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M.Sc in Civil Engineering

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GRADUATE SCHOOL OF

NATURAL & APPLIED SCIENCES

BENEFIT OF BIM TECHNOLOGY ON CONSTRUCTION MANAGEMENT

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IN

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BY

ALPER KARAKURT

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Hasan Kalyoncu University

Supervisor

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BY

ALPER KARAKURT

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Alper Karakurt

Abstract

Benefit of BIM Technology on Construction Management

Alper Karakurt
M.Sc in Civil Engineering
Supervisor: Prof. Dr. Yusuf ARAYICI
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The complexity of construction projects in a multidisciplinary and complex structure brings along administrative challenges. The two most important items in production management are time and cost management. Building information modeling technology, which allows construction projects to be viewed in 7 dimensions, eliminates administrative difficulties. Completing the structures completely in a virtual environment before production minimizes the margin of error. What can be observed in the entire structure in a virtual environment can be observed by simulating. This allows the digital transformation of the construction sector. Building information modeling technology will provide considerable ease to construction management teams. The projects drawn with traditional methods are prepared in 2 dimensional CAD environment and are represented only by lines. With building information modeling, construction projects can be designed in 3 dimensions by using intelligent objects. 4th Dimension is time management examined and cost estimation is done as 5th dimension. In this study, BIM systems were explained. One case study was conducted to observe the differences between traditional methods and BIM. The benefits of BIM for construction management were examined. As a result of the case analysis and literature review, BIM provides a digital transformation in the construction sector. It prepare the environment that provides the opportunity to speak the same language among all stakeholders.

Keywords : BIM, Construction Management, Project Management, Digital Transformation Of The Construction Sector

Özet

Yapı Bilgi Modellemsi Teknolojisinin Yapım Yönetimi Üzerindeki Faydaları

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İnşaat projelerinin çok disiplinli ve karmaşık bir yapıda oluşu yönetimsel zorluklarında yanında getirmektedir. Yapım yönetiminde en önemli 2 madde zaman ve maliyet yönetimidir. İnşaat projelerine 7 boyutlu bakma imkanı sağlayan yapı bilgi modellemesi teknolojisi yönetimsel zorlukları ortadan kaldırmaktadır. Yapıların imalatından önce tamamen sanal ortamda oluşturulması hata payını en aza indirmektedir. Tüm yapıda neler olacağı sanal ortamda simüle edilerek gözlemlenme imkanı sağlar. Bu inşaat sektörünün dijital döşümüne olanak tanır.

Yapı bilgi modellemesi teknolojisi, yapım yönetimi ekiplerine önemli ölçüde kolaylık sağlayacaktır. Geleneksel yöntemlerle çizilen projeler 2 boyutlu olarak CAD ortamında hazırlanır ve sadece çizgilerle temsil edilir. Yapı bilgi modellemesi ile inşaat projeleri 3 boyutlu olarak akıllı objeler kullanılarak tasarlama imkanı sunar. 4. Boyut olarak zaman yönetimi incelenir ve 5. Boyut olarak maliyet tahmini yapılır.

Bu çalışmada BIM sistemlerinin ne olduğu açıklandı. geleneksel yöntemlerle BIM arasında ki farkları gözlemlemek için bir adet vaka çalışması yapıldı. BIM'in Yapım yönetimine olan faydaları incelendi. Yapılan vaka analizi ve literatür taraması sonucunda görüldü ki BIM inşaat sektöründe dijital bir dönüşüm sağlamaktadır. Tüm paydaşlar arasında aynı dili konuşma imkanı sunan ortam hazırlamaktadır.

Anahtar Kelimeler: BIM, Yapım Yönetimi, Proje Yönetimi, İnşaat Sektörünün Dijital Dönüşümü

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Thank you very much to my family who has always supported me in life.

