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DEVELOPMENT OF BIM IMPLEMENTATION FRAMEWORK FOR DIGITAL CONSTRUCTION IN TURKEY

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Development of BIM implementation framework for digital construction in Tukey

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Mehmet SAKİN

ABSTRACT

DEVELOPMENT OF BIM IMPLEMENTATION FRAMEWORK FOR DIGITAL CONSTRUCTION IN TURKEY

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Building Information Modeling (BIM) is an innovative approach to integrate the process of planning, design, construction, and operation of a building in 3D and beyond. The developed countries have seen it as a strategic policy approach to transform their construction industry into a knowledge based sector from labor based sector. The Turkish construction industry is one of the largest sector and a major driver of the economic growth in Turkey. Yet, the construction practices and technologies used within the industries are the same old fashion methods and technologies affecting the productivity and efficiency negatively. Further, BIM based design and construction approach has no common use in the industry in Turkey. Thus, it is required to tackle this challenge and provide a feasible strategic roadmap to enable the industry for the BIM based practice.

This study aims to develop Building Information Modelling and Management framework to the Turkish construction industry in order to build awareness, capacity building for BIM use, and support BIM education and BIM policy initiatives. This research addresses the challenge of how BIM adoption and implementation is possible in the Turkish construction industry.

In this research, both qualitative and quantitative methods are employed. The qualitative data stems from document studies, observations and interviews while quantitative data is collected from a case study project and questionnaire based survey. Analysis of the data collected in the research so far has led to the development of BIM implementation framework in Turkey. This roadmap in its strategic implementation includes key aspects such as capacity buildings via events, developing BIM standards and protocols, university education system and related regulations, establishing BIM center acting as a hub for exchange of experience to implement the conceptual framework and accelerate the digital transformation and integration process.

Keywords: Building Information Modelling, Turkish construction industry, BIM implementation roadmap, Digital transformation

ÖZET

TÜRKİYE'DE DİJİTAL İNŞAAT İÇİN BIM UYGULAMA CERCEVESİNİN GELİŞTİRİLMESİ

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Yapı Bilgi Modellemesi (BIM), bir binanın planlama, tasarım, inşaat ve işletme sürecini 3B ve ötesine entegre etmek için yenilikçi bir yaklaşımdır. Bu yenilikçi yaklaşım ülkemizde henüz istenilen düzeye gelmemiştir. Gelişmiş ülkeler ise, inşaat sektörünü işçi odaklı sektörden bilgiye dayalı bir sektöre dönüştürmek için bir takım stratejik politikalar izlemektedir. Son yıllarda, inşaat sektörü Türkiye'de ülke ekonomisinin öncü sektörlerinden birisi haline gelmiştir. Ancak, bu sektörde uygulanan geleneksel inşaat yöntemleri ve uygulamaları, verimliliği ve sürdürülebilirliği olumsuz yönde etkilemektedir. Dünya geneline baktığımızda yaygın olarak kullanılan BIM tabanlı proje tasarımı ve yönetimi Türkiye'de henüz istenilen düzeye ulaşamamıştır. Ayrıca, BIM tabanlı tasarım ve yapım yaklaşımının, Türkiye'deki endüstriyel üreticiler tarafından ortak bir kullanımı da yoktur. Bu neden ile dijital dönüşümün önündeki engellerin üstesinden gelmek ve endüstrinin BIM tabanlı uygulamaya geçişini hızlandırmak için uygulanabilir bir stratejik yol haritası hazırlanması gerekmektedir.

Bu çalışma; dijital dönüşümün sosyal ve teknik yönleri, iş modeli, eğitim ve inşaat piyasasına entegrasyonu ve sürdürülebilirlik gibi temel unsurları incelemeyi amaçlarken, aynı zamanda, Türk inşaat sektöründe BIM kullanımının farkındalığının arttırılması, geçiş sürecinin doğru yönetilmesi ve engelleri sistematik bir şekilde ortadan kaldırmayı hedeflemektedir.

Yaptığımız bu çalışmada, niteliksel ve niceliksel araştırma yöntemleri bir arada kullanılmıştır. Nitel veriler doküman incelemelerinden, gözlemlerden ve görüşmelerden elde edilirken, nicel veriler ise vaka çalışması analizlerinden ve ankete dayalı verilerden oluşmuştur. Araştırmada şimdiye kadar toplanan verilerin analizi, Türkiye'de BIM uygulama planının gelişmesinde büyük bir rol oynayacaktır. Son olarak bu çalışma içeriği ile etkinliklerle kapasite oluşturma, BIM standartları ve protokolleri geliştirme, üniversite eğitim sistemleri ile ilgili düzenlemeler, profesyoneller arasında bilgi paylaşımı süreçlerini gerçekleştirilmesini kapsar. Bu kapsam doğrultusunda, uygulama planını sistematik bir şekilde hayata geçirilmesi için BIM merkezine ihtiyaç vardır.

Anahtar Kelimeler: Yapı Bilgi Modellemesi, Türk inşaat sektörü, BIM uygulama yol haritası, Dijital dönüşüm

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ABBREVIATIONS

AIR:	Asset Information Requirements
AR:	Augmented Reality
BHS:	Baggage Handling System
BIM:	Building Information Modelling
BOQ:	Bill of Quantities
BOT:	Build-Operate-Transfer
CAD:	Computer Aided Design
CCL:	Collaboration Communication and Learning
CM:	Construction Manager
DCC:	Document Control Center
DM:	Design Management
FM:	Facility Management
HVAC:	Heating Ventilation and Cooling
ICT:	Information and Communications Technology
IFC:	Industrial Foundation Classes
IGA:	Istanbul Grand Airport
IM:	Information Management
IT:	Information Technology
LoD:	Level of Detail
MAF:	Material Approval Form
MEP:	Mechanical Electrical Plumbing
MS:	Method Statement
NWC:	Navisworks Cache
NWD:	Navisworks Document
PM:	Performance Management
QA/QC:	Quality Assurance/Quality Control
RFI:	Request for Information

SAS:	Special Airport Systems
SD:	Shop Drawing
2D:	Two Dimensional
3D:	Three Dimensional
4D:	Four Dimensional
5D:	Five Dimensional
6D:	Six Dimensional
7D:	Seven Dimensional
TS ENs:	Transposal of European standards in Turkish
EFCA:	European Federation of Engineering Consultancy Associations

CHAPTER 1

INTRODUCTION

Building Information Modelling (BIM) is a collaborative working methodology characterized by digital technologies that promote efficiency in design and maintenance of physically built assets (Arayici et al, 2011). The role of BIM is to embed key product and asset data in a 3D computer parametric model used for managing information actively from concept design to operation stages of the project lifecycle (Arayici, et al 2012).

BIM introduces a new work paradigm that facilitates the integration and coordination of different domains and the processes involved in building design, construction and operation. BIM data is based on the IFC (Industry Foundation Classes), an international standard for the BIM data exchange, which provides a generic data schema covering among others architectural, structural elements and building operation.

BIM is an information technology platform based on the 3D planning, design, construction and operation of a building to provide collaboration and integration between stakeholders in the construction project lifecycle. Digital transformation has taken place in many countries. A number of countries globally such as UK, Denmark, US, Norway and Finland are starting to recognize important opportunities and are now investing heavily to develop their country capability (Khosrowshahi and Arayici, 2012). BIM processes form the basis of project management in infrastructure projects and superstructure projects. BIM offers the opportunities to use technological tools and techniques in order to simplify project process and management. It can provide great value in building design, construction and renovation projects using digital construction technologies such as laser research techniques and realistic energy analysis.

Turkey is currently experiencing a significant growth in urbanization and economic development. Owing to the public projects, housing and urban transformation projects, the construction sector has very high business capacity, the Turkish Architecture, Engineering and Construction (AEC) playing a significant role in Turkey.

The design and construction companies in Turkey need to be embracing modern and efficient methods of design, collaboration and documentation. With this in mind, the BIM application cannot be overlooked by stakeholders in Turkey. In their studies, Arayici et al. (2011); Navendren, Manu, Shelbourn, and Mahamadu (2014); show that application of BIM yields efficiency gains, eliminates waste and promotes value generation in the design and construction firms. The major question is the capability of BIM to offer similar benefits to the construction firms in Turkey. The aim of this project is to investigate how BIM adoption and implementation can be possible in Turkish construction industry to be a knowledge based sector within a knowledge based economy while the BIM use is becoming mature in nations such as the UK, considered to be developed.

1.1. Building Information Modeling (BIM)

The growth of IT and digital transformation has led to a paradigm shift in the AEC industry, which has adopted BIM to address the need for increased productivity, value, efficiency, sustainability and quality minimize the costs of a project life cycle (Arayici, et al., 2011). The transformation requires integration and cooperation of all groups in the construction industry. All stakeholders, from designers, clients and manufacturers, have to participate in the building process, a strategy that will result in effective transition management. Therefore, BIM is considered as an effective approach for maintaining communication and collaboration among all stakeholders, thereby improving productivity at all stages of the project (Becerik Gerber and Rice, 2010).

As reported by Eastman et al. (2011), several case studies show the importance of BIM in promoting efficiency and effectiveness of the building process. According to Succar (2009), BIM helps to address inefficiencies facing the AEC industry. All over the world, the benefits of using integrated BIM in the construction industry include the time and cost reduction and detection of clashes (Eastman et al, 2011). Moreover, BIM leads to improved collaboration, coordination and quantification, high visualization of design, the improvement in visualization of design, project delivery and proper coordination of all documents associated with construction (Olatunji et al, 2010; Sacks et al, 2010). On their part, Nederveen et al. (2010) cite other benefits such as high efficient communication and improved data exchange.

1.2. Turkish Construction Industry

Most of Turkish construction companies and the government are based on traditional design, construction and operation process, which is related closely to the time delays, reworks issues, rise of cost, lack of coordination and communication (Nawi et al. 2014b). The traditional method to work and plan in the construction stage is by using 2D drawings and related Gantt charts documents (Jongeling, 2008). All drawings and documents from the different disciplines need to be coordinated and compiled. Usually the design phase is not completed when the construction phase begins, which makes both phases much more complicated, because all decisions are not clearly made. These errors usually occur in the project drawings. Those errors often lead to problems in the drawings stage and their related documents, which the technical staff need to solve at the construction site and this takes extra costs and time to affect the quality and management. Current practice and fragmented construction projects processes has many problems such as:

- Lack of predictability
- Unacceptable levels of defects
- Excessive capital costs
- Excessive construction time
- The lack of productivity
- The low levels of profit
- The number of accidents is also excessive
- Lack of sustainability
- Lack of facility management

Furthermore, the AEC projects are inefficient and caused over processing, duplication of work, a lack of effective communication, design management and deadline pressures

(Arayici et al., 2012). As well as being laborious, time consuming and susceptible to errors, paper based quantity take-off causes to increase the probability of error in omission of quantity (Halpin, 2006). Accordingly, there is a need for collaboration between project parties through an intelligent system that integrates process and product information to manage barriers and challenges. Many projects have gained maximum benefits from BIM by using it in design and development, planning, construction, environmental planning, optimization energy simulation, code and safety checking (Mihindu and Arayici, 2008).

1.3. Rationale of the Research

Globally, a paradigm shift has occurred in digital construction to improve productivity, quality, efficiency, value, infrastructure, and sustainability; as well as minimizing time and costs associated with the entire life cycle (Arayici et al. 2011). In Turkey, researchers have implemented the BIM model to digitalize the construction industry and align it to the global completion. Nevertheless, there are some setback factors towards implementation of BIM framework for digital construction in Turkey. A significant gap of knowledge exists in digital construction in Turkey that really ought to be studied. Almost Turkish AEC companies have not implemented BIM, although they still drafting the model using 2D model. Moreover, few AEC firms have initiated BIM implementation without following the BIM policy entirely, process and project delivery.

Although a few AEC companies focus on enhancing technological workforce and training their employees, they have to examine other factors hindering development and implementation of the BIM framework for digital construction in Turkey.

Appropriately, this research seeks to bridge gap by development of the BIM implementation framework for digital construction in Turkey by determining specific barriers to adoption of BIM.

1.4. Research Question

The objective of the research question is to identify the investigation, provide direction, and set boundaries for assessing the research work' (Neuman, 2006). This research deals with proposing BIM roadmaps and an intelligent strategy for the development of BIM implementation framework for digital construction in Turkey. To achieve the research aim and objectives, and based on the research gaps, the following research questions are identified to challenge in the research;

- What are the underlying reasons for the setback for the BIM implementation framework development in Turkey?
- What are BIM implementation methods and guidelines for the digital transformation of the industry?
- How can we enable digital transformation process for the industry?
- Can associations or non-profit organizations contribute to the industry for BIM implementation?

1.5. Research Aim and Objectives

Research aim helps to develop a BIM implementation framework for digital construction in Turkey by identifying the key barriers of BIM adoption. Through a literature review, it is possible to identify information necessary for developing the BIM framework. Some of the information obtained through a literature review is include description of BIM, framework development, and BIM implementation to the construction industry in Turkey. As a result, objectives were set out as follows:

1. To explore the current practice and experience in Turkish construction industry.
2. To explore the identified practical and theoretical barriers of BIM adoption for digital construction in Turkey.
3. To examines BIM implementation in Istanbul Airport case study and conduct critical analysis.
4. To set up a conceptual framework for adoption of BIM in the AEC industry.
5. To test and validate the framework specifically for the Turkish construction industry.

1.6. Research Methodology

The research methodology part is a brief explanation of the research philosophy, research approach, scope of the research, research strategy, and research process plan for gathering data and data analysis. Chapter 4 covers the research methodology comprehensively.

1.6.1. Research Philosophy

According to Saunders, Lewis, & Thornhill (2007), research philosophy entails ideas regarding collection, analysis and interpretation of data. The research onion of Saunders identifies Positivism, Realism, Objectivism, Structuralism and Humanist to be highly significant (Saunders et al. 2007). For this study, the research philosophy identified is positivism.

1.6.2. Research Approach

As per the Research onion, research approach is the second layer consisting of the inclusive, deductive, qualitative and quantitative approach (Saunders et al., 2007). However, Jonker and Pennink (2009) identify inductive and deductive research as the two main approaches and hence, the research approach adopted in this research is a deductive and qualitative research approach. In light of this, the author of this research in the sense of conforming/disconfirming the proposition of excluding the digital transformation from the people, process and technology to the country level has benefitted from deductive approach. The researcher will look into Istanbul Airport case study, survey analysis and data collection from qualitative research approach.

1.6.3. Research Strategy

Saunders et al. (2007) identify research strategy as the third important layer in the research onion. The major research strategies are survey, experiment research, action research, grounded theory, case study, archival and ethnography research (Saunders et al., 2007). The research question used in the study determines the research strategy adopted (Yin, 1996). Key considerations to make when selecting the research strategy involves the required degree of control study focal point and expected outcome in relation to time, aim and objectives. For this study, the research strategy was selected based on the aim, which is to identify BIM adoption framework in the Turkish AEC, resources, limited time and all stakeholders.

The survey method helps to establish the relationship between variables, while promoting data collection economically through questionnaires. Istanbul airport case studies were useful for exploratory, or preliminary research, while surveys and histories were appropriate for a descriptive phase, and experiments were the only way of doing explanatory or causal research and so on (Saunders et al, 2009) as discussed in Chapter 4.

1.6.4. Research Process

The research process section defined to the different sequential steps adopted in this research process plan in figure 1.

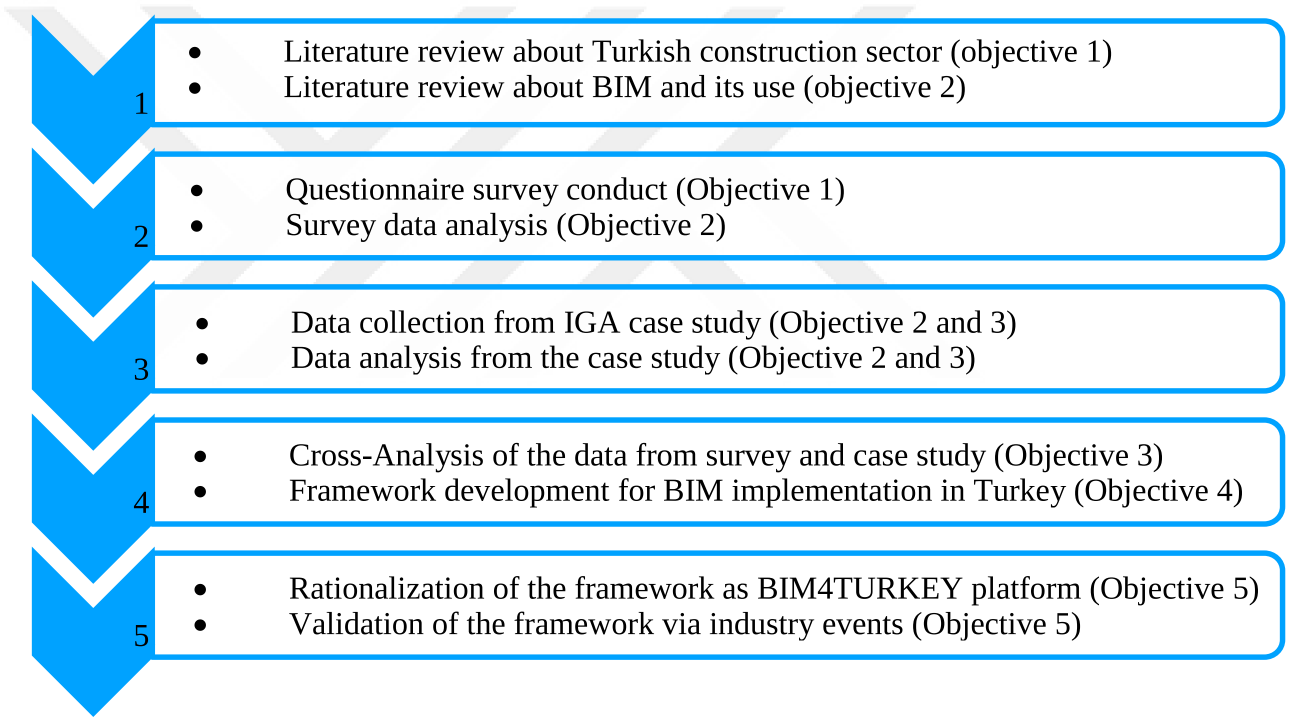


Figure 1: Research Process Plan in the research

Considering the beliefs, assumptions, and the nature of reality and truth about the phenomenon under investigation, set of processes which reflect the way in which this research is undertaken from design through to conclusion are sequentially organized as illustrated in Figure 1. Due to the nature of this study, triangulation has been applied to the overall research strategy to ensure the reliability and validity of the research through adopting multi-methods for data collection and analysis. Types of research methods and techniques adopted to perform each process are also depicted in the Figure 1. By all means, designed research process is compatible with the tasks performed to accomplish this study.

1.7. Scope of the Research

The scope of this thesis is the development of BIM implementation framework for digital construction in Turkey. This research analysis of the data collected in the research so far has led to the development of BIM implementation framework in Turkey. This roadmap in its strategic implementation includes key aspects such as capacity buildings via events, developing BIM standards and protocols, university education system and related regulations, establishing BIM center acting as a hub for exchange of experience.

The study aims to elaborate on the core aspects including social and technical aspects, business considerations, training and regularity to construction market transformation. This research addresses the challenge of how BIM adoption and implementation is possible in the Turkish construction industry.

1.8. Ethical Consideration

According to Denscombe (2005), general research ethics or principles refer to the respect for the rights of study subjects. The researcher has a duty to observe confidentiality, privacy, informed consent and anonymity throughout the study.

Ethical approval form for this research was submitted to Istanbul Airport for the provision of the data for the development of this research. In additionally, questionaries' surveys are instruments used to quantitatively evaluate subjective data. Ethical approval form was informed consent and scientific consent when using surveys.

1.9. Contribution to Knowledge

This research will develop new knowledge for the BIM adoption framework for the successful infusion of digital transformation in the AEC sector in Turkey. This research will seek to identify strategies and applications for enhancing the current BIM platforms toward a desirable future state of implementation and functionality. This research will provide the Turkish construction industry digital transformation enabler.

1.10. Guide to the Thesis

This section involves the entire structure guide to the thesis just as an introductory study overview to provide information on the chapter contents.

The second chapter (2) deals with review of literature on BIM framework and its application in the AEC industry as well as globally. Several examples have been included to show how BIM contributes to the construction industry.

The third chapter (3) is dealing significant literature in relation to the topic in a context scale. The chapter includes major classifications used in the AEC industry in Turkey, BIM use in the Turkish AEC and strategies for promoting BIM best practices.

The fourth chapter (4) covers the research methodology approach used in this research, with adequate discussion and justifications. The chapter also offers insights into the follow-up chapters.

The sixth chapter (5) aims to analyze the questionnaire based survey to explore the knowledge and awareness of professionals. Further, it evaluates the constraints and advantages of BIM from its implementation. For this purpose, an analysis of the impact of people, culture, technology, regularity and educational dimensions is needed. The survey questions include dependent and independent variables to obtain both qualitative and quantitative results from the survey.

The fifth chapter (6) provides an understanding on BIM integration to implementation of mega projects such as construction of the Istanbul Airport. The findings presented in this chapter will have a significant impact on understanding the current perceptions on application of BIM as a method applicable to the construction industry in Turkey.

The seventh chapter (7), the discussion focuses on the adoption of BIM to the Turkish construction sector, contributing to develop national BIM standard, BIM education and BIM policy initiatives. BIM adoption is currently remaining at the level of encouragement, with little financial encouragement offered and a lack of introduction of regulations and BIM-oriented standards. Thus, this chapter explains a new approach of BIM adoption and facilitate the BIM uptake in the industry.

The eighth chapter (8) aims to evaluate the situation of the Turkish construction sector for the roadmap planned to be integrated to the BIM system. There is a need for an analysis of the awareness and knowledge of BIM implementations of institutions and firms operating in the building industry. For possible implementation of the BIM framework proposed in chapter 7, this chapter explains the implementation the framework under BIM4TURKEY name in practice and evaluate how the framework is contributing to BIM use in the industry by taking into account people, process, technology and education dimensions.

The ninth chapter (9) is provides the overall conclusion of the thesis, provides the summary of findings and matches the research objectives with conclusions in the research. It does also provide recommendations for the future research and by also emphasizing that how this research contributed to knowledge and practice.

CHAPTER 2

IMPLEMENTATION OF BUILDING INFORMATION MODELING (BIM) IN CONSTRUCTION

For this study, the main objective is to identify critical barriers in BIM integration and implementation in the construction sector. The study is based on a comprehensive literature review to identify benefits associated with overcoming the barriers during the BIM implementation process in the construction sector.

2.1. Introduction : Building Information Modelling (BIM)

Undercurrent of the digital revolution and information technology, the construction AEC industry towards an effort to respond to increase efficiency, productivity, value, sustainability and quality to reduce lifecycle cost. In order to increase the importance of digital transformation and information technology, construction industry aims to increase the industry efficiency, develop technology infrastructure and more sustainable buildings which help to reduce the life cycle costs and improve the quality of products. (Arayici et al., 2011) are facing a paradigm shift in the BIM use Delivery Systems and Integrated Design (IDDS) (Owen et al., 2009). BIM embeds key supply chain and asset data in a 3D computer parametric model that can be used for effective information management throughout a building lifecycle from the pre-design through to operation phase (Arayici, et al 2012) that is illustrated figure 2.

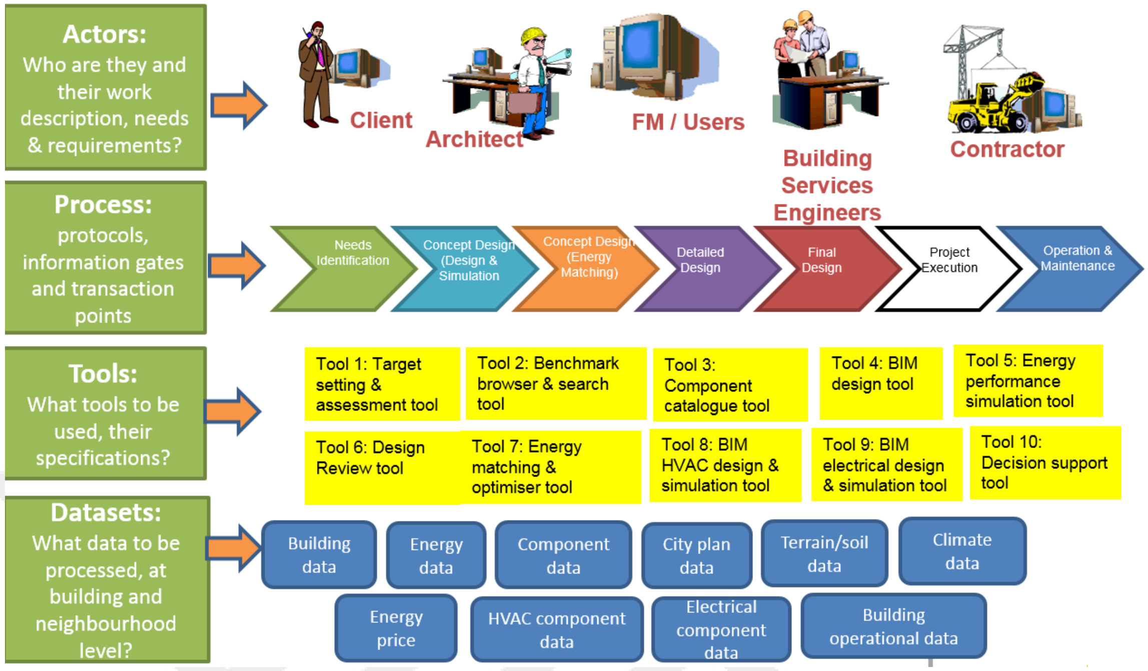


Figure 2: BIM for collaboration for resilient and sustainable housing

The growth of IT and digital transformation has led to a paradigm shift in the Architecture, Engineering and Construction industry, which has adopted BIM to address the need for increased productivity, value, efficiency, sustainability and quality minimize the costs of a project life cycle (Arayici, et al., 2011). The transformation requires collaboration and cooperation of all groups in the construction industry. All stakeholders, from designers, clients and manufacturers, have to participate in the building process, a strategy that will result in effective transition management. Therefore, BIM is considered as an effective approach for maintaining communication and collaboration among all stakeholders, thereby improving productivity at all stages of the project (Becerik-Gerber and Rice, 2010).

As reported by Eastman et al. (2011), several case studies show the importance of BIM in promoting efficiency and effectiveness of the building process. According to Succar (2009), BIM helps to address inefficiencies facing the AEC industry. All over the world, the benefits of using integrated Building Information Modelling in the construction industry include the time and cost reduction and detection of clashes (Eastman et al., 2011). Moreover, BIM leads to improved collaboration, coordination and quantification, high visualization of design, the improvement in visualization of design, project delivery and proper coordination of all documents associated with construction (Olatunji et al, 2010; Sacks et al, 2010). On their part, Nederveen et al., (2010) cite other benefits such as high efficient communication and improved data exchange.

Turkish construction industry employs over one million people and generates annual GDP of 784 million. However, the construction industry continues to have low levels of profits and productivity. The construction industry is the last sector to fully exploit the advantages of information technology.

At the moment, the focus has to be on the best strategies for increasing application of the BIM in the construction industry instead of assuming that its use will percolate unguided through the industry. Dependence of the current 2D CAD technology has its downsides such as lack of common guidelines, reduction in quality of documentation, and lack of consensus in either industry or government on standards and no process improvement. In Turkey, majority of the parties do not understand the construction management, event with some construction engineers failing to apply the correct concepts. The effect is improper construction management practices regarding planning, cost, time, quality and safety management.

This study seeks to prepare the adaptation of BIM and Management roadmap to Turkish government, contributing to the development of a national BIM standard, BIM education and BIM policy initiatives. Republic of Turkey Ministry of Environment and Urbanization should support for BIM adoption is currently remaining at the level of encouragement, with little financial incentives offered and a lack of introduction of BIM-oriented standards and regulations. Policy initiatives and standardized efforts for BIM will have a significant impact on its adoption in Turkey. The construction industry in Turkey needs to collaborate with the government to ensure effective initiatives for BIM implementation are established and the entire economy benefits.

Turkish government and public sector base on the traditional construction methods which need to arrange BIM regulations so as to improve quality of whole process of the construction. Government projects are generally inception or pilot projects of these regulations. Especially for government projects, the bidders have to produce their competitive offers in accordance with the related BIM regulations. Thereby, the authority which must control and evaluate the projects through the regulations for approval will be able to execute the process easily and rapidly. When the Turkey decided to make a regulation about BIM, the Republic of Turkey Ministry of Environment and Urbanization will study to improve a compatible BIM regulation which require to using BIM can be a good support for a new one. It is possible that the clauses which are required for the Turkey's vision can be settled into the specific BIM regulation. BIM codes will need to define which are about drafting rules, scheduling properties, project delivery methods etc. It is required that detailed drafting rules and approved annotation styles must be put into the regulations. Besides, developing standards should be conducted at a high speed. BIM practitioners in the construction industry need application standards that will offer guidance for implementation of the BIM tools. The developers of BIM tools have to set standards that allow unification of information exchanging format. Moreover, the BIM standards developers have to establish highly organized and coordinated BIM standard systems.

2.2. Understanding Building Information Modelling

The American Institute of Architects defined as BIM is a model-based technology linked with a data base of project information. Development of BIM as a technology product requires participation of all professionals (Ibrahim et al, 2004) The development process involves geometrical and non-geometrical spatial entities, relationships between objects, urban and geographical information, quantity and properties of building materials.

The new international BIM design efficiency benchmark, construction and building maintenance have a significant advantage over parametric design in specific construction management facilities and the lifecycle. BIM has attained an extensive popularity in construction industry all over the worldwide. BIM provides collaboration working workflow between between stakeholders and all construction parties. Yan and Damian (2008) argued many companies lack interest in development and implementation of BIM; however, the increasing use of BIM technologies s promising to the future of the construction industry.

Arayici et al. (2009) expressed that countries such as the United State, Australia, United Kingdom, Sweden, Finland, Norway, Germany and France, which the best management practices for the construction industry, applied BIM in some of their pilot projects, which have been since completed and documented.

2.3. Benefits of Building Information Modelling

BIM benefits range from better coordinate information standards, improve information sharing methods and a better design up to having a better information communication and improved QA/QC control and increases product quality and decrease waste of time (McGraw-Hill Construction, 2008). However, induces drastic changes in the design process and AEC construction methods by the professionals (Yan and Damian, 2008). Furthermore, structural engineering practices BIM adoption increase in the productivity from %15 to %41 (Sack and Barack, 2007). In addition, Azhar et al. (2008) state that BIM investments led to an increase in profits up to %94,86 with major added benefits being improved time utilization, reduction of costs and low on-site clashes. According to Eastman et al. (2008), BIM led to improved quality of buildings at lower costs and reduced project duration.

2.3.1. Clash Detection and Coordination Improvement

One of the benefits of BIM is improved coordination and collaboration among architects and engineers during the all project design stage. In addition, BIM facilitates harmonization of building structural assets, which leads to an improvement in the building service systems and easy identification of conflicts existing between structural building elements. However, BIM is provide improving services coordination the labor cost saving defined about %30 (Fischer and Reed 2008). Clash detection is illustrating in figure 3.

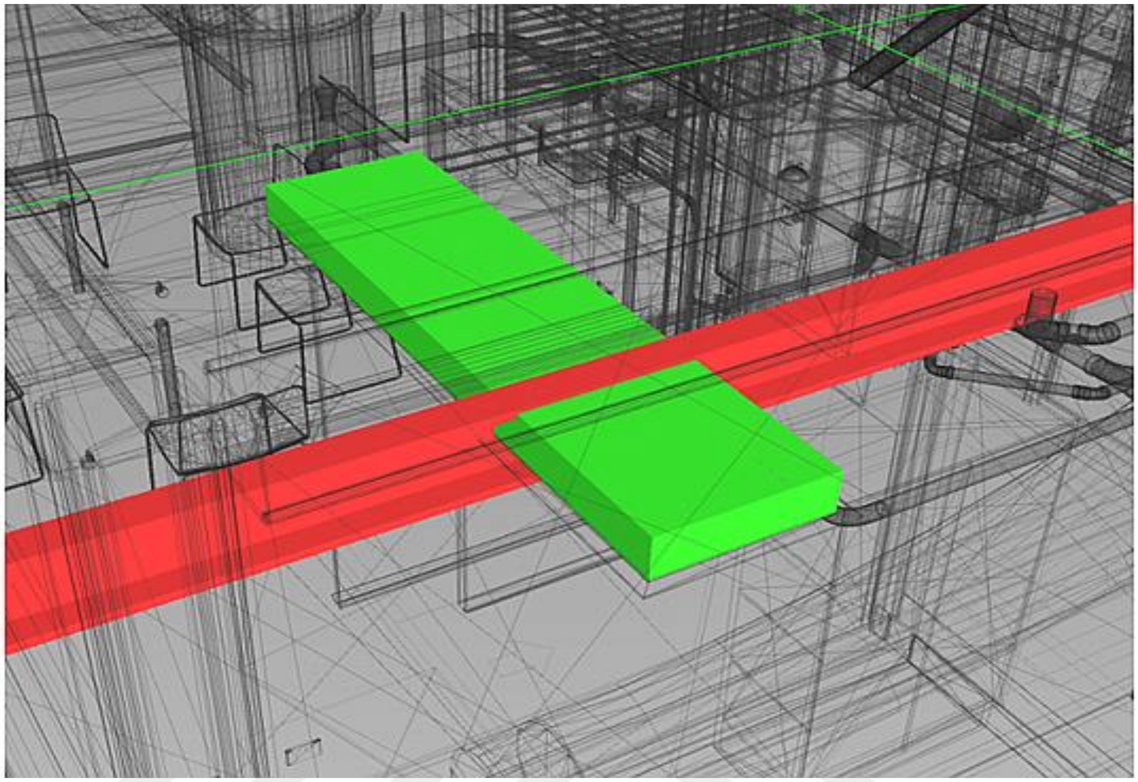


Figure 3: Structure elements clash detection test

2.3.2. 3D and 4D Visualization from Design Stage

Clients and contractors can use the 3D building visualization to get an idea on how the project will appear at the final stage (Suermann, 2009). Thus, through BIM, it is possible to design, construct and simulate a digital project in a virtual environment prior to its physical construction. The project stage can be integrated into 3D and converted into 4D, which makes it easy to highlight key logistic problems in the supply chain. Furthermore, 4D BIM simulation helps to quantify time and save 20% of the total duration taken to complete the project (Suermann, 2009).

According to Jongeling, Jakobsson, and Olofsson (2007), seeing the 3D and 4D simulation of the project helps to accelerate acquisition of building permits, while preventing intent misunderstandings in the design. 3D BIM model also applies to other areas of the project such as service connections and complex MEP.

2.3.3. Cost Estimation and Management Accuracy

A building designed digitally is automatically updated when the quantity takeoff is taken by the BIM model, which allows them to make accurate estimation of the project costs based on the quantities and programs produced by the BIM model. BIM model automated construction progress monitoring. (Azhar et al, 2008; Alder, 2006). If client decide needs financial change requests and other variations, a model can be easily and quickly created. The model's accuracy will be high if the design of BIM model incorporates cost estimation. However, Designer create BIM model accuracy which is responsible for cost estimation accuracy with the BIM tools (Alder, 2006).

2.3.4. Sustainability

The objective of this section is to assess ability of BIM technology in promoting sustainability in design, construction and operations. BIM drive sustainable development in water conservation, energy use reduction, sustainable procurement of materials, industrial development, recycling, waste reduction, climate change, transport strategies. BIM covers the various aspects such as considering building sun-path, location, orientation, heating and cooling loads thermal properties of materials, ventilation and daylighting analysis. Key aspects of BIM are social, technical and management processes that maximize time, cost, resources and capital. Through BIM, it is possible to have a smarter and more productive future evolving from more expensive inefficient construction methods. As noted by Eastman et al. (2011), BIM integrates procedures for design and construction procedures to improve building quality at a reduced cost as well as reduced implementation time.

2.3.5. Facility Management

According to Cotts et al. (2009), as cited in Arayici, Onyenobi and Igbo (2012), Facilities Management, is a "multi-disciplinary field encompassing multi-disciplines to ensure the functionality of built environment by integrating people, place, process and technology". The BSI for facility management defined the integration view as a "processes integration within an organisation to develop and maintain the agreed services which support and improve the effectiveness of its primary activities". FM aims to make an effective use for all people using the building by effectively operating and maintenance.

The main functional responsibilities of BIM are defined in the following for FM, as mentioned by The International Facility Managers Association (IFMA), (Wikipedia, 2013):

- Facility financial forecasting

- Long-range and annual facility planning
- Real estate acquisition
- Work specifications and installation
- Work space management
- AEC planning / design
- New construction or renovation
- Maintenance and operations management
- Telecommunications integration and security
- General administrative services

"The main task of facility managers is to ensure that the assets of the facility are fixed providing the services needed in each work space management" (Teicholz, 2013).

2.4. Barriers of Building Information Modelling

Despite the numerous benefits attributed to adoption of BIM in the AEC industry, several factors hinder the implementation process. The categories of these barriers are lack of skilled personnel, high application costs, lack of a national standard, legal issues and organizational issues. As shown in table 1, each barrier can be further subdivided into three groups. The far right column of table 1 shows different literature that describes the barriers.

Table. 1: Summary of barriers in BIM implementation

Category	Item	Literature
Lack of National standard	Incomplete national standard Lack of information sharing in BIM	Bernstein & Pittman, 2004; Thomson & Miner, 2006; Björk & Laakso, 2010; Azhar, 2011; Aibinu & Venkatesh, 2014; Alreshidi et al., 2014
High cost of application	High initial cost of software High cost of implementation process	Allen Consulting Group, 2010; Thomson & Miner, 2010; Azhar, 2011; Ganah & John, 2014
Lack of application	Lack of professionals High cost of training and education	Smith & Tardif, 2009; Allen Consulting Group, 2010; Sharag-Eldin & Nawari, 2010; Becerik-Gerber et al., 2011; NATSPEC, 2013 ; Wu & Issa, 2014
Organizational issues	Process problems Learning curve Lack of senior support Ownership	Arayici et al., 2011; Won et al., 2013; Aibinu & Venkatesh, 2014; Demian & Walters, 2014
Legal issues	Responsibility for inaccuracies Licensing problems	Thomson & Miner, 2006; Chynoweth et al., 2007; Azhar, 2011; Udom, 2012

The above-identified barriers to BIM implementation influence each other. As shown in Figure 4, BIM implementation is strongly linked to the five categories of barriers. BIM implementation has significant impacts on organizational structure and work processes in major firms in the AEC industry. BIM implementation could lead to legal and economic issues when external parties such as suppliers are involved. According to Allen Consulting Group (2010), BIM implementation can reduce significantly the project construction costs. The high BIM software costs are associated changes in enterprise organization or workflow as well as hiring competent professionals. Due to incomplete standards, conflicts could arise in relation to legal ownership of shared information and data. Simultaneously, absence of a national standard is an implication that there is no unified personnel training level, hence there is a high shortage of personnel.

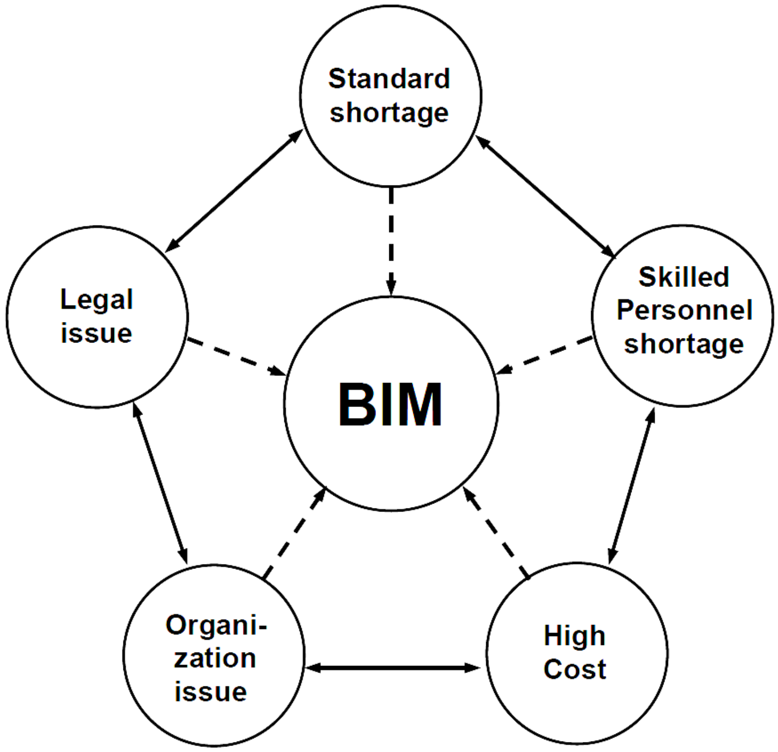


Figure 4: Relationship between main barriers

The focus of this section is to investigate the absence of legal issues, organization issue, a national standard, the high costs and the shortage of skilled personnel for BIM implementation. With investigation of the degree and nature of public attention to the main barriers to BIM implementation, this research proposes some recommendations to overcome these barriers.

2.5. Why Building Information Modelling?

BIM has become the new international benchmark for efficiency in parametric design, and building construction method. BIM is also significant to the management of the building life cycle (Yan and Damian 2008). Among the professionals of the construction industry around the world, the collaborative platform that BIM is gaining great popularity in recent years.

For this reason, it has been noticed that many stakeholders in the construction institutions and organizations around the world supporting BIM transition in AEC companies. (Haron et al., 2010). Although organizations provide roadmap for BIM transition in companies, they are not interested in BIM adoption, but According to the report of researchers and stakeholders, the future of BIM technologies will change the future of the construction industry (Yan and Damian, 2008).

