THE IMPLEMENTATION OF BUILDING INFORMATION MODELLING (BIM) IN TURKEY

Selda TOKLU [*] ***, Seher GÜZELÇOBAN MAYUK*** [**]

ABSTRACT

Building Information Modelling (BIM) is one of the most important development that has started to be used in Architecture, Engineering and Construction (AEC) sectors. BIM is also used in life cycle starting from designment, project design, feasibility, planning, energy analysis, construction, facility management to destruction. It is also defined as a process which covers not only three dimensions (3D), providing to superimpose of all project of the construction during modelling phases, but also seven dimensions (7D), being facility management. Despite of these advantages, it is seen that BIM is not commonly used in Turkey. Therefore, the questioning of both the reasons of this problem and the boundaries in Turkey are aimed within the scope of this study. For this reason, the situations and the examples in the countries where BIM is highly used in are analysed by the study. In addition to these, the comparison with the current situation of Turkey's BIM usage is made. By this way, the positive and negative states of BIM usage were tried to be defined. Also, the lacks of using BIM in Turkey's building sector are tried to be found. The study is completed with the evaluation of the obtained results. At the end of the study, it is found that there is a limited number of BIM experts and trainings about BIM in Turkey's building sector. Also, it can be said that there is a direct relationship between the usage of BIM system and the size of the project in Turkey.

Keywords: Building Information Modelling (BIM), BIM in the world, BIM in Turkey, Boundaries in the implementation of BIM.

1. INTRODUCTION

Time, cost and quality factors are at the forefront of the success of a project in the building construction sector. In this sense, the success of the cooperation between the stakeholders involved in the project is important. In recent years, it is seen that the data in the projects have increased and the projects have become

[*] MSc Student, Gebze Technical University, Faculty of Architecture, Department of Architecture, Kocaeli, Turkey, seldaseldatoklu.st@gmail.com

[**] Asst. Prof. Dr., Gebze Technical University, Faculty of Architecture, Department of Architecture, Kocaeli, Turkey, sgmayuk@gtu.edu.tr

more complex with the growths in the project scales and the innovations brought by the technology. Furthermore, it is seen that the cooperation between the stakeholders becomes more important in the construction process due to the expectation of the investor to finish the project in a short time, the depletion of natural resources and the increase in the need for energy efficient building. In order for this cooperation to be realized effectively, information needs to be managed correctly. Otherwise, project costs may increase due to reduced productivity and delays in projects (Becerik-Gerber & Rice, 2010).

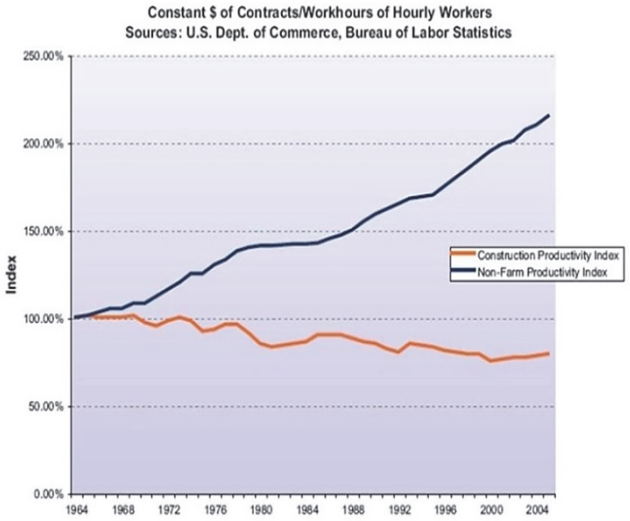

Figure 1: Construction Productivity Index (Teicholz, 2004)

As it is seen in the Figure 1, according to the results of the efficiency research in the sectors between 1964-2004 based on US Department of Commerce data; there is a 20% decrease in the Construction Productivity Index, despite the increase in productivity in other sectors by 80% (Teicholz, 2004). In recent years, digital transformation and technology have been utilized to increase this efficiency in the building sector. Building Information Modeling (BIM) is used for this purpose (Becerik-Gerber & Rice, 2010). Building Information Modeling (BIM) is a working systematic in which information is shared by creating a digital model of the designed project with the necessary software (Jernigan, 2008), and this information is used throughout the life cycle of the design, construction, use and destruction of the building.