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LIST of SYMBOLS/ABBREVIATION

BIM	**Building Information Modelling**
CM	**Construction Management**
CMAA	**Construction Management Association Of America**
PMI	**Project Management Institute**
CAD	**Computer Aided Design**
AECO	**Architecture, Engineering, Construction, and Operation**
AEC	**Architectural, Engineering and Construction**
CPM	**Critical Path Method**
QMC	**Quality Management Committee**
QM	**Quality Management**
TQM	**. Total Quality Management**
QA	**Quality Assurance**
QC	**Quality Control**
NIOSH	**National Institute of Occupational Safety and Health**
ERP	**Enterprise Resource Planning**
CIC	**Computer Integrated Construction**
CIM	**Computer Integrated Manufacturing**
BPM	**Building Product Models**
pBIM	**proprietary BIM**
IFC	**Industry Foundation Classes**
IFD	**International Framework Dictionary**
iBIM	**integrated BIM**
LOD	**Level of Developmet**
BREEAM	**Building Research Establishment Environmental Assessment Method**
BS	**British Standard**

FM	**Facility Management**
LEED	**Leadership in Energy and Environmental Design**
CMMS	**Computer Maintenance Management Systems**
CAFM	**Computer Aided FM**

CHAPTER 1

INTRODUCTION

1.1 Introduction

Wasting time and cost is undesirable for all stakeholders in construction projects. Many problems in construction and design organizations are due to lack of control resulting from inadequate communication. In any construction project, the total amount of information is not fully understood. Information is required at different times for different disciplines at different stages of the project. For instance, in large industrial projects, more than 50% of the problems in the field were attributed to the lack of design and communication, and more than 50% of the contract changes were related to the difference in design. This situation shows that all stakeholders should reach the complete right design and document and need early intervention for the solution of the problems (Arayici, 2015). Coordination is one of the most important elements in construction projects. Construction management (CM) is a technological and managerial discipline (Oral, 2010).

The Construction Management Association Of America (CMAA) (CMAA, 2010) defines CM as a " profecinal management practice consisting of an array of services applied to contraction project and programs through the planning, design, construction and post- construction phases for the purpose of achieving project objectives including the management of quality, cost, time and scope" (Oral, 2010). Construction management should ensure that the owner of the property in the most efficient manner, to finish the work, to avoid delays, to avoid conflicts among stakeholders, to increase the quality of design and construction and to supply material in construction construction in the fastest way (Yalcinkaya and Arditi,2013). Construction companies should identify problems with the integration and communication problems in traditional practices and observe how a change will take place with the application of technology (Arayici, 2015). According to CMAA, planning, design and construction management requirements of the companies in the construction sector strengthenin the communication between these criteria with technology brings a perspective to the management problem of (Arayici, 2015) and construction sector (CMAA, 2010).The digital transformation of the aforementioned construction sector. Building Information modelling (BIM) is an emerging technology in which digital information models are prepared (Abbas et al 2016). The design teams discuss the building model with the construction management teams and discuss the construction model and act in coordination (Hartman et al 2008). More efficient services with BIM training, building management teams occurs in building projects (Yalcinkaya and Arditi, 2013).

Researchers (Solnosky and Parfitt, 2015) have identified the need to incorporate BIM into university teaching to equip engineering graduates with an adequate understanding of BIM concepts and they identified engineers BIM skills as a means to help achieve the successful uptake of BIM within the AEC industry (Abbas et all, 2016). Project management is to integrate the construction teams and to implement the qualified design and construction works by adhering to the procedures (CMAA, 2010).

According to the published manual of the Project Management Institute (PMI), projects are examined under 9 sub-headings. The nine knowledge areas are ;

1) Project integration management

2) Project scope management,

3) Project time management

4) Project cost management

5) Project quality management

6) Project human resource management

7) Project communications management

8) Project risk management

9) Project procurement management (PMI, 2010)

Each of the above items shows the processes that need to be followed in a disciplined manner for efficient project management (Oral, 2010). Traditionally, 2D design is used for planning and designing (Sundarrajan and Vaardini, 2018).The rules of project management should be adapted to the developing technology and should be removed from the traditional methods.

BIM provides a series of functional applications to advance project management practices. Among the various functions and benefits of BIM, managing information, facilitating communication, and interfacing multidisciplinary cooperative efforts are necessary for implementing project management. Thus, linking BIM to projectmanagement is of great importance (Ma et al, 2018). BIM will break the very traditional structure of the construction sector and make workflow and coordination more effective. The construction sector, as old as the human history, is exposed to many uncertainties throughout the life cycle of construction projects (design, construction, operation, destruction). That's why it's a complex sector (Arayici, 2015).