Arayici et al (2009) reported that, recently, Australia, Norway, Singapore, Sweden, Finland, the United Kingdom and Europe Union in it building process of others to manage building life cycle, they have demonstrated the BIM is capable of using it in many live projects and has been documented with tested.

The surveys and observations have shown that traditional methods are used in the design processes of buildings. (Yan and Damian, 2008) and thus the AEC companies need continuous improvement is well cooperation and documented in the literature. Several governments published reports, it has clearly defined the request for change and improvement in the construction sector when comes to main business performance.

Nonetheless, traditional construction methods are used among all project stakeholders in the construction sector, communication on paper is used without a digital platform for a clear visualization of communication, collaboration and design. This resulted in lack of information and documentation data and management which those cause fragmentation in the project and companies activities. It is the result of the fact that the construction sector is far behind in digital transformation compared to other sectors, which has also given rise to many mistakes and waste, which poor coordination, low level of profits and low productivity.

Hence, BIM is considered as a reliable technology for supporting coordination between all actors on a construction project and facilitating communication among stakeholders. Thus, BIM helps to prevent conflicts that could arise due to poor coordination and communication.

2.6. Summary and Conclusion

The purpose of this chapter was to describe the benefits of BIM claimed by its proponents as well as BIM implementation barriers. We need to analyse the Turkish construction sector situation about construction management in the next chapter and then it will be necessary to identify research methods to analyze the benefits of BIM applications and barriers.

CHAPTER 3

BIM USE IN TURKISH CONSTRUCTION INDUSTRY

In this chapter, the current situation of the Turkish construction sector will analyze. Government public administration and permit process, companies' construction management system and knowledge capacity of professionals and construction site management systems will be examined. The extent to which the construction sector is integrated to digital transformation will be explored. A general assessment will be made at the country level.

3.1. Introduction

In Turkey, Construction sector plays an important role in Turkey's gross economy and contributes to approximately 10 percent of the Gross Domestic Product (GDP) annually. Turkish construction sector, despite playing a major role in contributing to the growth of Turkey's economy, the last 20 years developing and globalizing industry should be integrated in the Turkish construction industry. The Turkish construction sector should develop current construction approach in terms of design, implementation and management methods integrated new technology and methods. Turkey is a main construction material producer country and especially competitive and strong in producing cement, building steel, ceramic, chemical admixture and glass products.

Turkey's building regulatory system and almost AEC firms rely on the traditional approach. Turkish AEC sectors need to road map to implement BIM. To increase the BIM awareness within the construction sector and beyond is significant challenge in a BIM infant sectors. Being a Turkey and an industry with comparatively lesser standardized systems than those of developed countries, it should look for suitable adoption strategies to get the best advantage of BIM. Strategies and roadmap being identified and adopted in developed economies with considerable levels of industry and technological maturity may not be readily adoptable in the Turkish context.

On the other hand, lack of maturity is also a blessing in disguise that it allows greater flexibility in selection of options for BIM adoption since there is no significant investment in technology to go waste by the selection of any of possible options. However, an investor in BIM in such a context bears greater risk of making the wrong choice. Therefore, an industry with little or no BIM maturity should carefully study all possible options and select the best in term of efficiency and effectiveness. In this chapter presents a BIM maturity discussion in the Turkish construction industry and a review of a suitable software environment for it.

Once the information is kept aside; nothing is or related to BIM is practiced in Turkish industry. A conscious effort to adopt BIM in recent future in the local industry was not evident. However, a considerable interest on the topic BIM was increasingly found to be discussed at professional gatherings. For this reason, an industry that does not perform.

Recently, as BIM has increased in importance in the construction industry, due to the significant benefits, many countries have accepted and supported the adoption of BIM to provide the required data exchange between stakeholders. It can clearly be seen that the level of understanding, adoption, and implementation of BIM varies from one country to another, from discipline to discipline, and from client to client as a result of many contextual factors. According to Al Awad (2015), there is a great gap to be seen between the BIM adoption in the West's construction sector and its uptake in the Turkish construction sector.

3.2. Building Regulation in Turkey

Turkey's building regulatory system stipulates local role municipalities and Republic of Turkey Ministry of Environment and Urbanization. Local authorities in the Turkish governments as the planning authority. For the aim of streamlining and standardization, Turkish Government proposes and draft digital transformation roadmap, policies, rules and regulatory requirements, TSE standards and implement guidelines to be adopted and gazette by the Ministry of Environment and Urbanization so as to be enforceable by the local authorities. The notifying authority, Republic of Turkey Ministry of Environment and Urbanization have made full progress in publishing and implementing the regulations on Construction Products and also on market surveillance and notified bodies related to the different European Union directives. All standards have been developed by the Turkish National Standardization Authority (TSE). Turkish National Standardization Authority became a European Committee for Standardization full member in 2011. TS ENs (transposal of European standards in Turkish) have duly integrated the necessity to withdraw the mandatory standards and to replace local standards. Turkey adopted legislation on the publication of technical specifications and national and EU technical approvals.

Turkey have been integrated of technical specifications, adopted legislation relating to the technical specifications publication and EU technical approval, on conformity of verification systems and on construction products reaction-to-fire aspects.

Actually, Turkey's building regulatory system rely on the traditional approach. Local authority accepts as 2D drawings in CAD model. They calculate project time by using critical path method (CPM) that has been approved by manually calculation method for construction. This method is not good calculation method. It is really difficult for complex project as a result cause misreading project, consume time and misleading project. This method requires manual control for discrepancies in designs depending on the design complexity. The government of Turkey has not been pushing and promoting the construction sector to IT/ IS adoption and utilision in order to catch the developed country level. Turkish construction government must prepare roadmap for new construction development strategical approach.

3.3. Turkish Government to Dive into Public Projects

Turkey has made large investments in the construction sector. Turkish government have invested Airport, city hospital, residential houses, highway, subway and high speed rail projects and many other projects such hospital project is the Bilkent Integrated Healthcare Campus. Over 1.2 billion dollars have been invested in this project for the hospital, which will be the largest hospital in Europe.

One of the largest investments made by the state so far Istanbul Airport project. It will be one of the world's largest. In the project that was auctioned with build-operate-transfer model. The total cost of the project is around 10 billion dollars. The airport was fully opened in 2018.

TURKEY is one of the largest investments in the field of project partner is the Trans Anatolian Natural Gas Pipeline project. It aims to transport natural gas from Azerbaijan to Europe via pipeline. The length of Trans Anatolian Natural Gas Pipeline is 1,850 kilometers Natural gas capacity defined for Turkey and Europe will support the security of supply at an affordable price. The total cost of the project is around 12 billion dollars.

Another major infrastructure project with the strategy importance for Turkey for improving transport and trade connections between countries, the project will connect Baku- Tiflis - Kars cities. Turkish government are continuing investments for many more projects.

3.4. Turkish Local Architecture, Engineering and Construction Firms Framework

Actually, Turkey’s building regulatory system rely on the traditional approach. Local authority accepts as 2D drawings in CAD model. They calculate project time by using using critical path method (CPM) that has been approved by manually calculation method for construction. Turkish construction industry is dynamic, complex and fragmented in nature which frequently causes problems in sharing information and communication during current construction practices. Recently, the Turkish construction industry has been facing greater challenges in reducing project cost, duration and duplication via effective collaboration and communication between project parties (Arditi et al.,1985). The Turkish government has not been driving and pushing to implementation BIM systems. So, the Turkish AEC firms which use technology are in isolation and there is non-interoperability and a lack of integration between project parties which leads to inefficiencies in the cost control of projects, delaying and decreasing project quality.

3.5. International Competitiveness of the Turkish Contractors

Growing global competitiveness of Turkish construction materials producers and contractors, Turkey's payment is contributing significantly to the balance.

Last 50 years, Turkish contractors have undertaken almost 10000 projects in 120 countries, with a total value of 500 billion USD. In addition, Turkey is among the leading manufacturers and supply chains of building materials in the world. The geographic location of Turkey, makes a large contribution to the global competitiveness of Turkish contracting services in worldwide. After China, Turkish contracting companies are the second most capable country in the world. The investment environment in Turkey both for domestic and foreign investors are increasingly becoming more attractive and expected positive growth in construction in the coming years. Turkish contracting companies are successfully competing with high-quality, affordable services in 5 continents and 120 countries. They get an enhancing international strategical partnerships not only in contracting work, but also in construction and material production investments, ranging from building materials production to highway, infrastructure, housing, industrial building and mega projects in worldwide. Global market competitiveness increases every year due to changes in the construction sector parameters. ILK construction construct high rise building in Baku. Project show in figure 5.

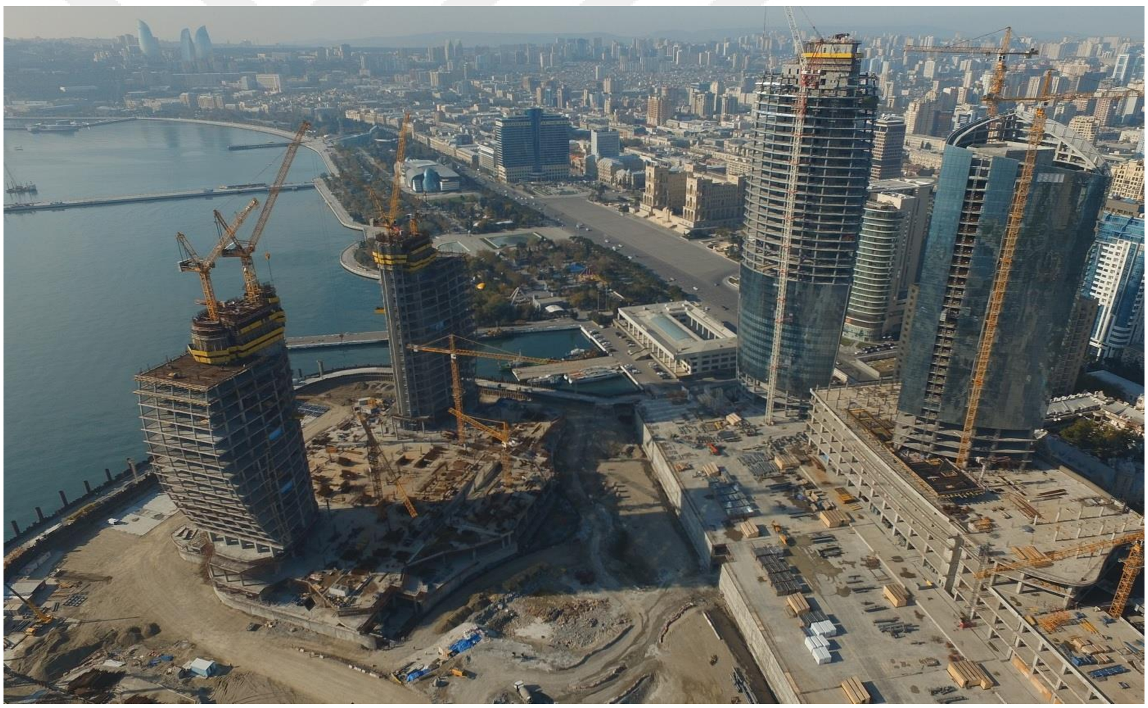


Figure 5: ILK construction Port Baku Residence project

BIM is rarely used for Turkish AEC firms; most projects base on traditional construction methods. When BIM tool and process is preferred, it is usually implement for mega scale and technically complex projects, for example, in the very complicated Istanbul Grand Airport project, where BIM is used and the model was populated with project information.

To ensure sustainable growth, sources of competitive advantage must be analyzed and contractors must adapt to changing needs in the construction sector. The more powerful and integrated the construction companies are with BIM, the greater their ability to capitalize on their benefits and ensure a strong return on investment in BIM. Contractors' most significant project benefits from BIM are reduced mistakes, omissions and reduced rework activities, both have a positive impact and contribute to strong rate of investment.

Sustainable growth can occur if contractors adapt to the changing needs in AEC and competitive advantage is analysed thoroughly. A powerful BIM integrated well into construction companies can lead to a high return on investment. BIM helps contractors to reduce errors, omissions and rework, thereby impacting the project positively and facilitating a strong rate of investment. According to contractors, BIM improved project control and delivery process by facilitating coordination and communication among the members. Contractors also cite other benefits such as better time and cost control / predictability and reduced cycle time for approvals and workflows.

3.6. BIM Education and Training

There is no government roadmap for BIM education on universities and institution courses. Very few universities in Turkey BIM courses are available. In addition, academics do not know enough about BIM. The Turkish some institute continually provide education through BIM conference, seminars, workshops and presentations. There are efforts to raise awareness of BIM at the university. Although the majority of the architecture and engineering department do not know much about BIM. Most of the architect and engineers practicing education models are conventional 2D design and tradition construction management environment.

In order to accelerate the integration of BIM in design and engineering firms, it is inevitable to provide BIM training to engineers and designers.

Turkish professional chambers need to understand the importance of BIM use and collaborate with BIM training and working principles. Turkish professional chambers should collaborate with educational institutions to revise the university syllabus for architectural and engineering studies BIM adoption process as their fundamental pedagogical platform.

The curriculum should aim to develop students in the fields of drawing skills, interdisciplinary collaboration skills and project management in the BIM environment.

In addition, professional chambers and associations need to collaborate with BIM software developers to implement continuous professional development training program to implement designers and ensure that they have sufficient BIM skills.

3.7. Benefits and Barriers of BIM Implementation for Turkey

3.7.1. Benefits of BIM Implementation for Turkey

BIM has many benefits to the Turkish construction industry, particularly in providing accurate and secure communication channels between different actors in construction projects. BIM is able to facilitates open communication between consultants, clients, owner, contractors and all actors in construction projects by provide a single respiratory system in one or more formats for digital information exchange.

Azhar et al. and Khanzode & Fisher believes that Implementation of BIM principles can reduce errors related to incompatible and uncoordinated project files because BIM is capable of accommodating building-related data with physical or functional characteristics.

According to Taylor & Bernstein and Kymmell, BIM implementation leads to 3D visualization, which is a key benefit. Through 3D visualization, it is possible for all project stakeholders to understand the entire building lifecycle. Kymmell added that an important task in Mechanical, Electrical and Plumbing (MEP) design is 3D model and calash detection, which helps to save time and cost. 2D traditional drawing model clash detection test occurs through overlaying 2D plan drawings to visualize the system components location in 3D space. With 3D parametric modelling between architect, MEP engineer and structural engineer, this project can be done in a shorter time and can be managed and implemented more successfully compared to the traditional method.

BIM utilization benefits are accurate project time and cost scheduling when the information define accurately BIM model. In terms of cost estimating, BIM can facilitate quantity surveyor quantifying the cost and the material of the projects in shorter time which can be reduced up to %80 compared to traditional methods. By accounting material cost and time scheduling in a shorter time, BIM can simplify the quantity surveyor that can be reduced by up to %80 compared to traditional methods.

3.7.2 Barriers of BIM Implementation for Turkey

Turkey has significant difficulties and obstacles in the transition to BIM. There is a lack of knowledge and awareness among users in the construction industry. If government and local authority consider BIM useless, it becomes difficult to BIM implementation in the construction sector. Although the Turkish government has not taken any roadmap for the implementation of BIM. In developing countries, one of the major barrier in using BIM software is the cost of the software. (Lindblad, 2013; Gardezi et al., 2014). Research by Liu et al. (2015) and Franco et al. (2015) The cost of software will be supported by the government or institutions, indicating that one of the major barrier to the implementation of BIM is the cost of software.

BIM software costs are followed by the absence of national standards, lack of technical staff, lack of training centers and BIM associations to raise awareness. According to Franco et al. (2015), participants had a common awareness of critical barriers, and most agreed that the cost of software was a critical factor. The first cost of investment in new technology and time is also important for educational technology. According to the study prepared by CIDB, Table 2 shows the interconnected key variables of BIM's implementation in construction.

This is followed by absence of national standards and inadequate technical staff. All research participants were aware of the critical barriers and accepted that cost was a critical factor for the project’s success. Another significant consideration is cost for the new technology and time needed to train personnel. Results for the survey are presented in Table 2 and they define the inter-related key variables stated as major barriers to implementing BIM in construction industry.

%26.2 of the participants stated that the barriers were due to cost of software and hardware. Following barrier is IT component %23 ratio. The barrier of time and readiness are %16,4 and %14,8 ratio. Meanwhile, the lowest barrier ratio is knowledge (%8,2), technology (%8,2) and information (%3,3). (CREAM, 2014; Eadie, 2013; Salleh, 2014; Chougule et al., 2015; Hedayati, 2015).

Table. 2: Barriers to the Implementation of BIM (CIDB, 2014)

Variables	Percentage %
Cost	26,2
Time	16,4
IT (Software, Hardware, Computer)	16,4
Readiness	14,8
Knowledge	8,2
Technology	8,2
Information	3,3

According to Yan (2008) and Manu et al. (2014), the responses of %40 of respondents from the United States and %20 of respondents from the UK believe they need to invest more in-company training and human resources. If the company BIM maturity level right BIM implementation process are not well established within the organization, there is a risk that BIM will lose adoption goal (Lindblad, 2013). This category constitutes the biggest hidden barrier in the implementation of BIM. Decisions taken in organizations are basically taken from a business criteria and perspective.

The Turkish construction industry is not delighted to BIM investment because evidence of BIM's financial benefit from a lack of case studies. AEC industry increase BIM investment on the other hand case study data results are reported when a good business case with proof of case study evidence.

There is also a customary and social resistance to digital transformation, as a number of architects, engineer and professionals are satisfied with using traditional design and construction methods to increase BIM's new advantages and opportunities.

Kushwaha (2016) is defined that BIM has revolutionized the construction industry, but the rate of BIM implementation in the industry is low due to various barriers. The resistance of educational institutions and government authorities to digital transformation and the lack of a roadmap claim that BIM is the main factor responsible for its limited awareness and implementation. In addition, it is not an easy task to switch from traditional approaches to BIM; it requires collaborative efforts from government authorities as well as all stakeholders.

Kushwaha (2016) says BIM has revolutionized the Architecture, Engineer and Construction industry, but BIM's application rate in the industry is low due to various barriers. He argues that his lack of initiative from government authorities and educational institutions is the main factor responsible for BIM's limited awareness and implementation. In addition, it is not an easy task to switch from traditional method approaches to BIM; Government agencies and private institutions requires set up collaborative working model.

Table 2 shows that Information Technology is one of the barrier that construction players face in implementing BIM. The lack of consistent standards and tool incompatibility throughout the project supply chain remains a challenge despite major improvements in recent years. (Manu, 2014; Smith, 2014; Ali, 2015).

Project delivery process fully integrated with IFC model multidisciplinary project actors operating in a single integrated and compatible BIM model is crucial for BIM optimal use. Currently, the scope of this is limited. The BIM use is considered more appropriate for mega scale and complex projects with larger contractors and owners with the scope to demand that the people involved in the entire project have the necessary technological equipment and convenient software. Some professional workers claim that working with BIM projects is not effective against projects that run outside the BIM model due to incompatibility issues with software, standards, and applications. This also does not meet the capabilities required by key parties in the project supply chain. All researchers and developers acknowledged that, although these problems continue to be resolved and improved, they remain critical to successful BIM applications in the industry.

Other challenges that need to be triggered in the BIM adaptation process can be divided into four perspectives to consider, (1) process-related obstacles; (2) technical obstacles; (3) social context obstacles; and (4) associated costs. There are three aspects of process-related challenges. First, BIM changes the traditional processes and management mentality in building projects, and consequently construction companies need to adapt to the new business plan and project implementation plan. At the same time, it is difficult to predict the results because users do not have sufficient information, and there are no clear company rules and execution plan. BIM has changed the traditional construction management and implementation mentality in construction projects, and therefore, construction organizations need to define new business modeling and process management. However, project actors are immature and there are no clear standards and rules, it is difficult to predict results beforehand.

Another point, there is a need to define new roles for people involved in the project; however, there may be uncertainty as to how they should be integrated into existing processes. The final problem with process-related barriers concerns the need to develop new contract obligations for BIM-based projects. These contracts should be able to division with the economic incentives section and knowledge. All construction players must integrate and adopt this change for the successful BIM implementation and adoption.

Table. 3: BIM adoption barriers [adapted from Alreshidi, Mourshed and Rezgui(2017)]

Social-organizational / Technical	Financial / Contractual / Legal
Social-organizational • Resistance to change • Lack of trust in and apprehension towards new technology • Lack of BIM understanding • Variations in practitioners' skills • Lack of BIM training • Lack of motivation • Clients' awareness • Adoption of traditional practices and standards • Avoiding/hiding potential risks and liability for mistakes **Technical** • Maturity of BIM-based technologies • Interoperability issues • Issues with existing BIM modelling and collaboration tools • Massive data inputs/outputs • Massive data and limited data storage • Limited accessibility and access rights • Lack of data sharing mechanisms • Lack of data tracking, checking and versioning control mechanisms • Difficulties coordinating large BIM models • Lack of notification mechanisms	**Financial** • BIM adoption cost and start-up costs • Personal Indemnity Insurance (PII) is not covered • BIM training cost • Limited budget • Expensive human-based services costs **Contractual** • Contractors benefit from confusion • BIM contracts are not yet mature • Lack of BIM-related aspects in current contracts • Failure to address BIM legal concerns in current contracts • Contracts need to accommodate changes in BIM collaborative environment **Legal** • BIM models ownership: intellectual property and copyright concerns • Liability for wrong or incomplete data • Lack of legal considerations in existing BIM contracts • Lack of legal framework for adopting collaborative BIM • PII does not cover legal aspects of collaborative work mechanisms • Difficulties coordinating large BIM models • Lack of notification mechanisms

Thus, there is a need to develop the ability and knowledge to meet the requirements of how BIM supposed to be used. If a single player involved in the project does not contribute, the expected benefit and value cannot be achieved because it cannot be used as intended (Lindblad, 2013).

Table 3 summarizes the most significant BIM adoption barriers identified in their research findings. Alreshidi et all (2017) have examined the barriers to BIM adoption and the key factors for effective BIM management. They have found that the major barriers include both non-technical and technical issues which are identify with socio-organizational changes, as well as contractual, financial and legal issues.

3.8. Summary and Conclusion

Turkey is still at early transition stage in BIM implementation. One way to overcome people's resistance is motivation. In this thesis, demonstrating the benefits of BIM will provide empirical and case studies have been reported to emphasize the importance of BIM implementation issues in Turkey. In this study, the current BIM use in the AEC firms to examine in Turkey and aimed to prepare roadmap to encourage the BIM use. Demonstrating the importance and potential benefits of building information modeling in this study, BIM has been prepared in this study to highlight implementation issues in Turkey to determine the road map of BIM implementation framework for digital construction in Turkey and the barriers to be faced in order to promote the use of BIM were aimed at identifying and preparing the necessary action to foster the use of BIM.

This study identified the barriers to integration into BIM, including lack of awareness, lack of training/education model, lack of standards and government regularity, lack of qualified technical staff and lack of client/owner demand. Support from government authorities/ professional bodies need to provide to improve the BIM uptake.

Support from professional organizations and government is needed to improve BIM recruitment, promote and support BIM guidance user, develop data exchange standards, define levels of BIM working and develop new form of contract. To support the adoption of BIM in Turkey to demand the government's use of BIM from every phase and every kind of need to take an active role in the project for the creation building regularity. In addition, the Turkish government should cooperate with universities, industry, professional organizations and educational institutions to provide clear standards and guidance on the use of BIM and to provide more specific training for future university students and practitioners.

Several lines of evidence, the Building Information Modeling can improve construction performance, but BIM implementation level in the Turkish construction industry has been at a slow pace. There are barriers to the right BIM implementation in Turkey such clients do not request/enforce BIM, lack of awareness about BIM, and reluctance from clients, owner, contractors or consultants to BIM implementation. If the government authority wants to control to BIM transition that the Turkish construction industry can compete globally, these issues need to be addressed. Government support also plays an important role in increasing the pace of BIM implementation in the Turkish construction sector.

Besides the government support, key players in Turkish construction industry such as clients, consultants and contractors need to initiate a paradigm shift from the traditional approach into a more innovative approach.

BIM implementation strategy and guidance for the provision of both parties in Turkish construction industry.

Successful BIM implementation in Turkey requires collaboration between the government and the industry players. The Turkish construction industry has to evolve by upgrading the current construction approach to the global standards in terms of practice, management or technology.

Turkish government authorities and industry players work together to establish the success of the implementation in Turkey. Turkish contraction industry to be integrated into the global standards in terms of management or technology development should result in improving the traditional building construction management approach.

CHAPTER 4

RESEARCH METHODOLOGY

4.1. Introduction

In this section, the research methods define in various sequential steps that are integrated in this thesis. The research methodology will be applied in different sequential steps in the research process. Furthermore, this is a systematic explanation method for a critical research and a defined study topic. The definition of the research steps adopted to conduct this research methodology is made synonymous with the elements description in the onion concept. (Saunders, Lewis and Thornhill, 2007).

4.2. Understanding the Research Process

According to Saunders, Lewis and Thornhill (2007), research onion offers a detailed understanding of the process used in research. Research onion concept represented as figure 6.

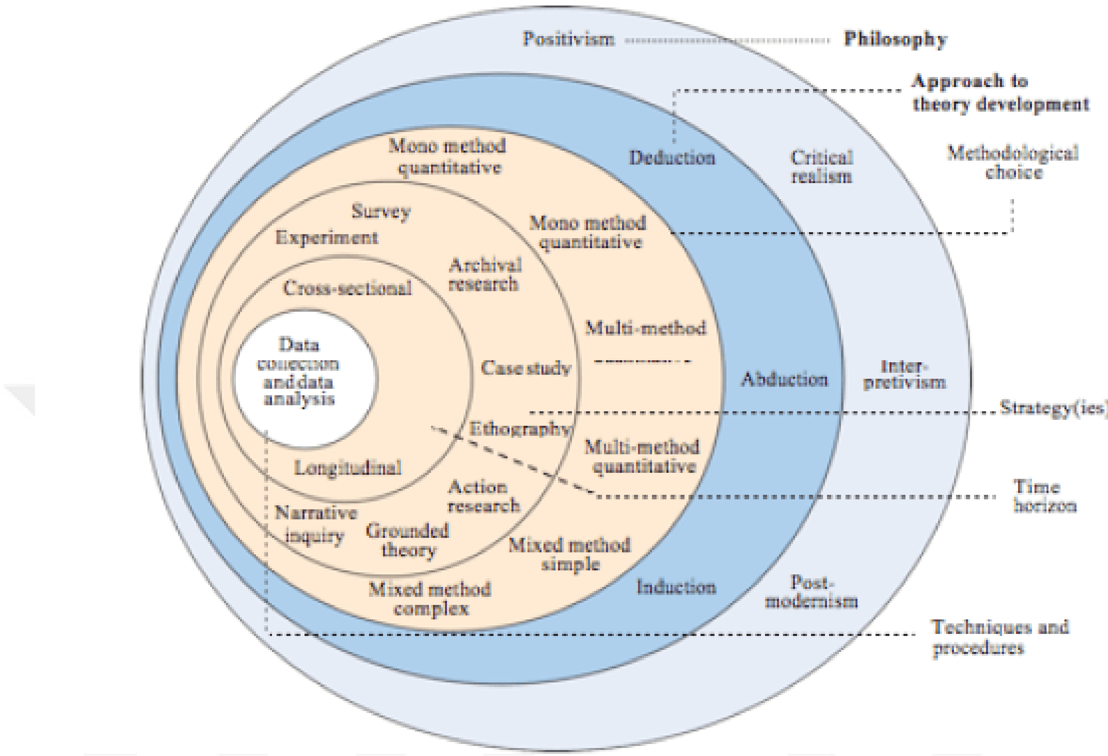


Figure 6: Research Onion Concept, Saunders et all (2006)

The research onion has seven layers categorized as philosophy of research, action research approach, the research strategy, the research choices, the time horizon, and the research techniques and the data collection methods (Saunders, Lewis, and Thornhill, 2007). When conducting this study, the researcher will access necessary information on the layer of the research onion.

4.2.1. The Research Philosophy

Research philosophy refers to an idea or belief in data collection, interpretation and analysis. The philosophies related to research explained in Saunder's research onion concept, which includes Realism, Positivism, Humanist, Interpretive and structuralism as the most significant (Saunders, Lewis, and Thornhill, 2007).

Ontology and epistemology are two different ways of viewing a research philosophy. Ontology in business research can be defined as "the science or study of being" and it deals with the nature of reality. Ontology is a system of belief that reflects an interpretation by an individual about what constitutes a fact.

In other words, ontology is associated with a central question of whether social entities should be perceived as objective or subjective. Accordingly, objectivism (or positivism) and subjectivism can be specified as two important aspects of ontology.

Positivism influences the truth of philosophical belief as stable and for this reason an objective research philosophy can be defined. Objective research philosophy also states that information that is not based on positivism is fuzzy and invalid. The research philosophy of realism is a philosophy that brings a scientific approach to development and knowledge. The basic assumption of realism is independent of people belief. There are two types of the realism. The first realism philosophy is critical realism and direct realist which from his believe that the world is static and unchanged from the critical realism that holds change constant. Nonetheless, problems are directly identified and addressed in pragmatism. This philosophy is more concerned with reality or outcome than the principles associated with it (William James, 2009). Philosophy also argues that this philosophy should be determined on the basis of concept or how a theoretical principle works. (Saunders, Lewis, and Thornhill, 2007). The philosophy ontological position accepted by the researcher in this study is positivism.

Epistemology is about 'how we know what we know' or 'the nature of the relationship between the knower or would be knower and what can be known'. Epistemology is concern with providing a philosophical grounding for deciding what kinds of knowledge are possible and how we ensure it is adequate and legitimate. The philosophy epistemological position accepted by the researcher.

Our research design starts by considering the ontological position which deals with the fundamental nature of existence, and for which there is no right or wrong answer as different people view topics differently depending on their role, values set or background.

4.2.2. The Research Approach

Locate in second later of research onion are research approaches (Saunders, Lewis, & Thornhill, 2007). There are two types of research approaches; the Inductive and Deductive research approach represented as figure 7 (Jonker and Pennink, 2009).

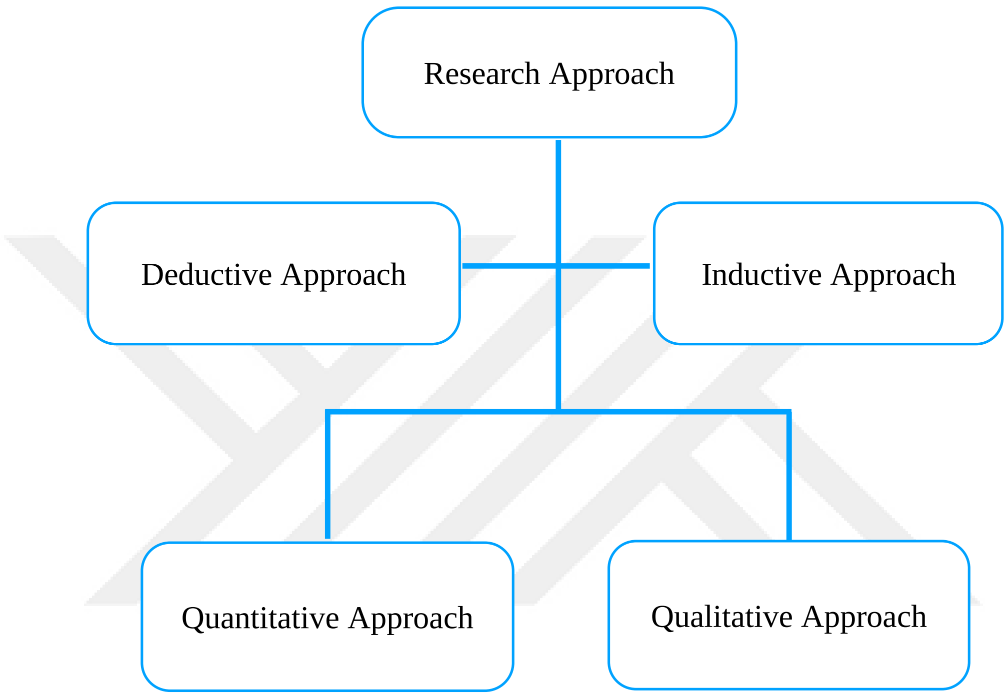


Figure 7: Research approach source

4.2.2.1. Deductive Approach

In a deductive research approach researchers check the hypothesis and the theory before moving to the result, which is more specific, the last part is the conclusion, which relies on available facts (Jonker and Pennink, 2009).

4.2.2.2. Inductive Approach

Inductive research approach entails empirical observation that lead to more generalizations and theory formation. As noted by Myers (2009), it is from the specific to the general and this method is mainly used in the qualitative research.

4.2.2.3. Quantitative Approach

The focus of a quantitative research approach is on the numbers and its frequencies. The method does not emphasize on the meanings and the experience but quantify the data collected therefore subjectivity to rigorous and strict analysis (Kothari, 2008).

4.2.2.4. Qualitative Approach

In a qualitative research, data collected describes factors rather than reaching to a statistical inference. The method is also part of an unstructured exploratory research whereby important factors of character, behavior, attitude, opinion is subjectively assessed (Myers, 2009). As noted by Kothari (2008), the qualitative studies are meant for explanatory purpose (Kothari, 2008). This research study is a qualitative research with a deductive research approach. Here the researcher will look into case study, survey analysis and data collection.

4.2.3. The Research Strategy

The next significant layer in the Saunders research onion is the research strategy, which refers to various strategies adopted for a particular study for example, experiment, survey questionnaire, case study, based theory, ethnography and archiving. (Saunders, Lewis, & Thornhill, 2007). According to Fellows and Liu (2008), five research strategies are survey study, ethnographic study, experimental study and case study. Yin (1996) states that the strategy applied to any study depends on the type of research question including the expected result, the degree of control required, the focus point of time (now or past), goals and objectives. The section below provides a detailed description of the research strategies.

4.2.3.1. The Experimental Research Strategy

Experimental research helps to validate the results and to determine cause effect relationships mostly in physical sciences. The strategy's main features are isolation of factors, repetition of experiments, and quantitative measurement of results.

4.2.3.2. The Survey Research Strategy

The Survey research strategy studies small and large populations by selecting and studying samples that are chosen from the population in order to discover the relative incidence, distribution and interrelations of the sociological and psychological variables and therefore this research is mainly used to investigate the psychological and social factors.

The research design is defined as an outline plan, structure and strategy that show how the research is carried out, methodology and techniques adopted for achieving the objectives (Myers, 2009).

4.2.3.3. The Exploratory Research Strategy

In exploratory research, the objective is to formulate a new perspective on a phenomenon and explain what is happening (Pope and Mays, 2006).

4.2.3.4. The Case Study Research Strategy

A case study is a research strategy and an empirical inquiry that investigates a phenomenon within its real-life context. Case studies are based on an in-depth investigation of a single individual, group or event to explore the causes of underlying principles. A case study research strategy and case studies focus on the person, group or social whereby the real life situation is analysed in details.

4.2.3.5. The Action Research Strategy

According to Coghlan and Brannick (2009) action research strategy helps to find an immediate solution to a problem encountered in a society. Through action research, it is possible to analyse data on current issue and predict future changes (Jonker and Pennink, 2009).

4.2.3.6. The Grounded Theory Research Strategy

This theory applies largely to a qualitative research in social sciences. The approach involves formulation of a hypothesis, collecting data, and coding the data collected. The coded data is then grouped to form a theory (Charmaz, 2006).

4.2.3.7. The Ethnography Research Strategy

This strategy is applied to qualitative research whereby the researcher has to interact with study population for a specified period to collect the data required. The ethnography research strategy facilitates collection of first-hand information from a particular culture or group of research (Murchinson, 2009).

4.2.3.8. The Archival Research Strategy

Archive research strategy is the final stage of the research strategy; this is based on the materials of the study, which the entire study will be based on some archives held by some other researchers, and there is a large amount of data in this research strategy, and the data cannot be controlled very often, and therefore, based on these data, temporary results are not possible. (Graham, Towl and Crihton, 2010).

4.2.3.9. Adopted Research Strategy

In this research, the researcher has adopted case study and survey strategy to obtain data in broad and in-depth range from the Turkish construction sector. The methods adopted for each research task have also been discussed. Adopted method includes a technology and literature review on awareness BIM technologies and construction supply chain, case studies on BIM implementation practices, development of BIM execution plan on country base and company base in the construction industry, validation of these scenarios with the digital transformation of Turkish construction industry, context BIM framework based on scenarios, development of the implementation framework based on scenarios and context models and evaluation of the digital transformation.

4.2.4. The Research Choices

The next layer in the research onion is selection, which can be further categorized into mono method, mixed method and multiple method. The mono method adopts only one research method, whereas the mixed methodology involves both qualitative and quantitative approaches. In multiple methods, several methods are used (Saunders, Lewis, and Thornhill, 2007).

In this study of development of BIM implementation framework for digital construction in Turkey, the researcher has adopted a multiple method yet only the qualitative and quantities research methods are used here by the researcher. Research approach is inductive approach using both qualitative and quantitative data. A series of research methods are combined to investigate of development of BIM implementation framework for digital construction in Turkey.

4.2.5. The Time Horizon

The definition of a time horizon is a fixed time target and a time limit in which a task or activity has to be completed. The first type of time horizon in relation to completing a research is longitudinal, which has no specific time for the data collection, analysis and completion of the studying. For the second type, cross sectional, a prefixed time is set for the completion of the research (Saunders, Lewis and Thornhill, 2009). For the present study, a cross sectional time horizon will be used to investigate BIM adoption barriers of Turkish AEC sector. There was a prefixed and planned time horizon for conducting the research and a limited time to collect data from the selected samples. Survey and IGA case study are also limited to a specific time frame and hence the cross sectional time horizon is used.

4.2.6. Research Process and Plan

This chapter presents the research design process and methodology applied for this study. The selected methodology and research design determine the outcome. Thus, it is necessary to discuss all philosophical assumptions, strategy, research design and methodology applied to the study. A diagram here showing the research stages in relation stage by stage process and plan of development of BIM implementation framework for digital construction in Turkey. The research process section defined to the different sequential steps adopted in this research process plan in figure 8.

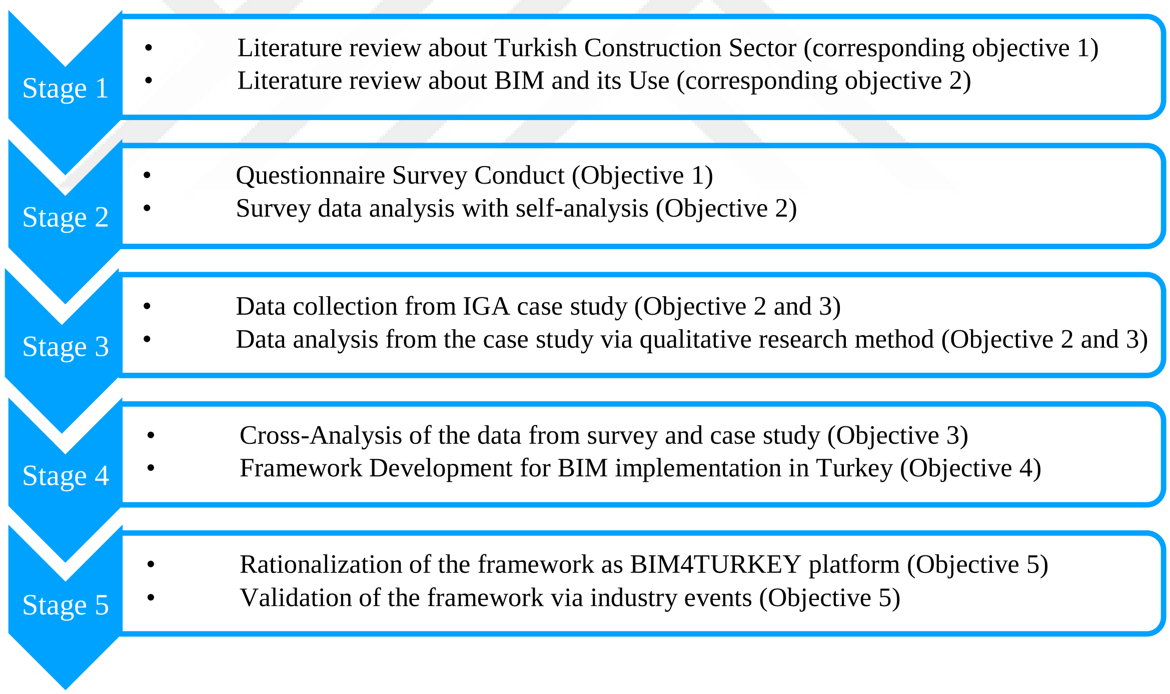


Figure 8: Research Process Plan in the Research

4.2.7. Data Collection and Data Analysis

Data collection and analysis are the most important elements in the research study. The data are collected systematically and the analysis of the collected data answers the research question by specific technic and procedure (Bryman and Bell, 2007). Data measurement is directly responsible for reliability and validity of the research (Wood & Ross, 2010). Thus, the primary data and secondary data are the two types of data collected for a systematic analysis for any research.

4.2.7.1. The Primary Data

Primary data information is created for the first time and created to meet specific requirements in the investigation, and primary data are directly collected data from experiments or respondents so, proper control of the collected information is specific to this type of data although, major disadvantage of primary data is time consuming if the suitable samples are not at hand (Reason and Bradbury, 2006). So, the various source of collected primary data are collected from interview, questionnaire, case study, experiments study, survey observation and discussions.

The researcher in this study has collected the primary source of data by employing an online survey and questionnaires that translate the research objectives in to specific questions and allow a place for the respondents to post their opinions.

In line with these justifications about the case study research strategy in the literature, the research in chapter 6 examines IGA BIM implementation case study and conduct critical analysis.

Collecting primary data on IGA site interviews are conducted with the BIM department staff in the project. A total of 15 BIM engineers were also interviewed. More specifically, they were asked to give a walkthrough, step by step process, and/or activities. A key emphasis was placed on the framework for the analysis of BIM implementation.

In this study, the researcher collected the primary data source using a questionnaire, online survey, site visit and interview that translate the research objectives into specific questions and provide a place where participants can give their opinions.

