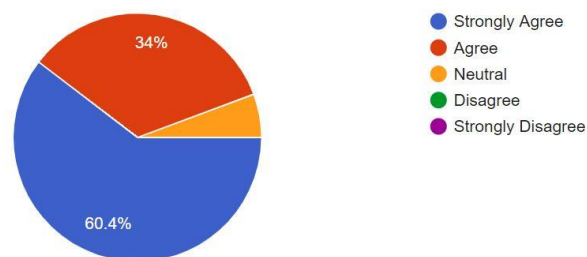


Figure 4.6.3.2 Use of advanced materials

The result revealed that 60 per cent of the participants “strongly agreed” that advanced materials shall be used for construction projects in UAE, following to 34 per cent “agreed” on the above-mentioned term. Meanwhile only 7 percent stated “neutral” where unexpectedly the result shows that none of the participants “disagreed” or “strongly disagreed” with the application of advance materials in construction projects.

#### 4.6.4 Theme 4: Enhancement of construction project delivery in UAE

The literature review section 2.4.2 explored the new tools and methods that enables companies to have better project deliveries. Therefore, questions were asked to select the innovation with high impact on better construction project delivery in UAE. According to figure 4.6.2.2, BIM was rated the best innovation to be increase the overall project productivity. Thus, figure 4.6.4.1 challenged questionnaire participants to choose one of the below mentioned innovations in figure 4.6.4.1 that can be adopted effectively by construction industry in UAE.

15. From the below innovative applications of 'Advanced Technology' which, in your opinion, is the most significan...adopt by construction industry in UAE?

53 responses

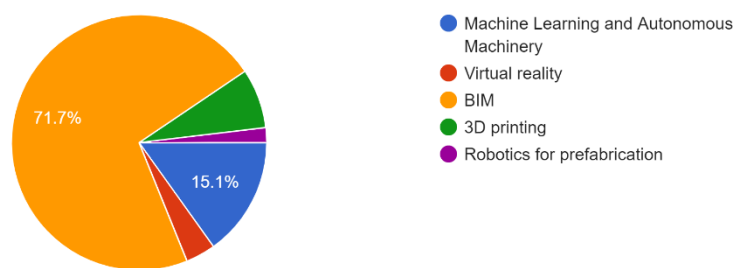


Figure 4.6.4.1 Innovative applications

The results illustrated that BIM is one of the best choices by the participants with 72 percent rating to be adopted by the construction sector in UAE. Followings the autonomous machinery with 15 percent is ranked by the participants that can be effective to adopt by the construction industry in UAE. 3D printing with 7.5 percent, virtual reality with 3.8 percent and robotics with 2 percent were ranked accordingly.

Based on the above analysis, the conclusion can be drawn that current construction industry uses mostly the traditional methods as shown in figure 4.6.1.1. However, Dubai market in terms of social life and spreading information across the city is highly active, smart Dubai government is a collaboration platform between the private sector and government. This shows that the city is moving towards digitalization by using the new technologies. Participants knowledge in technology is moving forward daily by being familiarized with innovations that were being used across the city such as, roads, trains, and other fabrications factories. Figure 4.5.1 shows that the participants came from the variety of fields, therefore, most of them agree according to figure 4.6.1.1 that, BIM as an innovation can be very beneficial to construction industry in UAE.

Moreover, there were many obstacles in the adoption of the advance technologies. The following section will discuss all the challenges from the participants point of view that happens during the technology adoption such as BIM.

#### 4.6.5 Theme 5: Use of BIM in managing construction data

The current challenges of the construction industry were illustrated in table 4.6.1.1 and following by participants opinion on the same that shown in figure 4.6.1.2 showed Delay and the cost over runs were the top two challenges. Therefore, participants were asked to rate (from 0 as very low to 4 as very high) which one of the challenges could be resolved improved by adopting the advance technologies within the construction sector in UAE.

10. In your opinion which of the following problems can be resolved or improved by adopting advanced technologies in construction projects in UAE? please rate (0=very low, 4=very high).

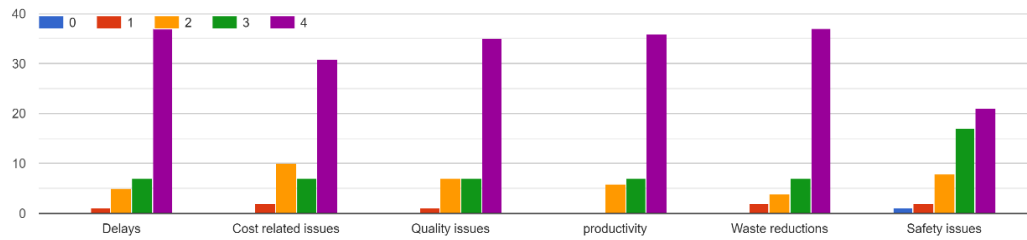


Figure 4.6.4.1 Impact of advanced technologies

The areas that technologies were aimed to improve have been presented in figure 4.6.4.1 and participants answers were perfectly matching the theory as explained in the literature review. Delays and waste reduction were rated 4 = very high with 37 numbers of participants. Where 4 = very high rate for productivity 36 participants, quality issues 35 participants, and safety issues 21 participants.

Furthermore, five challenges of technology adoption were derived from the literature such as industry resistant nature, overall implementation cost, government inadequate support, quality and security issues of data, and lack of skillful resources. As shown in figure 4.6.4.2, the questionnaire participant's level of agreements in relation to the above-mentioned challenges on the adoption of

16. To what extent do you personally agree that the following challenges are associated with application of the 'advance technologies' in the construction industry within UAE?