On the other hand, when it is looked at the use of BIM in the world, it is seen that the BIM experience of each country is at different times. It is known that BIM is mandatory for public projects in the UK in 2011 (UKCO, 2011) and in the United

States in mid-2012 by the National Institute of Building Science and the Building Smart Alliance National BIM Standard (National BIM Standard, 2012). In addition, the use of BIM is mandatory in Finland and Norway, and the rate of BIM use is very high in Australia, Singapore and many European countries (McGraw-Hill Construction, 2014).

Compared to other countries, it can be said that Turkey has live on the transition to BIM. Although the utilization rate is quite low in local projects, in this sense it is seen that Turkey has been increasing awareness in the expansion of domestic demand BIM contract. Therefore, the companies in Turkey BIM transition rates began to rise (Oktem S., 2016). However, the lack of documentation about BIM in Turkey as in other countries, lack of education and the transition to BIM reasons such as high cost has been slow. To overcome the process of transition in a more effective way, taking reference from the other countries in the same process previously and adaptation to Turkey is important. In this study, firstly, the definition of BIM was made, then the use of BIM in the world and Turkey was investigated and the data obtained and the findings were revealed. In this way, it is thought that awareness about BIM will increase in Turkey.

2. BUILDING INFORMATION MODELLING (BIM)

BIM is defined as the way in which all information about the building is managed during the whole life cycle of a project, from the design phase to the construction phase, from the operational phase to the demolition or reuse phase (Underwood & Isikdag, 2010), (Ofluoglu, Building Applications throughout the lifecycle BIM, 2014), (Seeker & Aouad, 2010), (Eastman, Teicholz, Sacks, & Liston, 2011). In addition, it is a system that enables all stakeholders related to the project to work on the same data so that they can be integrated with geographic information systems and learn about the relationship between the building and its environment (Przybyla, 2010). BuildingSMART 9 is one of the organizations established to improve the exchange of information between software in the BIM working format. In order to work on the compatibility of file formats under the name of International Alliance Interoperability (IAI), this organization, led by Autodesk and HOK companies in 1994 with 12 companies, changed its name to building SMART in 2005.

Ofluoglu (2012) summarizes the uses of BIM as follows in his study:

- In the design process,
- In structural / environmental analysis,
- Building in the process of construction,
- Building operation,
- GIS (within the scope of Geographic Information System (GIS).

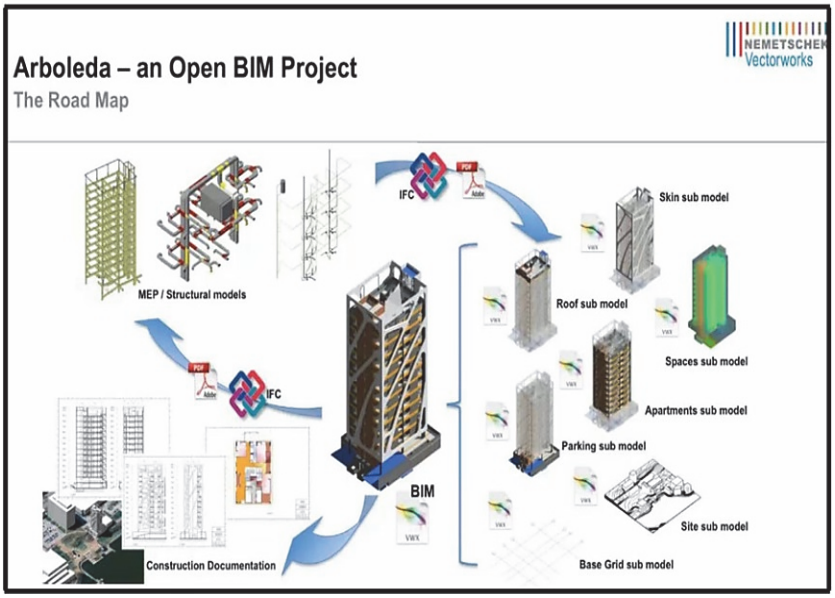

Figure 2. Data sharing between BIM and IFC (Samuel, Joseph-Akwara & Richard, 2017)