Construction management was discovered in the United Stated Of America in 1950s (Oral, 2010). Being one of the basic needs of humanity and being very disciplined in the construction sector becomes an industry that is difficult to manage. The three main constraints of the construction industry are time, cost and scope. Construction projects under the limits of time, cost, scope and quality are stuck. From these constraints, time refers to the time that the project needs to be completed. Cost creates the project budget. Scope is what should be done to bring the end of the project. (Oral, 2010).

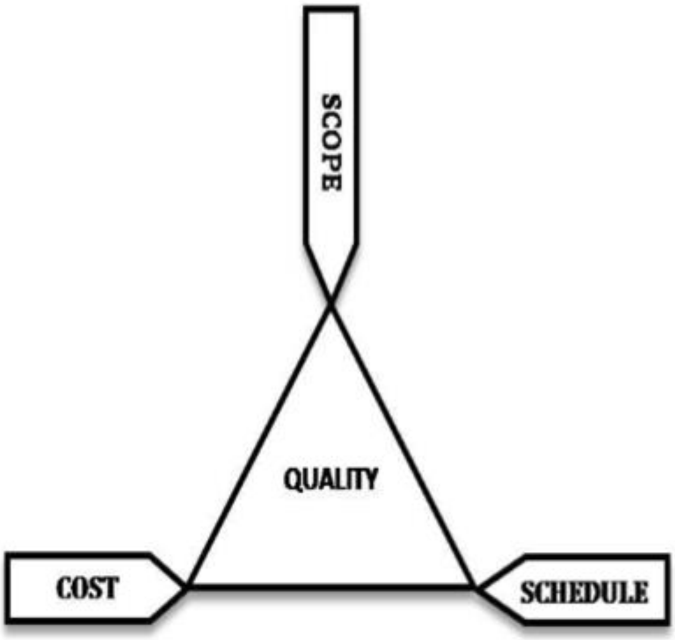


Figure 1.1 The project management triangle, (Oral, 2010)

Construction projects are aimed at realizing predefined goals and objectives that are laced with risks, these risks are further compounded by the existence of some project constraints viz; time, cost, scope and the project delivery methods deployed (Foster, 2008). According to Hassan and Yolles (2009), BIM follows a seven-dimensional process which can be portrayed thus: 3D – Modelling, 4D – Scheduling, 5D - Cost Estimating, 6D - Sustainable Design, and 7D - Facility Management (Hassan and Yolles, 2009).Review of project management under 9 headings, construction projects being squeezed between time, cost and scope brings the need for technology. Thorpe (2009) stated that BIM has advantages because it is more effective in design and construction processes, building plans and visuals are not possible with the CAD system, and information sharing is at an advanced level. BIM technology, discovered in the 80s, has improved the traditional structure of the construction sector and its efficiency from the dispersed operating methods and the cooperation has proven to be more successful (Thrope, 2009).

Project management, which encompasses multifarious procedures disciplines, and teams, has been widely adopted in the architecture, engineering, construction, and operation (AECO) industry to organize building production. The increasing complexity and scale of projects in the industry require the integration of processes and interfaces of multidisciplinary efforts to handle constant project changes (Alshawi and Ingirige, 2003). The continuously updated information and plans in the project management cause continuous change in the decision phase (Pich et al, 2002). The information and communication technologies (ICT) needed by the construction sector have prepared communication and working environment for the sector. (Ahuja et al, 2009).The researchers have seen the solution of these basic problems of the construction sector in information technologies. At this point, it is mentioned in the BIM technology construction sector that the above mentioned project management techniques will work more efficiently. The aim of this thesis is to search for the solution of managerial problems in the construction industry by using BIM technology. At this point, it was seen that the project management techniques of the construction sector should now be revised with BIM. The benefits of BIM on production management have been investigated. One of the agendas to advance BIM implementation into project management practice is to integrate BIM into the managerial systems and procedures of AECO projects (He et al, 2009).