4.2.7.2. The Secondary Data

Secondary data are not collected directly from the participants. Data collected by others. Collecting and examining primary data is easier in time and economically. Since data is collected from other sources for a particular purpose, the data may be vast, inappropriate and uncontrollable (Saunders, Lewis and Thornhill, 2007). Secondary data sources have variety like website, publications, government statistics, journals, newspapers, books and organization statistics (Bryman and Bell, 2007).

In this study, the researcher collected the secondary data related to the research subject from various materials. Information was used for secondary collected data and this consist of books, BIM journals, BIM report, web sites and BIM statistics.

4.2.7.3. Data Analysis

Data analysis consists of several analysis techniques to analyze the collected data. Like as the cross tabulation, frequency distribution, analysis variance, self-analysis, regression, descriptive statistics, factor analysis, discriminant and cluster analysis etc. (Bernard & Ryan, 2009) and it is an important field in using the right research data and completing the research. (Saunders, Lewis, and Thornhill, 2007). In this study of development of BIM implementation framework for digital construction in Turkey, the researcher has adopted a multiple method yet only the qualitative and quantitive research methods are used here by the researcher. A series of research methods are combined to investigate of development of BIM implementation framework for digital construction in Turkey.

In this chapter 5 questionnaire based survey for BIM implementation the researcher has used the self-analysis method of data collected and analyze the data systematically in which the information will be presented in tables with equivalent chats and diagram wherever needed or requires and also the use of pie chart and bar diagrams for the data analysis. The vital data collection instrument for this study shall be the online survey application, and it shall be containing two major sections; the profile section which shall curtail the demographic information of the firm which can be anonymous and then the survey proper section which shall contain questions regarding other aspects like the policy, the technology and the process.

In line with these justifications about the case study research strategy in the literature, the research in chapter 6 examines IGA BIM implementation case study and conduct critical analysis. In addition to that, a recommendation section for objective opinion shall be added.

4.3. Summary and Conclusion

This chapter describes the research methodology applied to determine the role of BIM technology in the construction industry. The chapter primarily describes the research philosophy applied to the study. Several aspects will be covered in the following chapters. Firstly, implementation of BIM technology and its effect on the AEC companies and Turkish Government will be discussed. Secondly, evaluation frameworks for AEC firms and Turkish Government will be explored with the roadmaps examined and related to the Turkish context. Thirdly, the identified framework will be modified to suit the context and subject in question to increase significance of the results. Lastly, a descriptive analysis of the findings will be conducted and the final outcome summarized as well as recommendations provided.

CHAPTER 5

QUESTIONNAIRE BASED SURVEY FOR BIM IMPLEMENTATION

5.1. Introduction

The purpose of this chapter is to describe and analyse data from the questionnaire. The structured questionnaire was disseminated through a web-based survey package to collect data from the respondents. The major information in the survey include demographic background of respondents, as well as construction management. Assessment of respondents' demographic profile was based on their years of experience in estimation of construction costs and time, ability to communicate effectively, sustainable perspective, professional background, their current role in the organization and nature of their organizations' business. The files for BIM adoption were evaluated based on their level of awareness on the use of BIM in the construction industry, level of knowledge on BIM, user's ability to apply the BIM software correctly in all stages of the project, significance of BIM in their current role, and planning on future use if BIM.

The survey consisted of 20 questions, which included 16 multiple-choice and four open-ended questions. The survey questions include dependent and independent variables to obtain both qualitative and quantitative results from the survey analysis.

5.2. Brief of the Survey Questionnaire

The purpose of the study is to establish the roadmap for BIM integration into the Turkish construction industry. In this regard, construction professionals' knowledge and awareness about BIM are required. Therefore, it is necessary to identify the constraints and advantages of BIM for its successful implementation. For this purpose, an analysis of the impact of people, culture, technology, regularity and educational dimensions is needed. We examined literature review of BIM benefits and gains from this literature chapter, how can we prepare a roadmap on a national scale? At this point, it is necessary to determine the awareness and technical capacity of the existing AEC professionals.

Thus, in the research, a questionnaire based survey with professionals working in the construction sector is conducted.

This questionnaire survey acted is supplemental to the preparation framework of Turkish construction digital transformation as the strategies. Figure 9 shows the stages involved in conducting the questionnaire survey.

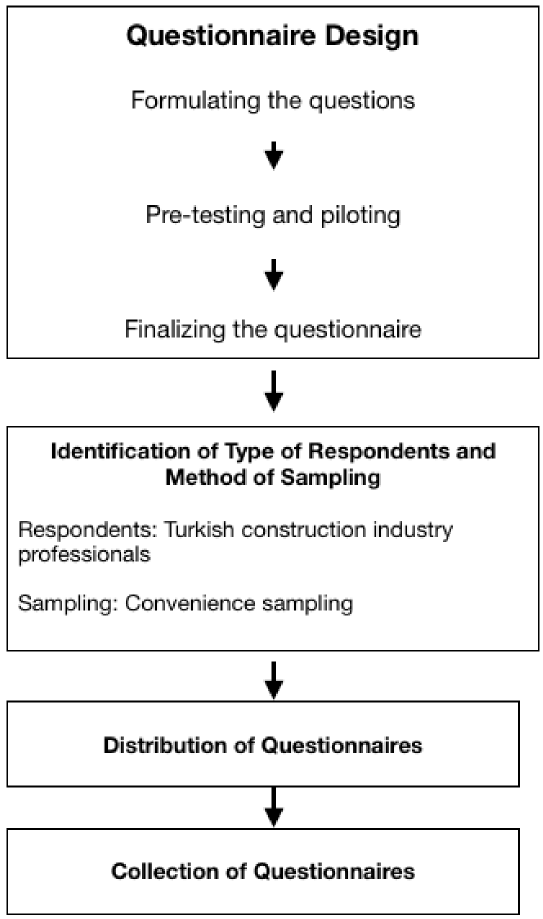


Figure 9: Stage involved in conducting questionary survey

Questionnaires provide understanding to the respondents on what the research is all about. The respondents were also requested to fill in the consent form provided as the proof of their voluntary participation in the research.

Two-month duration was given for the respondents to fill in and return the questionnaire. Efforts were made to the non-respondents via email and phone calls in order to encourage them to participate in the survey. The survey strategy is highly suitable and applicable for deductive approach.

5.3. Data Collection Process of the Survey Questionnaire

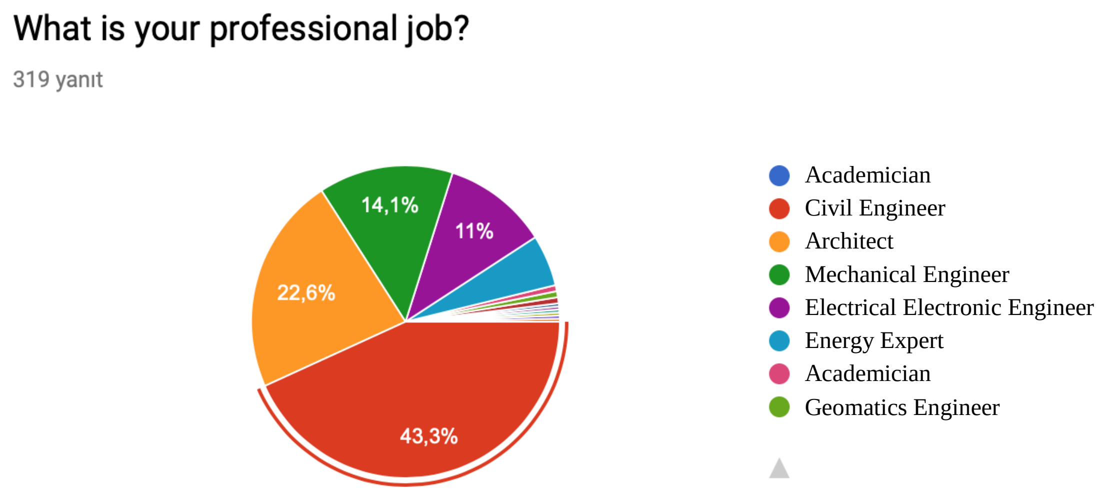
Questionnaire enables respondents to understand the objectives of the research. For this study, participants were requested to consent to the research process by signing a form of consent. This process was to ensure their participation was voluntary. The respondents were also requested to fill in the consent form provided as the proof of their voluntary participation in the research.

Two-month duration was given for the respondents to fill in and return the questionnaire. Efforts were made to the non-respondents via email and phone calls in order to encourage them to participate in the survey. The survey strategy is highly suitable and applicable for deductive approach. This extensive questionnaire is currently within professionals of data collection (316 participants engaged) in Turkey.

5.4. Data Analysis

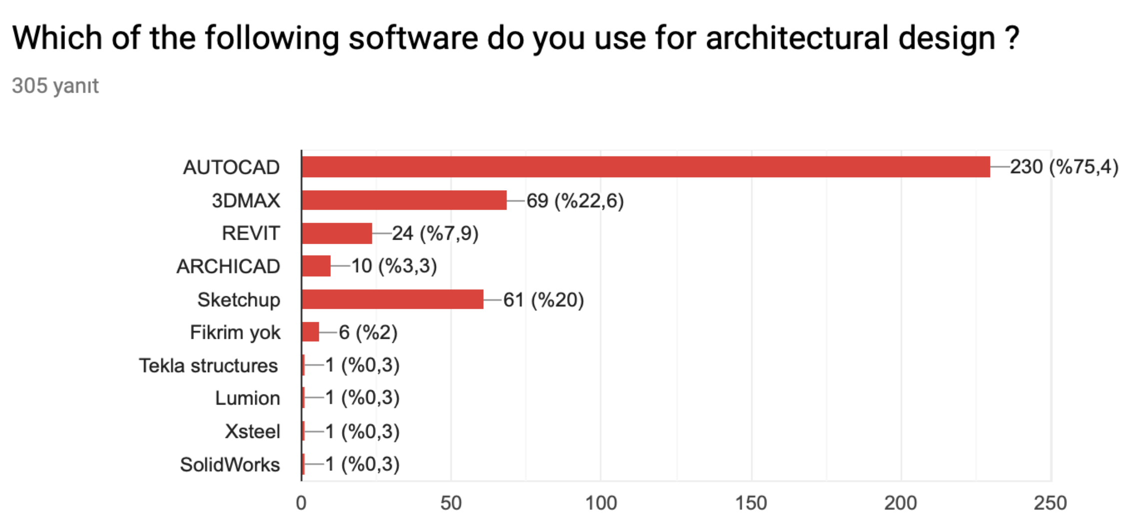
Analysis of the data collected helps to statistically validate the validity and reliability of questionnaire used. The data was first coded, screened and cleaned before performing the analysis. Data outliers were treated and normality of their distribution checked. Moreover, through validity and reliability measurements, it is possible to determine if the research instrument measures what was established in the research. Analysis of data collected involve descriptive analysis methods. The sample frequencies or percentage distribution was described through charts, figures and tables.

Question 1: The questionnaire was shared with the people who worked in the construction industry. The participants were asked to state their professions.



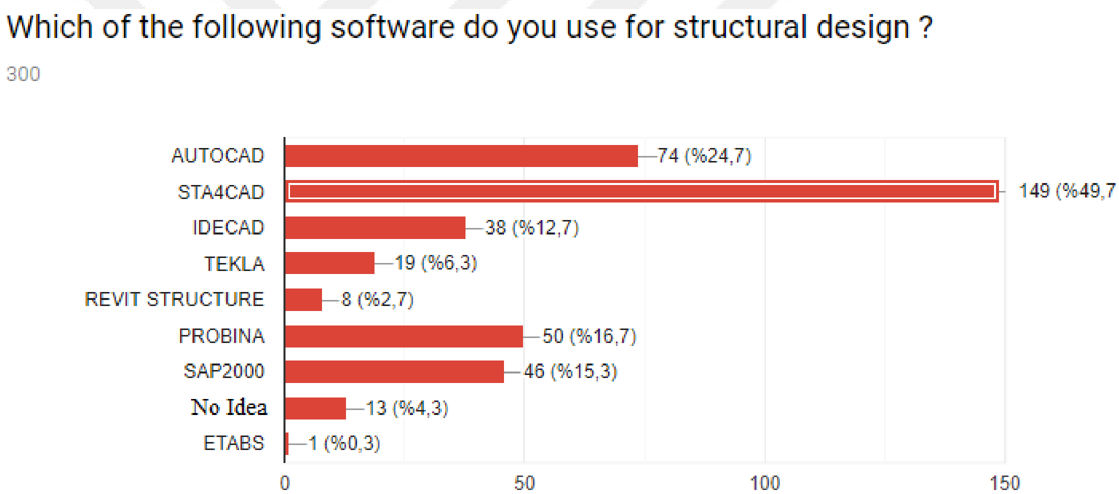
Analysis of Q1: The distribution of the participants was proportional to the number of professionals working in the construction sector, and along with them, people from different occupations participated in the study as well. Civil engineers and architects are the most frequent occupations. The total ratio of the two professions is %66.

Question 2: Participants were asked about the programs used in Architectural Designs section. They could mark more than one choice.



Analysis of Q2: In the design of the buildings, Autocad software is used at the rate of %75,4. 3DMax and Sketchup software are followed by a %22,6 rate. The percentage of usage for Revit was %7,9 and for ArhiCAD was %3,3. Companies and designers who are active in Turkey continues its mainly traditional method by 2-dimensional design. The 3DMax program and Sketchup program are used to visualize 2D designs in 3D. The ratio of Revit and ArchiCAD programs that are integrated into BIM is %11,2. Most of the companies and architects use these systems to transfer 2-dimensional drawings to 3-dimensional ones more than %90 of the architects in Turkey design in 2 dimensions.

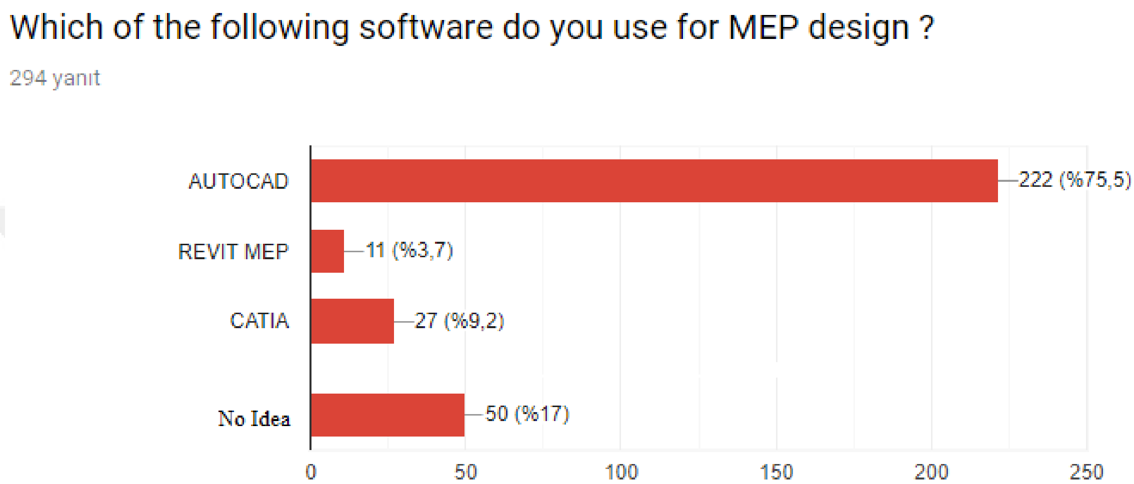
Question 3: Participants were asked about the programs used in building structure analysis. They could mark more than one choice.



Analysis of Q3: Structure analysis is carried out by civil engineers. Sta4CAD software is used most frequently with a %49,7 ratio for structure analysis. Autocad is used at the rate of %24,7. The other most popular programs such as Probina, SAP2000 and ideCAD are used at the rate of %15. The percentage of usage for Tekla is %6,3 and for Revit is %2,7.

Firstly, since the architectural projects are prepared in the Autocad program, it used as a utility in static calculations. The rate of use of Sta4CAD, IdeCAD and Probina programs is %79.1. The specified software is the local software used in accordance with traditional methods. They are not internationally valid and are integrated into the CAD system. The Tekla program, which is integrated into the BIM system, is used at %2,7. Most of the companies using the Tekla software do not have information about the BIM system; they only use the Tekla software because they found it successful in the design of steel structures. The rate of those who use the BIM-integrated system is very low.

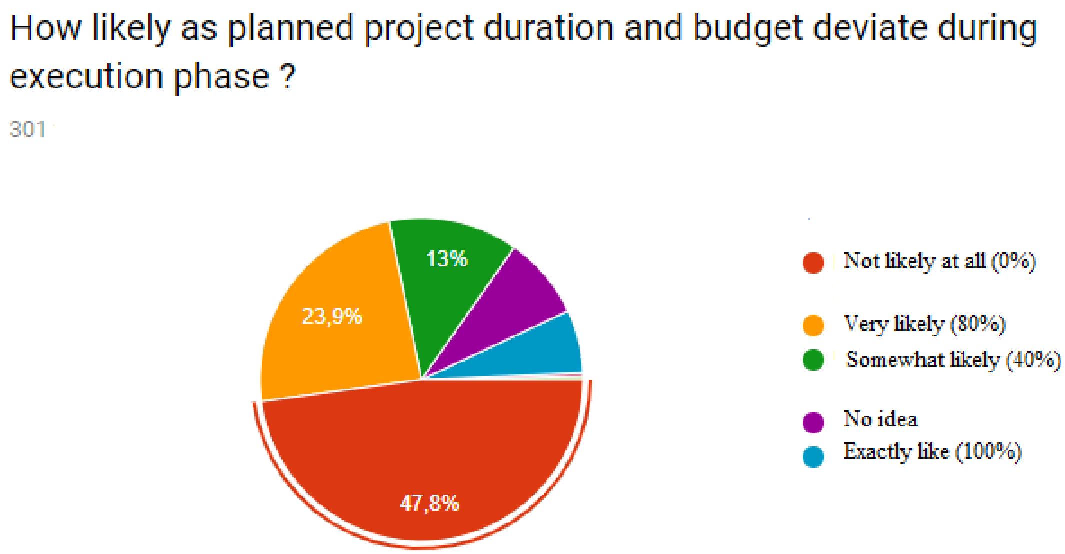
Question 4: Participants were asked about the programs used in the design of MEP. Participants could mark only one option.



Analysis of Q4: According to the survey results, AutoCAD software was used at %75,5 in the preparation of the MEP. Catia was at %9,2, and Revit MEP software was used at %3,7. The most essential factor in the use of AutoCAD at %75,5 is due to delivering architectural projects with the CAD system.

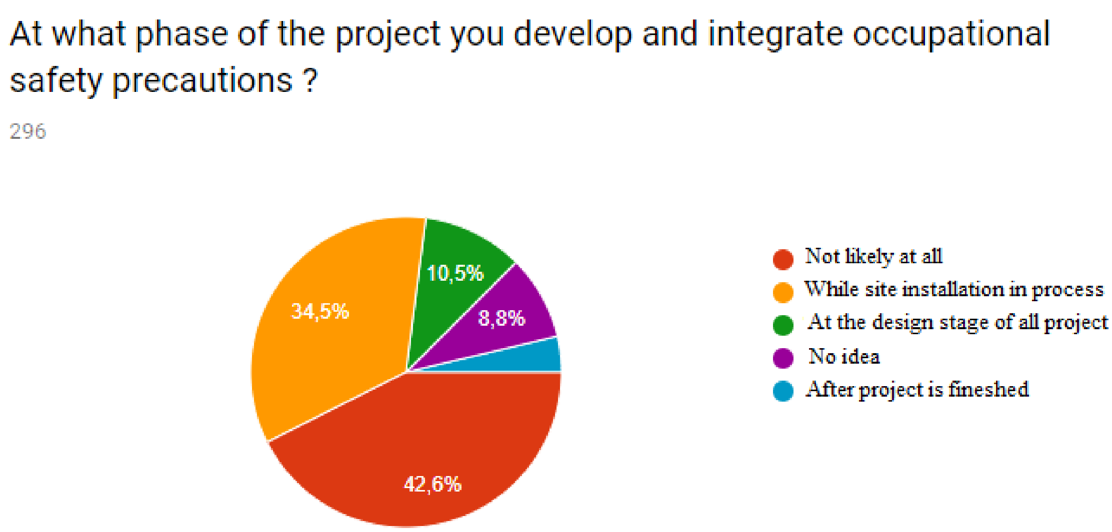
The other most important factor is that municipality only accept projects in CAD format. Revit MEP software is more widely used in companies that are fully integrated into the BIM system. Catia software, which is a 3D design program that can be integrated into the BIM system at %9,2, has been used in the industry.

Question 5: Participants were asked about the project budget and schedule planning. Participants could mark only an option.



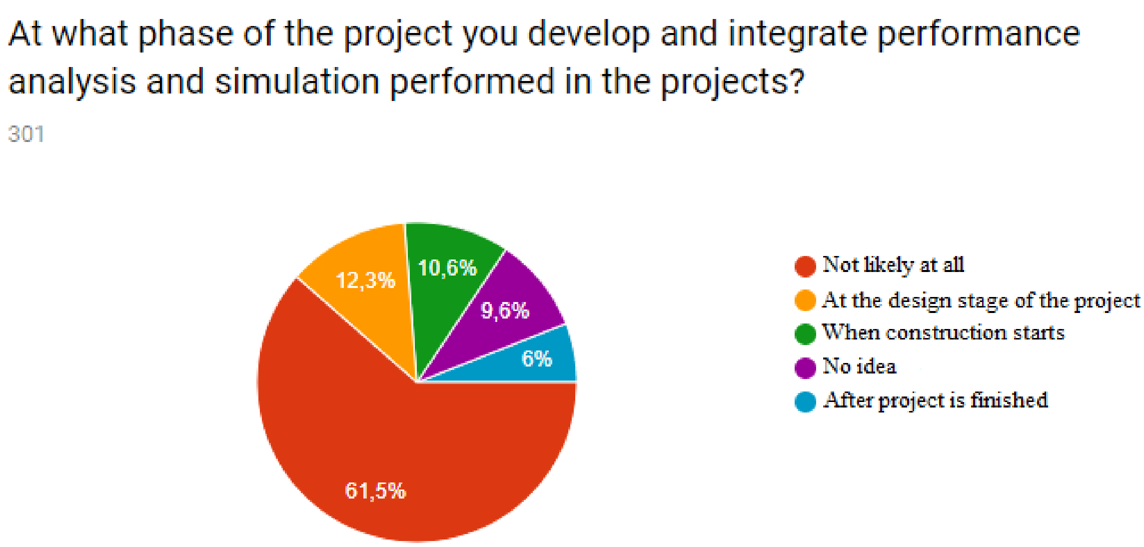
Analysis of Q5: 47,8% of the participants said that they could never be completed as planned. %23,9 of them stated that they generally completed as planned. The rate of completing it exactly as planned is %6,3. Budgeting and time planning or the failure to implement the structure correctly cause serious delays and financial losses.

Question 6: Participants were asked about work safety planning. Participants could mark only an option.



Analysis of Q6: %42,6 of the participants stated that work safety planning was not done in the projects. %34,5 of them stated that work safety planning was done in the fieldwork process. The work safety planning rate at the project’s design stage is %10,5. It was found, when the ‘Work Accident Statistics' published by the Social Security Agency in 2014-2016 was examined, that work safety precautions have not been taken into consideration enough. In Turkey, 286,068 work accidents occurred in 2016. 29,701 of them were in the construction industry. As a result of these accidents, 1.405 employees lost their lives, 496 (approximately %35) of them were in the construction business. There are severe short-comings in work safety planning. The standard of occupational health and safety available at almost construction work place is the main determinant of construction workers' health. Construction workers face dual occupational hazards, the traditional as well as novel in the complex work settings due to rapid industrialization, technological advancement and globalization, over the last few years. An equally wide variety of chemical, physical and psychological hazards in construction site.

Question 7: Participants were asked about integrated performance and simulation analysis. Participants could mark only an option.



Analysis of Q7: %61,5 of the participants said that they could not likely at all. When The ultimate aim of develop and performance analysis is to support such innovation by providing a high integrity representation of the dynamic, connected and non-linear physical processes that govern the disparate performance aspects that dictate the overall acceptability of buildings and their related energy supply systems. It understood that the construction industry professionals do not have enough knowledge about the concept of facility management.

Question 8: Participants were asked about facility management. Participants could mark only an option.

Subsequent to completion of the project. Do you create any computerized model for maintenance and operation tracking purposes?

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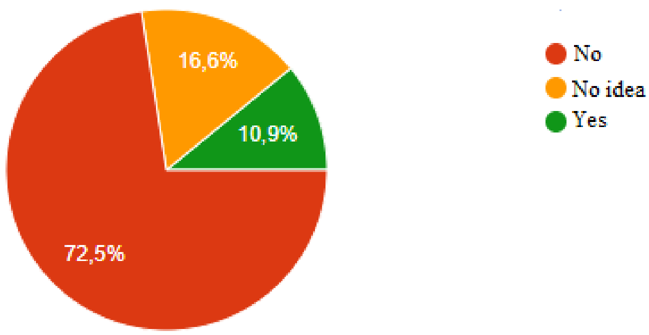
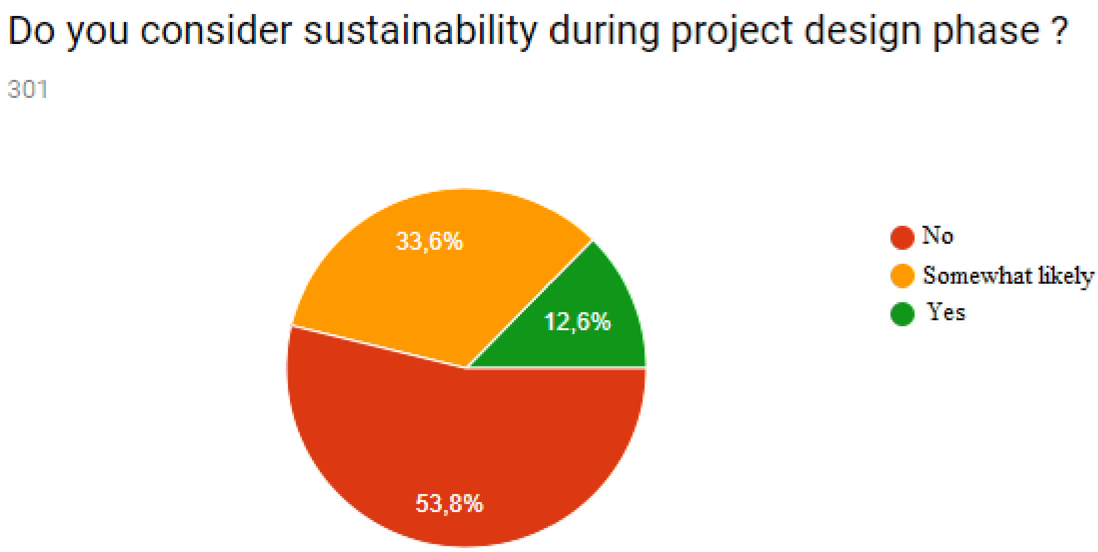


Analysis of Q8: %72,5 of the participants stated that they did not share the projects to be used in the facility management. %10,9 of them stated that they shared the projects to be used in the facility management. In order to increase the efficiency of the structures, it is vital to use the operating model in construction management after completion of the construction phase. The maintenance and operation of the structures should be available through the model. After the structures have been delivered to the participants, they did not have any idea about the structures. In case of any technical problems, traditional methods are used to produce instant solutions.

Question 9: Participants were asked about the sustainability perspective. Participants could mark only an option.



Analysis of Q9: %53,8 of the participants stated that they did not take the sustainability perspective into account in the construction of the structures and %33,6 of them were partially take them into consideration. %12,6 of the participants stated that they take the concepts of sustainability into consideration. Notably, construction industry professionals do not have enough knowledge about the concept of sustainability.

In the establishment of this concept, many parameters ranging from university education to cultural values are involved. It is possible to raise awareness in the construction industry and to change their philosophy in terms of structures. The sustainability of the structure is very low, carbon emission is very high, and they are not sustainable structure due to not having a sustainability perspective in Turkey. Moreover, Turkey signed the Global Warming Kyoto Protocol, and the United Nations Framework Convention on Climate Change. It is aimed to reduce carbon and greenhouse gas emissions to zero. Most of the carbon emissions are caused by housing. At this point, the necessary action plan for sustainability of building has not been considered.

Question 10: Participants were asked about their communication with the project units. Participants could mark only one option.

During the construction phase, do you have a computerized platform for instant information sharing and collaboration with the entire stakeholders of the project ?

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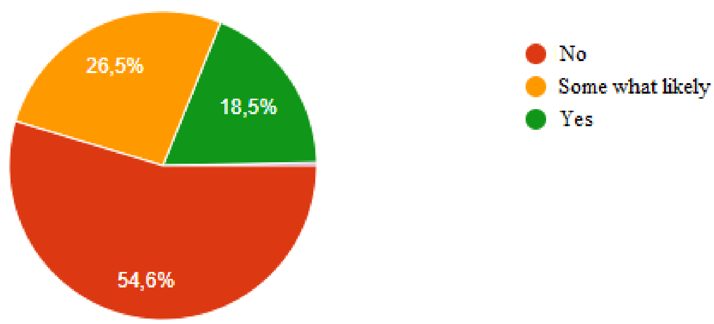
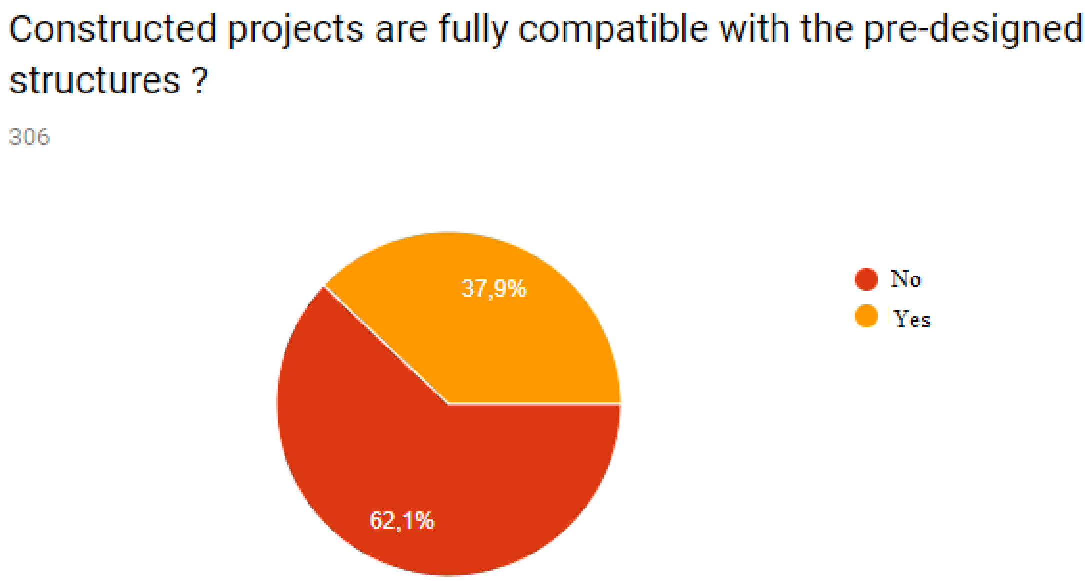


Analysis of Q10: %54,6 of the participants stated that they did not cooperate with all units. %26,5 of them stated that they are partly in cooperation. The percentage of those who can communicate in full cooperation and fast communication is %18,5.

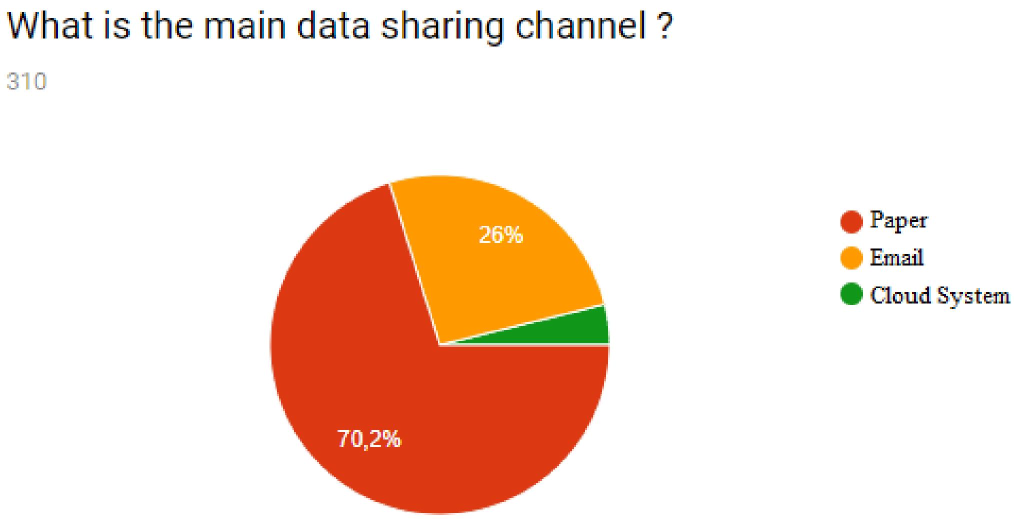
Based on the data, it is concluded that communication problems are experienced due to the widespread use of traditional methods used in structures. Therefore, the project cannot be carried out as a team. There are many errors and problems due to a lack of communication. Particularly during the project phase, the failure of all units to evaluate the project causes serious problems in field construction. As the units carry out different projects and no single programming language is used, serious data loss occurs in the transfer of projects.

Question 11: Participants were asked about the implementation of the project in the field. Participants could mark only an option.



Analysis of Q11: The percentage of those who say that the designed projects are applied one-on-one in the field is %37,9, and the percentage of those who do not apply is %62,1. The project is expected to be implemented one-to-one in the field. Lack of communication between units, failure to perform required tests during the design phase and not enough time, contractors making changes in the production stage, lack of communication between the design and field units, preparing the designs with the traditional methods and faulty design are some of the reasons of not being able to implement the pre-designed project as it is.

Question 12: Participants were asked about the implementation of data sharing. Participants could mark only one option.

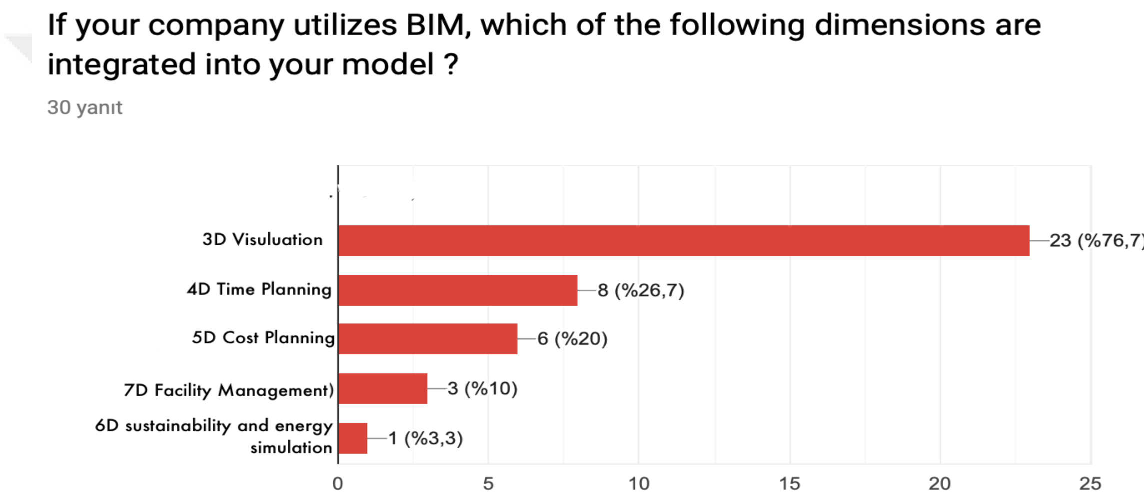


Analysis of Q12: The participants stated that %70,2 of data were shared in written documents, %26 of them were shared via emails, %3,8 were shared through the cloud. Reliance on traditional methods has made it difficult to use the cloud system in the construction industry. The reason for using written documentation is the processing of culture and official documents through written documentation. Data loss, errors, time and budget loss occur due to not using the cloud system. This reveals that the construction industry falls behind with digital transformation.

Question 13: Participants were asked about the use of the BIM application. Participants could mark only one option.

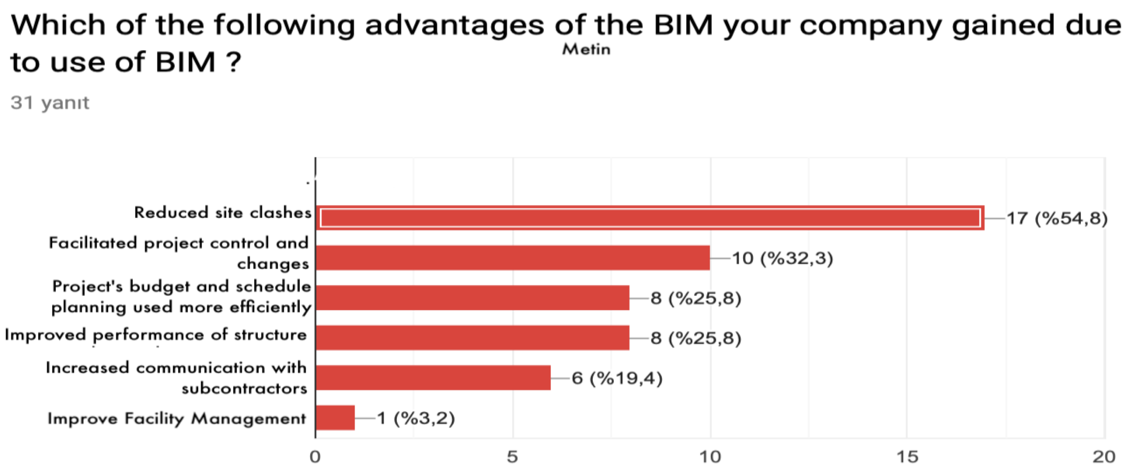
Analysis of Q13: %90 stated that the BIM system was not used, and %10 said they used the BIM system. In Turkey, the construction industry uses traditional building methods. There are a lot of parameters and obstacles affecting this rate. Some of them are insufficient knowledge about the system, poor emphasis on the system in universities, and lack of technical staff.

Question 14: Participants were asked about the extent to which they used BIM application. Participants could only mark one option.



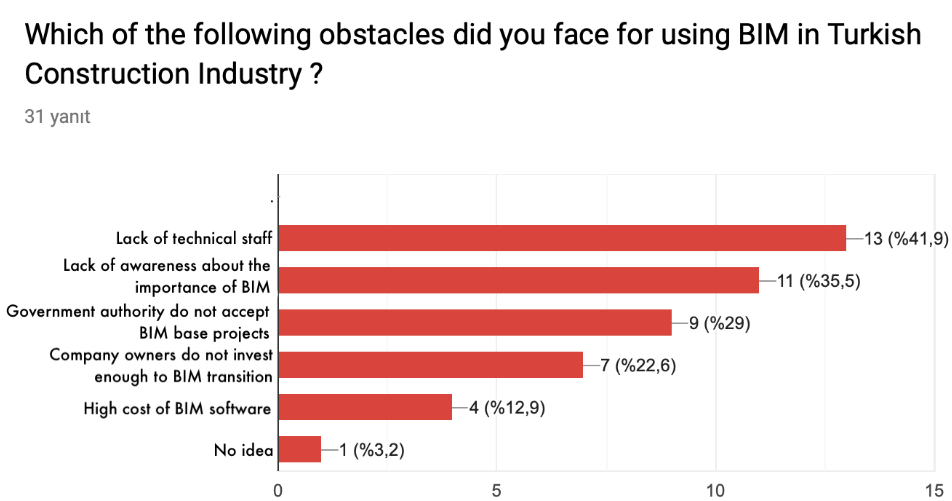
Analysis of Q14: Only 30 people answered this question. Twenty-three people (%76,73) who answered the question used the 3D dimension. It was revealed that the scheduling planning was used by eight people and the budget planning was used by six people. The number of people that can use it up to 7D is 3. A limited number of people and companies in Turkey and has operations in the BIM field. The use of BIM system is more common in the field of architectural design in the 3D dimension. The results revealed that the architects have more information about BIM since they use it in architectural designs. There are almost no use and awareness in effective use of BIM dimensions.

Question 15: Participants were asked about the benefits of implementing BIM. More than one option can be marked.



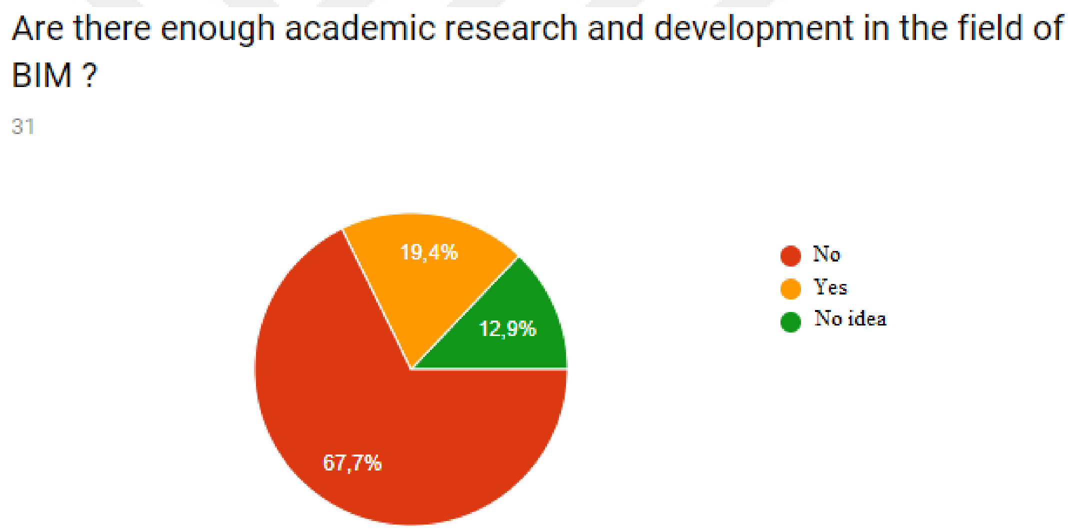
Analysis of Q15: The analysis and results of the benefits in the BIM usage are related to the BIM usage dimension mentioned in question 13. Due to the majority of BIM users used it in 3D, it helped to find conflicts and errors up to %54,8. Approximately eight people benefitted due to using the budget and timing dimensions. After the project was completed, only one person preferred to use it. Increasing this ratio depends on the fact that firms can use the BIM system with all its dimensions.