In the BIM system, projects can be produced on different softwares. By saving the file in IFC format, the information can be used without being lost among stakeholders. IFC provides a set of definitions for all object element types encountered in the construction industry, and it is possible to store these definitions in a data file based on text (Figure 2). In addition to the IFC format, in the BIM system, cloud-based document management (Common Data Environment) software is widely used as a common working platform. In the UK, National Building Specification (NBS) national BIM report construction performed with the participation of professionals in 988 by 2019, according to the most preferred cloud-based document management software; 41% Viewpoint/4projects, Autodesk 360, which is the second most commonly used software in Turkey is determined as the range of the software (NBS, 2019). The contributions of such softwares to the project can be sampled as follows:

- Allows all project team members to access the project online and offline from anywhere.
- Saves time as well as reduces risk and errors.
- Speeds up the project delivery process by providing a digital task description to the project team on issues such as description, location and delivery date.
- With authorization, limits can be imposed on which projects and data individuals can access.

- Without having any drawing or document software, it makes it easy for project stakeholders to access the correct information and the current version of the project.
- Facilitates coordination between project stakeholders.

  According to a 2008 study conducted by Alliance for Construction Excellence, the following positive features of BIM system use are mentioned in projects (ACE, 2008).
- Provides common design and construction techniques.
- Increases communication and information sharing among all project stakeholders such as owner, design experts, construction team and vendor suppliers.
- Defines the project risk, determines the conflict during the project's design phase as well as during the construction phase, determines the error, reduces the errors, risks and changes in the design and construction of the house at the same time.
- In the early stage of the design, system analyses such as energy, light, acoustics provide facilities and facilities for making energy efficient designs.
- Helps with facilities and asset management for the owner or investor.
- Provides all project stakeholders with a visual view of the project's digital twin during the early phase of the project.

3. THE IMPLEMENTATION OF BIM IN THE WORLD

BIM usage rates are very high in the world and some of the countries that adopt the BIM system can be counted as America, UK, Singapore, Australia, Japan, Brazil, South Korea, Scandinavian region (Figure 3) (Bahadir, 2018).

In the United States, which is one of the leading countries in the construction sector, the use of BIM in public projects is mandatory as of 2007. In the country, the General Services Administration (GSA) has developed several BIM guidelines under the "National 3D-4D BIM Program" (GSA, 2007), (Oktem S, 2016). Some of these guides are USC University of Southern California BIM Guidelines, V 1.6, Penn State University BIM Planning Guide for Facility Owners, Georgia Tech BIM Guidelines (Oktem S. , 2016). In 2014, the level of use of BIM between 2007 and 2012 was investigated by McGraw Hill Construction in North America. This survey, conducted with the participation of 592 people from different disciplines in the sector, shows that the level of use of BIM has increased from 28% to 71% in five years (McGraw-Hill Construction, 2012).

Figure 3. Global BIM Regulation Evolution (McAuley, Hore, & West, 2017)

In the UK, the BIM system is widely used, a five-year gradual implementation plan for BIM was established in 2011. According to this plan, BIM is required to be used at the second level in construction projects in the public sector by 2016 and BIM has published standards (Bahadir, 2018). The BIM usage rate in the UK was increased from 10% to 70% between 2011 and 2018, with the UK mandating BIM use in projects aiming to achieve savings in the construction industry (Figure 4) (NBS, 2018).