Although the knowledge domains of project management specifically define the management of the integration, scope, schedule, quality, resources, communications, risks, procurement, and stakeholders of a project (PMI, 2017), the adoption of project management in the AECO project requires a tailored approach, particularly when BIM is introduced. The integration of BIM into the AECO project lifecycle helps realize a new paradigm of project management, namely BIM-based project management. The integration of BIM into the AECO project lifecycle helps realize a new paradigm of project management, namely BIM-based project management (BPM). BPM integrates management requirements at distinct stages of a building project into the functional applications of BIM and achieves efficient project management using BIM models (Ma et al, 2015). Given the fragmented feature of the AECO industry project information management enabled by construction ICTs can change the conventional practice to achieve good performance and competitiveness (Stewart, 2007). Among the construction ICTs, BIM is interpreted as a disruptive technology that brings changes to the AECO project lifecycle (Davies, 2017). In this study, the idea of integrating BIM technologies into construction projects is suggested to make project management more efficient. The benefits of BIM on production management will be emphasized. The use of BIM technologies as a solution to the problem of transforming the project management to the information and communication focus mentioned above is determined as the methodology. The principal objective of BIM is to provide project teams with visual aids and to improve the AECO project environment with accurate data, simulation, and workflow analysis (Azhar S. , 2011). Communication between all stakeholders increases using BIM technologies, and productivity increases through collaboration. Therefore, BIM is seen as the driving force in the construction sector. (Amade et al, 2018). In addition to building information management, BIM can also provide a sociotechnical system to restructure the AECO project environment (Ning and London, 2010).

1.2 Scope and Objectvies

The scope of this research covers the detailed analysis and integration of construction information modeling technology issues of construction project management. If the critical process between building cost management and time is integrated into the technology, the reductions in the margin of error and the benefits to the project will be examined. A case study was conducted by integrating it into a residential project BIM technology, which was designed in a traditional way. The project is examined as deisgn (3D), time management (4D), and cost management (5D). The points focused on BIM are that 3-D BIM-based projects should be produced in order to avoid the repetition of errors in the design of traditional drawings. In addition, time and cost management in construction projects should be done professionally and to reveal the benefits. In the light of the results of the case analysis, the aim of the thesis is to reveal the benefits of BIM technologies on construction management in construction projects.

1.3 Methodology

This study consists of 2 main stages. First, a detailed literature review was performed to determine the problem. Direct and indirect articles and master theses on construction management, project management and BIM technologies were examined. In the second stage, a case analysis was performed. A construction project with traditional methods has been translated into BIM. The effects of BIM technologies on construction projects were investigated. The project design (3D), time management (4D) and cost management (5D) stages were evaluated using BIM-based software. The studies were explained with the visuals.

1.4 Aim of Thesis

In this section general information of each chapter is given except fort the first partof the thesis.

Chapter 2 gives detailed information about construction project management. PMI's standards are described in project management. How to integrate BIM Technologies of construction management.

Chapter 3 describes the building information modeling technology in detail. What is BIM, what is the purpose, how it is used, what stages it occurs, how it affects the sustainability, these issues will be evaluated.

Chapter 4 Sivas Turkey were examined as a case study in the housing project. The project has been drawn up with traditional methods and this project has been transformed into a BIM project with BIM-based software. The project has been converted from traditional drawing into design (3D), time management (4D), and cost management (5D).

Chapter 5 In the case analysis, time and cost simulation of the project were performed. This chapter shows how the project is developed in steps.

Chapter 6 Case analysis is made in this section. Differences between BIM technology and traditional methods are evaluated. The results of the benefits of BIM technology on construction management are discussed.

Chapter 2

Construction Project Management

2.1 Construction Project Management Overview

Project planning in construction is a basic activity in management and ensures the execution of the project. Technological selection, business drafts, resources and individual drafts will be required to estimate the process and different business drafts interrelated with each other. A building plan is essential to improve budget and working time (Baracco and Miller, 1987). The most common and accepted standards in construction management are Construction Management Association of America (CMAA). These are given in 7 items below.

1) Project Management Planning

2) Cost Management

3) Time Management

4) Quality Management

5) Contract Administration

6) Safety Management

7) Construction Management Professional Practice (CMAA, 2010).

Another standard developed by Project Management Institute (PMI) and ıt has 9 stages. These are as follows :

1) Project integration management

2) Project scope management

3) Project time management

4) Project cost management

5) Project quality management

6) Project human resource management

7) Project communications management

8) Project risk management

9) Project procurement management (PMI, 2010)

Two management systems are american centered and have given importance to time, cost, quality, communication and scope management. Construction management refers to the whole project. The scope of the project, cost, time program, quality control mechanism determines. The project determines the communication, roles and responsibilities of its stakeholders, and determines the organizational breakdown structure (Oral, 2010). The performance of construction projects is usually evaluated using cost and schedule considerations. Hence, it is important that the construction manager focuses on time and control needs of the project. Involving construction professionals in the project's early phase and have them take proactive part in the development of the project plan helps ensure that the construction plan and schedule are sound (Amade et al, 2018). The success of construction projects depends on the organization, planning and control mechanism. The project plan and organization is essential during the construction phase (Topliss et al, 2007).