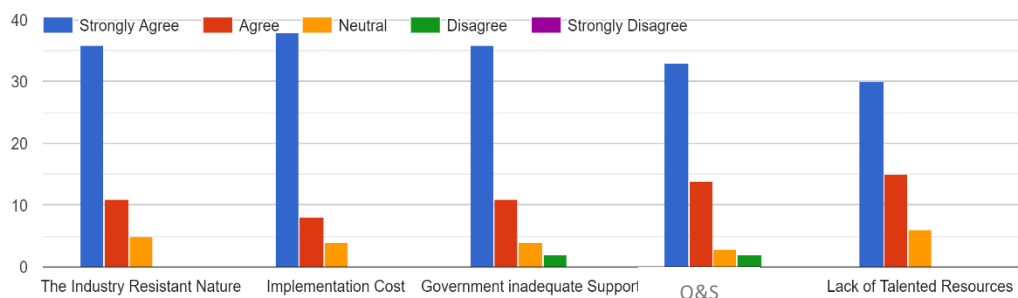


Figure 4.6.4.2 Challenges associated with application of advance technologies

advance technologies were asked. In accordance to the figure 4.6.4.2, the implementation cost ranked as the highest barrier for the technology adoption as 38 participants “strongly agreeing” that associated cost with the application of advance technology will remain one of the main challenges. In the following to the participants view of “strongly agreeing”, the industry resistant nature factor received 36, government inadequate support with 36, quality and security of data with 33, and lack of resources received 30. This result shows that participants were aware of the challenges and the benefits of technology adoption in construction sector, therefore, this knowledge will help the industry to effectively adopt the required technologies along with the analyzation of all upcoming risks prior adoption.

The figure 4.6.4.2 illustrates that none of the participants disagreed nor strongly disagreed with the association of the above-mentioned challenges with adoption of advance technology. From this analysis conclusion can be drawn that all the above-mentioned challenges were valid shall be taken into consideration prior application of any technology within the industry.

## **4.7 Data analysis by SPSS**

### **4.7.1 Quantitative research approach**

The research aimed to adopt quantitative research in order to collect data in statistically form in relation to the project delivery improvements and technology adoption. In order to obtain the result accuracy, this approach could be significant to use. The mathematics and statics were used to improve the result between independent and dependent variables by the use of numerical data. The obtained data from the questionnaire was tested by the SPSS software. Three main tests were applied on data. Reliability to check the dependency between the variables of independent variables (IV) and DV dependent variables. Regression is to identify the influence of many independent variables on a single DV.

The independent variables were the advance technologies and the dependent variables construction project delivery. Prior to conduct tests, below assumptions were taken into consideration:

- Data have a linear relationship
- Each variable is independent of each other
- Data of variables have equal variances
- Variables are normally distributed

### **4.7.2 Test findings**

Data is collected from the questionnaire and were tested in various techniques in the SPSS software. The standard guidelines on the conducting the tests were mentioned and findings will be elaborated in detail. Further the results were discussed in the discussion section of this chapter.

### 4.7.3 Reliability test

As of the first test to check the reliability between the independent and dependent variables, Cronbach's alpha ( $\alpha$ ) as internal consistency of the overall variables gives a total score that should be above the 0.7 or higher to be consider reliable. Results below than 0.7 shall be considered as deleted items and cannot be included in future tests.

Table 4.7.3.1 Reliability statistics

Reliability Statistics	
Cronbach's Alpha	N of Items
.952	26

The internal consistency of all the items were tested as shown in table 4.7.3.2 where reliability test applied on all the items of DV and IV.

Table 4.7.3.2  
reliability test  
on items

Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
challenges of const	87.90	176.690	.874	.948
challenges of const	88.12	169.260	.867	.948
challenges of const	87.83	180.245	.782	.949
challenges of const	88.17	173.695	.741	.949
challenges of const	88.15	169.578	.879	.948
tech resolves prob	87.95	175.148	.871	.948
tech resolves prob	88.27	172.001	.829	.948
tech resolves prob	88.00	175.400	.824	.949
tech resolves prob	87.88	177.360	.843	.949
tech resolves prob	87.95	176.498	.773	.949
tech resolves prob	88.37	176.688	.611	.951
advanced material	87.93	185.720	.518	.952
advanced material	87.83	189.245	.377	.953
advanced material	87.85	181.378	.669	.950
advanced material	87.78	183.226	.791	.950
advanced material	87.71	185.712	.592	.951
advanced material	88.17	187.145	.272	.955
advanced material	87.85	181.178	.899	.949
advanced material	88.02	183.824	.390	.954
innovationon productivity	87.93	185.370	.367	.953
Technology to adopt	88.02	184.524	.349	.954
challenges of advance technologies	87.88	179.960	.786	.949
challenges of advance technologies	87.78	186.176	.482	.952
challenges of advance technologies	87.90	178.840	.695	.950
challenges of advance technologies	87.88	184.260	.575	.951
challenges of advance technologies	88.07	184.220	.482	.952

Moreover, all the items were tested and table 4.7.3.2 reveals the results that, all items were considered reliable and have internal consistency, therefore none of the items shall be deleted as the Cronbach's alpha ( $\alpha$ ) is above 0.7 for all the items.

To conclude, all data used for the analysis in this chapter were counted reliable and have the internal consistency also, aligned with the research objectives.

#### 4.7.4 Regression test

This test is a prediction modeling technique that evaluate the relation among the independent and dependent variables, as well as the impact of multi independent variables on a single dependent variable. Coefficient of correlation ( $r^2$ ) determines the relation of the various independent variables, for instance, value  $r^2$  found to be 0.48 that means the independent variable has 48 per cent influence on the dependent variable.

**Table 4.7.4.1: Regression test on one DV factor and three IV factors**

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.902 <sup>a</sup>	.814	.800	1.82199

a. Predictors: (Constant), innovationon productivity, advmaterial, rentchallenges, resolvecurrentchallenges

The dependent variable as (current challenges) alongside with predators as independent variables were tested in order to measure their relation and influence on each other. Table 4.7.4.1 shows that R square is 0.80, this result shows that dependent factor 80 percent been influenced by independent factors.

**Table 4.7.4.2: Regression test one DV factor from three IV factors**

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.902 <sup>a</sup>	.814	.800	1.82199

a. Predictors: (Constant), innovationon productivity, advmaterial, resolvecurrentchallenges

Further another dependent factor was tested with the same independent factor to determine the relation and their influences. Table 4.7.4.2 illustrates that R square result is 0.161 which means the independent factors have 16 percent influence on the dependent variable that been tested on SPSS. Moreover, the final part of this section illustrates, a test result that is conducted on global independent with global dependent.