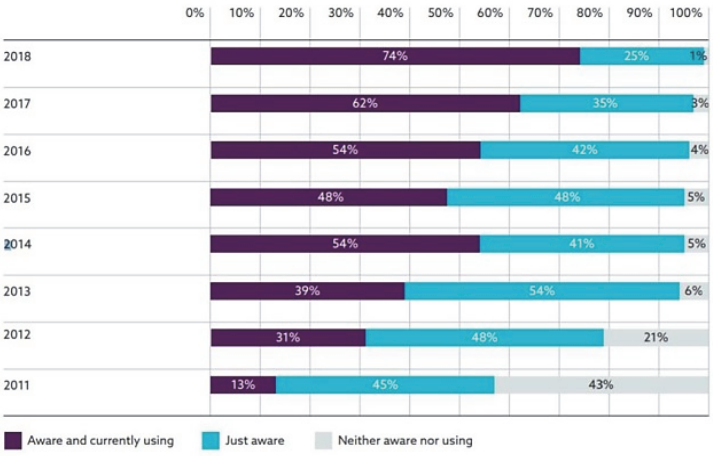

Figure 4. BIM Adoption over time in UK (NBS, 2018)

In addition, the UK Government has formed a BIM Task Group to support and further use of BIM (McGraw Hill, 2014; Kivircik, 2016). This group also assists in issuing specifications such as the Publicly Available Specification (PAS1192-5) and in identifying reference guidelines that need to be taken according to BIM maturity levels. In this sense, BIM maturity levels are shown in Figure 5 for the purpose of defining BIM usage levels in the UK.

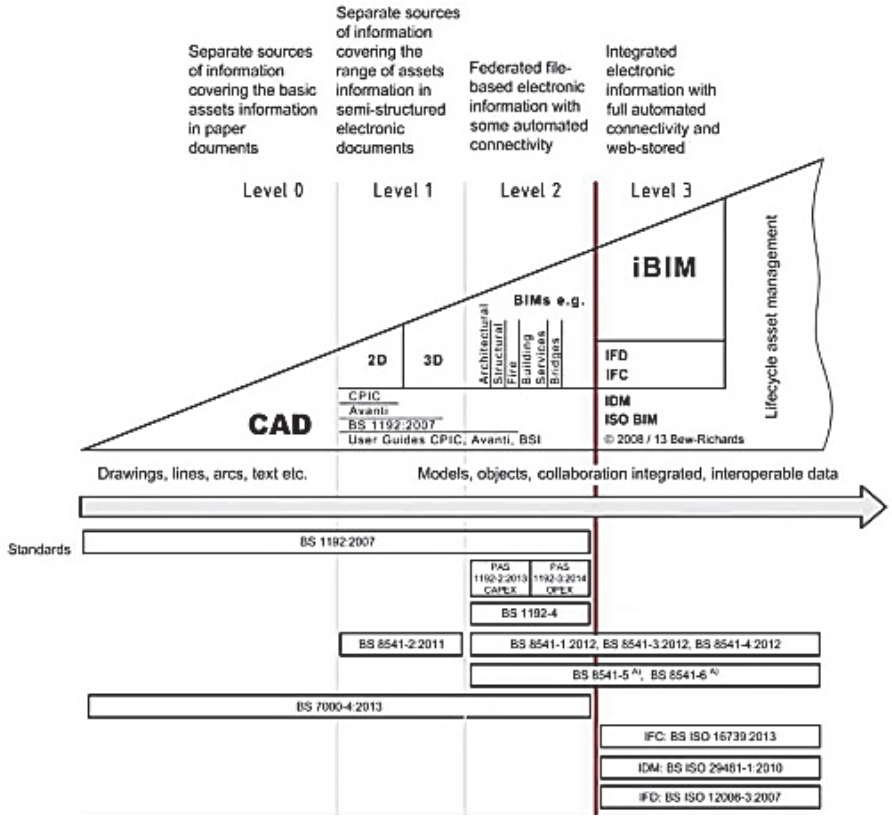

Figure 5. Mandatory levels of BIM use for the UK (Muratoğlu, 2015), (Alkawi, 2016), (Bahadir, 2018), (Bew & Richard, 2008)

McGraw-Hill Construction conducted a survey of 727 contractor firms from 10 different countries in 2014, including BIM utilization rate of firms between 2013 and 2015, the firm's scale knowledge and BIM experience. As a result of this research, the US used BIM in 2013 by 55%, while in 2015 it was ranked first by 79% (McGraw-Hill Construction, 2014).