Question 16: Participants were asked what the biggest obstacle to the implementation of BIM was. They could mark more than one option.



Analysis of Q16: %77,4 of the participants stated that the obstacles were due to a lack of awareness and technical staff. The failure of the university education system to renew its curricula is seen as the biggest obstacle to the construction industry. It is another factor that there is no center where the people who want to specialize in this field can take the necessary training and applications. %22,6 of the participants stated that it is another factor that municipalities do not accept BIM modeling and there is no road map. It is very difficult that the state will encourage the application of BIM and to realize the digital transformation of the construction barriers and benefits.

Question 17: Participants were asked the academic research and development in the field of BIM. They could mark more than one option.

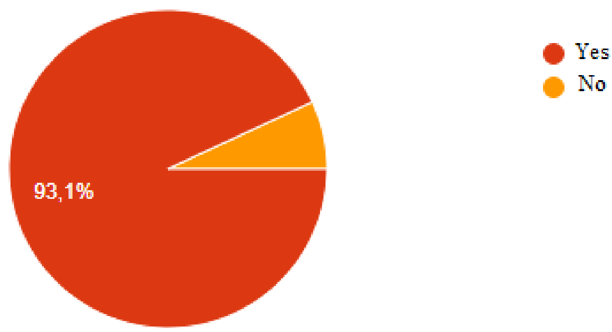


Analysis of Q17: 31 people who know the field of BIM answered this section. According to the participants' answers, %67,7 stated that there were not enough studies in the field of BIM, and %19,4 of them stated that there were enough studies. The number of companies making the transition to BIM system in Turkey is minimal. Much more social and technical studies are needed in the field of BIM.

Question 18: Participants were asked about the need for a BIM center. They could mark more than one option

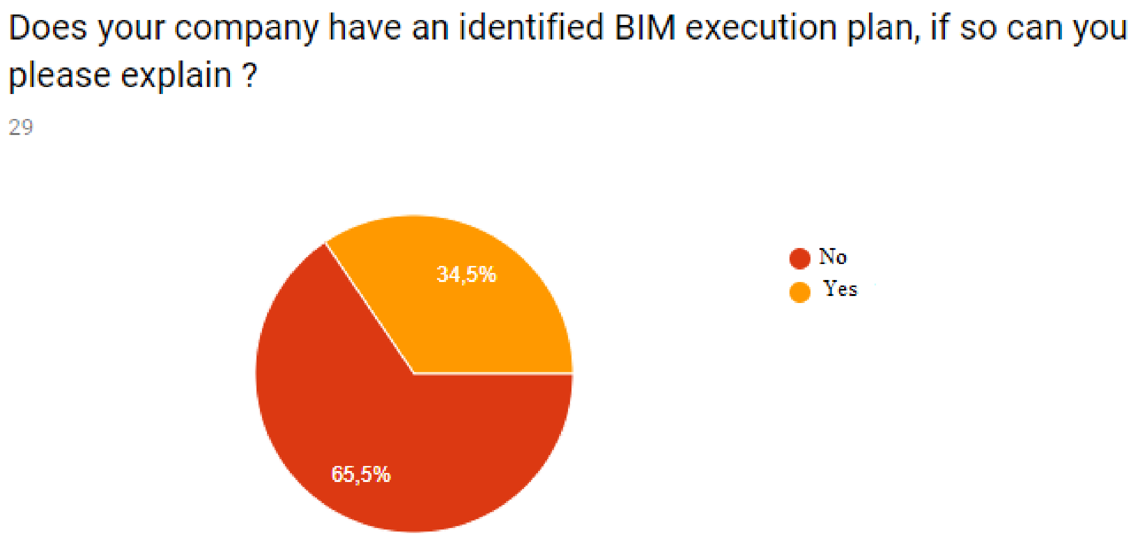
Do you believe there is a need for establishing a BIM centre for guiding BIM users for the right implementation of BIM system, setting national standards for BIM application in Turkish Construction Industry, increasing awareness of industry professionals, and providing training for novice users ?

29



Analysis of Q18: %93,1 of the participants stated that it is necessary to have a BIM center in Turkey. There is a need for a center to increase the awareness of BIM implementation and to implement it with the right methods. There is a need for a center that meets the demands of the BIM professionals, as well as provide the necessary recommendations and support for the change of the university education system, which can create BIM standards and provide a roadmap to the BIM capacity building.

Question 19: Participants were asked about the importance of BIM execution plan. They could mark more than one option.



Analysis of Q19: With any BIM project, it is critical to establish the way that BIM will be executed that is the purpose of the BIM Execution Plan. 31 people who know the field of BIM answered this section. According to the participants' answers, %65,5 stated that there were identified BIM execution plan. The participants noted that BIM is a powerful communication tool for holding all stakeholders together till the end. The aspect is significant to the AEC industry, since only a project that is well-coordinated project can sustain to the end and give output.

5.5. Discussion and Result

According to the survey results and discussion;

5.5.1. Technology

The survey results show that AEC industry in Turkey is lost as a result of the inadequate interoperability among participants in the industry, the continued paper based business practices, and a lack of standardization in technology adoption among stakeholders. To stop that tendency many regulation bodies have launched initiatives to improve quality, responsiveness, reliability and efficiency in Turkish AEC industry.

5.5.2. Construction Management

The results of the survey show that Turkish construction management are used among all project stakeholders in the construction industry, communication on paper is used without a digital platform for a clear visualization of communication, collaboration and design. This resulted in lack of information and documentation data and management which those cause fragmentation in the project and companies activities. It is the result of the fact that the Turkish construction sector is far behind in digital transformation compared to other sectors, which has led to many errors, poor performance, and low productivity.

5.5.3. Performance Analysis

The survey results show that serious loss of time, loss of budget and serious mistakes have been made in the construction industry. Energy efficiency is low, and carbon emission is high and unplanned structures are formed, and unlivable structures have been left for the future generations.

5.5.4. Information Management

The results of the survey show that based on the data, it is concluded that communication problems are experienced due to the widespread use of traditional methods used in structures. Therefore, the project cannot be carried out as a team. There are many errors and problems due to a lack of communication. Particularly during the project phase, the failure of all units to evaluate the project causes serious problems in field construction. As the units carry out different projects and no single programming language is used, serious data loss occurs in the transfer of projects.

5.5.5. Facilities Management

As per the survey outcome, almost of the participants stated that they did not share the projects to be used in the facility management. Factors contributing to poor facility management include poor coordination and inadequate information during the maintenance process. All areas of the design and construction are supposed to have a high quality, including coordination and maintenance of the building process. In facilities management, multi-disciplinary activities have to be integrated within the built environment and their impact on people and the workplace at large co trolled. The lack of information on the plans and assets data of existing buildings will make maintenance and repair difficult to access when necessary.

5.5.6. Sustainability

According to the survey results, majority of the participants did not take the sustainability perspective into account in the construction of the structures. Since the construction industry is the largest consumer of non-renewable resources, it is a massive producer of waste. Thus, the building process contributes to near half of the total CO2 emissions. Besides, the building lifecycle consumes a significant amount of resources and energy, especially at the construction phase. Developers still depend on traditional methods of construction since the Turkish government lacks a policy for promoting sustainability. Furthermore, there is no link established with the international construction to enable local developers realize significance of the latest technologies in enhancing sustainability during the construction process. These factors make it difficult for Turkey to develop sustainability in its construction practices.

5.5.7. BIM Use, Advantages and Barriers

There is a need for an analysis of institutional or firm's level of awareness and knowledge on implementation of BIM in the building industry. Implementation of the BIM system at a country and a firm scale will require evaluation of the obstacles and advantages of the system. For this purpose, it was necessary to analyze the impact of people, process, technology, regulation and education dimensions on the BIM system integration in the construction management.

The construction industry, which has the most significant proportion of Turkey's gross national product, has not accomplished the digital transformation and still used conventional methods. The use of the BIM system is very limited and is known among professionals. Many parameters affect this. At the very beginning of these factors are that the state does not have an action plan in this regard, the university education system and not being widely used in the sector. It is observed that the companies integrating the BIM system are the ones that have international business contacts.

BIM integration into the construction industry generates many opportunities besides the challenges unlike the traditional approach. The significant of BIM technology is that it facilitates proper control of the project while enabling the project management team to efficiently manage variables such as cost, quality and time. The benefits have an impact on productivity and efficiency in addition to every-activity related to information management.

5.5.8. Capacity Building for BIM Use

Turkey is going through major urbanization and economic development. Thanks to public projects, housing and urban transformation projects, the construction sector has a very high business capacity, the Turkish Architecture, Engineering and Construction (AEC) sector is hover to play a significant role.

Turkish construction industry meet to provides the ground for communication and cooperation for all stakeholders engaged to project design and construction. Develop and implement of digital transformation framework will help for capacity building and awareness about BIM in Turkey with regular reports on building standards and accelerate the integration of BIM into the sector.

5.6. Summary and Conclusion

According to the results of the survey, we have determined the construction management culture of the professionals working in the Turkish construction sector. Our observation that the construction industry working methodology base on traditional construction methods. There are a lot of parameters and obstacles affecting this working principles. Industry working methodology are insufficient knowledge about the system, lack of emphasis on the system in universities, lack of technical staff and lack of rules and regularity. The obstacles in the transition to the BIM system should be eliminated, and solutions should be presented. The most important part of integration into the BIM system is the preparation and implementation of a roadmap for the integration of the state into the BIM system. The results of the survey show that serious loss of time, loss of budget and serious mistakes have been made in the construction industry. Energy efficiency is low, and carbon emission is high and unplanned structures are formed, and unlivable structures have been left for the future generations.

The creation of the digital transformation roadmap will be shaped according to the survey results and the benefits of the IGA BIM implementation. The next chapter, we will prepare a concept Turkey's roadmap for digital conversion. It will include all AEC stakeholders in preparing the roadmap. The next chapter engulfs the development of the digital transformation framework for the Turkish construction industry as per the analysis and findings the BIM Implementation and Management in Istanbul Grand Airport Project and the questionnaire-based survey for BIM implementation.

CHAPTER 6

BIM IMPLEMENTATION AND MANAGEMENT IN ISTANBUL GRAND AIRPORT PROJECT

The purpose of this chapter is to develop a solid understanding of how integrated building information modeling (BIM) is implemented in a mega project such as the (Istanbul Grand Airport IGA) construction project, which is the main case study in the research methodology. The research methodology in the study is formulated as case study.

6.1. Introduction

This chapter presents information useful for understanding BIM as a new working methodology for the construction industry in Turkey. The BIM is applied to the IGA project that has become not only a key learning hub for the Turkish construction industry, but also a global landmark for digital construction and project delivery. At this stage, the outcome of the collaborative processes is a highly detailed virtual model signifying each of the airport components. BIM supports collaboration in different teams following clear identification of new roles and responsibilities of the key parties such as suppliers, architects, contractors, and sub-contractors. Impact of the enhanced technology use on the day-to-day activities of the project managers and the ultimate impact on the outputs and outcome of the projects would be inevitable. Since the IGA project is a mega-scale airport construction project with features beyond building industry challenges, its design and construction should occur within tight deadlines and budgets. Its operations should also be effective and efficient. In this chapter, the role of BIM in promoting timely and on-budget completion of the project has been described as well as its ability to support airport management after handover? How to present IGA project and analysis of BIM implementation levels for the setback of development of BIM implementation framework for digital construction in Turkey?

6.2. Project Information

The IGA as a joint venture was founded in 2013 with the purpose of constructing and operating the new airport for the city of Istanbul. Istanbul new airport project is World's largest airport project scope encompasses 4 phases. The first phase includes the construction of 3 runways, a terminal including 5 piers with an area of 1.3 million m2 (14 million-square-foot), a carpark with an area of 700,000 m2 (7.5 million-square-foot), ATC towers of 90 m. high and other site facilities which include deicing areas, cargo facilities, rescue and fire station, fuel farm, a jetty, waste separation and waste water treatment plant, GIS center, utility center, data center, many auxiliary buildings including main entrance buildings, VIP Terminal building, state guest house, meteorology center, surveillance towers, apron barrier buildings, airport guard house, customs service building, airport maintenance center, snow removal center, police and security center, radar and radio building, kennel club, railway station for metro and high speed train, and mosque. General project information is shown in table 4.

Table. 4: Istanbul Grand Airport project information

Project	**Istanbul Grand Airport**
Total Size	76.5 million m2
Indoor Area (Phase 1)	3.5 million m2 (phase 1 only)
Number of Passenger (Phase 2)	90.000.000 / Year
Number of Passenger	200.000.000 / Year
Number of Employee	30.000 / Day
Budget	€10,25 bn
Planing Start-Finish Time	2014 - 2019
Construction Method	BIM
Save/Over Time	On time

IGA project information at the end of the completion of all phases, a visionary project will come to life providing 76 million m^2 of the airport area with six runways, supporting 3.500

take-offs and landings per day, 200 million passengers a year and access to 350 worldwide destinations. A total of 35,000 workers are currently working on the IGA construction site, and the project is one of the largest investments in modern Turkish history.

6.2.1. Project Key Dates

IGA project important project key date tabulated Table 5

Table. 5: Istanbul Grand Airport project key data

Project Key Dates	
January 2013	DHMI issued tender for 25 Years BOT Concession for INA
3 May 2013	Our consortium won the Concession for € 22.15 billion + VAT
7 October 2013	SPV - IGA Havalimanı İşletme A.Ş. (IGA) was incorporated.
19 November 2013	Concession Agreement signed between IGA and DHMI
March 2014	Master Plan submitted to DHMI
June 2014	Groundbreaking Ceremony
January 2015	World's biggest duty free agreement signed with Gebr. Heinemann
March 2015	MOU signed with DHL to make INA its regional hub for Express Cargo
May 2015	Complete Site Possession from DHMI
Jun 2015	Op. Consultancy Agreement (IINA CPH)
29 October 2018	INA becomes operational
1 January 2043	End of Concession Period

6.2.2. Tendering & Contracts

IGA formed to construct and operate the Istanbul Grand Airport, has a 25-year plan for operations and sustainability. DHMI – General Directorate of State Airports Authority has issued the tender for 25 Years Build Operate Transfer (BOT) Concession for Istanbul New Airport on January 2013 with a preliminary project. The IGA project, is based on a government grant offered for a specified period to IGA consortium, which builds, operates and manages the projects for 25 years. Following completion of the project, IGA consortium recoups its construction costs and generates profits from commercial exploitation of the project transferred to the government DHMI apply the general legal and regulatory framework that guides the IGA Build Operate Transfer (BOT) project from start to finish. IGA's investors are; Cengiz Construction, MAPA Construction, Limak Construction, Kolin Construction and Kalyon Consturction companies all having an equal share of 20%. The identifying project stakeholders and responsibilities process represented as figure 10.

Stakeholder analysis helps to collect and analyse quantitative and qualitative information on project stakeholders in relation to their roles and responsibilities. IGA consortium, supervised by DHMI, is the main authority responsible for construction & operations of Istanbul Grand Airport.

Subcontractors' contracts contain some requirements and provisions to produce shop drawings in compliance with the BIM model, submission of the required 3D models in required detail and development levels which help facilitating the implementation of the Istanbul Airport.

6.3. IGA Pre-Design Stage via BIM

The approach of pre-designing IGA project involves integration of people, systems, control, communication and practices into a single process that can harness the participants' talents and insights. The benefits associated with project predesign are optimization of project results, increased value to the profit, reduced wastes, and improved efficiency in all phases of design, fabrication, construction, operational and maintenance.

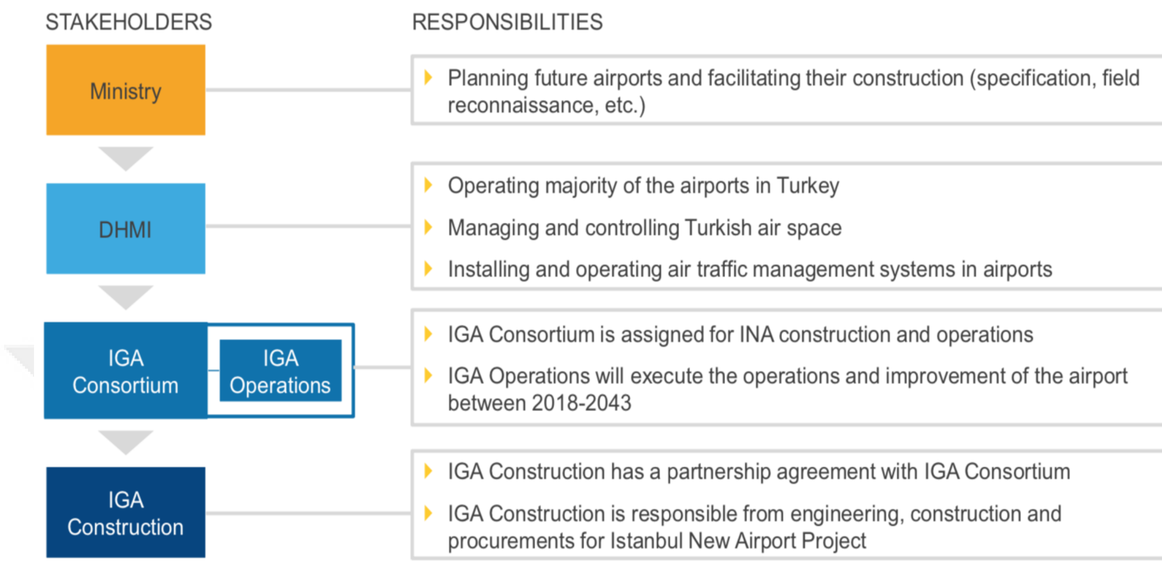


Figure 10: IGA roles and responsibilities

Technology is the main IGA project component that promotes collaboration among the team members, hence facilitating improved project delivery. Through BIM, it is possible to exchange digital information relating to the project. BIM technology helps to create a 3D, 4D and 5D models of the construction project. The 4D model shows the time required for implementation as well the scheduling information. By comparison, 5D shows the integration of cost. BIM covers geometry, spatial relationships, geographic information, quantities and properties of building components. These areas can help to demonstrate the entire building lifecycle including the processes of construction and facility operation.

6.3.1. BIM Implementation Process

BIM has a high efficiency in terms of handling IGA project information compared to traditional systems of construction. BIM adoption leads to a change in work processes thereby streamlining IGA projects leading to positive outcomes. For successful BIM adoption, substantial changes are needed in work processes to improve productivity and achieve the set goals. At the moment, the AEC-industry relies on tradition construction methods and is gradually adopting new BIM technology. Application of BIM technology will help to improve quality of design, work processes and final products in the AEC industry. One of the requirements for successful BIM implementation is changing the work processes. Unfortunately, it is difficult to change the work processes due to a high fragmentation in the industry, which makes only single actors to adopt the changes. As noted by Kiviniemi (2013), successful BIM adoption will improve integration, collaboration and innovation in the construction industry.

A fragmented construction industry poses many challenges during BIM implementation and adoption. Gu et al. (2008) presents the best method for categorizing relevant factors attributed to slow BIM adoption in the AEC-industry. These categories are; in terms of Product, Process and People. Multiple barriers for BIM adoption in the construction industry need to be addressed.

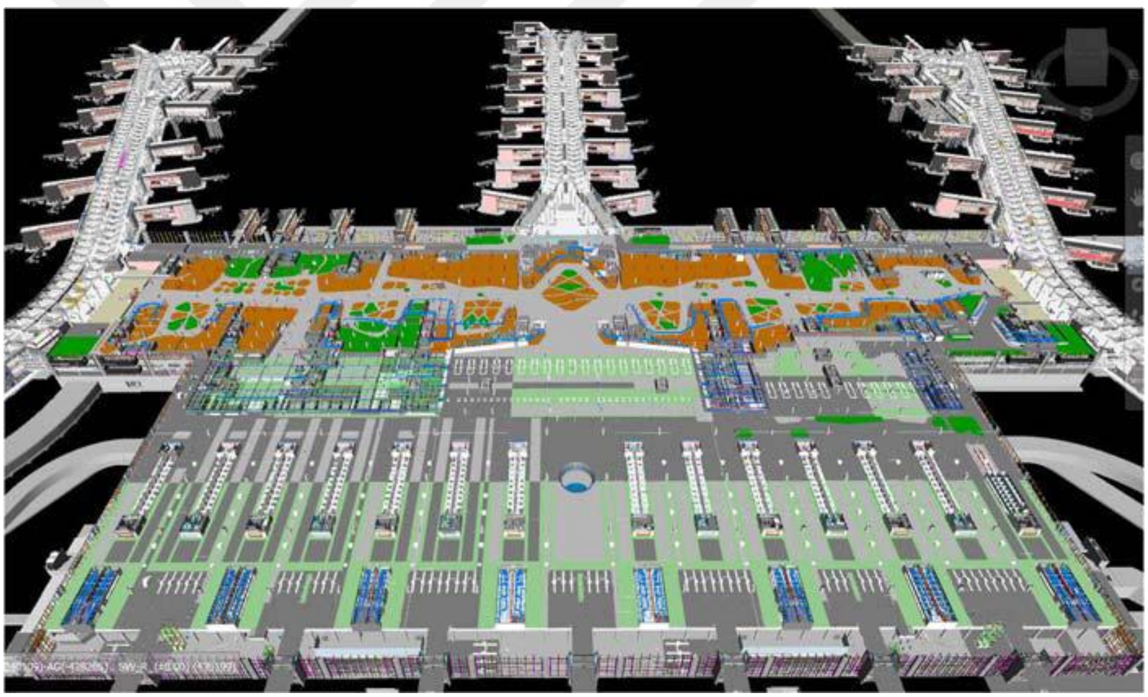


Figure 11: Istanbul Grand Airport master model

IGA implementing BIM process are the most influential factors when formulating an implementation strategy. It was also observed that some of the requirements for implementing BIM. Besides, the success of BIM implementation depends on factors such as transparency, process efficiency and decision making procedures adopted by suppliers and subcontractors.

6.3.2. BIM Execution Plan

A project team has to be formed to implement BIM successfully. The team has to prepare a well-documented execution plan for the BIM project that will ensure all parties understand opportunities and responsibilities resulting from incorporation of BIM into the IGA project workflow. A completed BIM Project Execution Plan should define the appropriate uses for BIM on a project (e.g., estimation of costs, design authoring, and design coordination), besides a detailed design and documentation of BIM execution process throughout a project's lifecycle. The project team should then follow and monitor their progress on BIM implementation against this plan to realize maximum benefits. All IGA projects on BIM implementation require the executive plan. Full BIM integration also requires a robust management plan to establish goals and roles for the project team, a concept referred to as interoperability. With a BIM execution plan, it is possible to identify responsibilities for all members of the project team. IGA BIM execution plan defines the process of planning, co-ordination, organizing, overseeing and control of the tasks in a construction project lifecycle from inception to completion. The focus of IGA BIM execution plan is on airport projects requirements to produce a functional, efficient and financially viable IGA project completed on time within budgeted costs and the required quality standards. IGA Execution plan published, as seen in Figure 12.

İSTANBUL YENİ HAVALİMANI PROJESİ / *ISTANBUL NEW AIRPORT PROJECT*		
iGA	BIM EXECUTION PLAN	Document No.
		INA-BIM-PLN-001
		Rev.00, 26.01.2016

ISTANBUL NEW AIRPORT PROJECT

IGA

ISTANBUL - TURKEY

BIM EXECUTION PLAN

INA-BIM-PLN-001

Figure 12: IGA Execution Plan

During execution phase of the construction project, the IGA BIM department considers the cost, time and scope of the planning, design and construction phases. The project implementation team requires BIM execution plan to define the main features, vision and details of the implementation process. The project team monitors and controls the implementation plan throughout the project lifecycle. The activities of IGA project teams include definition of the scope of BIM implementation, identification of procedures and practices for BIM processes that define the information exchange between the members of IGA team and subcontractors.

6.3.3. BIM Procurement Strategy

To utilize and sustain these practices, participants are gathered periodically, and procedures are followed as determined and published in the BIM execution plan. This practical implementation improved the quality of the design product, which will be finally applied on site, since it emerged with the latest design information by also considering constructability issues.

The IGA BIM office develops IGA BIM execution plan at tender stage, before a contract is agreed, to demonstrate the proposed approach, capability, capacity and competence to meet the IGA subcontractor in general terms. The IGA BIM project execution plan offers a detailed design of the process for BIM execution throughout the project lifecycle. The Project Execution Plan offers the protocols for BIM strategy, team roles and responsibilities, organization & workflow, communication and information exchange protocol, model management, collaboration process, model integration & clash analysis, model QA & QC process, 4D design & construction management, Level of development (LOD) definitions, BIM deliverables, subcontractor, BIM requirements, subcontractor technical requirement and subcontractor BIM reporting deliverables.

The IGA BIM team conducts meetings on a daily and weekly basis to realize and identify each significant assignment, workflow and execution plan schedules of the IGA construction. The competitive advantages by these meetings are identified as collaboration and workflow between all disciplines and the daily, weekly checks and quality controls of the execution of site activities.

The IGA BIM department develops and executes a BIM execution plan, which prescribes a roadmap for BIM implementation process of the IGA project. The BIM department gathers project information from all disciplines. Project coordination is achieved by weekly BIM coordination meetings, where major Request for Information's and other project issues are resolved. Leading the designers and subcontractors to familiarize and follow the BIM workflow as given in the BIM execution plan is highly critical for the success in project coordination.

IGA BIM team need to develop project information BIM authoring tools, data integration, and collaborative team workflow environments shall be used to develop and produce project information and documentation as required for submittals. BIM use shall be maximized for project reviews, decision support, design analysis, and quality assurance during all phases of the project.

IGA BIM implementation is to provide a framework that will Turkish construction companies, and AEC professional to deploy Building Information Modeling (BIM) technology and best practices on mega scale project.

6.3.4. Preparation of Dedicated Workflows

BIM has a significant role in IGA Project development by facilitating the coordination between the design and engineering firms including structure, architecture, mechanical electrical plumbing (MEP) and baggage handling systems (BHSs). Through BIM, it is possible to promote efficiency in design and construction, which is a key factor for timely completion of the project. The BIM department avails the necessary project information to whoever needs it at any time. Cloud-based data management tools are used to publish models and coordinate documents and the related information. Figure 2 shows the tools used to manage BIM workflows, as seen in Figure 13.

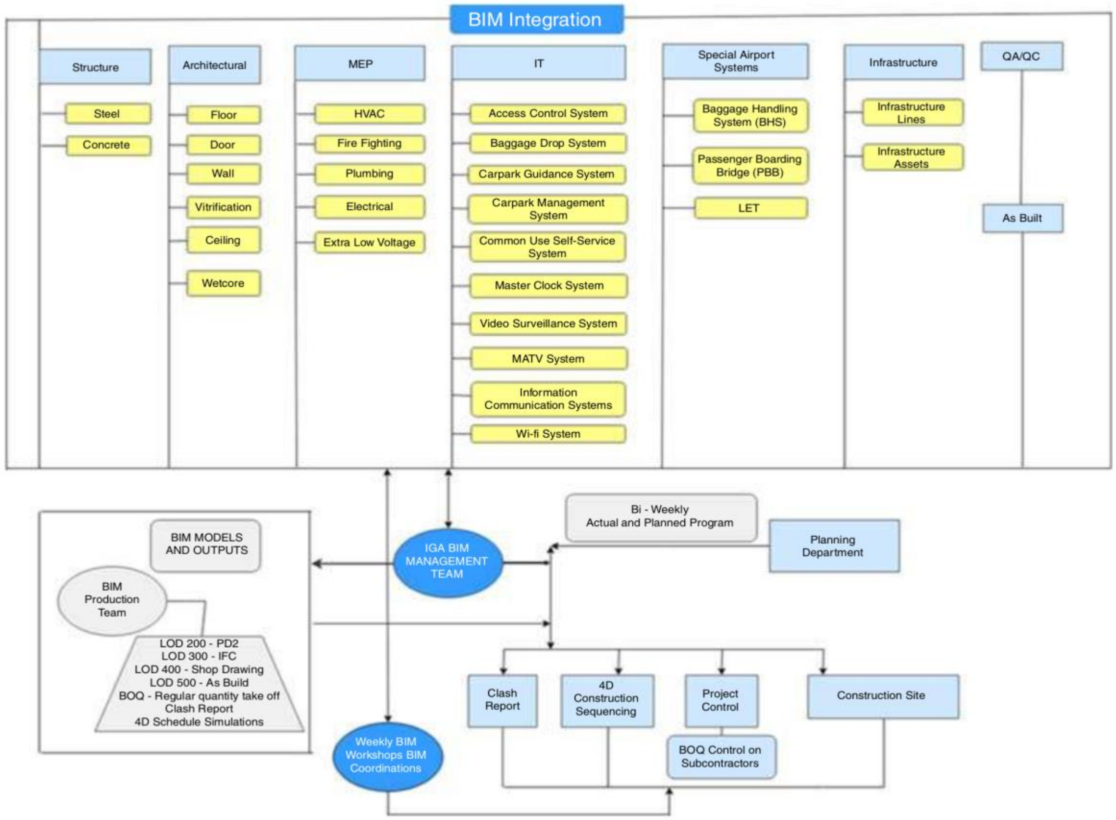


Figure 13: IGA-BIM workflow

As shown in Figure 13, the coordination process requires close follow-up with the parties and quick solutions; weekly BIM workshops are held to provide and maintain interdisciplinary coordination throughout the construction process of the building/ infrastructure assets in the airport construction. Clash reports are produced to identify the issues in case of the latest design information collected in BIM. With this collaborative work, the parties can visualize the latest status of design issues and be aware of the effects of any possible revisions to the other parties. In this way, the design process is optimized by the parties and any rework resulting from poor coordination and communication is eliminated. BIM integration in IGA is not only limited to design coordination but also aimed to improve project management with the 4D construction sequencing, 5D quantity estimating and construction site supervision processes. For the 4D construction sequencing, baseline schedule of the project is combined with the BIM model and discussed in the BIM Room with the construction teams in terms of both actual progress and possible site installation clashes for critical activities. With the up-to-date design information in the airport BIM model, quantities for each discipline are extracted in the format agreed with the technical office and used by them to control the subcontractors. These efforts done in the office are also controlled by the BIM engineers on the construction site to ensure that the decisions made are also applied to the construction.

The process of designing, integrating and documenting the design and construction information by developing an integrated BIM model evolved through the design and construction stages in IGA for the BIM-based project delivery. Automated data processing via integrated environment across the project stages also reflects a lean design and construction practice. The resulting BIM model, which is clash-free and helps in making necessary engineering decisions is shared to the site directly through mobile applications. The result is a faster and correct application of the coordinated design. BIM is used in many other areas such as quality assurance (QA), quality check (QC), quantity surveying, planning and project control, energy analysis and planned to be used for test & commissioning and facility management (FM).

BIM tools are fully integrated into the project. All engineering and coordination end-products are delivered to the site, and site supervision and all QA-QC processes of all disciplines are done by mobile. Designers, engineers and subcontractors are connected via the BIM meeting room that is also a physical platform for coordinating and decision making in a fast and straightforward manner. Figure 14 shows the BIM room.

The IGA BIM team conducts meetings on a daily and weekly basis to realize and identify each significant assignment, workflow and execution plan schedules of the IGA construction. The competitive advantages by these meetings are identified as collaboration and workflow between all disciplines and the daily, weekly checks and quality controls of the execution of site activities.

Figure 14: IGA BIM Room

The IGA BIM department develops and executes a BIM execution plan, which prescribes a roadmap for BIM implementation process of the IGA project. The BIM department gathers project information from all disciplines. Project coordination is achieved by weekly BIM coordination meetings, where major Request for Information's and other project issues are resolved. Leading the designers and subcontractors to familiarize and follow the BIM workflow as given in the BIM execution plan is highly critical for the success in project coordination.

6.3.5 Creating the Effective Management Team and Assigning Key Responsible

This section provides information on roles and duties linked to BIM project management. The identified duties, responsibilities and authorities are connected to information management. Within the IGA organization, each individual has to be assigned specific duties or responsibilities. The responsibility of IGA BIM office is to facilitate development, coordination, publication, and verification of all configurations and standards required for BIM integration to the IGA project.

6.3.5.1. BIM Management Team

This section provides a description of BIM roles and responsibilities for the IGA project.

6.3.5.1.1. BIM Director

- Creates and executes the BIM project strategy
- Reviews, monitors and approves the entire BIM progress
- Manages and offers necessary support for implementation of BIM project.
- Reports delivery of the BIM project to the CEO and the Board

6.3.5.1.2. BIM Manager

- Maintains the BIM Execution Plan
- Attends weekly meetings and workshops for BIM coordination
- Facilitates communication with subcontractor in and out of meetings.
- Performs regular AQ/QC checks on discipline models to ensure the level of compliance with project BIM standards is high.
- Ensures strict adherence to the BIM Project Execution plan throughout the project duration.
- Receives and manages multiple subcontractor models
- Reviews and documents design document and coordination conflicts.
- Reports to Director of virtual construction while working closely with project teams.
- Creates models including structure, interior and exterior architectural elements and MEP system

6.3.5.1.3. BIM Engineers

- Establish communication between disciplines and BIM production team.
- Flow RFI and clash procedures
- Manage Vault and Buzzsaw environments
- Ensure up-to-date project information is transferred to BIM production.
- Run and analyse clash detection on federated model.
- Prepare and distribute clash reports to facilitate the coordination process.
- Provide field subcontractors with the most current coordinated information.

6.3.5.2. BIM Technical Office

The IGA BIM technical office develops and executes a IGA BIM execution plan, which prescribes a roadmap for BIM implementation process of the IGA project. The BIM department gathers project information from all disciplines. Project coordination is achieved by weekly BIM coordination meetings, where major Request for Information’s and other project issues are resolved. The IGA BIM team conducts meetings on a daily and weekly basis to realize and identify each significant assignment, workflow and execution plan schedules of the IGA construction. The competitive advantages by these meetings are identified as collaboration and workflow between all disciplines and the daily, weekly checks and quality controls of the execution of site activities. Technical office cordially working with site office and BIM modeling team.

6.3.5.3. BIM Site Office

BIM site office has to implement the BIM execution plan to provide a perfect set out on the airport construction site to ensure work occurs on time and all checks are conducted regularly. Any revisions are updated directly in the BIM models and its consequences are monitored closely between technical office and site office. These revisions are also shared with all the related parties. BIM site engineers play an active role installation of final products on site.

6.3.5.4. BIM Modelling Team

BIM Technical office coordinate and optimize IGA master model with BIM modelling team to a system collaborates and improves all these functions/assets. BIM model is used for any clash detection between the two department, and problems and conflicts are resolved before the installation on the site. BIM is highly useful for construction of mega scale airport project. IGA modeling team use the BIM model to generate accurate drawings for sleeves, penetration and hanger locations before beginning the construction process. The drawings are used for fabrication and onsite construction. BIM master model helps in revisions management as well between all teams.

6.3.6. Technological Infrastructure (IT)

Determine the parties responsible for the project, the required design authoring software and appropriate version for BIM project as well as the best exchange models and protocols for the team.

The participant parties working on different design tools submitted their design information to BIM management team as agreed in the beginning of the project with a formal workflow. This is applied by getting the necessary revision or information with the use of cloud based information management tools such as Autodesk products Vault and Buzzsaw. In these tools, defined individuals from each party has been assigned and related permissions have been set by BIM team. After gathering all of the data from the parties, overall master model in Navisworks file format has been exported from Revit which includes all the latest project data to be used and reviewed during workshops. It kept updated by receiving all of the necessary updates which have been discussed in weekly workshops.

6.3.7. Information Exchange Protocol

The protocol for IGA BIM identifies specific models, which subcontractors and IGA team members should produce. Through IGA protocol, specific obligations, liabilities and associated limitations on the model use are defined. Clients can also use the protocol to adopt particular ways of working including common naming standards. The protocol has been drafted as per the following principles:

- The Protocol has to make minimal changes to the pre-existing contractual arrangements on construction projects;
- The Protocol facilitates all parties to oblige and provide defined elements of their works/services using models;
- The Protocol is a contractual document which takes precedence over existing agreements;

The Protocol is aligned with IGA and incorporates provisions which support the production of deliverables for ‘data drops’ at defined project stages. Another IGA BIM Protocol objective is to support the adoption of effective collaborative working practices in subcontractors’ members and IGA teams.

All project team members and stakeholders should have the BIM protocol appended to their contracts. The protocol will ensure adoption of common standards or working methods among all parties producing and delivering models. For each agreement, subcontractors have the responsibility for ensuring formulation of IGA information exchange protocols.
Majority of information drivers are concerned that wide application of data-rich BIM will make it difficult for IGA to protect the IT department. The general concept of the Protocol is the 'Permitted Purpose' to define the licensed uses of models, instead of providing each model's specific use. The information exchange protocol for IGA aims to eliminate separate electronic data exchange agreements between the IGA project team members. To achieve this objective, the protocol addresses risks associated with the provision of electronic data such as corruption of information following transmission. The BIM Coordinator has to focus on clash detection and model coordination activities as part of the design lead.

6.3.8. Model Management

Interdisciplinary coordination is performed using the BIM model, design errors are detected and addressed to relevant parties prior to construction on site. Any revisions are updated directly in the BIM models and its consequences are monitored closely. These revisions are also shared with all the related parties. Consequently, accurate design product is generated for high-quality and fast production on site by keeping design parties up-to-date and leading construction team to zero-defect and effective installation. Because IGA and subcontractors are also involved in the processes, they play an active role during the creation of a final product to be installed on site.

This section describes the process manage model terms of naming convention, sharing correct co-ordinates and establishing symmetry through the entire project. Below is a comprehensive list of section which have been coordinated in concern with BIM director and any change should need to be discussed and approved in advance.
Naming convention of model management to be followed throughout the lifecycle of the project. It covers naming for individual files, link files, work sets and master file. This

will further be classified based on the zoning for individual services like architecture naming convention to be executed in line with BIM director and BIM manger. The idea here is to maintain the uniformity of content at every stage project and update accordingly. Models can be classified by two simple types. Individual and master model which will be further segregated based on zones, levels, area etc. It also contains the naming convention to be followed for sheets.

Request for Information (RFI)'s is integral part of any project as shown in table 6. It is obvious that every time if there is any change in any design, any requirement in terms of project information etc. A RFI electronic format to keep track of all the changes and updates and exchange of information's. to track and maintain all the RFI's a simple process has been shown below and a combined log is maintained which will be updated weekly and same will reflect in Buzzsaw (BIM tool). The naming and revision as follows; The name of the RFI is kept as follows - (INV- BIM- Discipline- SI No.- Revision) for BIM related information and (INV-GEN- Discipline - SI No.-Revision) for general information as shown in Figure 15.

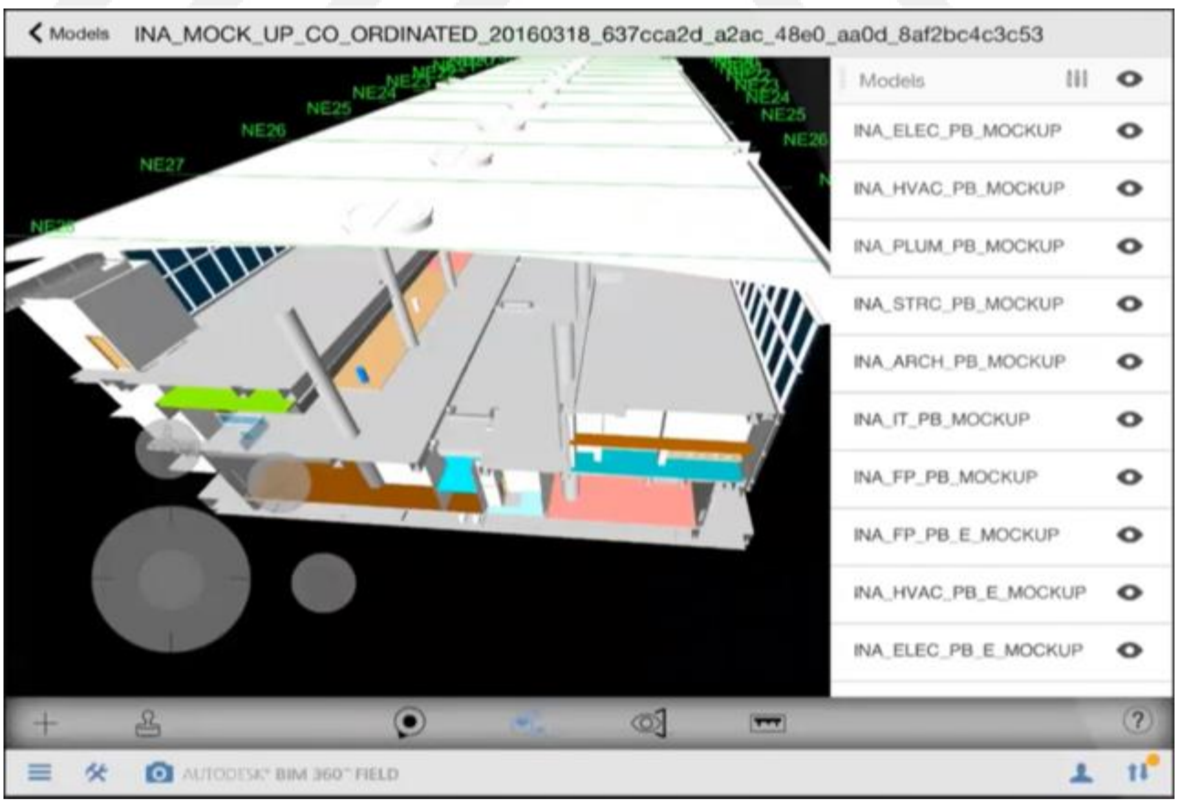


Figure 15: Istanbul Grand Airport RFI electronic format

6.3.9. Subcontractor Technical Requirements

Subcontractor shall submit a detailed project BIM methodology statement including technical references and past projects (at similar size, scope and complexity) delivered as part of their tender. Subcontractor to submit a comprehensive project BIM plan for approval within 7 calendar days of receiving a notice to proceed. The Project BIM plan approval must be obtained by the client before any shop drawings will be approved for construction. The project BIM plan shall include, but be not limited to, the following items:

Detailed strategy statements, diagrams, tables, etc. to describe the following:

- Management of the risk for the project BIM model and responsibility summaries.
- Project BIM integration with client's subcontractors and subconsultants include detailed, visual workflows to describe how teams and models will interact.
- Workflows the subcontractor will follow to ensure coordination of separate disciplines before the submission of shop drawings for approval, including:
- Run and analyze clash detection on master model.
- Virtual walkthroughs
- Drawing reviews, including quality assurance checks of the information against the BIM information.
- Linking the project BIM model to the comprehensive construction program (in Primavera P6, or compatible export in a Navisworks environment to illustrate planned vs.) actual progress
- Project BIM model development and security to ensure it accurately reflects quantities for procurement, installation, and justification of additional fees required for remedial/additional work to accommodate client instructed design change.
- Process and methodology for information input for as-built conditions
- Comprehensive project BIM model list with names, disciplines, areas, etc.