**Table 4.7.4.3: Regression test one DV global and IV global**

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.902 <sup>a</sup>	.814	.800	1.82199

a. Predictors: (Constant), innovationon productivity, advmaterial,

resolvecurrentchallenges

THE global independent factors were tested regression on global dependent to measure the influence percentage of overall independent on the dependent variables. Table 4.7.4.3 shows that R square result is 0.704 which clarifies that independent variables have 70 per cent influence on the dependent variables.

All the conducted tests result by SPSS on the data that was collected by questionnaire survey were reliable and have inter-consistency. Moreover, the independent variables highly influenced the dependent variables. These tests result assures that the research analysis is valid and collected data is reliable.

## 4.8 Further discussion on SPSS findings

Conceptual framework was structured by the derived variables from the literature review where the items were arranged to form into questionnaires. The collected data from the questionnaire were then discussed and analyzed into Themes from one to five. Furthermore, the same collected data been tested in the SPSS software. Two key tests were conducted as reliability and regression in order to check the inter-consistency between the variables and to check whether they were reliable or not. Thus, regression tests were conducted to measure the influence percentage of independent variables on the dependent variable. Tests results made it easier to analyze the influence of advance technologies on the construction project delivery. This section will briefly interpret the test results into meaningful information and provide further explanation on the findings gained in the previous section.

Firstly, in accordance to table 4.7.3.2 the result of the reliability test represented with all IV and DV with 0.955, 0.954, and .0953 as the highest scores for the factors of independent variable advance material and innovation on productivity. The high result in Cronbach's alpha assures that extracted items were highly reliable and also suggests on playing a key role on delivering better construction projects. Furthermore, as dependent variables scored Cronbach's alpha as 0.949, 0.948, 0.948 for current challenges. These results prove the reliability and dependability of the data that have extracted for the illustration of each factors and to suggest to importance of current challenges of construction industry, which is vital for this research to accept all as gaps and propose a framework. Thus, the results elaborate that all the items have passed the analysis with exceeding the range results. This means that the information derived from literature is acceptable and highly reliable.

Secondly, the regression test that illustrate the influence of advance technologies on the construction project delivery was conducted. The results accordance to table 4.7.4.1 shows that one of the dependent variables as current challenges of construction sector is being influenced up to 80 per cent, by the independent factors such as innovation and productivity, advanced materials, and the advance technologies that resolve the current challenges of construction projects. Same independent variables were tested on another dependent factor where according to table 4.7.4.2 only 16 percent influence of independent factors on dependent factor is observed. Moreover, the global (total factors) of dependent tested vs total factors of independent. As shown in table 4.7.4.3 dependent global factors were influence up to 70 percent on average by the independent global factors. In another word, advance technologies have total influence of 70 percent on the construction project delivery in UAE.

To conclude, the obtained data from the questionnaire participants were reliable and most of the independent factors of “advance technologies” have high influence on the dependent factors of “construction project delivery”.

## **4.9 Chapter summary**

Data were collected from the literature review and further questionnaire were developed based on the key findings and distributed among the construction practitioners for their responses. This chapter discussed the outcomes that derived from the respondent’s views. Their opinions on the key findings were critically analyzed and discussed. Further the same data has been analyzed by the software SPSS in order to check the reliability and regression. Lastly, a discussion has been presented on the final outcome. The next chapter will present an integrated framework for better project delivery with the targeted area (UAE).

## **CHAPTER FIVE: PROPOSED FRAMEWORK DEVELOPMENT AND VERIFICATION**

### **5.1 Introduction**

This chapter focuses on the validation and verification of the proposed framework. In addition, this chapter assesses the practicability, effectiveness and suitability of the proposed framework. All aspects of the framework are presented and discussed in alignment with the respondent's opinions and research objectives.

### **5.2 The need for the proposed framework**

Most of the clients aim to adopt methods and technologies that complete their projects at possible lower cost, good quality, and short in duration. Hence, planning and schedule management tools are important and require immense focus prior starting the work. Design automation processes, autonomous machineries, off-site fabrications, and latest construction methods enable clients to address better the market demands in relation to the time.

Construction work progress is a combination of different activities that results in completion of the project. These variant tasks such as; mechanical works, electrical works, civil works, fireworks, documentation, stakeholders' management, submittals, subcontracting works, and etc. are able to be done in parallel and help the project to move forward effectively. The challenges of the construction sector in UAE is not only related to one activity but all the activities are somehow included. The literature review chapter elaborated the current industry's challenges and the same further were verified by the participant's questionnaires. Multiple advance technologies were explored that has separately specific benefits to the construction projects. Moreover, some challenges require further solutions such as contemporary construction methods, contracts, management, and procurement. For instance, according to the survey result in figure, 4.6.1.2 delay is one the main challenges, the root for such a challenge is vital to be identified and related remedies to be proposed. Delay has variety of causes in construction projects, it could be from inappropriate planning, inappropriate implementation, inadequate information sharing, inadequate resource planning, etc.

The framework consists of construction advance tools, innovation and technology, contemporary methods and advance materials. Figure 5.2.1 illustrates the framework's areas that will be covered in detail.