Another country that uses BIM highly is Singapore. In Singapore, regulation checks were carried out in the building permits system with CORENET (Construction and Real Estate Network) software and BIM-based work Systematics

were preferred in the approval of more than 200 projects (McGraw-Hill Construction, 2014). "Singapore BIM Guide" was published in 2012 to guide studies on BIM in the country. BIM lectures, general seminars and workshops on BIM have been conducted at universities to raise awareness about the spread of BIM in the country and BIM (Kopuz, 2015).

Another of the countries with the most experience with BIM can be counted as Scandinavian countries. From the earliest years when ArchiCAD software was released, Finland, Denmark and Norway started using this system (Arac, 2018). These countries are those that adopt model-based design, prefer open standards and IFC technology as work Systematics, and are able to adapt to many collaborative initiatives (Smith, 2014).

One of these Scandinavian countries, Finland, has published standards for the implementation and dissemination of BIM by the country's government since 2007 (Bahadir, 2018), (Bolpagni, 2013). According to the 2007 study for Finland, 93% of architectural firms and about 60% of engineering firms use BIM (Wong, Wong, & Nadeem, 2010). Finally, the standards were updated in 2007 and the new BIM regulation (COBIM) was amended in 2012 (Bahadir, 2018).

In Denmark, efforts have been made to develop the BIM Classification Standard and to increase its efficiency in the construction sector, with the aim of establishing a common standard not only for Denmark but for all European Union countries. All Danish Employers are aware of BIM's returns and therefore demand the use of BIM in their projects (Arac, 2018), (BCA, 2012).

BIM applications in Norway are managed by the company Statsbygg (Arac, 2018). The firm has made the use of BIM mandatory in all public projects in Norway since 2010 by publishing a BIM manual to eliminate problems in the construction sector. At the same time, IFC compliance is requested in all files (Akkoyunlu, 2015), (Bahadir, 2018), (Arac, 2018), (BuildingSMART, 2012).

Looking at the examples around the world, the legal obligations imposed by governments to promote and popularize the use of BIM have been effective. Surveys conducted in Britain and America support this result (McGraw-Hill Construction, 2014), (NBS, 2018). The countries that have lagged in the use of BIM are Italy, China and South Korea, which can be said as a result of researches (Bahadır, 2018), (Akkoyunlu, 2015), (Kivircik, 2016), (McGraw-Hill Construction, 2014).

4. THE IMPLEMENTATION OF BIM IN TURKEY

As stated in Aladag's (2016) study on the use of BIM in Turkey's construction sector, the construction industry is undergoing a change due to the development

of technology, globalization, customer expectations and changing demands and BIM creates a competitive environment.

Turkey is known to be ranked in the list of the 250 largest contractors in the world, with 46 companies having the second most companies after China in 2018 (ENR, 2018). BIM usage in the world is over 60% in developed countries, while the BIM usage level is lower in Turkey which is one of the developing countries (McGraw-Hill Construction, 2014), (Ademci, 2018). In this respect, the country needs to adapt to technology and use BIM as an important tool by not resisting change in order to maintain its place.

However, while many countries that use BIM in the world have BIM-related standards and guidelines, there is no national BIM standard in Turkey. This obliges firms to apply the BIM operating system and try to compete by drawing up an implementation plan on their own. Although there is a lack of BIM standards in Turkey, awareness about BIM has increased with the Ministry of Transport mandating the use of BIM in railway infrastructure projects and the number of projects produced with BIM has started to increase (Selim, 2019), (Erdik, 2018), (Inusah, 2018). One of these projects is the Kabataş-Mecidiyeköy-Mahmutbey Metro Line project (Acar, 2019), (Inusah, 2018), which is the first metro project designed using BIM working system with a total construction area of 27.400 m2 between 2014 and 2018. This project has also been a finalist in the infrastructure category at the 2017 Autodesk AEC Excellence Awards (Prota engineering, 2019). One of the most important and major projects produced by BIM is the Istanbul New Airport project (Acar, 2019), which was completed in 2018 and has a total construction area of 76.5 million m2.