- Detailed project BIM model development plans, including: model linking strategy; Model ownership strategy.

6.3.10. Subcontractor BIM Reporting Deliverables

The subcontractor shall be responsible for providing monthly reports on project BIM development progress, including but not limited to the following:

- Model QA/QC reports
- Work in progress (WIP) model development against approved model development plan schedule against approved model development plan schedule of completed inputs, including: RFI's
- Change requests
- Value engineering changes
- Site conditions
- As-Built information
- Schedule of planned input updates for planned inputs updates for the upcoming month
- Clash detection reports
- Substantiation of progress/schedule linking reports
- Weekly / biweekly coordinated Navisworks
- IGA BIM model and IFC data files extracted from Revit.

6.4. Integration of Design & Engineering via BIM

6.4.1. Design & Engineering Coordination

BIM is playing a crucial role, facilitating the development of the IGA project. The BIM Department in IGA manages the coordination of key areas in engineering and design firms such as structure, architecture, mechanical electrical plumbing (MEP) and baggage handling systems (BHSs). The strategic role of BIM is to accelerate the efficiency in design and construction to ensure timely completion of the project and wherever it is needed.

Publishing and exchanging the correct data are crucial. Cloud-based data management tools are used to publish models and coordinate documents and the related information. BIM integration in IGA is not only limited to design coordination but also aimed to improve project management with the 4D construction sequencing, 5D quantity estimating and construction site supervision processes. For the 4D construction sequencing, baseline schedule of the project is combined with the BIM model and discussed in the BIM room with the construction teams in terms of both actual progress and possible site installation clashes for critical activities. With the up-to-date design information in the airport BIM model, quantities for each discipline are extracted in the format agreed with the technical office and used by them to control the subcontractors. These efforts done in the office are also controlled by the BIM engineers on the construction site to ensure that the decisions made are also applied to the construction.

The process of designing, integrating and documenting the design and construction information by developing an integrated BIM model evolved through the design and construction stages in IGA for the BIM based project delivery. Automated data processing via integrated environment across the project stages also reflects a lean design and construction practice. The resulting BIM model is clash-free and facilitates making of all engineering decisions that can be shared to the site directly by mobile applications. The effect is a faster and correct application of the coordinated design without encountering delays and challenges on the site. Other areas where BIM is widely used are quality assurance (QA)-quality check (QC), quantity surveying, planning and project control, energy analysis and planned to be used for test & commissioning and facility management (FM). BIM implementation during design and engineering in the IGA project created a common virtual environment for all the parties involved in the process. This is enabled by the data exchange procedures via cloud base data management tools and the development of BIM models with necessary engineering decisions by integrating different forms of design information.

To utilize and sustain these practices, participants gathers periodically, and procedures are followed as determined and published in the BIM execution plan. This practical implementation improved the quality of the design product, which will be finally applied on site since it is emerged with the latest design information by also considering constructability issues. The combined BIM model is shown in Figure 16 below to illustrate the complexity of the structure and how BIM helped for clash detection in the project.

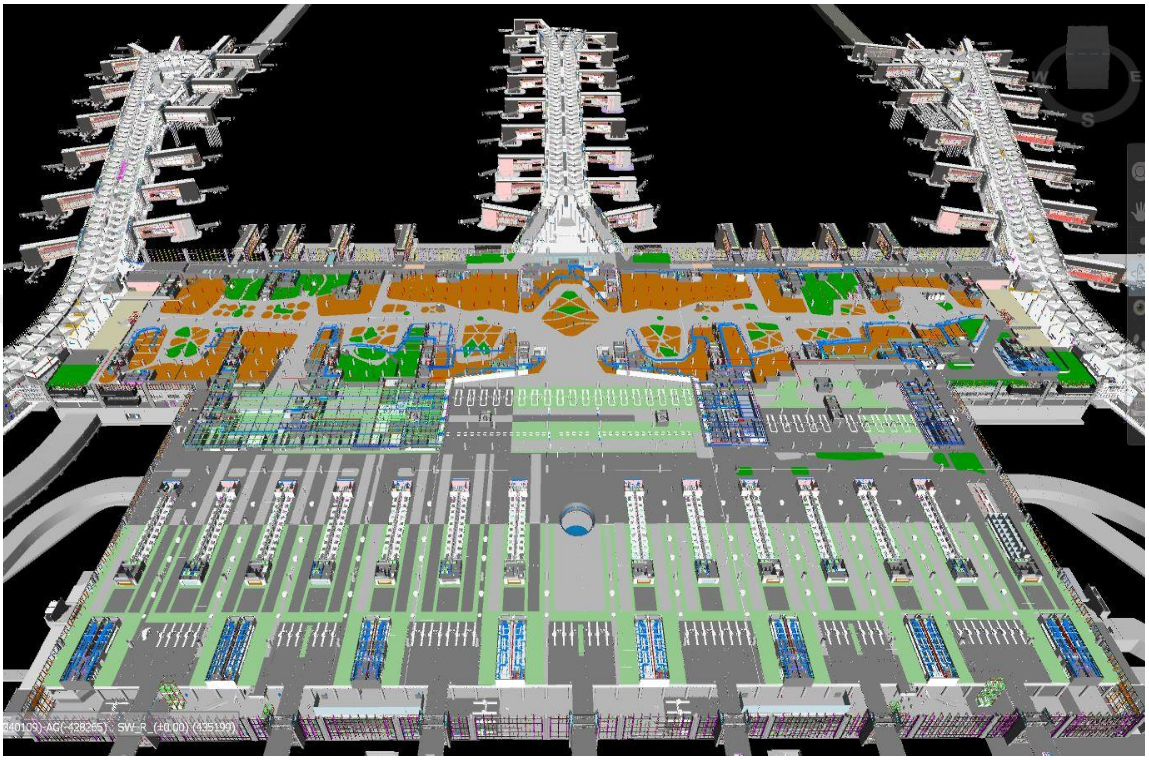


Figure 16: BIM master model for design coordination

Since interdisciplinary coordination is performed using the BIM model, design errors are detected and addressed to relevant parties prior to construction on site. Any revisions are updated directly in the BIM models and its consequences are monitored closely. These revisions are also shared with all the related parties. Consequently, accurate design product is generated for high-quality and fast production on site by keeping design parties up-to date and leading construction team to zero defect and effective installation. Because stakeholders and subcontractors are also involved in the processes, they have taken active role during the creation of final product to be installed on site.

6.4.2. Design Delivery Strategy

This section describes the design collaboration process terms of activity, workflow and meeting. It is basically the process to establish day to day progress, exchange of information, implementation of information, clash resolution and quality check process. BIM implementation first took a role to sustain integration of all disciplines and related parties in a single virtual environment. Asset wise meetings and workshops are scheduled in order to support BIM coordination among all project stakeholders starting from the design phase.

The workshops are held in a room equipped technological communication tools and named as BIM room and also equipped with a wide screen video wall and powerful computers in order to establish an effective decision making environment by enabling collaboration and communication. It is crucial to note that bring people together in a common environment plays an essential role in BIM success as well as technological improvements provided. The project individuals have had started to get familiarized with both BIM products and new way of collaboration enabled by BIM with the initialization of the workshops under a common environment provided.

6.4.2.1. Full collaboration between parties

Success of a mega scale airport project requires collaboration among IGA BIM stakeholders. Participants to the IGA project know that sharing of knowledge and information is a key elements of a successful contractual relationship. Collaboration process between main IGA and subcontractors has no clear guideline on how it should occur. Therefore, it is difficult for members to interact and achieve common project goals in relation to cost, quality and time. Collaboration in BIM is about more than information. Since the project involves several teams, they have to work in a shared space in real time to ensure decisions, updates and communications occur in real time and simultaneous. The collaboration process for the BIM project requires communication beyond email trails while creating a unified space and record for optimizing BIM's collaboration capabilities. Application of the right cloud solution requires integration of workflows across the key project lifecycle stages identified as planning, design, construction and operation. Besides, all barriers to communication have to be eliminated to promote real time collaboration on the project. Tools for facilitating cloud based collaboration can reduce design downtime and rework.

6.4.2.2. Coordination Meeting & Workflow

Meeting and workshops are important activity. They are scheduled in order to support BIM coordination among all project stakeholders. BIM coordination issues such as RFI's and clash resolutions are subject for BIM Coordination workshops. Attendees of workshops are BIM management, IGA design managers for relevant asset/discipline and design consultants for relevant asset/discipline. For the time being there are six workshops scheduled weekly. RFI document management is shown in figure 17.

ISTANBUL NEW AIRPORT - TURKEY

REQUEST FOR INFORMATION (RFI) SUBMITTALS LOG

INVICTA Project Code: 2015-008
RFI Log Ref : INV / INA / RFI / LOG / 2016 / 001
Last Updated on: 27-12-19 15:03

						ACTUAL				
SEQ	RFI SUBMITTAL NO.	REV NO.	DISCIPLINE	RFI DESCRIPTION	AREA/LOCATION	DATE OF SUBMISSION	RECEIVED DATE	LAG DAYS	STATUS	RESPONSE RECEIVED
64	INV-BIM-STRC-TB-00059	A	Structural	Please refer enclosed cad file, In which we have higlighted few queries with color coding & revert accordingly asap. DWG reference no. is as under:- Level +8.00 Formwork Plan	TB/Level E	03-03-16	05-03-16		CLOSED	Please follow our latest submission for Level E. Please note that some of these queries are in progress.
65	INV-BIM-STRC-TB-00060	A	Structural	Please refer enclosed cad file, In which we have higlighted few queries with color coding & revert accordingly asap. DWG reference no. is as under:- Level +15.00 Formwork Plan INA-B01-01-06-05-F-FC-DWG-STR-63-1001-001-R00	TB/Level F	03-03-16	05-03-16		CLOSED	Level +1.00 is still in progress =. We will revise our drawings accordingly to latest architectural layout & issue ASAP.
66	INV-BIM-STRC-TB-00061	A	Structural	We are not clear about the big opening (highlighted in blue). Please provide the levels of the same. DWG reference no. is as under:- INA-B01-01-06-01-B-FC-DWG-STR-62-7001-002-R00 INA-B01-01-06-01-B-FC-DWG-STR-62-7001-004-R00	TB/Level D	04-03-16	06-04-16		CLOSED	Please see the Prota's submission dated 04.04.2016 for latest version of "INA-B01-01-06-01-B-FC-DWG-STR-62-7001-002' and 'INA-B01-01-06-01-B-FC-DWG-STR-62-7001-004'
67	INV-BIM-STRC-TB-00062	A	Structural	The highlighted dimension do not corespond the dimension provieded in the section, whereas the openings are cut at correct levels. Please review and advise. DWG reference no. is as under:-	TB/Level D	04-03-16	05-03-16		CLOSED	You Can follow the plan drawings.We will revise our section and issue again.

Figure 17: Request for information document management

Engineers have to review zones considered critical for the project each week during the workshop and make necessary decisions while providing updated design information. Incorporation of the decisions to the BIM model can lead to resolution of clashes and facilitate installation on the site.

Every two weeks a clash report generated by BIM production team. Discipline model elements tested against other discipline model elements according to clash disciplines matrix. These issues have been discussed in the weekly coordination workshops and models are coordinated with the decisions taken in these meetings.

BIM model creation and its collaborative review has provided a common visual environment for the systems forming the airport facility, therefore cross disciplinary coordination and engineering decisions have been accomplished under the supervision and guidance of BIM department. This led a quick passage from design to construction.

6.4.3. Quality Assurance and Quality Check Process

All the design data, drawing, models, reports are being circulated through Vault and Buzzsaw in the consultant/discipline specific folders. Same folder structure has been used in vault and buzzsaw continuously to ensure all parties benefit up-to date information. All the information in Buzzsaw then synchronized to a local server as a backup procedure.

According to Blayse and Manley (2004), the construction industry is diversified and handles on-site production and services such as engineering, design, and management to achieve a unique project with variety of teams brought together". Successful delivery of the project requires effective management of several on-site and off-site tasks, large amounts of information, and continuous communication in between the parties. Through BIM, designers and contractors can collaborate to optimise, coordinate design the construction project and improve quality of the final product.

BIM model is used for any clash detection between the services, and problems and conflicts are resolved before the installation on the site. On field BIM applications, on the contrary to the traditional QA/QC practice, enable all QA/QC tasks being processed on iPads in a digital way, without awaiting any parties for signing documents. By delivering the constructible BIM model to the site, the construction team had all the necessary and applicable information, which led to faster and correct installation on site. Since all the issues are resolved and the latest information was shared with the site team, rework possibilities were minimized. A document of quality assurance is shown in Figure 18.

Istanbul Grand Airport	Task Report
	ID INA-A1002-00-00-NFI-ELC-10-0007-R00

Author	merve kardelen	Assigned To	Cigdem Tugrul Alkan
Author's Email	merve.kardelen@igairport.com	Assigned Email	cigdem.alkan@igairport.com
Author's Company	<not set>	Assigned Company	IGA
Author's Phone #	<not set>	Assignee Phone #	<not set>
Responsible Company	Alp Erdem	Resp. Company Phone #	<not set>
Date Created	28 Jun 2017 5:57 PM	Scheduled For	29 Jun 2017 3:00 PM
Name	KABLO TAVA, MERDİVEN VE KANAL İŞLERİ	Status	Closed
Description KABLO TAVA, MERDİVEN VE KANAL İŞLERİ		Types QA/QC: NFI-ELC	
Locations		Location Detail A1002 MRO GALERİ(ETAP 3) ANO 97-115(Batı göz iç dış perde), ANO 109-114, 124-132(Doğu göz içdış perde)	
Attached Checklists Service Tunnels-KABLO TAVA, MERDİVEN VE KANAL İŞLERİ			

Custom Properties on ID INA-A1002-00-00-NFI-ELC-10-0007-R00

NFI Approval	B		
NFI No	ELC-10-0007-R00		
Subcontractor (Only for Superstructure)	-		
TCR Approval	-		
Test Type	-		
Witness/Hold/Review	W		
Electrical Approval	☐	IT Approval	☐
ITP Checklist ile Uyumludur (Only for	☐	Mechanical Approval	☐

Comments on ID INA-A1002-00-00-NFI-ELC-10-0007-R00

Cigdem Tugrul Alkan (cigdem.alkan@igairport.com) 07 Jul 2017 6:09 PM	Suya maruz kalan tavalar temizlenmeli olası korozyona karşı korumaya alınmalıdır. Sismik kontrol sistemi imalatı yapılması ile ilgili rapor sunulmalıdır. Kablo tavası askı sistemleri yükleme hesap sunumları yapılmış olup imza sirkülasyonundadır, resmi sunum yapılmalıdır.

Signatures for ID INA-A1002-00-00-NFI-ELC-10-0007-R00

Figure 18: IGA Quality Control Assurance Document

After installations were fulfilled on site, they were also inspected with BIM based QA/QC procedures, and the records were stored digitally in a cloud. Digital QA/QC procedure reduced unnecessary paperwork and led to an effective workflow automatized via BIM. While all the engineering and coordination end products are delivered to the site, site supervision, and all QA-QC processes of all disciplines were done by mobile BIM as illustrated in Figure 19.

The large size of the project increases site management issues on a daily/weekly basis, which is a major challenge. Therefore, the primary goal was to steer site installation progress while improving the cost-effectiveness and quality, at the same minimizing rework-with BIM mobile access in the project.

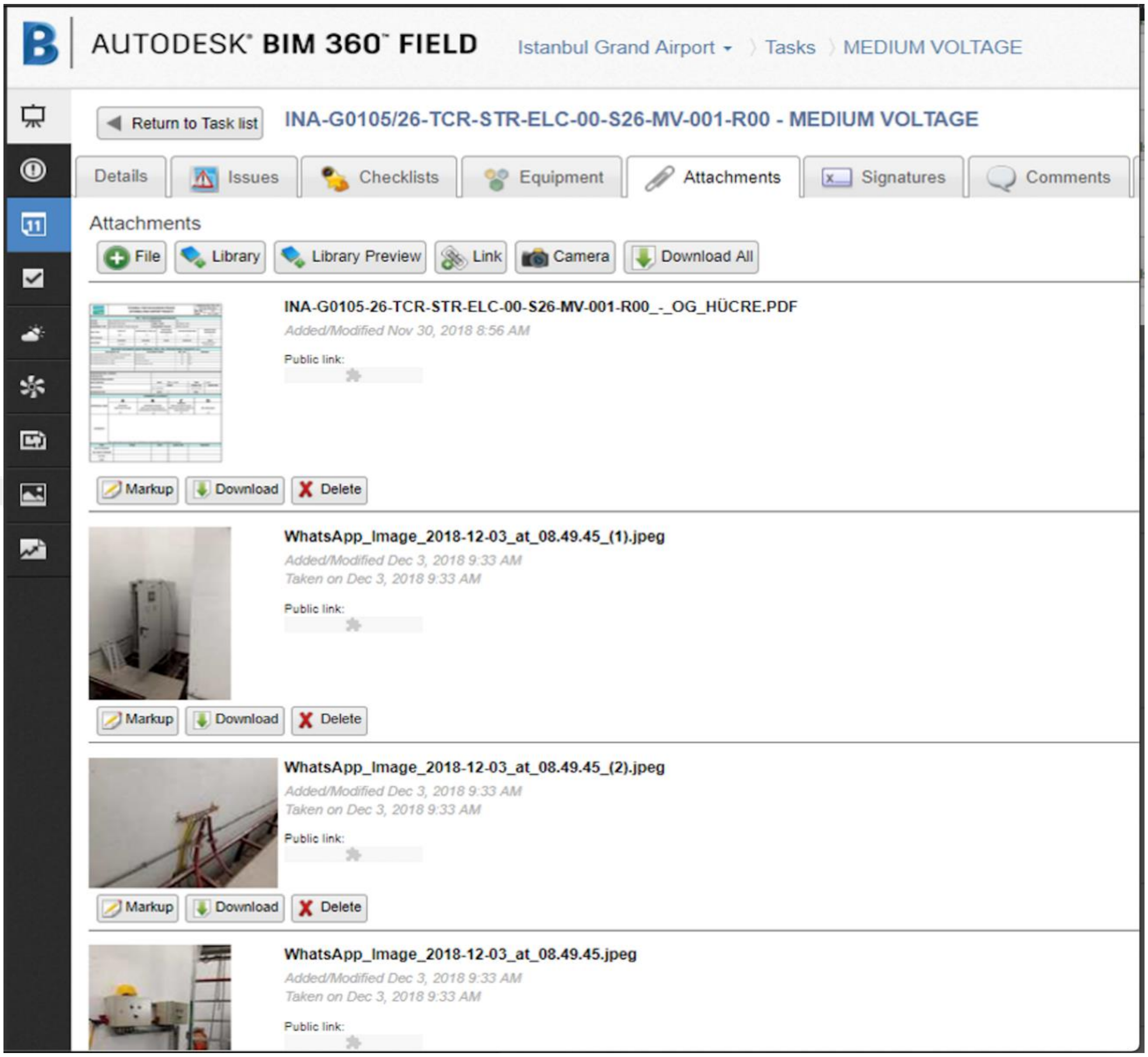


Figure 19: Quality check and reporting by the BIM site engineer

The main context that makes BIM tools more functional on site are full coordination, BIM Models, approved shop drawings, QA-QC documentation including material acceptance forms and method statements, QA-QC processes; inspection forms, inspection checklists and site observations, test & commissioning process that includes site acceptance test (SAT), and subcontractor availability. Besides application of BIM to the construction site, supervision of all tasks will lead to a positive outcome. Formation of BIM site team aimed at tracking the construction site to ensure implementation occurs effectively. The team also recorded all information digitally whenever a variation from the BIM model occurred. The records were stored with an asset, zone, site photo, related company information to make them easily accessible to all project stakeholders.

6.4.4. Model integration & Clash analysis

In the traditional design process, specialists use tracing papers to make separate drawings and determine the level of compatibility. The traditional method led to increased delays in project completion and high costs. The current BIM technology incorporates 2D, which improves the designing process. Through BIM clash detection or coordination, it is possible to execute the project at an excellent speed, engage multiple engineers to work on a single model and synchronize the model to ensure individual user changes are reflected. Advent BIM360 tool, a key innovation in the construction industry has made it possible to have a quicker and better clash detection and BIM co-ordination. Increased collaboration has made it possible for all parties to access and review the IGA master model at the same time. Comprehensive clash detection test makes it easier to identify minor and major clashes. Through this technology, BIM engineers or experts for MEP BIM coordination can identify, mark up critical clashes, and conduct a meeting with all parties involved to identify lasting solutions. Figure 20 presents a snapshot of clash analysis.

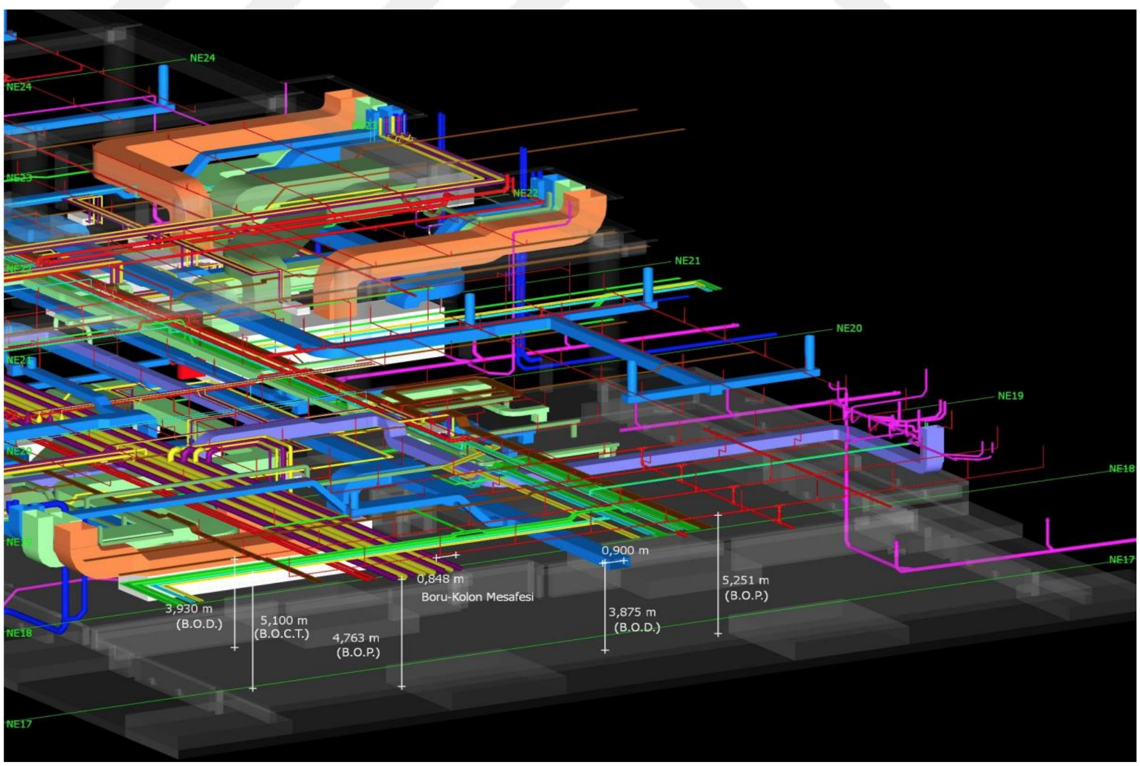


Figure 20: 3D clashes free shop drawing in the first phases of construction

Project implementation team manages to review the construction process and validation of the design prior to extraction of shop drawings by applying IGA BIM clash detection services and BIM coordination. In the past, it was only possible to identify issue resulting from the designs after preparing the shop drawings. However, with the BIM coordination model, it is possible to detect early conflicts during the IGA BIM coordination stage design and resolve them on time. Virtual review of the buildings and checking of clashes on via simulations or reports has been facilitated by software such as Revit and Navisworks. 3D geometric models imitate existing building base and present the design of the building exactly how it appears after construction. Users and compliances can be suited through building modification. Besides, the modification helps to understand impacts of clashes on the overall functions of the building and design aesthetics. The building modification reports can enable BIM engineers to change mode and use Navisworks to check if the clashes are resolved.

In BIM clash detection services and efficient coordination, the first step is to prepare a detailed and error free model in LOD 300 and above. In subsequent stages, Navisworks or Revit, in combination with Architectural, Structural, and MEP can be used to check the clashes. Minor and major clashes will be detected. Through meeting with all stakeholders, BIM engineers or MEP BIM coordination experts can identify, mark up critical clashes, finalize the clashes and resolve all the issues arising. The BIM production team has to generate a clash report after every two weeks. Discipline model elements tested against other discipline model elements according to clash disciplines matrix

Clash report submissions will be delivered through Buzzsaw on bi-weekly basis using IGA clash report format as shown in table 6. The clash report will include comment and resolution advise from BIM production team for faster clash resolution. BIM production comments will inform discipline teams if the clash requires a design change, coordination or clash is minor and can be solved by production team. The Navisworks file will be used in workshops for coordination purposes. Model elements are managed through selection sets based on discipline key/critical areas and based on Asset, Discipline, Level and Zone.

Table. 6: Clash analysis result (Istanbul Grand Airport 9)

Clash Detective

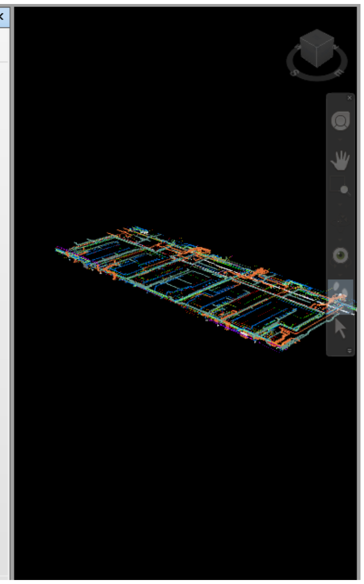
HAVC vs PLUM

Last Run: Monday, June 27, 2016 4:15:51 PM

Clashes - Total: 3956 (Open: 5 Closed: 3951)

Name	Status	Clashes	New	Active	Reviewed	Approved	Resolved
HAVC vs PLUM	Old	**3956**	5	0	0	0	3951
HVAC vs FP	Old	**8933**	11	0	0	0	8922
HVAC vs ELEC	Old	**3020**	21	0	0	0	2999
HVAC vs IT	Old	**1044**	3	0	0	0	1041
PLUM vs FP	Old	**1071**	0	1	0	0	1070
PLUM vs ELEC	Old	**250**	35	1	0	0	214
PLUM vs IT	Old	**207**	3	1	0	0	203
FP vs ELEC	Old	**915**	11	12	0	0	892
FP vs IT	Old	**264**	27	9	0	0	228
ELEC vs IT	Old	**92**	26	1	0	0	65
MEPF vs STRUC	Old	**3875**	471	810	0	0	2594
MEPF vs ARCH	Old	**10234**	0	258	0	0	9976
HVAC vs STRUC	Old	**1488**	471	0	0	0	1017
PLUM vs STRUC	Old	**825**	59	267	0	0	499
FP vs STRUC	Old	**1356**	92	277	0	0	987
ELEC vs STRUC	Old	**133**	18	42	0	0	73
IT vs STRUC	Old	**73**	34	21	0	0	18
MEPF vs STEEL	Old	**324**	4	86	0	0	234
MEPF vs BHS	Old	**15788**	11304	235	0	0	4249

Add Test | Reset All | Compact All | Delete All | Update All



BIM production team issues a Navisworks NWD file every Friday. BIM management team is responsible for distribution of 3D Navisworks BIM Model to relevant parties. Navisworks models have managed selection sets and viewpoints to enable easier Navigation for all users who have different 3D skill levels. Model elements can be selected according to discipline, zone or key areas. Clashes and issues are highlighted/clouded and saved as viewpoints.

The Navisworks file will be circulated to everyone in NWD format on Friday. The BIM managers/leads will merge all individual file in master NWD file for development purpose and also the individual file for every building for review and analysis. The viewpoints related to RFI's will only be added date wise and once the RFI's are resolved the same will be removed from the Navisworks file.

6.4.5. LOD 400: BIM Model Development & Production

Updating BIM models to LOD 400 upon receiving from IGA-LOD 300/350 BIM Model (Sub-contractors input & agreed LOD 400 with IGA). Ongoing development and maintenance of a three-dimensional project BIM of the works that includes (but not limited to) shop-drawing level (LOD 400) information of the following building components and systems. Production of coordinated shop drawings according to subcontractors drawing schedule and the following (but not limited to below). Use applicable project BIM and drawing as a basis for preparation of all project coordination drawings. Prepare sections, elevations, and details as need to describe relationship of various systems and components utilizing the project BIM and drawing. Coordinate the addition of trade specific information and drawing by multiple subcontractors in a sequence within BIM and its drawing that best provides for coordination of the information and resolution of conflicts between installed components before submitting to the client for review. Incorporate seismic support elements, if any, for all portions of the work, and provide suggested alternate routing to resolve if any spatial conflicts. Indicate space requirements for routine maintenance and for anticipated replacement of components during life of the installation.

6.5. IGA Construction Management via BIM

6.5.1. Construction Delivery Strategy

The delivery strategy adopted for IGA project involves integration of people, systems, control, communication and practices into a single process. The strategy also collaboratively harnesses participants' talents and insights on specific construction projects to optimize the outcome and increase profit value. Other aims include waste reduction and high efficiency in design, fabrication, construction, operational and maintenance.

6.5.1.1. Mobile BIM

The mobile BIM addresses 6 main processes targeted to improve construction projects by reducing costs and saving time.

Cloud based collaboration tools selected to facilitate data transfer from office to site are Autodesk BIM 360 Field and BIM 360 Glue. These tools are highly compatible with common design tools, besides having user friendly features.

Identification of these applications was based on studying organisation schemes in all company departments to determine the required tablets for purchasing. Through a discussion with heads of departments, 150 tablet user personnel were identified for all the 6 departments - MEP, IT, BHS (Baggage Handling System), SAS (Special Airport Systems), Superstructure, Infrastructure and QA/QC.

As expressed in figure 21, site engineers were given tablets installed with only selected and approved tools by BIM department. The company's IT department used Mobile Device Management system to restrict access to internet browsers or other selected applications. Through these arrangements, site personnel focused on only work related activities using iPads. Furthermore, privacy of project was maintained by restricting data sharing with any other device.

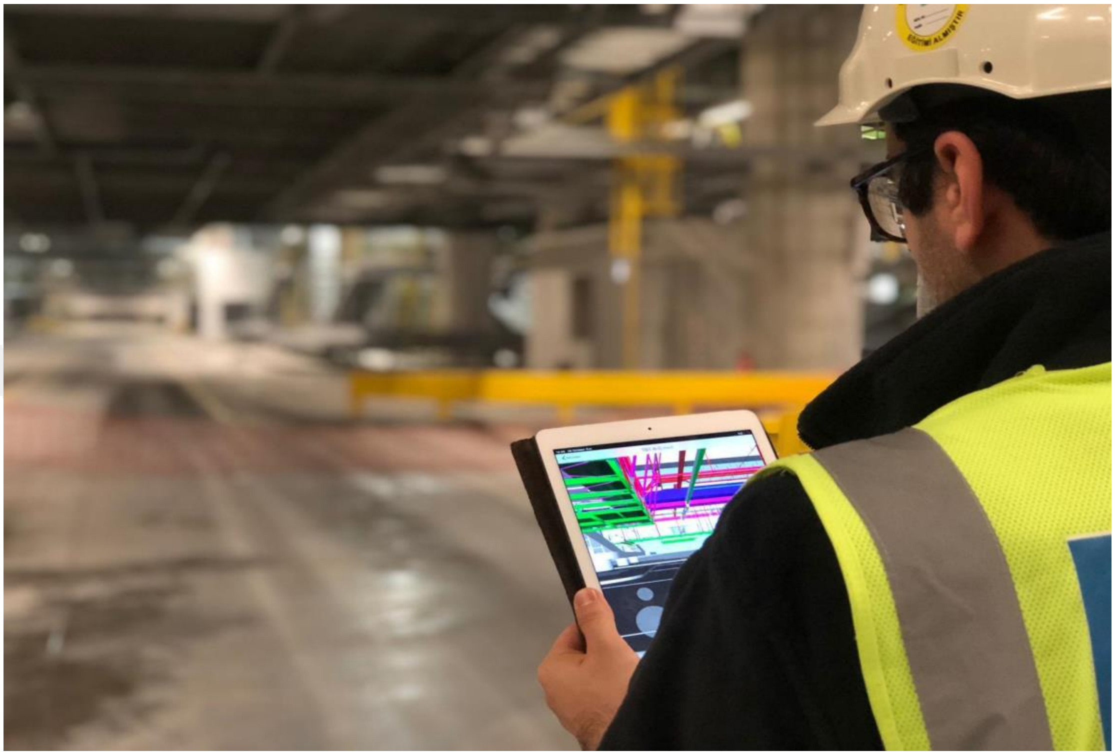


Figure 21: Mobile BIM - QA / QC Control

Site engineers and QA/QC personnel have been familiarized with the new tools, workflows and communication strategies through training facilitated by BIM engineers. Management of the onsite challenges associated with this project involved setting weekly sessions that enabled users to improve their skills on using the system. These sessions are-continous and applied periodically for all departments to educate new comers and also keep current users updated with the features and workflows used. The BIM department prepared and distributed the Mobile BIM Guide to enable all stakeholders access project information and enable all personnel assigned different tasks adhere to the required process of design and construction as shown in Figure 21.

The context in which Glue and Field tools are functional on site are categorized into fully coordinated BIM Models, approved 2D shop drawings, QA-QC documentation including Material Acceptance Forms and Method Statements, QA-QC processes; inspection forms, inspection checklists and site observations, Test& Commissioning process that includes Site Acceptance Test (SAT), availability for all subcontractors.

6.5.1.2. Sustainable Coordinated Model Delivery

BIM model creation and its collaborative review has provided a common visual environment for the systems forming the airport facility, therefore cross disciplinary coordination and engineering decisions have been accomplished under the supervision and guidance of IGA BIM department. This led a quick passage from design to construction. Any design change or installation information with integrated disciplines is delivered to site within minutes. The result is increased application of the coordinated design correctly without further delays.

6.5.1.3. Approved Project Information Delivery

The role of BIM tools in IGA BIM project is to provide step-by-step guidance to define, manage and validate responsibility for development of information development, level of detail and delivery at each stage of the asset IGA project lifecycle. The BIM tools ensure that the data remains in the same environment, is updated, and easily accessible to the right team members throughout the project lifecycle. The focus is to improve the creation, share and issue information underpins to improve project delivery between IGA BIM office and IGA site are important for IGA BIM model sustainable delivery. Sustainability in delivery of IGA BIM model requires procurement scheduling, site layout and handling, and labor effectiveness. IGA procurement scheduling refers to the planning of materials/equipment to procure while arranging for sequenced delivery dates with selected supplier. IGA BIM team can rely on the BIM based dynamic model to optimize materials to be procured and the strategy to use in relation to the construction site. The integrated information provided by BIM repository creates an opportunity for simulating impacts of decisions made on material procurement. Availability of appropriate materials at the right time on construction site is essential for improving the level of productivity. On the same note, delivery of the project depends partly on the lay out and handling of the IGA site. Construction activities management has to involve the co-ordination and movement of materials, people and equipment on site. The coordination promotes efficient and safe work environment. With BIM, it is possible to have a virtual environment for layout planning of the IGA site, which enhances identification of site facilities and the existing inter relationships. IGA BIM leads to simulation benefits that optimize the layout, sizes of facilities and other constraints on IGA site. IGA BIM team relies on the BIM repository information to determine the actual travel paths of on-site personnel and equipment, space limitation on site, dimensions of facilities, and interior storage within building.

6.5.2. Construction Management

Construction management is the act of overall planning, co-ordination, organizing, overseeing and control of the tasks involved in a construction project from inception to completion focused on client requirements to produce a functional, efficient and financially viable IGA project that will be completed on time within budgeted costs and the required quality standards. The IGA BIM department manages the execution of the construction project through the planning, design and construction phases by considering the quality, cost, time and scope.

6.5.2.1. Digital Site Engineering

Supervising tasks associated with BIM application to the construction site to maximise its efficiency requires a BIM site team. By using mobile BIM applications on tablet, coordinated BIM models and other related project documents as SD, MAF and MS are followed during installation. A vital role of BIM site team is to record any as-built information digitally when there is any variation from the BIM model.

As shown in figure 22, control of critical site installations requires the BIM site team to use BIM360 layout application compatible with the robotic total stations and BIM models. Site control points which BIM Management team require measurement are created in Revit models and shared with Glue application to be measured via layout application.

Figure 22: BIM Site controlling & installation with BIM360 layout application

6.5.2.2. Digital Project Control

This workflow ensures that all the parties are coordinated during the design review for the collaborative clash detection process. Therefore, generated construction documents (shop drawings, BIM models, etc.) are improved in terms of any potential clashes on site to avoid any possible rework on site. These documents do not only stay in the office, but are also transferred to the site seamlessly with cloud-based mobile applications to the site personnel's iPads for BIM complied installation management in the construction field. 3D/4D/5D modeling and coordination environment is provided by the BIM authoring and the 4D and 5D simulation tools. The most outstanding advantage of coordination work-flow is the real-time progress control, monitoring and timely communication of the QCs and control on site via the 150 iPads including all the coordinated BIM models used by the site engineers. 2D design drawing inconsistencies and omitted information is gathered through raised RFI's from BIM production team to the revenant disciplines. Major design issues are subject to RFI's and discipline responses are logged as open/closed by BIM management. Open RFI's are agenda item in BIM Coordination Workshops. RFI's are critical for developing PD design to IFC level. In the following page is the chart showing RFI/Clash contacts/ responsible from IGA and subcontractors as shown in table 7.

Table. 7: IGA and subcontractors RFI/Clash contacts/ responsible

Type of Checking	Description/ Responsibilities	Frequency	Requirement of Checklist
Self - Check	Every production member is responsible for this. They need to follow the checklist and review based on the LOD matrix.	Regular Basis	Yes
Superior Check	Every BIM production lead is responsible for this. They need to check whether the BIM standards and model audits are maintained at production level	Weekly	Yes
Head Check	Every BIM Production Discipline lead is responsible for this. The main part to check in this regard is design integration.	Monthly	NA
Final Check	BIM Manager is responsible for this.	Prior to each milestone submission	Yes

6.5.2.3. Digital QA - QC

In total, 3,210 notifications for inspection are identified in a year period by using BIM360 Field and brought tremendous time saving equivalent to approximately 6,420 man-hours, which means 802 man-days for the project; subsequently, this also means enormous cost saving. This leads the designers and subcontractors to know and follow the BIM workflow, which is one of the most important key factors for the successful project coordination. BIM MEP-IT coordination workflow can be seen in Figure 23.

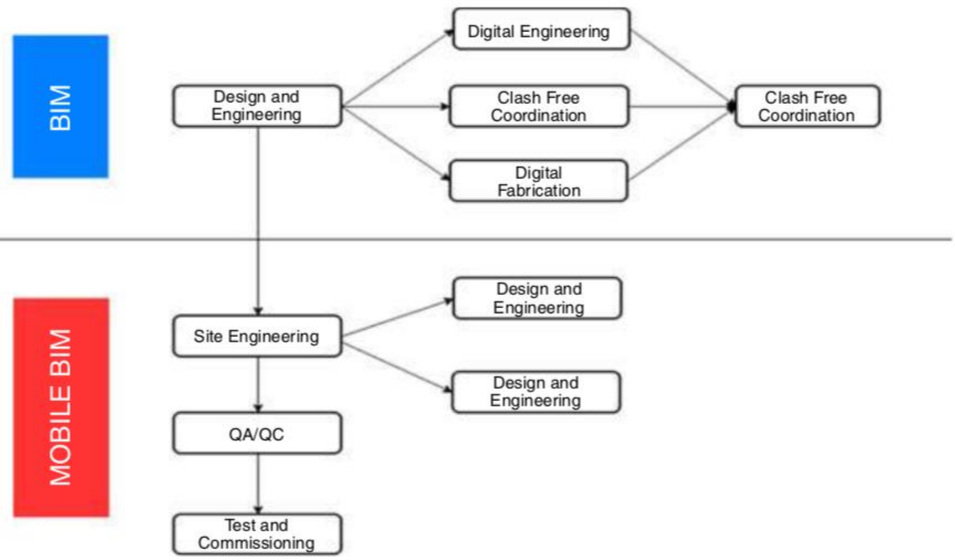


Figure 23: BIM MEP-IT coordination workflow

BIM360 layout and compatible robotic total stations are utilized in the project by the BIM Management team too closely track the BIM conformity of the site installations. Total stations fully compatible with Autodesk BIM360 layout are procured and used precisely.