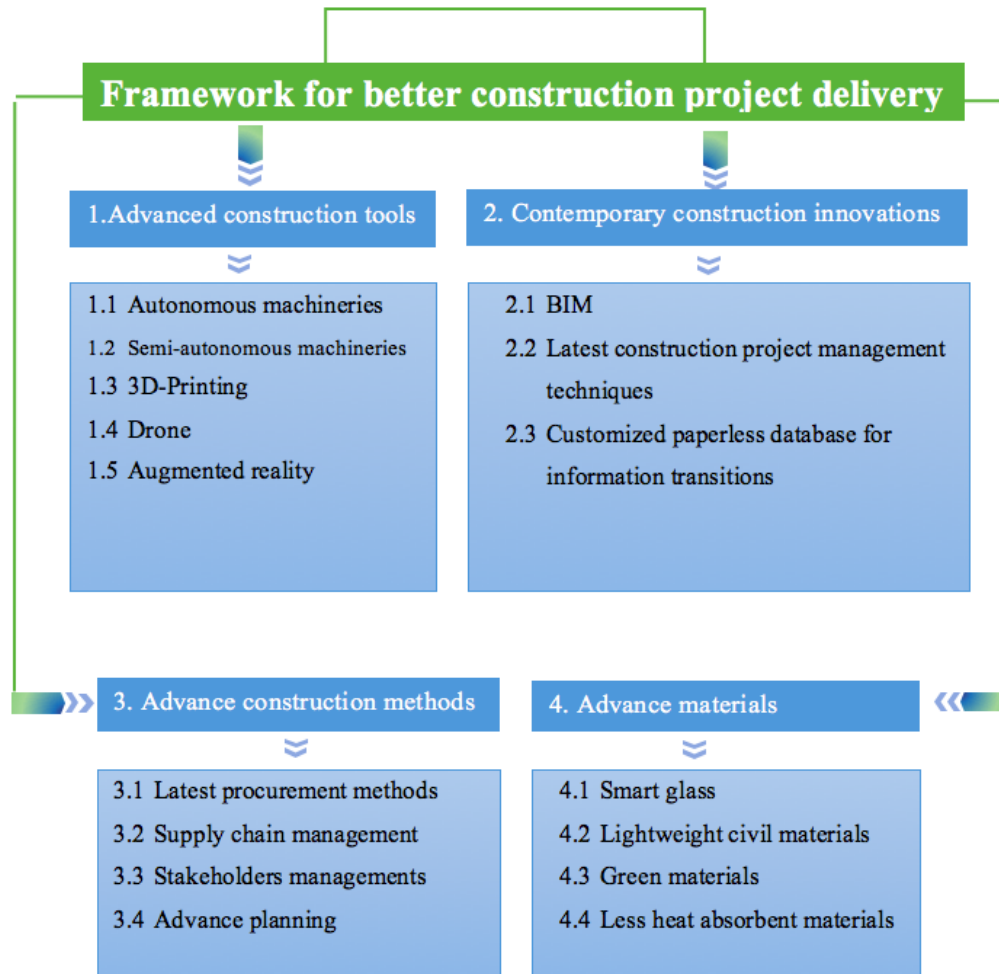


Figure 5.2.1 Proposed framework for better construction project delivery

This framework tends to address the construction projects' main challenges such as delays, cost overruns, quality issues, low productivities, and the regulatory issues. Such solutions are the current need of construction sector to overcome its challenges. As part of the objectives of the research, it is to identify the current gap within construction industry and propose an integrated framework that consists of advance technologies in order to fill the gaps and enhance overall productivity of the construction projects in UAE. The framework could positively impact the construction project progress from design stage till the operation and maintenance. Furthermore, the framework had been presented among the focus group and their opinion were elaborated and analyzed. Verification and validation objectives, processes and results will be discussed in the following sections.

### 5.3 Verification and validation objectives

The verification and validation are considered as vital parts of the framework proposal as it requires to be verified by the other professional participants views in construction projects in UAE. The verification and validation had been carried out in order to obtain the following objectives:

1. Ensure that the proposed framework can be used to address the current challenges of construction sector in UAE;
2. Validate the applicability of the framework in real construction projects in UAE;
3. Verify the framework's aims; and
4. Ensure the suitability of the framework in the current market situation.

## 5.4 Verification and validation process

The focus group were used as verification process for this framework. A twenty-minutes session was presented to the group of professional engineers involved in different types of construction projects. All the participants were UAE based construction practitioners. The validation questionnaire comprised of Likert scale and variables, see appendix 2. Each variable in the validation was organized as described below.

- **Strongly agree** - participants accept the terms were explained.
- **Agree** - participant generally believes the principle in relation to the subject was asked.
- **Neutral** - participant was unsure about the subject and unable to confirm or deny the subject that being questioned.
- **Disagree** - participant generally did not agree with the principle that being questioned in relation to the subject.
- **Strongly disagree** - participant was completely opposing on the terms were explained.

### Respondents

The framework was validated by the construction practitioners through focus group. The validation questionnaire was used to address the followings:

- Advanced construction tools;
- Contemporary construction innovations;
- Advance construction methods;
- Advance materials;
- Applicability of the framework;
- Suitability of the framework; and
- Framework is able to address the current challenges of construction sector in UAE.

Respondents were all from construction sector based in UAE. The total number of participants were nine. They came from variety of roles in construction sector. Most of them were senior managers in architectural and civil engineering and some at mid-level mechanical and electrical positions.

## 5.5 Verification results

Most of the participants suggested that the proposed framework can be used to address the current technological and project delivery challenges in UAE. Some noted that, the application of proposed framework requires a huge support from the top management and government. On the other hand, some suggested that without the training and adequate knowledge, it is difficult to implement the proposed framework. Moreover, the framework workability is based on the resources that could be used to run the system. It was, therefore, not surprising that the key categories that emerged from the verification process were arranged and grouped within the four main sub-categories of 'advanced construction tools', 'contemporary construction innovations', 'advance construction methods', and 'advance materials'. These categories were found to have interconnection and hence they were reported together. The following table 5.5.1 summarizes the key variables that were presented to symbolize the application of the advance technologies in the UAE construction sector.

**Table 5.5.1 verification result on effective factors on application of advance technologies for better construction project delivery**

Questions		Respondent score										Average	
		1 strongly disagree and 5 strongly agree										Score	%
<b>ADVANCED CONSTRUCTION TOOLS</b>		Participants starts from A to I										<b>4.36</b>	<b>87%</b>
		A	B	C	D	E	F	G	H	I			
1	Autonomous machineries	5	5	4	5	5	5	4	5	5		4.78	96%
2	Semi-autonomous machineries	4	4	4	4	5	5	5	4	4		4.33	87%
3	3D-Printing	5	5	4	5	4	4	4	5	5		4.56	91%
4	Drone	4	4	3	4	4	4	4	4	4		3.89	78%
5	Augmented reality	4	4	4	4	4	5	5	4	4		4.22	84%
<b>CONTEMPORARY CONSTRUCTION INNOVATIONS</b>												<b>4.85</b>	<b>97%</b>
1	BIM	5	5	5	5	5	5	5	5	5		5.00	100%
2	Latest construction project management techniques	4	5	4	5	5	5	4	5	5		4.67	93%
3	Customized paperless database for information transitions	5	5	5	5	5	5	5	5	4		4.89	98%
<b>ADVANCE CONSTRUCTION METHODS</b>												<b>3.53</b>	<b>71%</b>
1	Latest procurement methods	5	5	5	5	5	4	5	5	5		4.89	98%
2	Supply chain management	4	5	5	4	4	4	4	5	5		4.44	89%
3	Stakeholders managements	5	4	5	5	5	5	5	4	5		4.78	96%
4	Advance planning	4	4	4	5	5	4	5	4	5		4.44	89%
<b>ADVANCE MATERIALS</b>												<b>3.58</b>	<b>72%</b>
1	Smart glass enhance the quality of work	5	5	5	5	5	5	5	5	4		4.89	98%
2	Lightweight civil materials	5	5	5	5	5	5	5	4	4		4.78	96%
3	Green materials	5	4	4	4	5	5	5	5	5		4.67	93%
4	Less heat absorbent materials	5	5	5	5	5	4	4	4	5		4.67	93%