Some of the projects produced with BIM in Turkey are listed below (Erdik, 2018), (Inusah, 2018), (Acar, 2019). Looking at the list, it is seen that large-scale projects such as airport, subway and hospital projects have started to be produced in the country with BIM. Later, the use of mixed-use buildings began to become widespread. When the projects and applications are examined, it can be said that the awareness about BIM in public and private sectors has been increasing in the last 5 years.

- Okmeydani Education and Research Hospital (2015-2016)
- Emaar Square Mall (2013-2017)
- And Pastel Housing Project (2016-2018)
- Ataköy-Ikitelli Metro Line (2016-2019)
- Dudullu-Bostanci Metro Line (2016-2019).

On the other hand, looking at the usage rate of BIM in Turkey, although many survey studies have been done on this subject, the report covers the 2018 Turkey BIM report (Basyazici 2018). Although the BIM usage rate is 54.26% as a result of this report, it is stated in the comments in the report that this rate is actually 40% according to the other information in the report.

When the standards and concepts related to BIM are considered on the basis of experience, it is seen that those with experience between 1-3 years have more knowledge (Basyazici, 2018). The majority of BIM users in Turkey are technical personnel with between 1-3 years of experience, and it can be said that Turkey is at the beginning stage of its awareness of BIM. Although the rate of use of BIM in Turkey is still considered as at the beginning stage, it is seen that there is an effort. However, many of the survey studies show that the obstacles to BIM are customer demand, lack of technical personnel related to BIM, lack of BIM experts, lack of education, software and time-dependent expenses (Basyazici, 2018) (Adamci, 2018) (Bahadir, 2018). In addition, the adoption of BIM is difficult as there is resistance to change during the transition period from traditional method to BIM working Systematics. As the number of projects using the BIM working style increases and the benefits are discovered, the use of BIM will increase by learning by doing as Arayici (2011) says.

5. COMPARISON: BIM IN THE WORLD VS BIM IN TURKEY

Looking at the literature review, a comparison between BIM in the world and Turkey can be done summarized as the Table 1.

Table 1: A comparison of BIM in the world and in Turkey

COUNTRY	USA	UK	Singapore	Finland	Denmark	Norway	Turkey
Start year	2007	2011	2007	2007	2007	2007	2013
Mandatory year	2008	2016	2015	-	2015	2010	2014 (only railway projects)
Experience of personnel	more than 5 years	more than 5 years	more than 5 years	more than 5 years	more than 5 years	more than 5 years	1-3 years
Project type	public projects	public projects	for all project over 5000 m2	public projects	public projects	public projects	railway systems projects

Looking at the Table 1, it can be said that Turkey has started to use BIM nearly seven years. It shows that Turkey is in a transition position at a beginner level. Despite the other countries have mandatories using for other public projects, BIM has been a mandatory at railway projects in Turkey since 2014. Especially in Singapore, it has been used for all projects over 5000 m2. When it is looked at the experiences of personnel using BIM in the world, it is seen that they are more experienced persons than who works in Turkey. After the Table 1, it is possible to say that there are several boundaries in the implementation of BIM in Turkey.

6. RESULTS AND SUGGESTIONS

Findings show that Turkey have a position at beginner's level of BIM. In this study it is also seen that Turkey is in a transition period in the implementation of BIM and there are several boundaries regarding BIM in Turkey. These are basically summarized as follows;

- lack of technical personnel and lack of employee at high level of BIM specialty as well,
- not working of subcontractors of project stakeholders with BIM,
- lack of public standards, guide and regulations about BIM,
- lack of government promotion to use BIM,
- lack of BIM implementation plan,
- high software and hardware costs,
- few institutions providing training for BIM,
- lack of competent technical personnel in companies offering consulting service
- lack of knowledge about contribution of BIM to construction sector.