6.5.2.4. Digital Test & Commissioning

The BIM system has to be tested through the IGA test and commissioning process. This test helps to verify operation of the systems according to the intended design. Any deficiencies identified during the testing phase are documented and logged by test and commissioning work flow.

The procedures for verifying IGA test are part of the commissioning specification and have to be communicated to the subcontractor detailing the level of rigor expected during the testing phase. The plan for IGA execution consists of checklists for documenting all systems prepared for testing. The instructions provide a detailed procedure for IGA test verification applicable to each system.

The team commissioning functional and performance testing, as well as operator training has to move to the forefront during the testing/commissioning period. The commissioning team also develops detailed test procedures, which IGA team uses to verify airport systems performance, which leads to identification of the most efficient equipment settings.

Testing should occur under all circumstances, and sequences of operations while applying real time simulations. The systems should be examined through the integrated systems testing to assess the design and compatibility. Another role of the commissioning team is to supervise staff training and operations on the commissioned system and equipment as well as organizing warranty information. The team has to prepare extensive document relating to the commissioned systems, which should include benchmarks. The IGA project test and commissioning phase has to be initiated with zero defects. Through BIM models, it is possible to capture as-built and facility information on site and perform asset tagging as requirements for complete passage to facilities management.

In the IGA Project, more than 600,000 clashes have been solved so far, saving time and money and preventing rework on site. Any unexpected claims, time extensions and cost overruns are also prevented. Table 8 also shows a perspective image from the combined BIM model used for clash analysis.

Table. 8: Clash detection and analysis and related time and cost savings achieved

TERMINAL	Number of Clashes	Clash depency Coefficient	Number of Clashes with dependencies	Per Clash /Man*day	Total Savings Time (Day)	Labor Cost (35€ /Per Day)	Reconstruction (Avg:€500)	Total Cost Saving
BHS vs MEP Clashes	52.305	0,25	13.076	*45 days*10 men	5.884.200	€205.947.000,00	Negligible	€205.947.000,00
MEP vs MEP Clashes	240.176	0,33	79.258	*21 days*5 men	8.322.090	€291.273.150,00	Negligible	€291.273.150,00
MEP vs ARCH & STRC	76.275	0,5	38.138	* 2 days*2 men	152.552	€5.339.320,00	€76.276.000,00	€81.615.320,00
BHS vs ARCH&STRC	96.750	0,5	48.375	*2 days*2 men	193.500	€6.772.500,00	€96.750.000,00	€103.522.500,00
PIERS								
MEP vs MEP Clashes	49.521	0,33	16.342	*21 days*5 men	1.715.910	€60.056.850,00	Negligible	€60.056.850,00
MEP vs ARC&STRC	86.891	0,5	43.446	*2 days*2 men	173.784	€6.082.440,00	€86.892.000,00	€92.974.440,00
TOTAL	601.918		238.635		16.442.036 man-days	€575.471.260,00	€259.918.000,00	€835.389.260,00

In the table, cost and time savings are computed using the normalized values. In other words, dependency between clashes is also taken into consideration: if a clash is resolved, some other clashes are also subsequently resolved due to relevance and correlation between them. For example, when a major clash is explored and fixed in the combined BIM model, there are possibly four or five other clashes that are also resolved, which are therefore normalized with 0.25, while medium clashes are normalized with 0.33 and minor clashes with 0.5. As a result, the normalized clash numbers are calculated accordingly. In the normalized clash numbers, a clash with its dependency clashes is considered as one clash. This leads us to total normalized clashes, which is 238,635 clashes all together so far.

As per digital test & commissioning process, it was possible to save 442,036 days of time was saved and the £835,389,260 of project costs, equivalent to %10 of the total budget for the phase 1 of the IGA project. This amount would be around £2.5bn if the raw clash numbers (601,918) are considered, which would be the case of time delays and financial burden if the project would have used traditional ways. These numbers already prove the synergies between BIM and lean in terms of eliminating waste and generating values.

In a design and construction scenario based on a traditional practice, expecting the encounter of those 600,000 clashes would normally cost extra around €2.5bn and more than 10 years of overtime in the project.

6.5.3. BIM 360 subcontractor performance tracking & issue workflow

The BIM 360 platform and relevant attachments such as checklists are used to hold the entire process from documentation to inspection sites. Improved workflows, effective communication, new information management approaches, and coordination practices which increased the productivity on site by improving quality, saving time and money. Realization of this outcome requires effective technologies as well strategic implementation and organization transformation. Engineering, QA/QC and use of technology are given priority to create an environment that favours collaboration with the subcontractors and facilitate product delivery via tablets on field. BIM’s strategic role is facilitating integration among all stakeholders as well as related disciplines such as MEP, architecture, structure and baggage handling system. BIM implementation in the project gave many opportunities in means of providing easy access to all project data or from a single digital common platform and also allowing a fast modification or update on data whenever needed while eliminating great waste of time and cost.

6.5.4. 4D Planning & Executive Reporting

An enormously big 4D model is developed after which 30,000 activities are integrated to monitor the IGA construction progress on daily and monthly basis, as the best approach for dynamically controlling the IGA project. Especially for the executive, decisions making and 4D snapshots of the key assets and zones are shared weekly with directors and the responsible bodies. The 4D BIM model is used for coordination and communication with the related stakeholders, who also attend the BIM meeting. Schedule is integrated with 3D BIM model in order to simulate construction actives by zones. In IGA BIM workflow the 4D BIM model is an analysis tool for decision makers to establish preventive and corrective actions to avoid delays. Besides showing construction activities status, 4D schedule utilized to manage design development and coordination as well.

- Intelligent linking of 3D model with time/schedule
- Construction project visualization
- Track and monitor project progress
- Review planned versus actual
- Decision making

6.5.5. 5D Quantities Management

The BIM implementation in IGA project gains via design and engineering BIM procedures and construction management are realized through BIM utilization. With the use of the 4D model, progress monitoring is simulated and observed by the management team. Any possible delays are addressed and prevented before occurring. 5D integration provided effective quantities management. The latest and most accurate information is derived from the BIM Model. By delivering the constructible BIM model to the site, the construction team had all the necessary and applicable information, which leads faster and accurate installation on site. Since all the issues are resolved and the latest information is shared with the site, rework possibilities are minimized. After installations are fulfilled on site, they are also inspected with BIM-based QA/QC procedures and the records are stored digitally in a cloud. Digital QA/QC procedure reduces unnecessary paperwork and leads an effective workflow automatized via BIM as shown in figure 24.

While storing QA/QC records digitally, any high-level reporting, which can be generated periodically or spontaneously in various forms to show progress, completeness, trend or details of the defects, is utilized and distributed to the responsible departments. This draws a clear picture for spotting errors and made possible to take preventative actions to facilitate zero-error production. Since everyday site installation practices are handled and improved with BIM practices, error reduction is made possible, which leads to the lean production.

Figure 24: BIM 360 application

This approach leads to initiation of the IGA project's testing and commissioning phase without defects. On site BIM models facilitate easy capturing of as-built and facility information while performing asset tagging as a complete passage to management of facilities.

The main advantage of using BIM for quantities management is to derive actual quantities of items used in the project to remove out any excess amount and to verify the estimated amount. Bill of quantities (BoQ) from the BIM model is generated and issued to the technical offices of each discipline.

The workflow shown in Figure 25 explains how BIM-based project progress monitoring is applied in IGA. Since planning, quantities and QA/QC are directly carried out with BIM and the progress payments and cash flow are done accordingly, subcontractors must comply with BIM both for their work on site and also reporting to IGA. This means they should follow the milestones given in the baseline, install on site by conforming QA/QC standards together with BIM model and report the quantities in line with the BoQ extracted from BIM model.

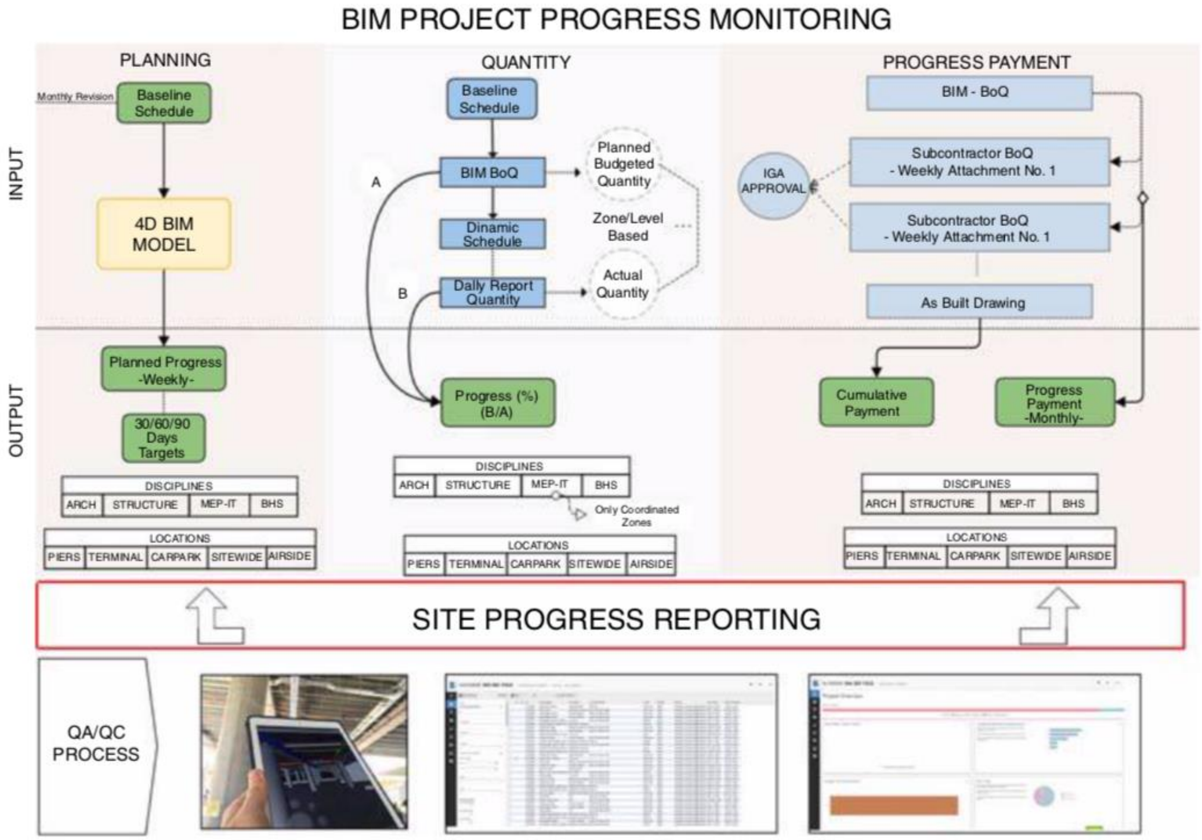


Figure 25: BIM-based project progress monitoring

BIM will play a significant role in operations of the port for 25 years after IGA consortium completes it. The operational role by BIM will occur after the design and construction stages. BIM will play a crucial role. In other words, procurement philosophy and project requirements make BIM use critically important for cost-effective and sustainable facilities management of the airport infrastructure.

The main advantage of using BIM for quantities management is to derive actual quantities of items used in the project to remove out any excess amount and to verify the estimated amount. BoQ's from BIM model will be detailed parallel to the 3D level of development

(LOD). From LOD 200 to LOD 500 model detail and information incorporated will develop in each step. Below are the processes for simple extraction, parameters and code assignment in line with project requirement.

6.5.6. Enhanced Reporting of Construction Deliverable

Although having multiple subcontractors dealing with different services in several buildings in such a huge project, it was made very easy to monitor the project with its all participants and all the time from everywhere with mobile BIM implementation. Apart from tablet environment, the "big data" is also accessible from web for each user defined as shown in Figure 26. This webpage is specialized by BIM department according to different companies with different permissions and also different filters put on use.

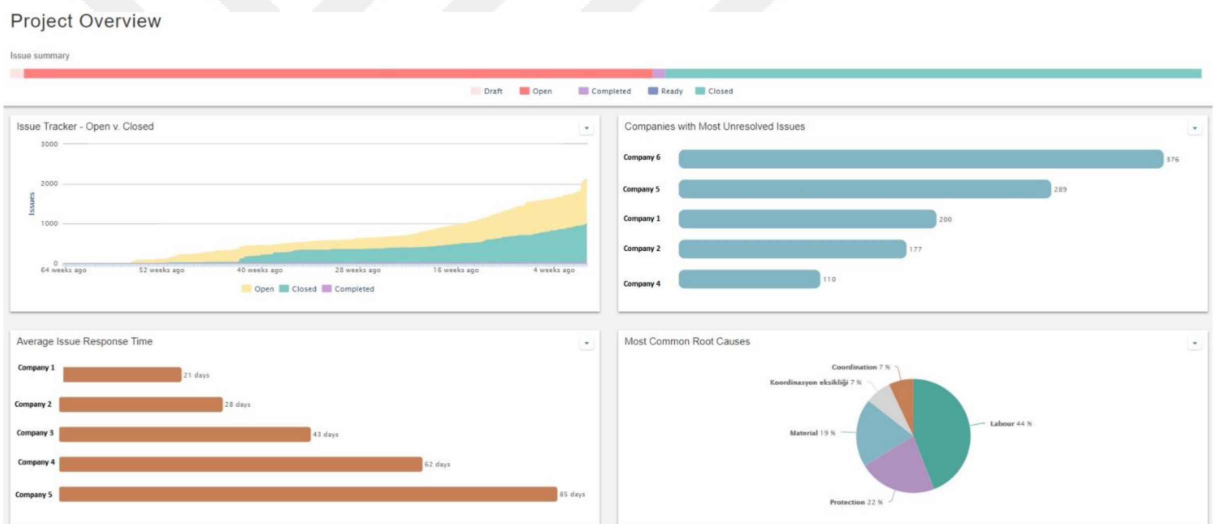


Figure 26: Sample web dashboard of mobile BIM progress

All users can access vital documents such as inspection forms, observations, MAF, SD, and MS can be reached on the web platform. Another significant process enabled with web access was reporting of all this huge amount of various forms of data. With the defined formats by BIM department, users could run the reports by putting company, time period, location, discipline and status filters. Moreover, it is possible to generate and discuss detailed reports in weekly meetings as well as prepare summary reports for presentation to the executive. There are both detailed reports to be discussed in the weekly meetings and summary reports to be presented in executive level can be generated. The significant part of the reporting is having access to real-time information updated automatically at any time or from any location. The subcontractor involvement to BIM implementation have been listed below.

- Executive level has been informed with the reports generated through BIM system, which prevents the, from relying on unstructured and outdated reports. Analysis of BIM reports helps to make most of the management decisions.
- Spontaneous reporting relied on the availability of the required information.
- Data from different departments was not gathered and used for creating reports pertaining to the project.

6.6. IGA Operation Phases via BIM

6.6.1. BIM Model Maintenance

If the employer instructs a design change through LOD 400, the employers consultant producing the design change will be required to use a copy of the current version of the design as defined by the project BIM model as the basis of the current design, which will be modified to reflect the design change requested by the employer.

The employer's consultant will indicate the revision date of the project BIM which they will use as the basis of the design they are modifying to reflect the design changes. All of the models which the subcontractor is developing in a format other than Revit will need to be issued to the employer's consultant at these times in a 20 DWG and PDF format and the subcontractor shall ensure that such models are updated or otherwise incorporated in the project BIM model. The drawings models issued by the employers' design consultant illustrating the design change will indicate the model extraction date, so it is clear what design "enhancements" have been already incorporated into the design

Any discrepancies or coordination issues which arise because of design adjustments made by the client through RFl's, value engineering, as-built conditions, etc. will be found, raised & resolved by the subcontractor through use of the current project BIM. Similar to the RFI process, all changes made to the project design in this way will be documented as part of the project BIM for change tracking.

The subcontractor shall update the project BIM with all as-built information within 14 calendar days of installation. The client acknowledges that all shop drawing submittals submitted after installation shall rely on the as-built condition as incorporated in the project BIM model and shall be coordinated accordingly. The method of as-built information input into the model shall be explained thoroughly in the BIM execution plan.

6.6.2. LOD 500: BIM for as Built and Facility Management

The project BIM model handed over by the sub-contractor upon completion of the project must be developed to reflect all As-Built conditions, defined as LOD 500 by the American Institute of Architects (AIA) and successfully re-installed in the employer's database in a form which is readable by the client.

The sub-contractor shall hand over final versions of all native project BIM models (RVT), all composite models (NWD), IFC models (industry foundation class), as well as native versions of any additional databases developed to update or administer the BIM processes. The subcontractor shall ensure that any additional databases utilized by them are handed over in a form which is readable by the employer. The format of this handover (i.e. external drives, cloud-based delivery, set up on a web server, etc) shall be determined by employer.

The sub-contractor shall hand over a database containing information on how the facilities have complied with the latest COBie (Construction Operations Building Info Exchange) standards pertaining to:

- Project BIM Objects (via a unique ID in both a native and IFC environment)
- Physical asset tags (they include QR codes on rooms/spaces, commissioned equipment and movable assets).
- All relevant handover documents such as commissioning reports, product submittals, warranties, plans, and O&M Manuals.

The sub-contractor shall establish workflows during the construction process to capture and link all required handover information. This workflow needs to be submitted to the employer's representative for approval at the beginning of the project (at the same time as the project BIM plan), and will be audited by the client at regular intervals for compliance.

Production of as-built drawings from BIM-LOD 500 Model. As-built quantities to be produced from BIM-LOD 500 models according to client cost control system.

BIM models are developed depending on the project stages. First, construction model is developed during the construction phases. Design and coordination, clash detection, shop drawing production & control depended on construction model. After that commissioning model which has includes tagged equipment, asset information is produced. Finally, operational model is developed for facility management purposes. Some of the BIM centered airport operations are including the following;

- Work order
- Process analysis
- Business process development
- Incident management
- Work specifications and installation
- Airport space management
- Airport maintenance and operations management
- Telecommunications integration and security
- General administrative services
- 3rd party integration

6.7. Summary and Conclusion

The IGA project has to be designed and constructed within the provided deadline and budget since it is a mega-scale airport construction project that includes features beyond building industry challenges. The operation of the project should also be effective and efficient. When considering the barriers, a significant barrier on realizing value from BIM implementation will be several technical BIM staff in Istanbul Airport. This can be specifically in people with high expertise in traditional methods, who know how to integrate sub-contractor companies by using BIM. It is true that these skills are difficult to produce and improve.

Overall, the results from the BIM implementation in Istanbul Airport project showed that the more companies leveraged on applying BIM for their projects, to gain a higher ROI, and save up to 20% of the total project cost. For example, when implementing a $ 12.5 billion project, the implementation team anticipates that using BIM will increase saving by $ 2.5 billion. However, such benefits can be only realized if all stakeholders are involved in BIM integration to the project. The project implementation team realized that differences in results depend on project complexity, time-to-market urgency and the type of contract.

The study outcome presented makes it possible to understand the strategic role of BIM as a working methodology in Turkish construction industry. The IGA project is not only a key learning hub for the Turkish construction industry, but also a global landmark for digital construction and project delivery.

CHAPTER 7

FRAMEWORK DEVELOPMENT AND DISCUSSION

This chapter discusses the development of the digital transformation framework applicable to the Turkish construction industry as per the analysis and results from the previous chapters about the BIM Implementation and Management in Istanbul Grand Airport Project and the Questionnaire-based survey for BIM implementation. Review of collected date from the IGA case study and survey responses in those previous chapter has led to obtaining valuable insights for the development of the framework.

7.1. Introduction

Categories of factors affecting adoption of BIM are non-technical strategic issues and technical tool functional requirements and needs. The level of adoption and understanding of BIM varies according to clients or disciplines. Countries also have a variation in the level of BIM adoption despite the collaborative environment shared by researchers and practitioners from those countries. Different parts of the world still encounter challenges in adoption of BIM, especially establishing a fully integrated multidisciplinary and collaborative approach as the best mode of operation. The research community experiences challenges in addressing human centered issues, technical problems and establishing an environment that facilitates decision making for both technical and non-technical challenges. The exploratory study showed the benefits of seeking guidance on where to begin, available tools, and the process for addressing legal, procurement and cultural challenges. Thus, adoption of BIM in the construction industry in Turkey facilitated by the digital transformation framework for the Turkish construction industry consists of four interrelated core aspects.

The construction and infrastructure sector has adopted BIM as a global language that enables collaboration and capability movement across borders. As per the current prediction, deliverance of global public infrastructure projects will rely primarily on the

BIM. Several metro schemes in the construction industry are already using BIM in many parts of the world. Process and learning within the construction industry, including its clients, is highly fragmented. The industry largely depends on ad hoc improvements across the projects. Thus, sustaining the long term investments and development capacity/capability requires an industry wide approach.

The recommended tools for inducing positive change in the construction sector are government policy and enhance public procurement process. The sector has to rely on the top-down leadership to increase its investment in information technology and ensure it delivers a high value for the money invested as well as increasing the level of productivity. The public sector and government can offer leadership that can enable the construction sector to utilize untapped opportunities in the digital sector, improve the quality of public services and improve the value of public money.

Success in adoption of BIM in the AEC industry requirements a detailed understanding of the consistent approaches required for implementation of BIM. The role of the public sector is to regulate the process of developing BIM guidelines, BIM adoption and its subsequent implementation in the construction projects. The used BIM standards and guidelines could be based on a region or be universally applied. In some cases, organizations could have their BIM standards. With BIM, it is possible to address the industry fragmentation and create a platform for enhancing collaboration and sharing of information in the construction supply chain.

Technologies and processes should be deployed throughout the built environment supply chain of the built environment to facilitate delivery of information in a standard format that will assure the owner its continuous availability in the entire life of the building. Most of the international activities focused on developing such technologies, which could minimize costs and enable Turkey to quickly implement the BIM. The government and industry has increased adoption of BIM in several areas of the construction industry. The incentives are meant to encourage construction firms to accept the BIM technology since some are still resisting it. BIM utilization cannot be reached at the desired level. It is the most effective way improving the usage of BIM that governments constitute the BIM standards and codes.

To implement all these suggestion and studies, step by step all parameters are structured. BIM framework will facilitate the integration of BIM easier and smoother to the building industry, higher education and public companies in Turkey. Four major aspects of the BIM Implementation Strategy framework for the digital transformation of the construction sector in Turkey are as follows and illustrated in Figure 27.

- Awareness Building,
- Capacity Building,
- Rules and Regularity,
- Professionals

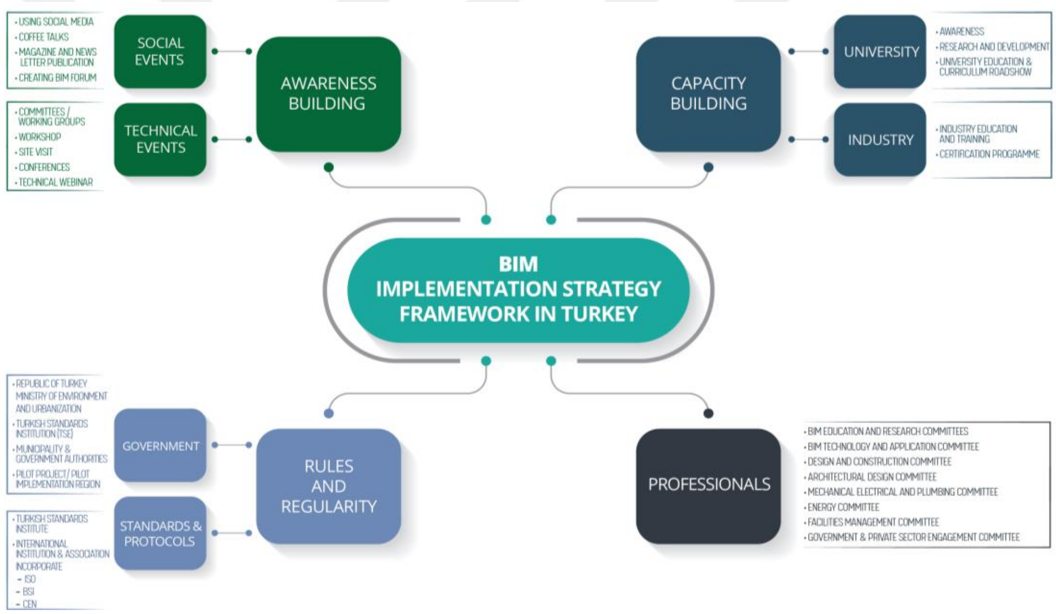


Figure 27: BIM adoption roadmap for Turkish Construction Industry

The correlation and integration of these elements is essential for proper implementation and digital transformation in Turkey. In the following sections, the strategic framework planning process consists of the following parts together with the derivation process are discussed in detail.

7.2. Awareness Building

In chapter 5, survey findings show that resistance to a change in culture and limited awareness on BIM are the leading obstacles for BIM implementation in Turkey. Furthermore, survey studies result show that the assessment of the current levels of BIM awareness and use in the Turkish construction industry have led to numerous benefits. As per the survey findings in chapter 5, many respondents still lack understanding and knowledge on the BIM concept. Besides, the application of BIM in the construction industry was still at low levels. Factors making it difficult to adopt BIM use in the Turkey’s construction industry are limited understanding on BIM. Adoption of BIM is enhanced through increased awareness on benefits of BIM, education and training, through either formal or informal approaches that lead to acquisition of relevant information.

Learning and adapting use of new technologies could be challenging for AEC professionals. As indicated in chapter 5, for the 70 engineers trained to use the Revit software, only 6 managed to effectively use it. The implication is that traditional methods are still common among many engineers in Turkey. According to Memon (2014), the main obstacle for BIM implementation in Malaysia is incompetent staff with limited ability on operation of the software, limited awareness on the BIM technology, high costs for the software, and requirement of much time for developing the software. Similarly, Chan (2014) had related results in Hong Kong and Middle East with the main barriers identified being inadequate competent staff for the BIM related tasks, lack of training /education, low client demand, and reduced government commitment in providing the required direction. The major important aspect of the survey was the willingness of respondents to state how they used BIM and the achievements made. The general findings show that a significant number of the respondents lacked knowledge and awareness on the benefits of BIM in Turkey.

7.2.1. Social Events

The organization of social activities is received more attention from the people. BIM activities with the organization of associations, student communities or institutions throughout the country are very important to raise awareness. People are more likely to participate in events where they will be more comfortable than formal ones. Such as coffee talks events attended outside working hours. It is a social atmosphere, where people can easily ask questions about BIM. It provides a socialized atmosphere to people can openly discuss BIM aspects in a relaxed environment with BIM professionals.

Social media channels lead to access to many people if they are used actively. People spend most of their time using social media. An important channel for reaching people is no longer billboards and posters but social media channels. The social media channels are highly cost efficient and help to increase the level of BIM awareness. With dependence on social media platforms, it is possible to increase the benefits of BIM. People easily interact with BIM content will increase BIM awareness and accelerate digital transformation.

Newspapers and magazines followed by all segments of the society are a very important channel for raising awareness and information about digital construction. Publishing successful BIM projects to be featured in some AEC journals will encourage traditional based companies. The benefits of the society published in newspapers, such as sustainable building, low carbon emissions and global warming, concern the entire society.

There are not enough Turkish resources and publication about the BIM system. There are very few academics and professionals in this field. Technical information should be shared to reach the correct information in Turkish. When people can't get the right information, they have difficulty believing in digital transformation. Turkish publications are important for increasing the technical capacity of AEC professionals. There is a need for forums and platforms where technical BIM knowledge about BIM can be shared. There are many technical departments in the AEC industry. The sectoral transformation is not limited to architects and civil engineers. All stakeholders in the sector should have sufficient knowledge of BIM.

7.2.2. Technical Events

Technical events are significant factors that determine transformation of the construction industry. Technical activities are very important way to increase the knowledge capacity of AEC professionals and public institutions and knowledge development. BIM technical events can organize as workshops, conferences, site visits and working groups. One of the biggest obstacles to digital transformation is the lack of technical staff. Technical staff should be provided with training. In addition, it is necessary to provide the opportunity to meet more experienced people so that people interested in raising awareness through technical activities can learn their knowledge and the answers to the questions they have formed.

BIM working groups are a very critical part of the digital transformation process and management. Working groups to be prepared according to occupations will play an important role in developing industrial solutions, implementation ISO standards, sharing knowledge and experience, publish sectoral reports and define national standards and requirements. Respective ministries and agencies create and lead technical working groups in the identified focus areas and induce discussion amongst the stakeholders.

Through a series of workshops, it was possible to bring together government agencies, ministries, and AEC firms from different sectors and representatives from the education and research community, who discussed on future opportunities.

A construction site visit or field trip is an interactive BIM site implementation to observe the BIM based site management and installation with the objective of comprehending the ongoing site practices. Site visit to utilize the experience based learning model to provide an opportunity for people interested in BIM for the observation of roles and responsibilities. They can observe mobile BIM use, BIM implementation plans and processes, shop drawing installations and QA/QC processes.

Turkey will be held throughout the conference are of incredible importance to increase awareness of BIM. It is necessary to reach out to the members of the universities and institutions, to tell about successful pilot projects and to overcome the BIM benefits. These activities should be carried out throughout the country.

Online webinars are an important tool to reach people in the digital age. People may not be able to come to events in a particular place. In addition, transportation is another difficulty if you live in other cities. Online webinars are a very good communication channel to access information more easily. Especially, online webinars are suitable for international experts living outside to share their experience and meet people.

7.3. Capacity Building

In recent years, BIM has been the most common term in the construction industry. It does not only involve technology, but also several processes applied in the construction workflow that contributes significantly to the development of projects in terms of time, better communication and collaboration among the construction parties, facilities management, implementation of sustainable and lean principles, in brief, a myriad of important benefits for the development of a successful construction project. However, there are still registered challenges, which hinder some countries and organizations to implement BIM more successfully. Inadequate skilled personnel are a key challenge that affects the demand of BIM projects and also increases the inefficiencies of the workflow, reducing the benefits that can be obtained from its implementation.

This section intends to investigate which aspects are required to educate and train the companies and professionals involved in implementing BIM project in Turkey. The methodology consists of reviewing literature on BIM education and training. Challenges that Turkey experiences in initiating BIM education are identified and categorized into four classes as well as potential solutions given. BIM training in the industry and BIM education required for clients is also presented along with the revision of Turkish BIM education frameworks.

The targeted outcome is establishment of a framework seeking to educate the construction parties on the BIM technology and process adopted in its implementation. Through BIM education, it is possible to address the gas in the level of knowledge and increase the professionals' level of skills in BIM application in the AEC industry. Furthermore, BIM education is required to promote adoption of BIM in the AEC industry in Turkey. The education on BIM in Turkey encounters challenges such as shortage of experts and few companies as well as institutions that offer training on BIM technology.

7.3.1. University Education & Training

Most of the academic institutions globally have established and integrated programs for BIM technology and its application to the AEC industry (Wong et al., 2011). However, educational institutions are criticized by scholars for their poor plans and limited ability to apply BIM on current and future programs. Similarly, several academic programs fail to comply with industry and student's expectations. Furthermore, most of the BIM programs given at an undergraduate level are either optional or post-graduate. Because of the extra time and cost, this may not be a choice for the majority. To overcome these issues, academia must meet the criteria of accreditation bodies and reconsider its pedagogical approach by including BIM into an undergraduate curriculum.

Few Turkish universities have incorporated undergraduate and master programs in their academic programs. However, the programs offer only basic information on the concepts of BIM software. At this stage, these courses are not yet looking at collaborative BIM across all AEC disciplines. Some universities want to integrate BIM into their curriculum, but there are no academics staff trained in BIM. Students will be encouraged to collaborate in establishing BIM programs, whose integration will accelerate depending on the Turkish university curriculum. There is need to revise and reformulate full academic programs to ensure they emphasize on the current changes in the BIM technology.

In chapter 5, survey study has shown there are challenges that Turkish universities needs to overcome to manage to include BIM into the curricula successfully. The process of BIM implementation has also presented several challenges to the industry, which have not been totally overcome yet. Some of the challenges identified in academia are from a different nature of the ones presented in practice, for instance the ones related to curricula development. However, the remainder challenges are majorly cultural issues associated to the infancy and essence of BIM and high cost can be perfectly associated to the BIM implementation in the industry. From that, it can be inferred that the implementation of BIM in the industry influences positively the subsequent implementation of BIM in academia. Once the challenges in practice be reduced and overcome, the trust in BIM will increase and academia will feel assured about the decisions and actions required for a successful development and implementation of a BIM curricula.

7.3.2. Research and Development

Successful innovation and implementation of BIM technology requires a high level of Research and Development. The construction industry collaborates with academia to produce a high BIM value. Due to a rapid technological development, the industry has to remain competitive through research and development.

Priorities in Research and Development depend on the current issues experienced in the construction industry. Application of BIM technology is still a new concept in the Turkey’s construction industry. Thus, universities have many opportunities to incorporate BIM into their academic programs. Researchers need to work with universities to identify the needs and specific areas for exploration in BIM use. Through collaboration with learning institutions, researchers will easily get research grants from the Turkish government.

7.3.3. Industry Education & Training

Turkey's building regulatory system rely on the traditional approach. Most of Turkish construction companies and government based on traditional design, construction and management process. An important aspect in BIM education is training on use of BIM technologies in the Turkish industries. Due to instant business benefit, numerous companies of different disciplines in the industry give the required training to their personnel to work collaboratively with project partners. The training can occur on the job or through registered training organizations. The training is technical and its focus is to create abilities in wide scale application of BIM tools and workflows. Nonetheless, the focus of training it to manage cross-disciplinary teams and promote collaboration in BIM projects. In Table 9 are shown important aspects that need to be considered when providing BIM education within companies.

Table. 9: Considerations to be taken when providing BIM training in companies (CIC,2013)

Type of Training	Internal
	External
Expertise levels	Management of the organization
	Staff actively implementing BIM
Method of training	Internal training created by a BIM champion
	Training from software providers and local partners
	Continuous training for the BIM staff

Some companies prefer to have their own and unique in-house BIM training, however those with inadequate resources for training would suggest implementation of BIM education and training into universities. Thus, students will have skills in BIM application upon completion of academic programs and start working in the industry. Moreover, other companies would propose provision of non-technical training programs for managerial positions (e.g. Project leaders, team managers), which is offered occasionally through BIM-related conferences and workshops. Even though some companies can offer training to their staff, that indicates that the insertion of BIM in educational institutions is actually a necessity for them.

In order to implement the highest BIM value, clients need to know its basic principles. The clients also can request for correct information of high quality at the appropriate time. Through educating the clients, sole clients will obtain more from the projects they are authorizing and also, in the long term and maybe more significantly, they will support BIM and champion for its implementation. It is very important that clients receive training about BIM. They need to know all the technical details about BIM. Efficient leadership for the BIM project is required to enhance client's level of knowledge on production of a detailed EIR (Employer's Information Requirement) and the procedure for checking the BEP (BIM Execution Plan) elaborated by the supply chain, according to what has been established in the EIR is essential for an efficient BIM leadership of a project (Al Ahbabi and Alshawi, 2015; Wallbank, 2014; Designing buildings, 2016). Moreover, a very detailed preparation of the AIR (Asset Information Requirements) form, the client is important. The project implementation team can provide clients with relevant and reliable data. The clients also have a right to ask questions pertaining to the project and get accurate feedback. Thus, they can get the most benefits of BIM after finalizing the process (Sharp, 2015). Clients should understand what their role is and information they should access and control in a BIM process.

7.3.4. Collaboration between University and Industry

The largest domain in BIM education is the university since it covers educational institutes that teach many people. The student's performance can help to determine if the educational materials on BIM technology are of the high quality and address the key concepts. Another significant domain is the construction industry, although it mainly trains its employees to develop skills in their area of specialization. The remainder providers are even more specific. Software companies only provide training of their software. Local chapters of different associations would offer the type of training they are capable to conduct. A limited number of skilled personnel in the industry is an indication that the strategy used to deliver and disseminate BIM education has to be improved.

Most professionals find the University a suitable venue for putting their knowledge into practice and improve their skills. Existing alliance between the industry and academia increases the values and benefits from implementing BIM. The alliance also addresses the inadequacy of skilled BIM professionals in the industry and maintains updates on the academic related to the industry.

Through this evaluation, it is possible to determine the student's or professional's level of preparedness in terms of BIM knowledge as well as establishing additional measures required to address the knowledge gap. In the industry, execution of this stage requires performance evaluation of the personnel trained and the client during and after the development of a project. On the other hand, it is suggested that academicians should continue to update and change the BIM programs along with what is happening in the industry.

Clients have to be encouraged to be part of the BIM process even when they are not among the professionals in the construction industry. Since the clients do need to have a strong academic background, a BIM consultant was found to be ideal in enabling them acquire the required knowledge. Nevertheless, interested the clients can get involved with educational activities such as seminars and short programs.

7.3.5 BIM Education Framework Recommendation

Through this study, it was possible to comprehend the importance of BIM education and how challenging its development and improvement are, and more efforts are required from the academia to offer BIM learners a high standard education that can address the shortage of professionals with adequate BIM skills in the industry. The involvement of the government is a key in this respect. Turkish government should create strategies to drive its implementation and give support to the academia for a better delivery and diffusion of BIM education across the industry.

BIM teaching has to be incorporated into the university curriculum to equip engineering graduates with detailed knowledge and understanding on BIM concepts and BIM skills. This strategy will increase application of BIM into the AEC industry. Several universities have already incorporated BIM into their construction/civil engineering curriculum.

BIM education in academia is the most required BIM education for the spread of the BIM implementation. However, it is more directed to new practitioners. The acquisition of BIM education is harder for current practitioners. They are the most affected in the transition from CAD to BIM. Thus, it takes more time for them to learn and adapt to the new practices. In the process of BIM education, companies need to assess closely the aptitudes of their staff and pay more attention to these professionals, to whom the training required may be deeper than the one the rest of the staff would need. Reluctance from this type of professionals can also arise. Thus, the education strategy needs to be very encouraging for the professionals to understand and adapt to the process.

As clients monitor the construction process, in some cases through other people depicting them, the BIM knowledge they require is not as deep and extensive as the one the professionals of the industry need. They need to understand how the process of BIM is and their role within. A high understanding of the documents, information sharing, legal implications, the information they require, depending of their objectives with the project, is a plus for a successful implementation of BIM.

The framework can be beneficial for governments that want to be involved in BIM education or improve current practices; academic bodies and construction companies for the development and/or enhancement of BIM education and training planning; and for current and future professionals, who are interested in the subject.

7.4. Rules and Regularity

The ACE industry in Turkey encounters several challenges not common in other sectors due to paper-based drawings and fragmented working relationships with different stakeholders. These problems have led he Turkish governments to push for adoption of BIM in the AEC industry. Despite shifting to computer-aided design (CAD), the professionals' approach to design, construction and delivery did not change. Whereas CAD emphasizes on format and output, BIM focuses on open information and workflows. Adoption of BIM is gaining a high significance to the Turkish construction industry.

In its traditional model, Turkish construction industry relied on manual drafting and hard-copy documents. Introduction of CAD was aimed at improving the degree of accuracy, designing and documenting. CAD tools were based on a new computer technology considered as part of the digitalization process. However, Turkish construction sector failed to utilize the new CAD environment to the maximum due to hesitation in adoption of the digital paradigm. Therefore, use of CAD continues reduce economic productivity with lower quality and investment value.

Turkey has a limited application of digital modelling technologies such as BIM in the built environment. These technologies have the potential to improve productivity in the sustainable design, integrated construction and improved performance and maintenance management of buildings and infrastructure.

BIM is one of the most promising recent developments in digital engineering in the AEC industry. In Turkey, there are no standards that respect the best practices of BIM. Several studies have been developed but its application has found great resistance. The fact that there is no obligation on its use in private and public procurement implies disinterest by of the construction sector. In Europe the use of BIM is mandatory in United Kingdom (UK), Denmark, Finland, the Netherlands and Norway. These countries are highly developed in the use of BIM, especially the UK, which has contributed to the development of a European Union (EU) implementation. Shared knowledge and und understanding among construction professionals and regulators will lead to increased support of BIM standards in Turkey.

Many countries are establishing new BIM standards for the construction industry. With these standards, construction teams can leverage a high value from implementation of BIM and model authorship efforts. This study reflects on ongoing standardization initiatives in Turkey and considers where current research efforts fit in. The current research on stakeholders’ perceptions on BIM adoption to the construction industry is still limited, especially on whether the research community or construction industry should establish requirements for BIM standardization. A national survey was conducted to address this gap by studying the impact and correlation of particular process-orientated standardization initiatives and related research on BIM implementation.

The Ministry of Environment and Urbanization in Turkey has to establish a pathway for BIM adoption to the EAC industry. Most companies in Turkish construction industry are worried that they would find it difficult to compete in future if they do not shift to BIM technology. The construction industry and professional bodies in Turkey have to collaborative and apply a multi-disciplinary approaches to promote adoption of BIM. Furthermore, effective leadership is needed by major contracting and consultancy organizations to ensure their supply chain fits with their BIM requirements.

The Turkish Government needs to address the barriers making it difficult to adopt BIM. The government should then initiate pilot projects to test and validate the outputs from the respective work programs. All government departments and units need to have an agreement with construction industry players on the best strategy for BIM adoption. Lack of a common standard and protocol for data interoperability and data management so that BIM models in Turkish government and public sector. They have got common standards and protocols between all disciplines. They need to project work from the same data and meet the same standards, requirements and protocols.

Three major roles of the Turkish government and public sector standards and accreditation regarding BIM. Adoption are analyzed and illustrated in Fig.2, which are:

- Government Policy
- Rules and Regularity

7.4.1. Government Policy

Turkish government has to establish policies for promoting national standardization of BIM adoption. From the analysis, the Turkish national governance and institutional frameworks will integrate BIM adoption. Increased use of BIM technology will lead to improved economic performance in Turkey.