### **5.5.1 Advanced construction tools**

As observed from the above verification results, the autonomous machineries have been rated the highest ninety-six per cent among the other factors such as semi-autonomous machineries, 3D-printings, drones, and augmented reality. Based on the weather condition mainly in UAE practitioners mostly prefer the machinery work rather than human. Machineries produce effective results under different weather conditions. The participants considered vital 3D-printing for small scale projects, where the productivity is assumed very high with maximum efficiency and less wastage. During the focus group discussions, the participants highlighted that, merging the autonomous machineries with other advanced tools and innovations such as (BIM) will increase productivity within construction projects. For instance, excavation works in construction projects could be done in shorter time with machinery than human power. Therefore, planning, logistics and management of the project could be by human sources with the use of the latest software's and methods. This is also in alignment to the research objectives that integrated framework is required to enhance the overall project productivity.

### **5.5.2 Contemporary construction innovations**

The verification results show that 100 per cent of the respondents agreed with the application of BIM as part of this framework that could play a vital role on the overall productivity enhancement of the construction project in UAE. BIM as the latest trend require immense trainings in UAE as the professionals argued that inadequate knowledge on BIM will lead to unexpected results. Furthermore, some commented that BIM requires huge support from the government and top management. On the other hand, ninety-eight per cent of the participants believed that, in case companies denying to adopt BIM for their projects, a customized database based on the latest technologies and software's in the market could also be very beneficial for better delivery of construction projects. Furthermore, 93 per cent of the participants believed that construction management techniques which professionals have gained through years of experiences could also help the project to decrease the errors and to avoid reworks during the work progress. During the discussions, participants also suggested that BIM and latest construction management techniques could be combined and used at the same time in order to assure that enhancement on the productivity of the overall project. As pointed out in the literature review, BIM has variety of advantages and at same time has challenges during the implementation. Participants pointed out that the industry's professionals shall be aware of such challenges prior implementation of BIM. As of the research objective to explore the advance technology tools that improves the project delivery, literature review has been pointed out many details about the BIM, it has been identified by researcher as a key innovation that enhances productivity in construction projects.

### **5.5.3 Advance construction methods**

It could be observed from the verification table 5.5.1 that participants identified the importance of the latest procurement methods as 98 percent of them agreed that it would benefit the construction project delivery. In UAE, construction practitioners mostly tend to use the latest trends, tools, and methods available in the market. They believe that updated versions of such methods will address to

current challenges and it will enhance the project delivery. Stakeholder management was considered vital factor by the participants in success of project delivery. Ninety-six percent of the participant agreed on the stakeholder management knowledge shall be spread to the project teams and implementation to be done accordingly, “this practice will improve the project delivery” they said during the presentation. An equal recognition of the supply chain management and advance planning was identified in this verification where eighty-nine percent of participants agreed the effectiveness of both factors on better construction project delivery. It could be concluded that all the factors are reliable and important to the success of the project and each has its own effect on the project. Therefore, application of all factors will play a positive role on better project delivery.

#### **5.5.4 Advance materials**

In addressing the advance material section, all the participants considered the quality of material as important factor. Smart materials are emerging into the construction market where the application of such products will lead to user’s satisfaction and the society will go green. As Dubai government’s vision to increase the environmentally friendly materials in construction, practitioners aim to mover their projects in alignment to the government vision. Using the smart and green materials will help the project in terms quality, time, and cost; receiving authorities’ approvals faster, quality of work will satisfy the clients and users, and also will lead to energy savings. As exterior (façade) of the buildings in Dubai is mainly consist of glass, therefore, ninety-eight percent of the participant have agreed to use smart glass in projects in UAE. The usage of such glass will lead to energy savings and environmentally sustainable. Lightweight materials will decrease the total load of the project and it will lead to cost savings. Ninety-six percent of the participants believed that these materials shall be used for the projects in UAE as it brings cost savings to the clients. Furthermore, other factors such as materials with less heat absorption and green materials have been rated equally by the participants with ninety-three percent. All the factors considered vital for better project delivery and the same have been discussed with the participants.



## 5.6 Validation results

The following table 5.6.1 represent the assessment of the proposed framework on better project delivery by using advance technology and latest construction methods and materials.

**Table 5.6.1 Respondents assessment on effective factors on application of advance technologies for better construction project delivery**

Questions		Respondent score										Average	
		1 strongly disagree and 5 strongly agree										Score	%
ADVANCED CONSTRUCTION TOOLS		Participants starts from A to I											
		A	B	C	D	E	F	G	H	I			
1	Framework is able to address the current challenges of construction sector in UAE.	5	5	5	5	5	5	5	5	5	5.00	100%	
2	The framework is applicable in real construction projects in UAE.	4	5	4	5	5	5	4	5	5	4.67	93%	
3	Advanced construction tools	5	4	5	5	5	5	5	5	4	4.78	96%	
4	Contemporary construction innovations	5	5	5	4	5	5	5	5	5	4.89	98%	
5	Advance construction methods	5	4	5	5	5	5	4	4	5	4.67	93%	
6	Advance materials	5	5	5	5	5	5	5	5	4	4.89	98%	
7	The framework is suitable to use in the current construction market situation.	5	5	5	5	5	5	5	5	4	4.89	98%	

## 5.7 Framework implications

As project has many main categories where each category has a sub-category. Adding the latest methods, tools, systems, skills, etc. to these categories will positively impact the project delivery. Adding advance technologies and latest methods and to train the staff on how to run the system under each category, then a person is required as a leader in order to manage the whole system. The leader shall be highly qualified with knowledge about all the categories and section of the project in order to be able to manage the whole system. Running such a system will have huge impact on better project delivery. The successful implementation of each part of this framework on real projects depends on points as bellow:

- Trainings;
- Skillful staff;
- Risk assessment prior application;
- Market demand;
- Cost assessment; and
- Support from the top management.