Planning, coordination and control form the basic stages for construction project management (Arayici, 2015). The participation of all stakeholders in the planning, engineering, design and implementation phases in construction projects can be defined as simultaneous engineering. The design phase is a stage that all stakeholders must observe and arrangements should be made there must be consensus. Project management is to complete the project by eliminating the design problems by keeping costs under control in minimum time (Oral, 2010). Project management is time management and control of project activities in order to achieve scope, cost and time objectives. The project is to manage the project with the lowest cost and loss. It is a combination of all the tools and techniques needed to develop the project (Englert, 2002). Project management is a necessary requirement for successful construction projects. Hanna (2010) achieved a 23% profit margin in a project with a specific dispensing process. This rate was reduced to a poorly than the project -3%. (Hanna and Skiffington, 2010). As the research in the literature shows, management and planning for the construction sector is of paramount importance. The stages of project management are discussedbelow in terms of PMI standards.

2.2 Effect Of BIM PMI Rules

Project management is divided into 9 headings. These titles are inseparable (Balaban, 2003).

2.2.1 Project Integration Managemet

Dissemination and implementation of a project plan in order to ensure coordination within the project, and then making necessary changes to this project plan. Risks such as unfavorable planning, poor resource allocation, poor integration management, unhealthy review of integration management can fail the project (Balaban, 2003).

Project integration management for PMI is the first rule and phase. It includes the requirements for coordinated progress in projects by combining various components. Compliance of the components of complex projects is ensured by project integration management. The time, cost and quality triangle complement each other in this way (Butt, 2013). Quality can be ignored as time and cost come ahead for project management. Processes carried out by traditional methods prior to project delivery can lead to serious problems in failures, cost overruns and quality. As a result, there may be increases in complaints and lawsuits from construction projects (Butt, 2013).

Since building projects have a multidisciplinary and complex structure, project integration may not always be easy. The fact that the stakeholders are in close communication with each other will facilitate the integration of everyone in the project. Design teams in different disciplines may not be fully integrated into the project due to lack of coordination and project problems may occur as mentioned above. Building information modeling (BIM) technology ensures that all disciplines are fully integrated into the project. This integration continues throughout the entire life cycle of the project. BIM tools help integrate all stakeholders.

2.2.2 Project Scope Management

The planning, identification and control processes that are required in quantity form the project scope management. Quantification of all works for successful completion of the project is the necessity of scope management. An inadequate amount of work can be difficult to manage, and productivity will be reduced. too much information can lead to a huge amount of time and money loss. At this point, project management should clearly demonstrate the scope of the project. In light of these data, project scope management is managed with necessary and sufficient information (Derenskaya, 2018). Scope refers to the content of the product and project according to the Guide to the Project Management Body of Knowledge (PMBOK® Guide, 2008). The scope management is described below in figure 2.1.