BIM technology can streamline a building’s lifecycle through the integration of design, engineering, construction, maintenance and decommissioning information. With digital modelling tools, it is possible to facilitate urban planning, infrastructure development and the designing and understanding of city environments.

There is a variation in standardization policies at national and global level for BIM adoption. Turkish government need to determine BIM adoption national policy initiatives and standardization of the regulatory environment have a significant influence. Comparison of national and global BIM standardization will enable Turkish government to establish effective policies.

It is intended to start the study with an analysis of the use of BIM on an international level and then progress to the national level. More specifically, it is intended with this section: Evaluate international initiatives in the adoption and application of BIM standards.

Successful BIM adoption in Turkey will depend on national leadership and coordination, which can maximize efficiencies and avoid the many problems created by piecemeal and disjointed approaches. Government entities need to drive this leadership through collaboration with major industry players including private sector clients, contractors and industry/professional associations. Global leadership should also facilitate BIM implementation globally. Turkish government should encourage, specify or mandate the use of BIM for their publicly funded metro projects, hospital projects, airport projects and government projects. The Ministry of Environment and Urbanization in Turkey should secure international construction contracts for its industry players. These global initiatives should receive support from the international BIM standards and protocols.

The municipalities that play the most active role in the development and construction process are obliged to make a development plan and issue a building license in accordance with figure 28.

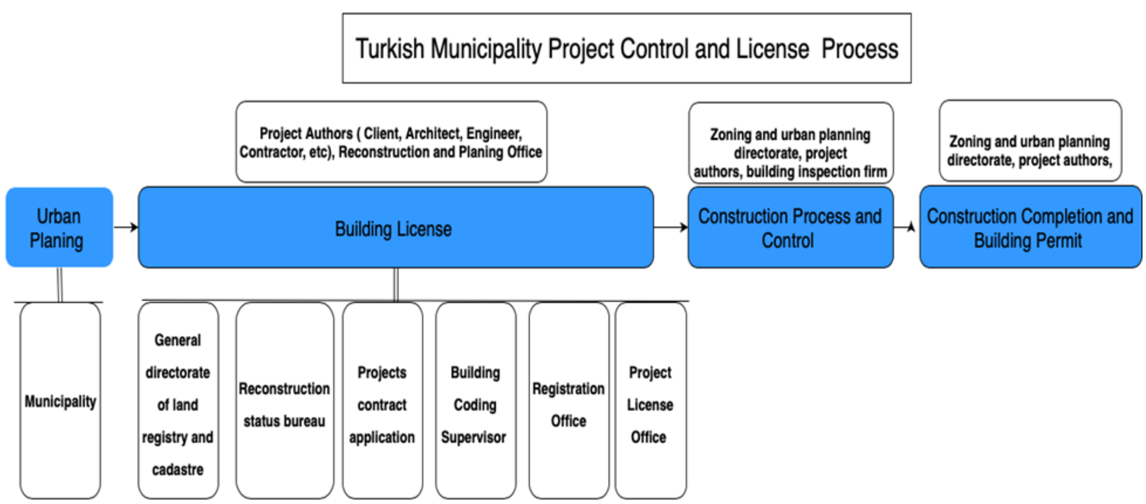


Figure 28: Turkish Municipality Project Control and Process

As described in Figure 28, the process of building and building permits; development urban plan, building license, construction process and control management of building supervision activities and regulation of building use permit. Accordingly, after the registration, control and approval of the projects (architectural, static, electrical, mechanical, landscape) submitted with the documents submitted to the municipality in the building license application, the construction process starts with the license granted. The zoning status document and the construction station relief / elevation section document, which are among the documents required for application, are also issued by the relevant unit of the same municipality.

The main problems identified in the municipality are as follows:

- Processes cannot be monitored and applied to the citizen
- No feedback is available on the status of services provided to citizens cannot be measured
- Workflows are hierarchical in the municipality, not according to the process flow, the structure is arranged
- Processes are not implemented in a standard way.
- Municipal employees' performance and workloads were not assessed
- Adequate information on the past jobs and services cannot be taken

In this research, it is suggested to develop Figure 28 services and documents related to making zoning plans, issuing of building permits and issuing of building permit documents started to be managed and produced in electronic environment in Turkish municipalities. Considering that these processes have the highest volume of transactions and documents in municipalities, it is clear that the model and activities implemented in the project will set an example for municipalities in terms of increasing the service quality for the institution. Municipalities works in an integrated manner with e-government applications, also observes the required legal arrangements and practices aimed at increasing the service efficiency of public institutions and organizations through the infrastructure works realized.

7.4.1.1. Government Project E-Submission

Government electronic submission integration goals to implement the fastest building permission and communication in Turkey. Systems streamline the process for regulatory submission. Project teams just need to submit one digital building model, which contain all project information need to meet the requirement of a regulatory government authorities. Project model should be 3D BIM model for approval through electronic submission. This will be followed by the acceptance of mechanical, electrical and plumbing (MEP) and structural BIM models.

The Turkish Government will start project architectural BIM e-submissions, which is improving construction productivity. The Government's strategy for BIM development is based on the public sector leading the way. However, the strategy encourages the private sector by eliminating existing barriers. The Turkish Government has to create a roadmap for digital transformation, which should include industry-wide BIM guides, a legal and contractual framework for BIM-based projects and studying the BIM workflow. Government need to afford into developing building capacity. Project electronic submission of some benefits;

- Real time notifications of approval status
- Centralized database avoids data duplication and minimizes file losses/misplacements
- Reduced cost elimination of printing plans and reports for physical submission
- Standardized business processes and automation of standard computations
- Consistent standards based on international standards that manages the convention in which BIM model are created

7.4.2. Rules and Regularity

Developing Turkish BIM standards that are more compatible will enhance the construction sector for services of BIM. Moreover, will enhance the accommodation of improved briefing systems as well as ensuring savings in construction. The sufficient development of the standards will ensure proper functioning market BIM activities. Furthermore, it will help the sector in determining the functioning of standards for higher order replica as well as application of analysis. Therefore, there is need for integration of Turkish BIM codes. Turkish government will give confidence to owners for their availability and data fidelity over construction and offer motivation to ensure improvement in technical instruments. As a result, Turkey will show improvement and join the standard of European Union members. Moreover, the BIM tools have a good international market as well as a preferable growing process for ensuring their interoperability.

A strategic plan will be formulated in conjunction with all Turkish sectors that are affected for the final move to approval systems that are model based in support of the strategy for Turkish government. It will be undertaken in conjunction with the implementation of BIM of the Turkey industrial base.

7.4.2.1 Information Standards

There is no official organization and/or institution that are engaged in establishing standards and/or regulations for the successful management of construction processes in Turkey. In other words, no professional body has put forward standards of practice in construction management. The development of construction management in Turkey has been slow when compared to that in the world. Turkish architecture, engineering, and construction (AEC) professions have gained reputation as the most inefficient industries today. time delays, unforeseen work and costs, and resulting lawsuits among key industry players.

The losses encountered in Turkish AEC industry arise from inadequate interoperability among participants in the sector, reliance on paper based business practices, and poor standardization in technology acquisition amongst the stakeholders. To stop that tendency many regulation bodies have launched initiatives to improve quality, responsiveness, reliability and efficiency in Turkish AEC industry. Information standards defined by courtesy of COWI are shown in Figure 29.

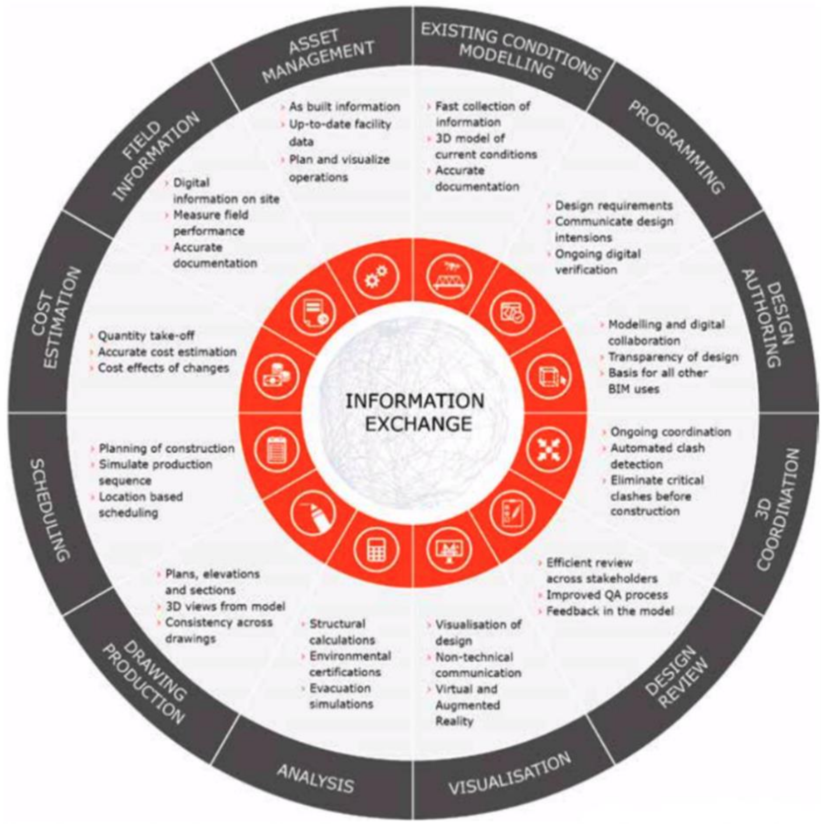


Figure 29: BIM uses as identified by consulting engineers (by courtesy of COWI)

BIM offers the construction engineer, and architects the potential and capabilities in planning, designing as well as managing projects more effectively. BIM gives project participants the promise of a common details repository. Many participants can join the project applying Building Information Modelling to get information for tasks, for instance, energy analysis, environmental compliance, and project costing as well as material take-offs. Various software methods that are standard are utilized by developers to exchange of ideas and information between BIM models and applications of building analysis. A crucial decision involved in coordination of project construction information is identifying the accurate system of classification. Besides, it helps in portfolio management.

7.4.2.1.1. Industry Foundation Classes

BIM is a modelling as well as managing building data during its life cycle. BIM enhances the improvement of building planning, designing, construction process, and maintenance through warranting participants in exchanging a sharing information using the same standardized model. As a result, the members will understand one another. Each crucial aspect for the facility will be well stored, researched as well as captured. IFC working principles are represented in Figure 30

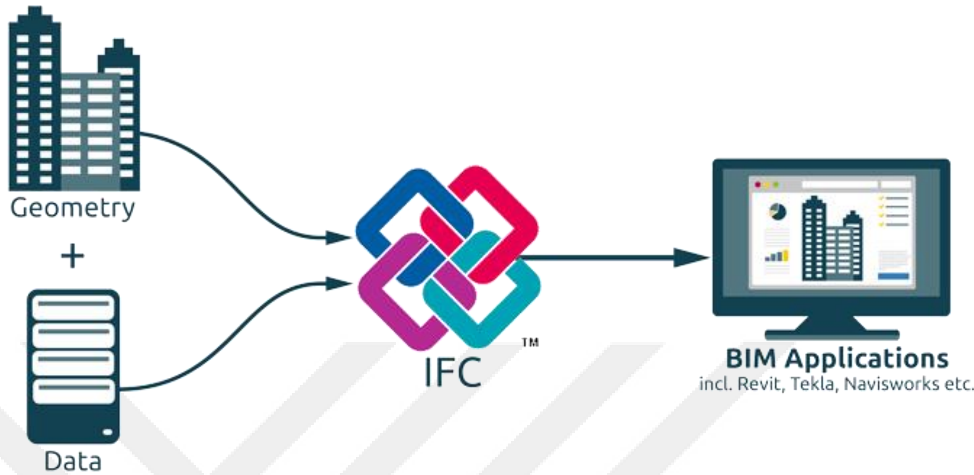


Figure 30: IFC working methodology

Essential objectives of this process are;

- To build the facility's electronic model prior to building it physically so that detailed analyses can be accomplished early in the process. Problems can be solved electronically, and decisions can be made earlier at lower cost;
- To collect data at its point of creation and enter that data only once. Then allow it to be used, improved, and passed along to others throughout the lifecycle of the facility;
- To make data entry and data maintenance part of the process linked to a building and not separate steps;
- To recognize that detailed information can be summarized at a global view, but summary information cannot be broken down into detailed information. Therefore, collecting detailed information is a basic concept.

The notion of Building Information Modelling is constructing a building virtually to do away with difficulties, and ensures the simulation as well as analyzing the potential impacts. For instance, it is an easier process to fix difficulties using a mouse than demolishing and building element on a construction site. Before actual construction, the problems among building systems can have worked upon.

The approach has several benefits such as:

- Reduction of information loss during takeover of ownership of data from different disciplines taking place in the process.
- Errors are reduced since data is only recorded once.
- Conflicts are detected and realized earlier hence reducing the cost of maintenance, designing as well as construction.

The authoritative model of building is the central point of the BIM. A model is a digitalized representation of the functioning and the physical features of a given facility. As a result, it serves as a source of information concerning a facility hence forming a basis for decision. Collaboration by all stakeholders is a basic factor at different phases of the life cycle of a facility. It is undertaken to update, extracting or modifying data in the process of modelling to support as well as reflect the stakeholders' roles. The model does not depend on only one entity but it is made up of a set of interrelated files. The function of BIM is to track data on all components that comprise a building and can range from the very to the fully detailed.

7.4.2.2. Information Exchange

BIM provides a common information repository for every project participant. Many participants can tap into a project Building Information Modelling to obtain element information for tasks like analysis of energy, environmental compliance and material take-off. Standard software methodologies are applied by developers to enhance information exchange amongst BIM models as well as external building analysis.

The use of BIM in Turkey allows collaboration, communication as well as coordination amongst the stakeholders in the process of project delivery. It is easier said than done.

Practically, it will lead to an open-source data representation that allows exchange of information electronically in Turkey. Design and analysis software should be used in the built environment sector, each applying data representation that is proprietary.

Turkish BIM standards will consist of public and private sectors that have combined to give improve standards. These standards are able give open as well as public representation of data and exchange in the built environment sector and Turkish government process. The current lack of standardization does not provide the required incentive for industry participants to invest in the collaborative processes that will maximize the benefit of the use of BIM technologies.

Building Information Model dispenses many interoperability affairs given the reliance on rooted information. Upon resolving these particular issues as well as developing processes of information interoperability that is computerized will help in revising for design models as well as exchange of data and information in Turkish AEC sector. BIM exchange of data involve specification of objects, classifications and providing an important structure for transfer of data between applications.

Upon ensuring effective communication amongst industry exponent, identity of information exchange is required. BIM information exchange among the parties are illustrated in Figure 31.

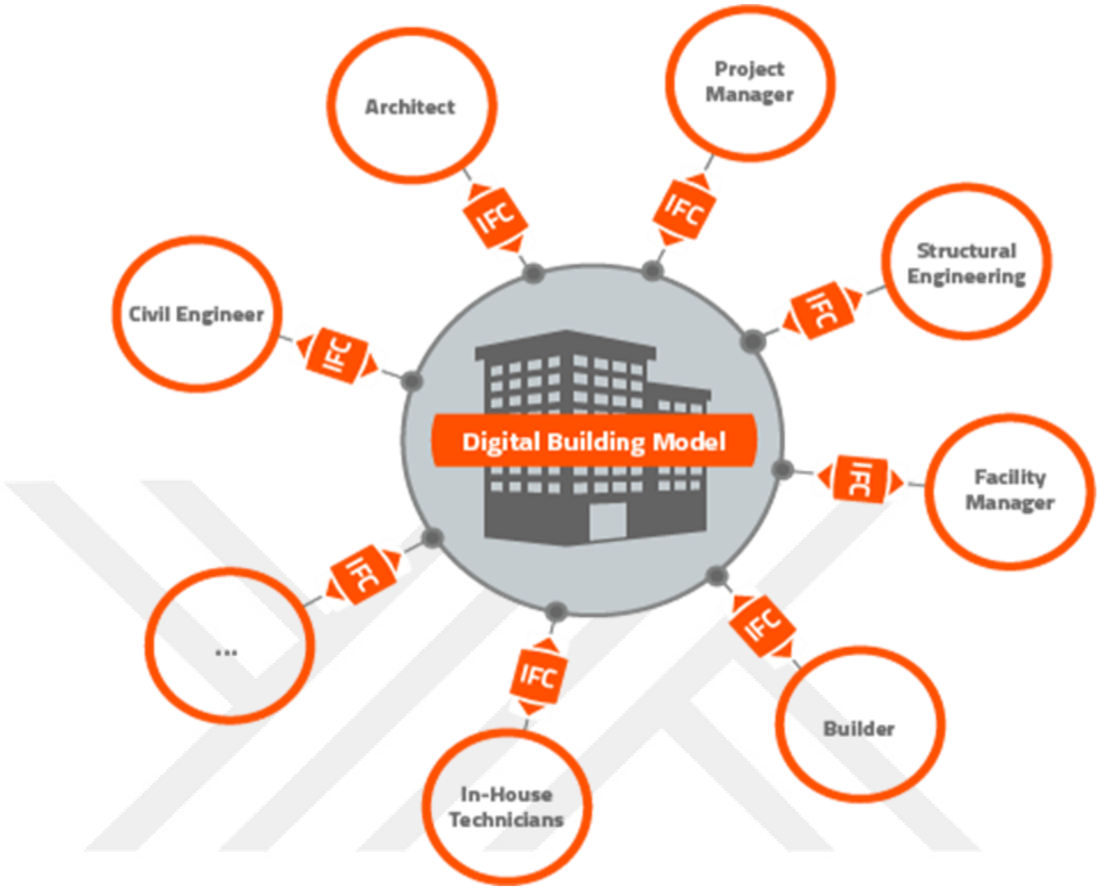


Figure 31: BIM Information Exchange Management

Alignment of the process is necessary for international competitiveness of Turkey. Establishing a mechanism for Republic of Turkey, planners, local government, Ministry of Environment and Urbanization bodies with integrated data of building and service system elements and analysis performance of built form would be a critical advantage for the abovementioned international competitiveness. BIM will help the Turkish Government to meet its strategic aims, specifically:

- Reducing the construction costs as well as the whole life cost of built assets by %33;
- Reducing overall time to completion specifically from inception for new and assets that are refurbished by %50;
- Reducing greenhouse effect in the built environment by %50, and

- Reducing the trade gap between exports as well as imports for construction product by %50.

Object data has significant characteristics and features; therefore, integration of BIM one database environment allows broader analyzing, performance as well as simulation. BIM data setting protocol is essential in transforming current wasteful processes and loss of data that are endemic in the sector; and be a stimulus for innovation and productivity in the built environment sector.

Scientific community as well as product manufacturers are required in enabling the analysis based on BIM to be of more importance in building code and compliance. Republic of Turkey Ministry of Environment and Urbanization need to control a single part of more exhaustive information needed for multi-disciplinary, and life-cycle product data usage.

Republic of Turkey Ministry of Environment and Urbanization will be initiating a building product project, which should be supported by the building product manufacturing industry, and have powerful connections to Turkish standards, the Turkish Building Codes Board and other relevant industry organizations and government agencies.

7.4.2.3. BIM Contract

Contract administration practice is crucial construction projects beginning from the invitation stage to bid through close-out of the project. Various documents such as graph representations, joins hence forming the contract. These documents define the scope of work.

Traditionally, contract documents include

- The contract,
- General conditions,
- Plans,
- Specifications
- Any other written conditions upon which the parties agree.

The plans included in these documents include typically two-dimensional drawings. Contract documents definition is more than an insignificant part of the process of construction.

It creates the basis from which the parties will work, coordinate and collaborate throughout the process of building. To stand in place of traditional two-dimensional contract documents, BIM must contain a tremendous amount of information and be relied upon by the parties as the primary source of information.

Owners change of requests, owners failing in terms of payment, and the failure of owners in fulfilling their contractual obligations is claimed to be the most severe problems. In this case, it includes late approval of the project documentation, lack of proper arrangement of domestic materials, inefficiency and lateness in visa permissions that are to be granted to the project personnel to enter the country. Moreover, there may be failing of owners in terms of administration, issues related to design as well as contractual problems, and deficiencies in recovering the additional costs. The reported dispute resolutions concerning the Turkish contractors is that most them solve issues through negotiations hence few of them employ arbitration method.

BIM can upset the definitions of contract documents of Turkish traditions hence replacing some or all of the two-dimensional drawings, specifications and other written conditions with BIM based data. Theoretically, each construction project using Building Information Model will possess a complete model that is integrated from which all information concerning designing and construction could be obtained. If this were the case, BIM could be used to replace many contract documents and stand by itself as the single source of information for the design, construction and operation of a facility.

With possible concepts, various essential has bared BIM from being adopted in full in the following ways:

- Develop BIM standard for contracts for application, focusing on integrated project delivery to maximize the value from the development of Building Information Model technologies.
- Developing an appendix that can be utilized in co-existences with current building and construction and design and construct standards.

The standards are required to be fixed when tested. As a result, it collaboration will be facilitated expected for Integrated Project Delivery type contracting that will ensure maximum benefits from the use of BIM, lowering risk, costs, and better encouragement of use of offsite digital fabrication, just-in-time manufacture. The contracts made will need to be scalable, with at least a short version for small projects and a comprehensive contract for larger projects.

Utilization of contracts provides insufficient incentive for participants of Turkish industry generally to invest in the provision of BIM services. Lack of Turkish standard as well differing contracts leads to increase in the perception of risk for market participants, and increasing clients' costs. Turkey need to develop technical codes and standards for the BIM adoption.

7.4.2.4. International Standards

Construction industries are on the streak of adopting the building information modelling which is a digital information management approach that increases productivity as well as quality in building projects. Moreover, it reduces financial losses during construction, and provide insights for developing future services. For instance, a 3-D modelling containing embedded information that can be shared amongst all project partners, at all stages of a project from design through to maintenance. Each partner is responsible for his/her own data whereas project managers apply BIM as one 'agreed source of truth' to enhance the process of decision-making. This results into effective utilization of resources, effective communications thus collaboration within the partnership, greater flexibility and improved long-term planning the benefits of which accrue to client, project manager and contractor.

The demand for projects based on BIM platforms is increasing significantly among public and private sector clients. The current consensus is that BIM will benefit social and environmental performance of all parts of the world regardless of the rate at which some industries are adopting the technology. Therefore, BIM will promote sustainability in the construction industry at the international level.

A) A Start of delivery phase – transfer of relevant information from AIM (Asset Information Model) to PIM (Project Information Model)
B) Progressive development of the design intent model into the virtual construction model
C) End of delivery phase – transfer of relevant information from PIM to AIM

Figure 32: Information management lifecycle related to ISO standards

International standard ISO 19650 published in 2018 supports BIM and encourages its wider use. Thus, the European Federation of Engineering Consultancy Associations (EFCA) made a timely decision to guide its members on the standard and highlighting its far reaching benefits. BIM under the ISO 19650 concepts represents unprecedented opportunities for increasing the added value of engineers during the construction process.

ISO 19650 describes the advantages of BIM adoption to the projects in the construction industry. It shows how, by managing the ownership and liability of project data, project managers can stay in control during the whole lifecycle of assets, including operations and maintenance, experiencing less contradiction or misinterpretation of data. Figure 7.6 describes the general information on management life cycle for operational assets and project delivery and the relationship between these two distinct parts of the asset life cycle, within ISO standards 9001 (quality management) and ISO 19650.

The figure shows "A" as the start of the delivery phase which, in an asset life cycle. It also shows 'B' as the phase where development of the design intent model occurs. The last part ‘C’ shows that handover is a bridge between the construction process and the operational phase.

7.5. Professionals

The Architecture, Engineering and Construction (AEC) industry has long been characterized with the lack of efficiency, proneness to disputes and consistently lower than expected levels of productivity due to its predominantly fragmented supply chain in Turkey.

Architecture, Engineering & Construction (AEC) professional workers need a specific BIM roadmap to enable integration from traditional construction methods into the BIM system. AEC working groups are needed to implement the BIM roadmap for professionals. Technical events will be organized periodically brings construction experts together to form special working groups. Sectorial knowledge is shared in these events, technical workshops and training are organized. It would help for the digital transformation of the construction industry and BIM integration into practice.

The committees will contribute to the digital transformation by raising awareness, sharing information, developing capacity. These committees include building professionals and scientists focused on the integration of Building Information Modelling and Management (BIM) into the Turkish construction industry and act as a hub for sharing knowledge and practice in BIM in Turkey and beyond. Committees foster education, enable strategic roadmap developments for successful BIM adoption and implementation in accordance with the required BIM standards and protocols.

The Turkish BIM society will provide the ground for communication and cooperation for all the parties involved in a design and construction project. BIM committees help for capacity building and awareness about BIM in Turkey with regular reports on building standards and accelerate the integration of BIM into the sector. BIM committees will aim to support construction companies to improve their competitiveness in the international arena. BIM committees have important roles for digital transformation construction industry in Turkey.

7.6. Summary and Conclusion

The purpose of this chapter was to define the conceptual digital transformation framework for the Turkish construction industry. This chapter focused on data analysis of the Istanbul Grand Airport case study and questionnaire based survey from the previous chapters in order for the development of the conceptual framework. The impact of people, process, technology, regulation and education dimensions on the integration of BIM systems in industry are elaborated. Four major roles of the BIM implementation strategy framework defined in this chapter.

The conceptual framework needs to be validated in Turkey. Therefore, it is implemented in practice via the establishment of the Turkish Building Information Modeling and Management Association for the verification and validation of the conceptual framework and for the acceleration of the digital transformation and integration processes. The conceptual framework validation will be expounded on in the following chapter.

CHAPTER 8

FRAMEWORK VALIDATION

This chapter verifies the conceptual digital transformation framework for the Turkish construction industry. We will establish Building Information and Management Association as well as define corporate structure, roles and responsibilities, implementation plan and working mechanism that is planned to be established to implement the conceptual framework. This chapter also summarizes the results of an undertaken validation process, confirming the components of the proposed digital transformation roadmap in Turkey.

8.1. Introduction

A roadmap refers to a strategic plan that demonstrates the steps which an organization can apply to attain set objectives and goals. Moreover, it openly outlines links among tasks and priorities for activities in the near, medium and long term. An implementation plan also involves metrics and milestones that allows repeated tracking of progress towards the ultimate objectives of the roadmap.

In this study, we have prepared a strategic implementation plan for the development of BIM implementation framework for digital construction in Turkey as shown in Figure 33. This figure also shows how we have reached to the validation of framework stage in detail.

Initially, a literature survey was performed in the first step. Findings about Turkish construction industry and BIM were evaluated in the literature review stage.

Later, we prepared a questionnaire survey based on our findings in literature review stage. We applied the survey to determine the current acceptance BIM level in the Turkish AEC industry, professional knowledge capacity and some key strategies for best BIM practices in the construction industry. After analyzing results obtained from the survey, we have synthesized the level of construction management and BIM usage at the national level.

In this case study, we conducted various fieldwork at Istanbul Grand Airport to develop a solid understanding of how BIM is integrated and implemented in a mega-scale project. This case study made a significant impact in understanding the strategic BIM perception as new method of working methodology for the Turkish construction industry.

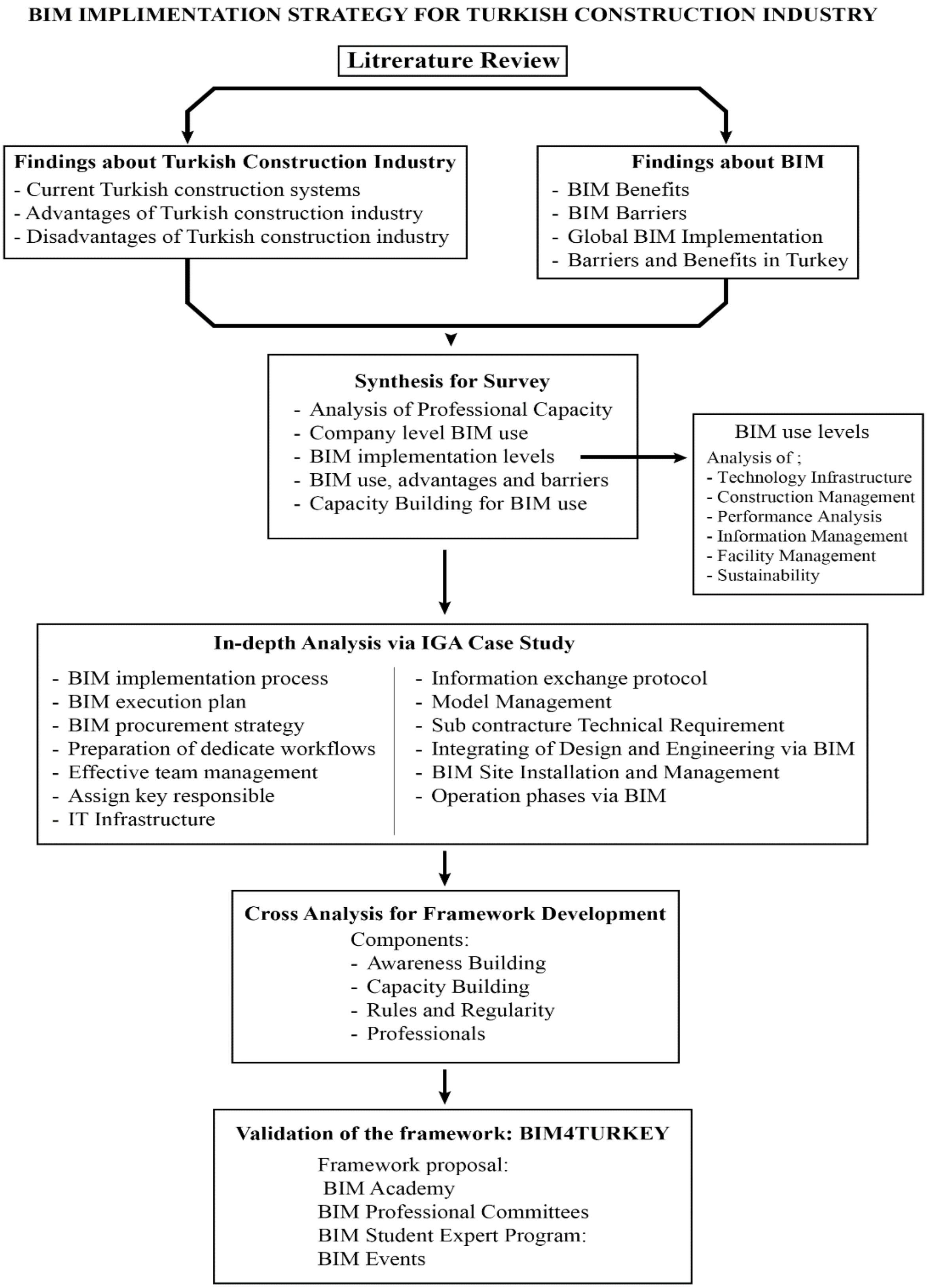


Figure 33: BIM implementation strategy for Turkish construction industry

Then, we have created a cross analysis for the conceptual framework by analyzing literature review, survey, and case study. Our cross analysis aimed to study the adaptation of Building Information Modelling and Management to Turkish government, contributing to developing national BIM standard, BIM education and BIM policy initiatives. Framework prepared by cross-analyzing the literature review, survey, and case study.

Lastly, BIM4TURKEY summarizes the results of an undertaken validation process to confirmed the components of the proposed digital transformation roadmap to accelerate the implementation process in Turkey.

We decide to establish Turkish Building Information Modeling and Management Association (BIM4TURKEY) to implement the conceptual framework and accelerate the digital transformation and integration process. In this context, we established a BIM4TURKEY to manage the transition of the nationwide construction to BIM. Therefore, validation leads to a broader perspective to enhance the generalization of the framework more importantly, implementations are utilized in the validation of the framework. It is through measuring the usefulness and investigating the justification of the criteria selected for the framework. There is a need for an analysis of the awareness and knowledge of BIM implementations of institutions and firms operating in the building industry. In order to implement the BIM system at a country and a firm scale, the obstacles and advantages of the BIM should be evaluated. For this purpose, it was necessary to analyze the impact of people, process, technology, regulation and education dimensions on the integration of BIM systems in the construction management.

8.2. What is the BIM4TURKEY

BIM4TURKEY is a platform belonging to the Building Information Modelling and Management Association. It is the center of transformation for the construction industry. BIM4TURKEY aims to facilitate the integration of Building Information Modelling and Management (BIM) in a straightforward way for the construction industry, higher education and public companies. BIM4TURKEY provides the ground for communication and cooperation for all the parties involved in a design and construction project. BIM committees help for capacity building and awareness about BIM in Turkey with regular reports on building standards and accelerate the integration of BIM into the sector. We aim to support construction companies to improve their competitiveness in the international arena. We organize events and workshops to build awareness towards these goals and develop critical mass in BIM and form a community of practice and academics in BIM, sharing knowledge and technology via BIM University. We defined organization structure of BIM4TURKEY which is figure 34. The role of BIM4TURKEY organizational structure is to find people who best fit each job description.

Each of these people form part of a team with an overall mission to manage the responsibilities, while each has a specific set of duties the add to the efficiency and ensure the thoroughness of the team.

8.3. BIM4TURKEY Corporate Structure

BIM4TURKEY corporation's organizational structure determines decision making processes and the allocation of resources among the association's subsidiaries, such as Media and finance. BIM4TURKEY corporate structure influences the business organization's capabilities in developing competitive advantage. For example, the form, system, and arrangement of the corporation's lines of authority and communication in strategic management are based on the characters of the organizational structure. In this regard, it is essential to design and continuously adjust the corporate structure's design to minimize possible strategic barriers within the cultural and retail association's organization. The BIM4TURKEY structural framework is among the determinants of how streamlined and effective strategic implementations are in group as shown in figure 34.

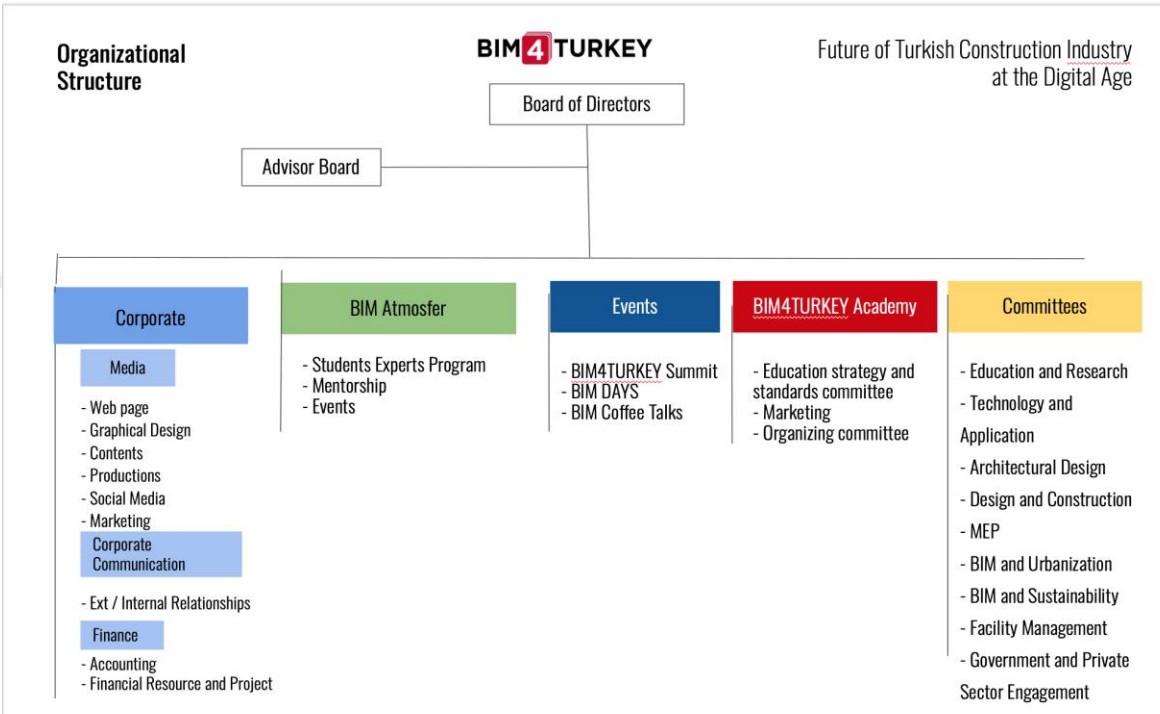


Figure 34: BIM4TURKEY structural framework

This organizational structure allows considerable autonomy and corresponding organizational flexibility to ensure that each division or subsidiary achieves its business goals as it competes against cultural resistance and financial problems.

8.4. BIM Atmosphere: University Students Training Program

One of the most important criteria of the digital transformation of the construction sector is the lack of technical staff. We believe that the digital transformation of the Turkish construction sector will be provided by university students. BIM integration is very difficult for people working professionally in the industry to take the time to learn BIM. They have not got enough time to integration and they have a cultural resistance for integration new systems. BIM atmosphere event is shown in figure 35.

Figure 35: BIM Amosphere Conferences in Kahramanmaras

The perfect combination revolves around the young and new technology. Regarding this, with the emergence of new generation, uses more advanced tools that will result in easy adoption as well as integration of BIM. BIM Atmosphere purposes to offer opportunities for learners. It develops academic curriculums reflecting the true understanding of BIM philosophy to properly implement BIM in practice. It organizes mentorship programs and events. It also offers field applications, training sessions and strategy development in support of firms.

What is the BIM Atmosphere?

- BIM Atmosphere enables professionals and students develop together.
- It creates the academic curriculums for proper incorporation of BIM philosophy in practice.
- Facilitates planning of mentorship programs and events.

• Also, it offers field applications, training sessions and strategy development support to firms.

BIM Atmosphere organize conferences, workshops, mentor program and students' expert programs. BIM4TURKEY endeavors to promote BIM awareness in the construction industry. It organizes periodical conferences/seminars in different universities and aims to make BIM practices more popular in the industry. It keeps the industry updated and informed about the newly developed BIM technologies.

BIM4TURKEY mentorship program aims to increase communication between students and professionals in the construction industry via transfer of knowledge and experience. Mentorship program brings mentors and mentees together support each other and themselves develop mutually while working on projects contributing to society. Mentors and mentees interaction figure in 36.

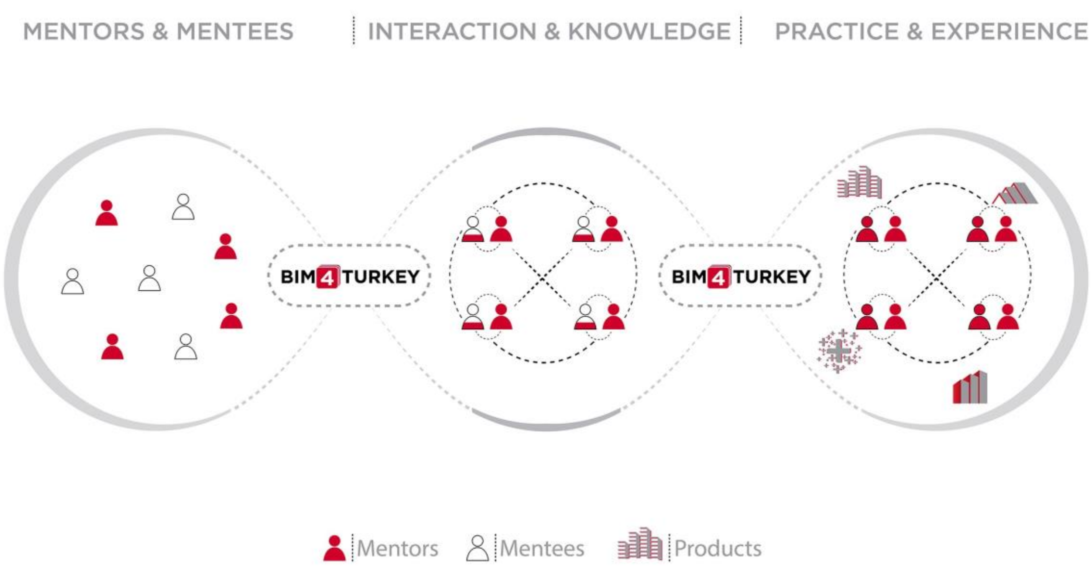


Figure 36: Mentors and Mentees working process and interaction

BIM student experts program develops young professionals in BIM. In this context, program collaborates with students, who are both successful and potential leaders. It supports educational progress of the student experts through the mentorship programs and interactions. Student experts organize activities to foster BIM awareness in the academic environment as shown in figure 37.

BIM Atmosphere- BIM Student Expert Program				
Student	**BIM Student**	**BIM Student Expert**	**BIM Ambassador**	**Expert Alumni**
Meeting BIM4TURKEY	Taking BIM Training Programs	- Start Mentor program - Start BIM Internship - Complete BIM Training Program	- BIM4TURKEY International Representer - Participate International Competition	- Professional Worker - Committee Member - Expert Alumni Representer

Figure 37: BIM Student expert program

8.5 BIM4TURKEY Committees

The BIM4TURKEY Committees are specialized groups working on digital transformation of the construction industry as shown table 10. These committees include building professionals and scientists focused on the integration of Building Information Modelling and Management (BIM) into the Turkish construction industry and act as a hub for sharing knowledge and practice in BIM in Turkey and beyond. Committees foster education, enable strategic roadmap developments and for successful BIM adoption and implementation in accordance with the required BIM standards and protocols.