Trainings are required to run the system in a popper manner in order to reduce the number of errors and reworks. Skillful staff should be hired with experience in order to deal well with the upcoming challenges. One of the key factors of successful application of this framework is to identify all the related risks prior the application. This will help the top management to be aware of the upcoming risks and to have remedy at the time it is needed. Implementation cost shall be estimated and based on the project and its type the decision shall be taken in order to implement or not. Always top management involvement is vital for this framework application and their support is considered very significant to the successful implementation.

## **5.8 Summary**

This chapter presented the results obtained from a validation practice of the framework for better project delivery in UAE. The aim of the verification and validation was to identify whether the framework is valuable, workable, suitable, practical, and the current UAE's construction market need. The framework is aimed to propose more efficient construction methods by use of latest technologies by which the project delivery could be enhanced. Further the same data were verified and validated by the construction project practitioners. In conclusion, it is believed that the proposed framework is considered as an effective tool to enhance the construction project delivery in UAE. The next chapter will present the conclusion and further recommendations along with further required research work.

## **CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS**

### **6.1. Introduction**

The aim of this research was to identify the current gaps of construction industry in UAE and develop a framework for enhancing the project delivery by using of latest advance technologies, tools, and methods. The previous chapter discussed the outcomes of the research within the context of the objectives and the literature. This chapter discusses key findings and provides recommendations to industry and area of suggestions for further research based on the literature and findings.

### **6.2. Summary of findings and conclusions**

#### **6.2.1. Objective 1: Current project delivery processes in UAE**

The literature review identified the current construction project delivery in UAE along with its types, methods, and processes. Further the gaps were identified within the current processes. Literature review chapter pointed out that construction projects in UAE is facing multiple challenges such as; delays, quality issues, low productivity, poor stakeholders' management, etc. Discovering the current challenges of UAE construction projects has helped the researcher to analyze and develop factors that possibly could be used as a remedy to overcome the current challenges. When addressing the construction projects challenges from a practical viewpoint, the review of literature acknowledged variety of factors that address the current challenges of the construction projects. These factors were considered as a major finding from the literature chapter on addressing the current challenges of construction projects in UAE. The findings suggest that a solution shall be considered very specific for each of the challenges based on its type and nature. From the review of the literature, it has been found that advance technologies, tools, innovations, construction methods & techniques, and latest advance materials could be considered as vital factors in success of construction project delivery in UAE. This has been confirmed by the survey participants and further the same data have been analyzed. Certain type of the latest trends such as BIM have been rated high to be used for better construction project delivery in UAE.

#### **6.2.2. Objective 2: Impact of traditional construction delivery tools and non- traditional tools**

Currently, UAE construction industry is proceeding with traditional methods. Literature reviewed the current processes and indicated that traditional methods are no longer capable of completing complex projects based on the clients' need. It was found that the market demand is very important in UAE. Literature review chapter introduced the contemporary construction methods that are capable of addressing the current construction market needs in UAE. These tools, methods, and systems were identified and each of the technologies' role has been elaborated for specific area. These latest innovations further been listed and developed into questionnaire format. Construction practitioners who participated in this study approved or rejected the effectiveness of the latest technologies on addressing the current challenges of construction projects in UAE. All the impact and risks of application of these innovations have been tackled in the literature review chapter, and further it has been recommended that using the latest trends will highly impact the project delivery in

UAE. The main target of the application of technologies for construction projects was to enhance the quality of work, increase the productivity, lessen the timeframe of the project, etc. In conclusion, the application of non-traditional tools will enhance the overall project delivery, and will also addresses the current challenges of construction sector in UAE.

#### **6.2.3. Objective 3: Advance technological tools and systems including (BIM)**

The usage of advance technologies along with the risk of application have been explained in literature review chapter. Trending technologies have been identified by the researcher and briefly elaborated in the literature review chapter. Technologies such as autonomous machineries, 3D printing, augmented reality as well as the latest innovations such as BIM have been chosen as highly effective factors that could enhance the construction project delivery. 3D printing is suggested to be used for small scale projects, which will highly reduce the wastage, and increase the productivity and project's timeframe. Furthermore, latest construction contractual methods been introduced that will facilitate the projects to be constructed under the latest international standards. These findings further have been developed in form of questionnaires and confirmed by the construction professional practitioner working in UAE. Moreover, participants suggested that the latest construction technologies and methods positively impact the construction projects when all aspects have been studied prior its implementation. To sum up, the evidence reveals that, despite all the application challenges of advance technologies, systems, methods, and materials, they are considered very beneficial for construction projects in UAE.

#### **6.2.4. Objective 4: Enhancement of construction project delivery in UAE**

Literature review chapter have explored variety of latest technologies, innovations methods, and materials that will influence the project delivery. Further the same findings were developed into questionnaire format and distributed among the construction professionals for their views. The result revealed that BIM as the latest technology has the highest capability to enhance the construction project delivery in UAE. Moreover, the autonomous and semi-autonomous machineries, also could play vital role on the enhancement of the project delivery. Latest construction methods of procurement and stakeholder management have been considered significant in relation to the success of project delivery in UAE. Material selection plays vital role in quality of the project, where advanced materials are recommended to be used for construction projects with high efficiency in order to reduce the energy consumption and to increase the quality of work. The results suggest that these factors shall be considered for successful construction project delivery in UAE. Lastly, each of the latest technologies could remedy some specific part of the project, while BIM is considered as a best solution that covers a wide range of the current challenges of construction project in UAE.