Turkey needs to increase the knowledge about BIM and its' usage as well in order to gradually meet the boundaries regarding BIM and maintaining its position in the construction sector. Furthermore, both the professionals in sector and specialists in academia should collaborate with each other. Also, they should contribute to development of BIM in Turkey by organizing voluntary trainings. BIM should take more place in AEC education in the whole curricula .The countries have already experienced this transition and are succeed in the implementation of BIM can be taken as a reference for a more effective transition period in Turkey.

REFERENCES

ACE. (2008), Alliance for Construction Excellence.

Acar, B. (2019), Implementation problems of Building Information Modelling:Case Study of Istanbul Airport project, Master's Thesis, MSGÜ, Institute of Science, Istanbul.

Ademci, M. (2018), An analysis of BIM adoption in Turkish architectural, engineering and construction (AEC) industry, Master's Thesis, MSGÜ, Institute of Science, Istanbul.

Akkoyunlu, T. (2015), BIM Execution Plan Proposal for Urban Transformation Projects, Doctoral Thesis, ITU, Institute of Science, Istanbul.

Aladag, H., Demirdogen, G., & Işık, Z. (2016), Building Information Building (BIM) use in Turkish Construction Industry. Procedia Engineering, 161, 174-179.

Alkawi, G. (2016), A proposal of BIM-based multidisciplinary collaboration in architecture curriculum, Master's Thesis, MSGÜ, Institute of Science, Istanbul.

Araç, E. (2018), A Case Study on Building Information Modelling Implementation Process of Railway Systems Sector in Turkey and Managerial Suggestions, Master's Thesis , ITU, Institute of Science, Istanbul.

Arayici, Y., & Aouad, G. (2010), Building Information Building (BIM) for Construction Lifecycle Management.

Arayici, Y., Coates, P., Koskela, L., Kagioglu, M., Usher, C., & O'Reilly, K. (2011), Technology adoption in the BIM implementation for lean architectural practice. Automation in Construction, 20, 189-195.

Bahadır, Ü. (2018), The use of building information modeling in management process of retrofit projects: A case study, Master's Thesis , Karadeniz Technical University, Institute of Science, Trabzon.

Başyazıcı, İ. (2018),Turkey BIM Report, BIMgenius.org.

BCA. (2012), Building Smart – The BIM Issue. Building & Construction Authority.

Becerik-Gerber, B., & Rice, S. (2010), The perceived value of Building Information Modeling in the US Building Industry. (s. 185). Itcon.

Bew, M., & Richard, M. (2008), Bew-Richards BIM Maturity Model.

Bolpagni, M. (2013), The Implementation of BIM within the Public Procurement. Finlandiya: VTT Technology.

Bosch-Sijtsema, P., Isaksson, A., Lennartsson, M., & Linderoth, H. (2017), Barriers and facilitators for BIM use among Swedish medium-sized conrtactors-"We wait until someone tells us to use it". 5:3.

BüildingSMART. (2012), National Building Information Modeling Initiative. Vol.1. Strategy: A strategy for the focused adoption of building information modeling and related digital technologies and processes for the Australian built environment sector. Australia: Sydney: Innovation, Science, Research and Tertiary Education.

Çuhadar, F. (2017), Building information modeling within the scope of architectural services 'Villa G' housing project, Master's Thesis, Istanbul Kültür University, Institute of Science, Istanbul.

Eastman, C., Teicholz, P., Sacks, R., & Liston, K. (2011), 2nd Edition BIM Handbook: A Guide to Building Information Modelling for Owner, Managers, Designers, Engineers, and Contractors. New Jersey: John Willey & Sons.

ENR. (2018), https://www.enr.com/toplists/2018-Top-250-International-Contractors-2, (accessed 20 December 2019).

ENR. (2018), https://www.enr.com/toplists/2018-Top-250-International-Contractors-3, (accessed 20 December 2019).

ENR. (2018), https://www.enr.com/toplists/2018-Top-250-International-Contractors-1, (accessed 20 December 2019).

Erdik, M. (2018), Adoption of Building Information Modeling in Construction Sector, Balıkesir University, Institute of Science, Balıkesir.

GSA . (2007), BIM Guide Overview,GSA BIM Guide Series. U.S., U.S. General Services Administration Public Buildings Service Office of the Chief Architect.