Table. 10: BIM4TURKEY working committees

BIM4TURKEY Committees
BIM Education and Research Committees
BIM Technology and Application Committee
Design and Construction Committee
Architectural Design Committee
Mechanical Electrical and Plumbing Committee
Energy Committee
Facilities Management Committee
Government And Private Sector Engagement Committee

8.5.1. BIM Education and Research Committees

Digitalized design, construction and facilities management is regarded as a paradigm shift. This is through BIM that is through the transition from a 2D, representational approach to the development of project documentation and communication of design intent and technical information to a 3D, integrated digital repository containing both geometric and non-geometric project information. The consolidating and associating the building information is also transforming roles and responsibilities of project stakeholders and their relationships while providing many opportunities for data management through an integrated supply chain processes. While the construction industry is globally embracing the practical applications of BIM due to the many reported benefits of its use, it still does not exceed, nor does it permeate the current practice.

Challenges to overcome and promote understanding between academia and construction industry have been highlighted in BIM4TURKEY. Some of the solutions include increasing the number of skilled and capable professionals who have a high level of technical proficiency. On the other hand, academics should focus on providing new programs for engineering and architecture that can lead to acquisition of the desired skills. Fragmentation in academia also makes it difficult to promote collaboration among professionals interested in BIM adoption. Such fragmentations should be addressed.

To do away with difficulties and problems, BIM4TURKEY Education and Research group will work towards providing:

- Important opportunities for learning regarding capacity building in Building Information Model
- Connection of sector and academic partners on an online platform;
- Researching results and educational materials, look outwards and learn from other countries
- Developing multi-disciplinary studio projects involving stakeholders that leverage BIM in the sector;
- Educational programs that are agile through shifting technical concepts of BIM into core theoretical foundations.

8.5.2. BIM Technology and Application Committee

BIM incorporates many cross-cutting processes that need several software solutions, hence it is not a single process. Each process involves unique as well as specific functional capabilities to undertake specific work-related activities within the cross-cutting cross organizational business processes.

There are several classes of BIM tools which are: preliminary tools BIM design tools, structural design tools, BIM construction tools, fabrication tools, environmental analysis tools, construction management tools, cost estimation tools, specification tools, facility management tools and mechanical tools. BIM4TURKEY technology and training group will be responsible the main topics of BIM methodology and the core technologies behind it. Further, BIM implementation processes, BIM goals and lean oriented efficiency gains via BIM use, deliverables and workflow demonstrations, real-life examples, analysis of BIM models, interoperability and standards such as IFC, and development of BIM processes and BIM execution plans on sample projects will be within the main purpose of this group.

Use case of BIM Technologies and applying BIM in practice and common problems will be also within the scope of this group through the sample BIM projects around the globe such as hospitals, hotels, sport complexes, museum, commercial and residential complexes, metros, etc.

8.5.3. Design and Construction Committee

The construction industry is pressurized to give monetary value, design and building, which has propelled the BIM adoption that transforms the paradigm of the construction industry from 2D drawing information systems to 3D object-based information systems. In this case it facilitates changes in the base documentation utilized in building design and construction to new representation which is machine readable for automation as opposed to human readable for manual conducts.

Whereas, there exist problems in BIM implementation in the UK construction practice. For instance;

- Convincing individuals to know the value of BIM compared to drafting of 2D is hard.
- Hard to adapt workflows to learn oriented as well as unique processes
- Training individuals on BIM, besides getting employees who are aware of BIM operations.
- The understanding of the required high-end hardware resources and networking facilities to run BIM applications and tools efficiently.
- The preferred collaboration, integrating and interoperability amongst the structural and the MEP engineers.
- Clarity in understanding of the duties of different members in the new process by construction lawyers and insurers.

Therefore, effective BIM implementation requires significant changes in the building process. Key areas to consider are learning on new software applications, workflow reinvention, training staff and assigning responsibilities during the construction process.
Since most firms are grappling with the same fundamental issues of change in the construction sector, BIM4TURKEY Design and Construction Group has an objective of providing clear set of guidelines outlining effective strategies and methodologies of implementing BIM at the organizational level. Therefore, the Design and Construction Group will introduce best practice studies and projects for the design and construction companies and highlights the implications on the company workflows and lean efficiency gains from BIM use.

8.5.4. Architectural Design Committee

Application of 2D CAD tools in architecture improves the level of efficiency in deadline pressures, duplications, lead times, lack of continuity in the supply chain, over processing, reworking, overproduction, conveyance, distractive parallel tasks, reliability of data and plan predictability, lack of rigorous design process, lack of effective design management and communication.

As per the current literature, there is need to achieve performance-based design via Integrated BIM use. Through performance-based design, architectures can create and explore different design alternatives and to select those with lower energy consumption. Unfortunately, poor integration has led to poor collaboration among team members, thereby making it difficult to achieve the full potential of BIM.

For the past 30 years, AEC industry has relied on digital tools. Nonetheless, new tools and methods for information management have increased efficiency of project life cycle in the AEC industry. The most important of these contemporary trends is Building Information Modeling (BIM), which consists of tools, processes and technologies able to manage information for a building, its performance, planning, and operation.

BIM integration into architectural practice faces challenges similar to those experienced during first introduction of CAD into the architectural industry. CAD or computer-aided design in many ways failed in its role of aiding design. BIM introduction has led to a new opportunity to align the technology not just with the requirements of design but with the demands of the wider architectural process and the professionals and administrative staff that bring their own expertise and requirements to such endeavours.

Thus, BIM4TURKEY Architectural Design Group will engage with the systematic approaches for BIM use and adoption and recommends guidance for the architectural practices.

8.5.5. Mechanical Electrical and Plumbing Committee

MEP engineers can design complex building systems more efficiently with BIM. By coordinating projects more effectively with 3D modelling, MEP engineers can reduce conflicts, optimize designs, and minimize costs.

Coordinating the mechanical, electrical and plumbing (MEP) disciplines during construction can involve significant challenges. To enable them practice in synchronization in a project requires the successful coordination of different professionals working on a project.

Traditionally, MEP design layouts have often run into several drafts as spatial and functional interferences (clashes) gradually tackled. However, Building Information Modelling can help to improve MEP coordination by addressing various potential design issues.

Changes in traditional design must be manually included into the project documentation that results in the possibility of human error. With a centralised BIM model, all changes are instantly available to collaborators.

Within BIM4TURKEY, the MEP group will discuss and justify the use of BIM through evidence based arguments, share best practices and foster education for capacity building amongst the MEP engineers and companies. BIM4TURKEY BIM DAYS events periodically brings construction experts together to form Mechanical, Electrical and Pumping working group. Sectoral knowledge is shared in these events and technical workshops are organized. BIM Days MEP event is figure 38.

Figure 38: BIM DAYS MEP event in Istanbul

It would help for the construction industry and BIM integration into practice.

8.5.6. Energy Committee

As a result of the disturbing rat of global warming, many individuals and designer organizations are concerned with various requirements which are being dealt with worldwide. For example, the necessity of more energy efficient structures. However, efforts incurred have not fulfilled the possible capacity in creating new generations with high-geared green buildings. The Building energy performance simulation tools have been proven as challenging to use by the engineers and other personnel involved such as architects. Merely, the basic process depends on manually drawn 2D simulations. Hence, the attribute lacks combinations and connectivity between the tools, design and building energy models.

The energy simulation tools are not only complex for use but also conflict with the needs and methods required by the architects during work. This drawback reduces the benefits from using the tools in the beginning of the design phase. More importantly, the architect beginners in the practice of energy simulation. Thus, they find it hard to effectively use the simulation tools due to lack of knowledge and experience. As a result, the architects are less likely to collaborate.

Collaboration is a major concern during the implementation of performance based design. This fact depends on the effectiveness of links between various technologies across different domains with comprehensive building performance analyses in the design process.

Also, insufficient know how of thee design tools required for bearable design. Lacking the essential knowledge renders the team under limitation while using the novel BIM tools. The maximum likely capacities of the BIM tools require technicians who have the skills for effective use. The stakeholders will have clear results with easily available drawings in compatible file formats.

A ‘cradle to grave’ perspective defines the processes such as design, construction, utilization and finally the destructions of the structures or designs. Enhancements in the efficiency of the energy in the building process form a huge percentage regarding the lifecycle footprint of the building.

BIM4TURKEY Sustainability group aims to critically assess BIM concerning the design and construction. It appraises the system as suitable for the improvement of sustainability in design and construction.

The group views BIM as a recent way to improve the working environment by creating tolerable and energy sufficient structures. In addition, BIM technology is the light of the Architectural Engineering Construction (AEC) field. It has the potential to oversee more intelligent and an evolved as well as a cheaper future. The Facility Management group of BIM4TURKEY focuses on discussing and justifying the application of BIM through creating arguments based on practical or objective evidence. It also shares the best practices and encourages education for capacity building to the experts as well as organizations.

Occasionally, BIM4TURKEY BIM DAYS events join the experts, forming Energy and Sustainability working group. Information from various sections is shared during these events. Also, this brings about the chance for organizing technical workshops.

8.5.7. Facilities Management Committee

Building Information Model is an essential tool that assists in reduction of the environmental damage that a building may during its lifecycle, for example reduction of waste in energy as well as resources. It provides the design and maintenance team the ability to carry out a life-cycle assessment, evaluation and maintenance that allows both the design and construction teams to collaborate in evaluating the behaviour of a structure as a single entity and/or in relation to its environment throughout its existence.

Many people as well as organizations spend lots of their investment on property maintenance. BIM tools can be applied in testing the performance of a building before its actual construction to analyze how it will function when constructed. This process is essential since it saves resources like time and capital. The important benefits comprise:

- A better understanding of current needs and options through rapid space and energy assessment
- Effective communication of requirements as well as project options
- Reduction in expenses as well as time in project developments
- Superior conveyance of as-built information
- Easier contribution of new facility/asset information into cost analysing
- Facility Management systems
- Reduction in maintenance
- Estimation of precise as well as estimation of expenses.
- Reduction of waste

Within BIM4TURKEY, the Facility Management group will discuss and justify the use of BIM through evidence based arguments, share best practices and foster education for capacity building amongst the FM experts and companies. BIM4TURKEY BIM DAYS events periodically brings construction experts together to form Facility Management working group. Sectoral knowledge is shared in these events and technical workshops are organized. BIM Days Facility Management event is figure 39.

Figure 39: BIM DAYS Facility Management event in Istanbul

8.5.8. Government and Private Sector Engagement Committee

The BIM Government and Private Sector Engagement group sees that Government, as the biggest client of the construction industry, has a critical role to play in the BIM adoption across the design and construction projects and procurement activities.

BIM adoption within Government agencies and private sector is still hardly existing. However, both government agencies and private sector companies are exploring opportunities to utilise BIM across their construction programs.

They are looking for:

- Faster, more efficient and problem free design and construction processes

- Extending their understanding about how BIM can be integrated into asset management systems at operation and use stage
- Whole lifecycle approach and procurement philosophies for the construction sector
- ·Better outcomes with cost and time savings
- ·Collaborative stakeholder engagement and experience

Hence, Government and Private Sector Engagement Group within BIM4TURKEY will initiate activities for

- Raising awareness and promotion of BIM to Government agencies
- Active participation and engagement with Government agencies implementing BIM on construction projects
- Exploring further the role of asset management & soft landings
- Addressing barriers and challenges, identifying strategies and roadmaps for BIM adoption and use in public and private companies involved in the construction industry.

8.6. BIM4TURKEY Academy Program

BIM4TURKEY Academy aims to foster education and develop educational programs for professionals, who would like to either increase their knowledge and skills in BIM or build capacity in BIM to attain sustainable competitive advantage in the sector, including integrated lean processes, standards and protocols, lifecycle management and integrated project delivery.

BIM4TURKEY academy, aims so that people and corporates who want to increase their level of knowledge and skill on the area of BIM, can learn the processes and practice it on their business. It offers education programs towards these goals as shown in table 11.

Table. 11: BIM4TURKEY education program

BIM4TURKEY ACADEMY PROGRAM	
BIM Fundamental	BIM Fundamentals
BIM Tools Experience	Architectural Design Tool
	Structure Design Tool
	MEP Design Tool
	Plant Design Tool
	Infrastructure Design Tool
	GIS Design Tool
	Laser Scanner Modelling Tool
	Project Management Tool
	BIM Energy Simulation and Modeling Tool
	BIM Facility Management Tool
BIM Project and Site Implementation	Standards, Contracting and Project Delivery
	BIM Execution Plan and QA / QC Training
	Mobil BIM ve Site Implimentation (BIM 360)
Advance Level BIM Implementation	Advance BIM Computational Design
	BIM Master Class

BIM4TURKEY Academy programs should be noted that the development of BIM knowledge and skills is not just confined to software training. Transferring required ideas of digital design as well as collaborative relationship among the members it is necessitated by enhancing skills in BIM. The skills development process includes logical as well as critical thinking in the utilization of digital technology as well as aspects of communication and teamwork. Through the establishment of aspects of professional and management in BIM education, it ensures the graduates have the necessary knowledge as well as job-specific competencies to assist in management of the BIM innovation and digital transformation.

8.7. BIM Activities and Awareness

Awareness and knowledge in BIM is increased b events in different categories and groups as a result, it helps to facilitate the access to correct information and data. Each year, a city hosts a BIM4TURKEY Summit, where the heart of the BIM world beats. In summits, exhibitions, conferences, panels, symposiums and workshops in a wide range of BIM topics, ranging from the use of latest BIM technologies to the cutting- edge scientific research about BIM will be included. The BIM Summits are the meeting point professionals and construction firms. BIM implementations at the global scale are also explored at the summits.

BIM DAYS periodically brings construction experts together to form special working groups. Sectoral knowledge is shared in these events and technical workshops are organized. It would help for the digital transformation of the construction industry and BIM integration into practice. BIM DAYS Malaysia Digitalizing Construction Industry through BIM event is shown in figure 40.

Figure 40: BIM DAYS Malaysia Digitalizing Construction Industry through BIM

With BIM Coffee Talks, it becomes possible to have conversation with the construction professionals. It provides a socialized atmosphere to people can openly discuss BIM aspects in a relaxed environment with BIM professionals. BIM coffee talks event organized in Izmir as shown in figure 41.

Figure 41: BIM4TURKEY Coffee Talks event in Izmir

It helps young professionals gain hands-on skills in BIM. The BIM ACTION is an international BIM design competition and its goal is to encourage students from different disciplines to work together to develop a common project. It gathers students to gain BIM skills, learn from each other and spread the philosophy of project oriented collaboration.

Global Strategic Partnership Initiatives contribute to the global partnership's vision by directly implementing the internationally agreed development effectiveness principles and sharing their knowledge to support greater development impact. As part of strategies to increase the knowledge of professionals across the all over the world built environment, we are partnering with country base BIM initiatives. We sign Memorandum of Understanding (MOU) agreement between BIM4TURKEY & BIM AFRICA as illustrated in figure 42.

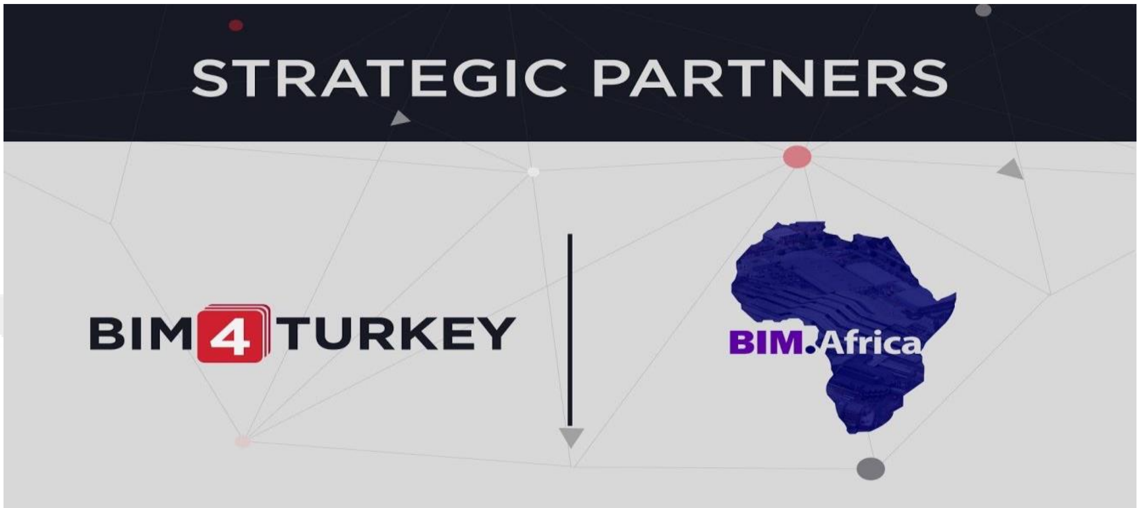


Figure 42: BIM4TURKEY and BIM AFRICA partnership

This partnership with BIM initiatives creates the framework for cooperation that will enable each group to benefit from the common activities in their respective strategies. This will further mutual understanding, and, where areas of joint interest identified, close coordination between the Parties. Greater cooperation will help both organizations pursue their respective goals and will help avoid any unnecessary duplication or inconsistency of work and publications.

We use online webinars are an important tool to reach people in the digital age. People may not be able to come to events in a particular place. In addition, transportation is another difficulty if you live in other cities. Online webinars are a very good communication channel to access information more easily. Especially, online webinars are suitable for international experts living outside to share their experience and meet people. Online webinar events periodically bring construction experts together on the online platform. Sectoral knowledge is shared in the online platform among all over the world. We examined chapter 6 the BIM implementation in the Istanbul airport project. Following online webinar organization, BIM4TURKEY and BIM Africa were facilitating to discuss BIM and digital twin based project management utilizing the Istanbul Airport case study from its design to the operation as shown in figure 43.

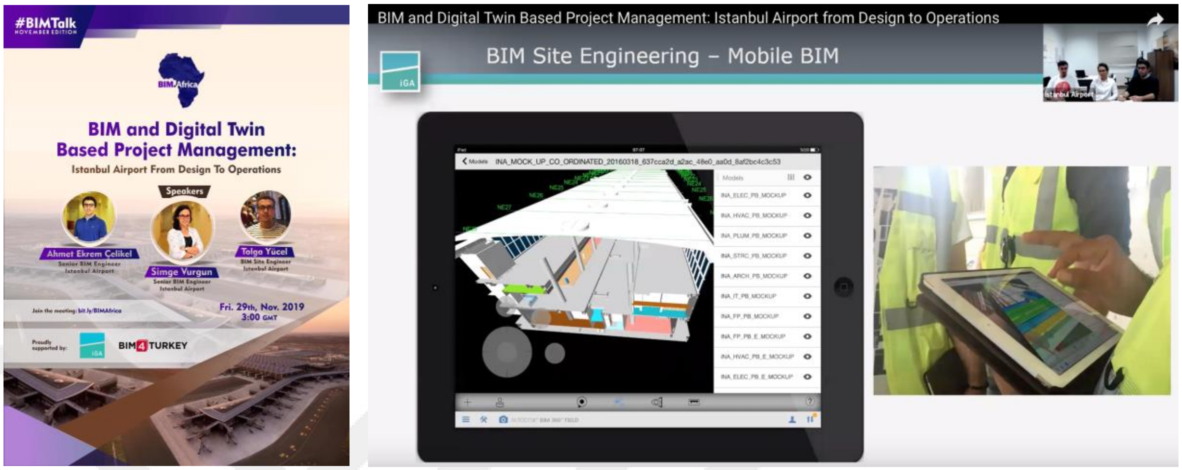


Figure 43: Istanbul Grand Airport online webinar

Thanks to the online platform, we enable professionals from different parts of the world to share information with the online platform. In this way, we improve the information capacity.

8.8. Summary and Conclusion

Through his doctoral studies, we had the opportunity to establish an important institution such as BIM4TURKEY which is internationally recognized. BIM4TURKEY has become an important organization with international validity. The organization of the team and the advisory board has been the most important factor in the development of adoption. We are working too hard all together. BIM4TURKEY have more than 3,000 members, which has become one of Turkey's major institutions. If the government accredits BIM4TURKEY, it will manage all country digital transformation process. BIM4TURKEY’s vision is to develop a robust community of Turkish construction industry leading practitioners from the architectural, engineering, construction, client, owner, operator and educational sectors who are proactively engaged in the effective deployment of digital technologies and processes. BIM4TURKEY is to provide our professional, educational, construction, fabrication and supply chain members a collective voice dedicated to digital technologies and processes. We provide our members with advocacy, learning opportunities and best practices for digital technology in a Turkish context while maintaining connectivity with our international partners. If BIM4TURKEY is officially accredited by Republic of Turkey Ministry of Environment and Urbanization, BIM4TURKEY accelerate to prepare the adaptation of Building Information Modeling and Management roadmap to Turkish government, contributing to the development of a national BIM standard, BIM education and BIM policy initiatives. Republic of Turkey Ministry of Environment and Urbanization will support for BIM adoption is currently remaining at the level of encouragement, with little financial incentives offered and a lack of introduction of BIM-oriented standards and regulations. BIM standardization efforts and policy initiatives that ultimately influence the adoption varies significantly in Turkey. While industry is working on a variety of BIM initiatives to address specific immediate needs, a coordinated approach with industry and government collaborating to accelerate adoption of BIM would provide productivity benefits flowing to the entire economy.

CHAPTER 9

CONCLUSIONS AND RECOMMENDATIONS

9.1. Conclusion

The study focuses to develop a BIM implementation framework for digital construction in Turkey by identifying the key barriers of BIM adoption. In order to develop a framework of BIM adoption in Turkish construction industry, literature review is very important to focus on the explanation of what BIM entails and case studies of BIM implementation in Turkish construction industry is also required for accurate diagnosis before the framework development. As a result, objectives were set out as follows:

- To explore the current practice and experience in Turkish construction industry.
- To explore the identified practical and theoretical barriers of BIM adoption for digital construction in Turkey
- To examines BIM implementation in Istanbul Airport case study and conduct critical analysis.
- To set up a conceptual framework for adoption of BIM in the AEC industry
- To test and validate the framework specifically for the Turkish construction industry

This research has achieved all of its objectives. In relation to the first objective of the study, an investigation was carried out by in-depth review of the literatures concerning articles, books, government documents and contractual documents of the current practice and experience in Turkish construction industry. Based on the literature, the literature is significant to the topic in a context scale, which includes the classification that exists in the AEC industry in Turkey, the current acceptance of BIM use in the Turkish AEC industry, some key strategies for the best BIM practices in the construction industry. Most of Turkish construction companies and Government are based on traditional design, construction and management process, which is related closely to the time delays, issues of reworks, rising cost, lack of coordination and communication. The findings have been presented and discussed in Chapter 2.

In relation to the second objective of the study, the investigation was carried out by an in-depth review of the literatures concerning articles, books, and government documents on BIM. The findings indicate the vast benefits and potentials that BIM can offers during pre-construction phase, construction phase, and post-construction phase. This is because the capabilities of BIM in generating visualisation; fabrication drawings; code reviews; forensic analysis of a building or facility; tools to assist facilities management; cost estimating; schedules for construction sequencing; systems to visually check conflict, interference or collision; and system to monitor the construction progress. Although there are many benefits to adopting BIM such as those described in Section 2.4. BIM implementation in the construction industry has been restricted by many barriers, which categorised into five major groups: lack of a national standard; the high cost of application; the lack of skilled personnel; organizational issues; and legal issues. Each barrier divided into two or three sub-groups, as shown in Table 1.

In relation to the second objective of the study, having undertaken a comprehensive literature review, the author of this thesis made an attempt to analysis of Turkish construction project management methodologies. For that purpose, a questionnaire was conducted in Turkey by 316 respondents in 2019. This has been presented in chapter 5. The aims to analyze the questionnaire based survey to explore the knowledge and awareness of professionals. Further, it evaluates the constraints and advantages of BIM from its implementation. For this purpose, an analysis of the impact of people, culture, technology, regularity and educational dimensions is needed. The survey questions included dependent and independent variables to obtain both qualitative and quantitative results from the survey. According to the results of the survey, we have determined the construction management culture of the professionals working in the Turkish construction sector. Our observation that the construction industry working methodology base on traditional construction methods. There are a lot of parameters and obstacles affecting this working principles. Industry working methodology are lack of knowledge about the system, lack of emphasis on the system in universities, lack of technical staff and lack of rules and regularity. The obstacles in the transition to the BIM system should be eliminated, and solutions should be presented. The most important part of integration into the BIM system is the preparation and implementation of a roadmap for the integration of the state into the BIM system. The results of the survey show that serious loss of time, loss of budget and serious mistakes have been made in the construction industry. Energy efficiency is low, and carbon emission is high and unplanned structures are formed, and unlivable structures have been left for the future generations. The findings have been presented and discussed in Chapter 5.

In relation to the third objective of the study, a case study was undertaken to develop a solid understanding of how integrated building information modeling (BIM) is implemented in a mega project such as the (Istanbul Grand Airport IGA) construction project. The IGA project is a mega-scale airport construction project with features beyond building industry challenges, and it should be designed and constructed with tight deadlines and budgets and be operated afterwards in an effective and efficient way. When considering the barriers, a significant barrier on realizing value from BIM implementation will be several technical BIM staff in Istanbul Grand Airport. This can be specifically in people with high expertise in traditional methods, who know how to integrate sub-contractor companies by using BIM. It is true that these skills are difficult to produce and improve. Overall, the results from the BIM implementation in Istanbul Airport project showed that the more companies leveraged the use of BIM on their projects, the higher the ROI, and that up to about 20% of the total project cost can be saved. On a $ 12.5 billion project, that means the actual project team anticipates that BIM has the potential to drive as much as $ 2.5 billion in savings. To achieve these results, project teams and their executives realized that if they go all-in with BIM by involving all the stakeholders and embracing all the benefits of an integrated initiative, they can experience the most significant benefits. They realized that project results differ depending on contract type, time-to-market urgency, project complexity, and other variables. The research findings in the chapter make a significant impact in understanding the strategic perception for BIM as a new way of working methodology for the construction industry in Turkey, since the IGA project has become not only a key learning hub for the Turkish construction industry, but also a global landmark for digital construction and project deliver. The findings are presented in Chapter 6.

In relation to the fourth and five objective of the study, we decided engulfs the development of the digital transformation framework for the Turkish construction industry based on the analysis and findings from the previous chapters about the BIM Implementation and Management in Istanbul Grand Airport Project and the Questionnaire-based survey for BIM implementation. Reviewing the data collected from the IGA case study and survey responses in those previous chapter has led to obtaining valuable insights for the development of the framework. The discussion on the conceptual framework for BIM adoption roadmap for Turkish Construction Industry was presented in Chapter 7. For this purpose of this study, the adoption of Building Information Modelling and Management to the Turkish construction sector are contributing to develop national BIM standard, BIM education and BIM policy initiatives. BIM adoption is currently remaining at the level of encouragement, with little financial encouragement offered and a lack of introduction of regulations and BIM oriented standards. There is a need for an analysis of the awareness and knowledge of BIM implementations of institutions and firms operating in the building industry. In order to implement the BIM adoption framework proposed. The findings are presented in Chapter 7.

Finally, in relation to the fourth and five objective of the study, conceptual framework is implemented in practice via the establishment of the Turkish Building Information Modeling and Management Association for the verification and validation of the conceptual framework and for the acceleration of the digital transformation and integration processes. Accordingly, the strategies to drive BIM implementation were also recommended. We had the opportunity to establish an important institution such as BIM4TURKEY which is internationally recognized. BIM4TURKEY has become an important organization with international validity. The organization of the team and the advisory board has been the most important factor in the development of adoption. BIM4TURKEY's vision is to develop a robust community of Turkish construction industry leading practitioners from the architectural, engineering, construction, client, owner, operator and educational sectors who are proactively engaged in the effective deployment of digital technologies and processes. BIM4TURKEY is also providing professional, educational, construction, fabrication and supply chain members a collective voice dedicated to digital technologies and processes. It provides our members with advocacy, learning opportunities and best practices for digital technology in a Turkish context while maintaining connectivity with our international partners.

If BIM4TURKEY is officially accredited by Republic of Turkey Ministry of Environment and Urbanization, BIM4TURKEY accelerate to prepare the adaptation of Building Information Modeling and Management roadmap to Turkish government, contributing to the development of a national BIM regularity and standards, BIM education and BIM policy initiatives. Republic of Turkey Ministry of Environment and Urbanization will support for BIM adoption is currently remaining at the level of encouragement, with little financial incentives offered and a lack of introduction of BIM-oriented standards and regulations. BIM standardization efforts and policy initiatives that ultimately influence the adoption varies significantly in Turkey. While industry is working on a variety of BIM initiatives to address specific immediate needs, a coordinated approach with industry and government collaborating to accelerate adoption of BIM would provide productivity benefits flowing to the entire economy.

9.2. Recommendations for further research

The findings indicate that there should be more research conducted in the topic of BIM implementation framework. Apart from contributing to the body of knowledge, the rationale of having more research in this area is to provide references and guides to improve the understanding and practical implementation of BIM in the construction industry. Some recommendations for the area of further research which the researcher feels appropriate to be conducted are as follows:

- Further research should be conducted to test the conceptual framework on BIM-oriented standards and regulations.
- Further research should be conducted to confirm the findings of this research with larger sample size comprising academics and practitioners involved in captivity building.

- Further research should be coordinated to approach with industry and government collaborating to accelerate adoption of BIM.
- Further research should be conducted to investigate the BIM integration roadmap of AEC companies.
- Further research should be conducted to investigate the suitability of using multi-party contract for BIM implementation plan.
- Further research should be conducted on contractual risks management for BIM base project management and implementation.

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APPENDIX A

1. Istanbul Grand Airport content approval for Journal

İGA Havalimanları İnşaatı Adi Ort. Tic. İşletmesi
İstanbul Yeni Havalimanları İnşaatı
Tayakadın Mah. Ulubatlı Hasan Cad.
No: 255 Arnavutköy / İstanbul
T +90 (212) 601 41 00
F +90 (212) 601 41 20
www.igairport.com

iGA

05.07.2018

To Engineering, Construction and Architectural Management Journal;

Figures, photographs and tables in the Exploring the BIM and Lean Synergies in the Istanbul Grand Airport Construction Project paper attached have been authorized to publish.

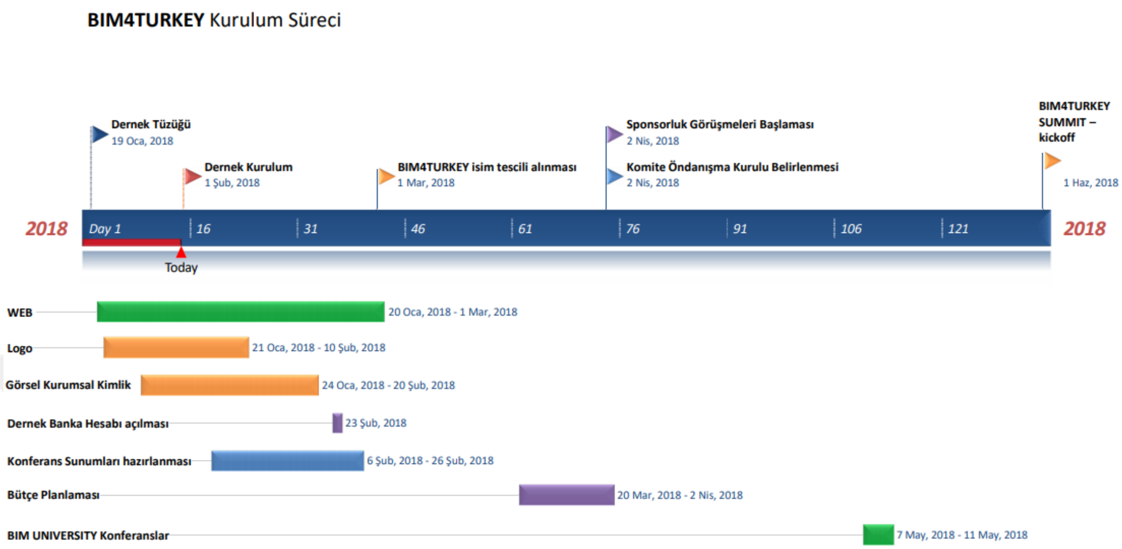
Kind regards,

2. Comparison of Berlin Airport and Istanbul Airport projects

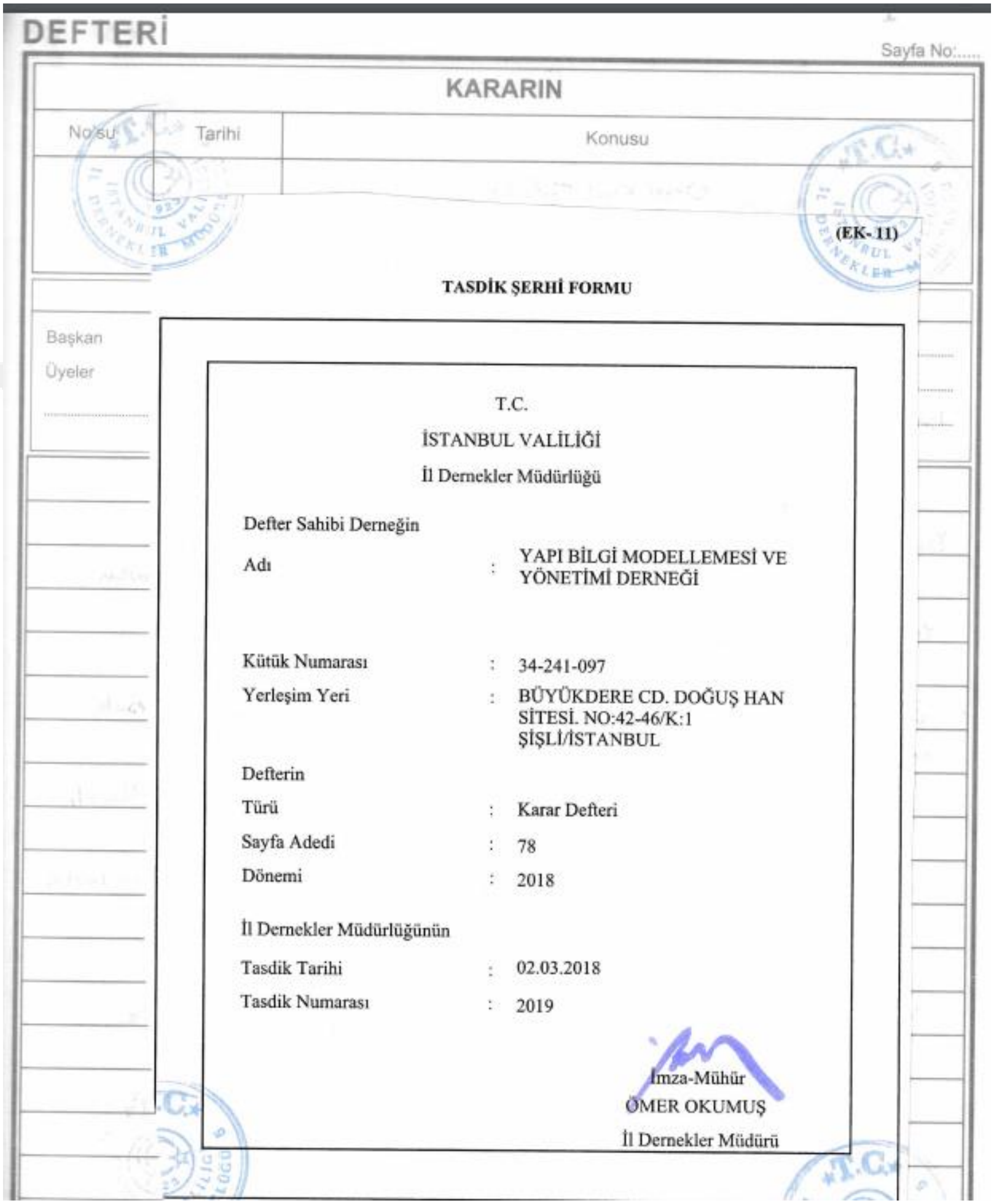
Project	Istanbul Grand Airport	Berlin Brandenburg Airport
Total Size	76.5 million m2	14,7 million m2
Indoor Area	3.5 million m2 (phase 1 only)	1.8 million m2
Number of Passenger	200.000.000	24.000.000
Number of Employee	30.000	1.500
Budget	€10,25 bn	$2 bn
Planing Start-Finish Time	2014 - 2019	2006-2011
Construction Method	BIM	Traditional Method
Save/Over Cost	+ €2.5bn	- €6bn
Save/Over Time	On time	2019

APPENDIX B

3. BIM4TURKEY foundation process



4. Building Information Modelling and Management Association Formal Document



DEFTERİ

Sayfa No:.....

KARARIN

No'su	Tarihi	Konusu

(EK- 11)

TASDİK ŞERHİ FORMU

T.C.

İSTANBUL VALİLİĞİ

İl Dernekler Müdürlüğü

Defter Sahibi Derneğin

Adı	:	YAPI BİLGİ MODELLEMESİ VE YÖNETİMİ DERNEĞİ
Kütük Numarası	:	34-241-097
Yerleşim Yeri	:	BÜYÜKDERE CD. DOĞUŞ HAN SİTESİ. NO:42-46/K:1 ŞİŞLİ/İSTANBUL

Defterin

Türü	:	Karar Defteri
Sayfa Adedi	:	78
Dönemi	:	2018

İl Dernekler Müdürlüğünün

Tasdik Tarihi	:	02.03.2018
Tasdik Numarası	:	2019

İmza-Mühür

ÖMER OKUMUŞ

İl Dernekler Müdürü

Başkan

Üyeler

APPENDIX C

1. Low level information survey

Sample of Conducted Questionnaire Survey

What is your professional job? *

Mechanical Engineer

Which of the following software do you use for architectural design ?

Autocad

Which of the following software do you use for structural design ?

Autocad

Which of the following software do you use for MEP design ?

Autocad

How likely as planned project duration and budget deviate during execution phase ?

Not likely at all (0%)

Subsequent to completion of the project. Do you create any computerized model for maintenance and operation tracking purposes?

No

During the construction phase, do you have a computerized platform for instant information sharing and collaboration with the entire stakeholders of the project ?

Some what likely

Constructed projects are fully compatible with the pre-designed structures ?

False

What is the main data sharing channel ?

Paper

Does your company/organization have any experience with using BIM ? *

No

2. Medium level information survey

Sample of Conducted Questionnaire Survey

What is your professional job? *

Civil Engineer

Which of the following software do you use for architectural design ?

Autocad

Which of the following software do you use for structural design ?

Tekla

Which of the following software do you use for MEP design ?

Autocad

How likely as planned project duration and budget deviate during execution phase ?

Somewhat likely (100%)

At what phase of the project you develop and integrate performance analysis and simulation performed in the projects?

At the design stage of the project

Subsequent to completion of the project. Do you create any computerized model for maintenance and operation tracking purposes?

No idea

Do you consider sustainability during project design phase ?

Somewhat likely

During the construction phase, do you have a computerized platform for instant information sharing and collaboration with the entire stakeholders of the project ?

Yes

Constructed projects are fully compatible with the pre-designed structures ?

False

What is the main data sharing channel ?

Email

Does your company/organization have any experience with using BIM ? *

Yes

BIM sistemini kullanıyorsanız aşağıdaki soruları cevaplayınız lütfen

If your company utilizes BIM, which of the following dimensions are integrated into your model ?

4D Time Planning

Which of the following advantages of the BIM your company gained due to use of BIM ?

Reduced site clashes

Which of the following obstacles did you face for using BIM in Turkish Construction Industry ?

Lack of technical staff

Are there enough academic research and development in the field of BIM ?

No

Do you believe there is a need for establishing a BIM centre for guiding BIM users for the right implementation of BIM system, setting national standards for BIM application in Turkish Construction Industry, increasing awareness of industry professionals, and providing training for novice users ?

Yes

According to your opinions, for mutual benefit of the parties, what could be the grounds of collaboration among a proposed BIM centre and the industry ?

Increase awareness. Reduced project cost and time

How can BIM Center benefit the academy ?

Accelerate digital transformation process

Does your company have an identified BIM execution plan, if so can you please explain ?

No

What are the most important topics for you in the BIM execution plan? silll

We do not use execution plan

3. High level information survey

Sample of Conducted Questionnaire Survey

What is your professional job? *

Civil Engineer

Which of the following software do you use for architectural design ?

Revit

Which of the following software do you use for structural design ?

Revit Structure

Which of the following software do you use for MEP design ?

Revit MEP

How likely as planned project duration and budget deviate during execution phase ?

Very likely (80%)

At what phase of the project you develop and integrate performance analysis and simulation performed in the projects?

While site installation process

Subsequent to completion of the project. Do you create any computerized model for maintenance and operation tracking purposes?

Yes

Do you consider sustainability during project design phase ?

Yes

During the construction phase, do you have a computerized platform for instant information sharing and collaboration with the entire stakeholders of the project ?

Yes

Constructed projects are fully compatible with the pre-designed structures ?

True

What is the main data sharing channel ?

Cloud System

Does your company/organization have any experience with using BIM ? *

Yes

BIM sistemini kullanıyorsanız aşağıdaki soruları cevaplayınız lütfen

If your company utilizes BIM, which of the following dimensions are integrated into your model ?

7D Facility Management

Which of the following advantages of the BIM your company gained due to use of BIM ?

Better coordination. Easy site installation control. Saving huge amount of time and cost.

Which of the following obstacles did you face for using BIM in Turkish Construction Industry ?

Lack of technical staff

Are there enough academic research and development in the field of BIM ?

No

Do you believe there is a need for establishing a BIM centre for guiding BIM users for the right implementation of BIM system, setting national standards for BIM application in Turkish Construction Industry, increasing awareness of industry professionals, and providing training for novice users ?

Yes

According to your opinions, for mutual benefit of the parties, what could be the grounds of collaboration among a proposed BIM centre and the industry ?

Yes

How can BIM Center benefit the academy ?

BIM center provide professional training and increase capacity

Does your company have an identified BIM execution plan, if so can you please explain ?

Yes

What are the most important topics for you in the BIM execution plan? silll

Define roles and responsibility. It stands as a powerful communication tool which connects all the dots in the picture and holds them together till the end.

CURRICULUM VITAE

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Master: Hasan Kalyoncu University (Civil Engineering)	2015
Bachelor: Gaziantep University (Civil Engineering)	2013
High School: Kadirli Lisesi	2006

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	Place	Enrollment
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Articles:

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