#### **6.2.5. Objective 5: Use of BIM in managing construction data**

BIM has been explored in detail in literature review chapter. It is one of the top innovations that has been used widely in countries such as US, UK, and Finland, etc. Significance of BIM has been recognized by the construction practitioners in Dubai

through an online questionnaire survey. The survey method has been elaborated in chapter three and further the results have been analyzed in chapter four. The result suggest that BIM usage is very significant for the success delivery of construction project in UAE. Sharing information and data during the construction project is vital for the success of the project. BIM with multi-dimensional model created an easy, accurate, and transparent platform for information sharing during the project progression. Literature has indicated that, BIM application improves the communication by providing accurate information among the stakeholders. Moreover, BIM reduces the construction RFIs. In accordance to table 2.4.2.1, BIM has variety of benefits which could address the current challenges of UAE's construction projects. It improves the work from design till the operation of the project. By visualization it allows clients to have a clear image of their projects, moreover, in design stage the latest software's were used which could easily and rapidly brings the alteration and any modification to the project concept. With BIM it is possible to create more effective and accurate schedules and cost estimations, in which, the decision making will be easy and more effective. Accurate information and multi-dimensional models will help the maintenance and operation team to cooperate better with the project challenges in future. In conclusion data management by BIM in construction project is easy and much effective where it leads to better and successful project delivery.

#### **6.2.6. Objective 6: Proposed integrated framework**

As it was established in this study, Construction projects in UAE are facing challenges in many aspects and further specific remedy for each section is required to be applied. Enhancement of construction project delivery is possible when all the related gaps within sections of the project is identified and addressed accordingly. Solution is not always technology for the industry's challenges, some of the challenges have to be addressed by latest construction methods and practical experience; such as procurement, stakeholder management, project management, construction project execution, etc. Consequently, an effective framework needs to be developed which is consist of combination of latest construction trends such as: tools and machineries, methods, construction techniques, and innovations. Material selection plays an important role in the quality of work, especially in UAE where the weather is sensitive and reduction in energy consumption is the government vision. The literary research has identified the application of the latest construction technologies will lead to the success of project delivery. Findings of the literature review have been tested through a quantitative research method and the results shows that there is a link between the latest construction technology and the better project delivery. Participants agreed that application of the latest technologies and innovations will lead to the success of the project. Moreover, it has been noticed that lack of 'framework' does create limitation to the success of the project delivery.

Chapter five discussed about the development of a framework that is capable to improve the project delivery in UAE. The framework consists of four important categories refer to figure 5.2.1. First, advance construction tools where it is about the construction heavy equipment's that facilitate the project productivity and reduce the timeframe. Second, contemporary construction innovations consist of BIM and latest trends in the market where those are capable to enhance the overall project delivery in most aspects. Third, advance construction methods, these are the latest construction standard methods that can be used to complete projects at internationally

standardized methods. Fourth, material selection was found to be very important in UAE, as the weather is hot and government pushes the construction sector in order to align their projects with the government vision. According to a report by environment agency Abu Dhabi (2010), UAE's goal by 2030 is to reduce the construction wastage and energy consumption. Using advance and smart materials for the construction projects will increase the sustainability and reduce the wastage and energy consumption. All these categories are in alignment with the research objectives. Further, these findings were confirmed by the participants of the focus group. Practitioners agreed that the framework implementation is very significant for the current situation of construction sector in UAE.

### **6.3. Recommendations to the UAE government and construction sector**

Application of any contemporary trends in construction sector has risks and challenges, depends on the area that the technology is being implemented. During this research the below top three challenges of technologies adoption factors have been identified:

- Top management support;
- Government support;
- Systems security issues.

The government should mandate the use of BIM for all the construction companies in UAE. A department of advance construction to be established, where they are able to monitor all the projects via online portals. The government needs to create products such as: software's or online identifications. Further these products could be bought by the construction companies in UAE for their project use. The core system shall be created by government and yet the government to access and secure all the projects' information across the county at all time. The cost of application of such project is assumed high for the government but the accuracy and transparency of the obtained information in regards to the projects is vital for the future of country and in alignment to the government visions.

One of the main concerns of the construction sector on usage of innovations such as BIM is the security of data transfer during the project lifecycle. Companies tend to trust more in using of BIM software's that is being offered and controlled by the government. Government could provide training centers for BIM adoption, as well with the certificates for the qualified professionals. Also, to mandate that each company have to have minimum numbers of employees holding that certificates. Profit gain will be continuously for the government from the training centers and the selling membership or software's to the construction companies working within the country.

Companies tend to feel more secure when the database being monitored by the government. Transparency in information sharing will lead companies to have better project delivery. Skillful and trained staff will lead to better outcomes as they will have less errors on implementation of the advance technologies such as BIM for their projects. The benefit is shared with both parties; government and construction companies. In conclusion the researcher suggest that further research should be carried out on this theme.

## **6.4. Recommendations for further research**

Technologies application has multi challenges, whilst some are the key challenges that pushes the construction companies to resist in adopting the technologies such as BIM. Economic benefits and productivity of BIM for AEC industry is acknowledged and well known. Further, the technology to implement BIM is ready and rapidly maturing. Yet the adoption of BIM has been very slow than the expectations (Azhar, Hein et al. 2008). There are multiple reasons behind this. Firstly, for instance on the application of BIM, security of data transaction is very important. The malwares, viruses, and hackers could easily attack the database. What is the guarantee to not lose all the vital information of the project? Secondly, there is an issue among the shareholders (i.e., clients, engineers, and contractors) that who to develop and operate the model. Also, how the cost of implementation is distributed among parties? Thirdly, unlike other construction practices, there are no clear explanation on how to implement BIM. No single document has found to elaborate the application of BIM and its usage (Associated General Contractors of America, 2005). Furthermore, there is a need to standardize the BIM processes and create guidelines for the its application. The ownership to be specified and data security assurance to be given to the users.