Hooper, M. (2012), Building Information Modeling Anatomy-An Investigation Into Implementation Prerequisites.

Inusah, Y. (2018), An Exploration of the Extent, Use and Success in the Application of BIM in Turkish Construction Sector, Master's Thesis, Mediterranean University, Institute of Science, Antalya.

Jernigan, F. (2008), BIG BIM, little bim- The Practical Approach to Building Information Modeling-Integrated Practice Done the Right Way! .

Kıvırcık, İ. (2016), An Investigation into the Building Information Modeling Applications in the Construction Project Management, Master's Thesis, ITU, Institute of Science, Istanbul.

Kopuz, B. (2015), Evaluation and review of BIM protocols between participants for efficient BIM execution in construction projects, Master's Thesis , ITU, Institute of Science, Istanbul.

McAuley, B., Hore, A., & West, R. (2017), BICP Global BIM Study-Lessons for Ireland's BIM Programme . Costruction IT Alliance (CitA) Limited.

McGraw-Hill Construction. (2014), SmartMarket Report, The business value of BIM for Construction in Major Global Markets: How Contractors Around the World Are Driving Innovation With Building Information Modeling. McGraw-Hill.

McGraw-Hill Construction. (2012), The Business Value of BIM in North America Multi-Year Trend Analysis and User Ratings (2007-2012). North America.

Muratoğlu, H. (2015), BIM Kullanımının Tasarım Aşamasından Kaynaklanan. İstanbul: İTÜ, Fen Bilimleri Estitüsü.

National BIM Standard. (2012), National Institute of Building Sciences, United States™ Version 2.

NBS. (2018), National BIM Report. İngiltere: RIBA Enterprises Ltd.

NBS. (2019), National BIM Report 2019, İngiltere: RIBA Enterprises Ltd.

Ofluoğlu, S. ,Building Information Modelling: New Generation Architectural Softwares, http://www.sayisalmimar.com/yayin/ybm, (accessed 23 December 2019).

Ofluoğlu, S. (2014), BIM Applications in the Building Life Cycle, http://www.sayisalmimar.com/2014/06/simdi-bim-ile-koordinasyon-zamani

(accessed 23 December 2019).

Öktem, S. (2016), Organizational and Operational Frameworks of BIM Transition, Master's Thesis, ITU, Institute of Science, Istanbul.

Özorhon, B. (2018), Building Information Modelling, Abaküs Publishing, İstanbul.

Prota Engineering, http://www.protamuhendislik.com.tr/TR/Projeler/kabatas-mahmutbey-metro-hatti, (accessed 25 December 2019).

Przybyla, J. (2010), The next frontier for BIM: Interoperability with GIS", Journal of Building Information Modeling (JBIM). (Fall 2010), 14-18.

Samuel, E. I., Joseph-Akwara, E., & Richard, A. (2017). Assesment of energy utilization and leakagesin buildings with building information model energy. Frontiers of Architectural Research, 6, 29-41.

Selim, S. (2019), A case Study on BIM Usage in Architecural Projects in Turkey, Master's Thesis, Karadeniz Technical University , Institute of Science, Trabzon.

Smith, P. (2014), BIM Implemantation - global strategies. Creative Construction Conference 2014 (s. 482-492). Australia: University of Technology Sdyney.

Teicholz, P. (2004), Labor Productivity Declines in the Construction Industry: Causes and Remedies. AECbytes 4.

UKCO. (2011), Government Construction Strategy. London: United Kingdom Cabinet Office.

Underwood, J., & Işıkdağ, U. (2010), Handbook of Research on Building Information Modelling and Consrtruction Informatics: Concepts and Technologies. USA: Information Science Publishing.

Wong, A., Wong, F., & Nadeem, A. (2010), Attributes of Building Information Modelling Implementations in Various Countries. Architectural Enginering and Design Management, 288302.

Yöndem, F. (2017), Determination of design problems of public construction work with building information modeling before the tender, Master's Thesis, Karadeniz Technical University , Institute of Science, Trabzon.