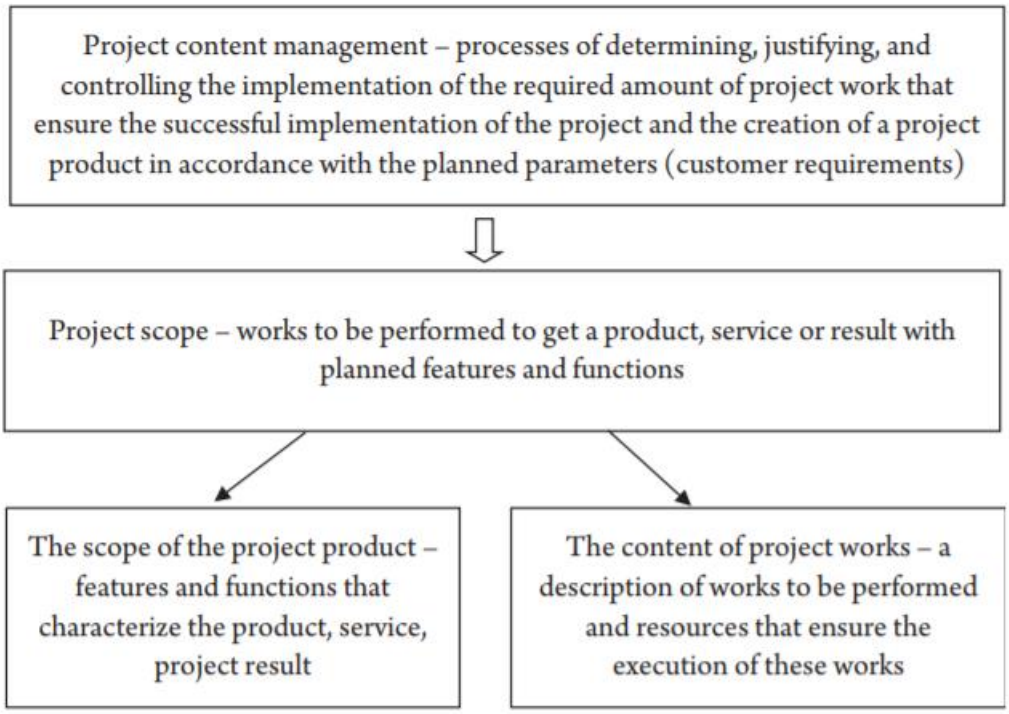


Figure 2.1 Components of project scope management, (Derenskaya, 2018)

According to (Arayici, 2015), he is responsible for the day to day work and management of the construction sites. Responsible personnel should take responsibility for all work done as planned. The project management team should ensure that the site is inspected during the construction period and that the necessary resources are supplied. (Arayici, 2015). It is inevitable that the construction management teams define the project scope very clearly and transfer them to the stakeholders. At this point, each stakeholder should be very clear to the project. With the BIM technology, the entire work team is able to work in a coordinated manner. In a BIM-based construction project, the whole team is integrated into the 3D project from design to production. The architectural projects, drawn in 2 dimensions by traditional methods, did not contain enough information (Crotty, 2012). Failure of traditional methods to not provide satisfactory information prevents stakeholders from covering the project. BIM tools use a parametric design system to integrate the project into all stakeholders and understand the scope. Working in three dimensions from the beginning will enable all professionals and project stakeholders to have higher decision making capacity and avoid changes during the execution phase of the project (Staub and Khanzode, 2007). BIM platforms trend to simplify the work of designers and engineers if they keep their products within the standards (Wahbeh , 2017). More simplified 3D drawings and intelligent objects prevent project stakeholders from having difficulty in scope.

2.2.3 Project Time Management

There may be time and cost overruns with the shift of the project program (Ramanathan et al, 2012). Construction projects can be defined as the time out due to the reasons surrounding the project (Najjar, 2008). The time of completion of the project, the use of resources and the cost of time management through the integration of all stakeholders and the estimation of delays. The problems in the program are the main reasons for the incompatibilities in the project. Time management is important for the solution of events that cannot be understood in the project (Oral, 2010). The critical path method (CPM) is used for time management purposes in projects. This method determines all the activities and durations required for the project and determines the integration of these activities with each other and determines the total duration of the project (Halpin and Woodhead, 1998). The critical path method defines all the tasks, determines the activities that need to be postponed due to lack of resources and ensures that the project is completed on time. Provides the time required to complete the project. The activities of the project can be determined by CPM at both early and late start dates (Prensa, 2002).

BIM based Oracle Primavera P6 is used in time management in construction projects. This software enables the creation of project activities using the critical path method. Resources, roles and responsibilities are determined. Manufacturing dates are planned with the experts of the relevant discipline. In case of a negative situation in the project, a new program is created and how much extra resources will be needed.