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# **CHAPTER EIGHT: APPENDIX 1**

7/2/2019

SURVEY QUESTIONNAIRE ON THE APPLICATION OF ADVANCED TECHNOLOGIES IN THE CONSTRUCTION SECTOR

## **SURVEY QUESTIONNAIRE ON THE APPLICATION OF ADVANCED TECHNOLOGIES IN THE CONSTRUCTION SECTOR**

As is the case with many questionnaire surveys there may be some questions which appear, irrelevant or impertinent. However, it is necessary in this study that all questions are answered, as the questionnaire is designed to achieve particular research objectives, and it is hoped not to offend participants in any way. If there are any questions, which you are unwilling or unable to answer, then it is my wish that you continue to answer the remainder of the questionnaire.

Remember that both your identity and that of the company you work for will remain strictly confidential.

Research aim: The research aims to examine how advanced technological tools can be used to reduce the number of construction project delivery errors in UAE and propose an integrated framework that will comprise of advanced technological solutions for better delivery of construction projects in UAE.

For further clarification, you may contact the researcher:

Iraj Hamayoon  
+971 (0) 525920580

I and the British university in Dubai is very thankful for your participation in this survey.

Best Regards

**1. Application of advanced technologies are very significant to improve delivery of construction projects.**

*Mark only one oval.*

- ☐ Agree  
☐ Disagree

**2. In what sector does the main aspect of your business activities fall under?**

*Mark only one oval.*

- ☐ Construction and Engineering  
☐ Oil and Gas  
☐ Real Estate  
☐ Manufacturing  
☐ IT  
☐ Other (please specify)  
☐ Other: \_\_\_\_\_

**3. 3. What is your current role?***Mark only one oval.*

- ☐ Contractor Engineer
- ☐ Client representative
- ☐ Consultant Engineer
- ☐ Client
- ☐ Other (please specify)
- ☐ Other: \_\_\_\_\_

**4. 4. How long have you worked within your sector?***Mark only one oval.*

- ☐ 0 to 2 years
- ☐ 3 to 5 years
- ☐ 5 to 9 years
- ☐ 9 to 12 years
- ☐ 12+ years

**5. 5. How many years of experience do you have in construction projects management?***Mark only one oval.*

- ☐ 0 to 2 years
- ☐ 3 to 5 years
- ☐ 5 to 9 years
- ☐ 9 to 12 years
- ☐ 12+ years

**6. 6. How advanced do you find the construction industry in UAE with the latest trends such as BIM, advanced materials, 3D printing etc.? (regardless of the size or nature of the projects)***Mark only one oval.*

- ☐ Very Advanced
- ☐ Advanced
- ☐ Fairly Advanced
- ☐ Slightly Advanced
- ☐ Not Advanced

**7. 7. Based on your experience, how many percent of construction companies in UAE still using the traditional construction methods for their projects?***Mark only one oval.*

- ☐ 75-100%
- ☐ 50-75%
- ☐ 25-50%
- ☐ 5-25%
- ☐ 0-5%



8. To what extent you agree with this term: Traditional construction methods are no longer capable to deliver complex projects on time, environmentally acceptable, at lowest possible cost, high quality, and to have easy and safe operation processes along with client's satisfaction.

Mark only one oval.

- ☐ Strongly Agree
- ☐ Agree
- ☐ Neutral
- ☐ Disagree
- ☐ Strongly Disagree

9. Which of the below challenges occur the most in construction projects in UAE? please rate (0=very low, 4=very high).

Mark only one oval per row.

	0	1	2	3	4
Delays	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Quality issues	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cost overruns	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Regulatory issues	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Low productivities	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

10. In your opinion which of the following problems can be resolved or improved by adopting advanced technologies in construction projects in UAE? please rate (0=very low, 4=very high).

Mark only one oval per row.

	0	1	2	3	4
Delays	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cost related issues	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Quality issues	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
productivity	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Waste reductions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Safety issues	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

11. To what extent do you agree that construction companies in UAE shall use advanced materials for better quality of their project delivery that is capable to; reduce the life cycle cost, high recyclability, high energy efficiency, and improved health wellbeing.

Mark only one oval.

- ☐ Strongly Agree
- ☐ Agree
- ☐ Neutral
- ☐ Disagree
- ☐ Strongly Disagree

**12. 12. How important you consider accurate information sharing across the project lifecycle in succession to the project delivery?**

*Mark only one oval.*

- ☐ Extremely Important
- ☐ Important
- ☐ Fairly Important
- ☐ Slightly Important
- ☐ Not Important

**13. 13. To what extent do you personally agree that the following factors are associated with the application of advance technologies such as (BIM) in the construction Industry within UAE?**

*Mark only one oval per row.*

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Cost	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Productivity	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Time	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Safety	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Waste Reduction	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sustainability	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**14. 14. Which of the following innovations has the most significant impact on enhancing the overall construction project's productivity?**

*Mark only one oval.*

- ☐ Machine Learning and Autonomous Machinery
- ☐ Virtual reality
- ☐ BIM
- ☐ 3D printing
- ☐ Robotics for prefabrication

**15. 15. From the below innovative applications of 'Advanced Technology' which, in your opinion, is the most significant and effective to adopt by construction industry in UAE?**

*Mark only one oval.*

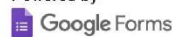
- ☐ Machine Learning and Autonomous Machinery
- ☐ Virtual reality
- ☐ BIM
- ☐ 3D printing
- ☐ Robotics for prefabrication

**16. 16. To what extent do you personally agree that the following challenges are associated with application of the 'advance technologies' in the construction industry within UAE?**

*Mark only one oval per row.*

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The Industry Resistant Nature	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Implementation Cost	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Government inadequate Support	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Quality of Data and Security Issues	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Lack of Talented Resources	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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## **CHAPTER NINE: APPENDIX 2**

The following is a list of factors which are associated with advance technologies for better project delivery and the proposed framework for this study. Please indicate (i.e. tick (√)) the extend of level of agreement on each variable using a scale from 1-5 where: 1 indicates 'strongly agree'; 2 'agree'; 3 'neutral'; 4 'disagree' and 5 'strongly disagree'.

<b>Level of agreement</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. Framework is able to address the current challenges of construction sector in UAE.					
2. The framework is applicable in real construction projects in UAE.					
3. The framework is suitable to use in the current construction market situation.					
4. Advanced construction tools					
5. Contemporary construction innovations					
6. Advance construction methods					
7. Advance materials					

For any comment please write:

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