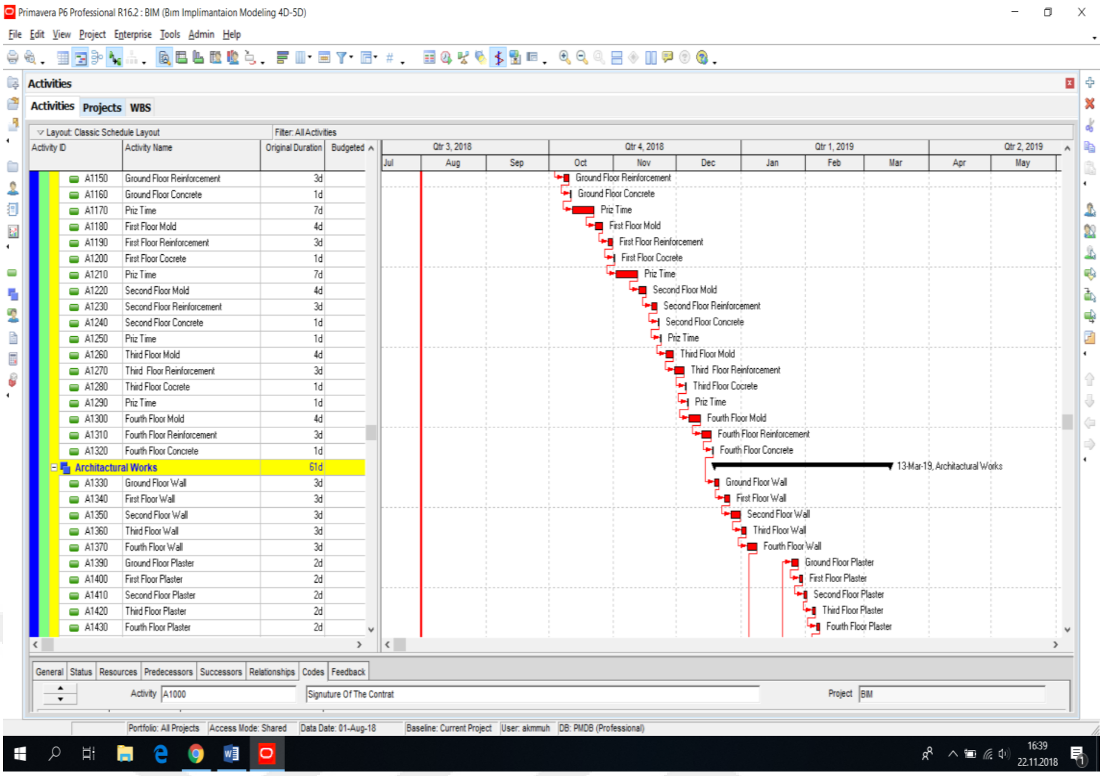


Figure 2.2 Critical Path

The above figure shows a critical path designed with Primavera P6. The critical line created according to the activities of the project is red colored.

The progress of the project occurs through the identification of activities. Project completion dates change as a result of incomplete or incorrect production of activities. Failure of projects that have a lot of costs for each day due to such errors increases the costs. Manufacturing errors occur due to the difficult understanding of conventional 2D projects and their relative inability to evaluate. This extends the production time and activity exceeds the project time. These problems can be avoided with BIM technology. This case study will be demonstrated by analysis. The progress of the project based on time is evaluated by visualizing. Possible problems can be seen and measures can be taken.

2.2.4 Project Cost Management

Cost management in all stages of the project to keep project costs at defined limits, control systematically creates project cost management to be followed (Oral, 2010). The costs of construction projects are as follows (Hendrickson, 1998) :

1) Land acquisition, including assembly, holding, and improvement,

2) Planning and feasibility studies

3) Architectural and engineering design

4) Construction, including materials, equipment and labor

5) Field supervision of construction

6) Construction financing,

7) Insurance and taxes during construction

8) Owner's general office overhead

9) Equipment and furnishings not included in construction,

10) Inspection and testing (Oral, 2010).

In order to complete the project without opening the approved project, it is an application of financial analysis and audit management, including resource planning, cost accounts, budgeting, cost control (Balaban, 2003).

All these mentioned expense items are of great importance in construction management. The cost management of projects is to provide resources throughout the manufacturing and operation processes of the project and provide maintenance repair support (CMAA, 2010).

Cost management in construction projects can be done with BIM based Oracle Primavera P6 program. The project does the time planning account as mentioned in the time management. Calculates the project cost items mentioned above and the monetary counter of all activities. According to Zigurat 5D BIM technology comes with the capability of automating measurements and project cost. This is sometimes achieved by direct linking of modelling software to a cost control software. Since the budget is derived from the project design, cost values are obtained from actual measurements and not estimates from global variables or direct percentages (Zigurat, 2018).

Structural Works		77d	$0.00	$44,800.00	$800.00	$45,600.00
A1060	Excavation	1d	$0.00	$0.00	$800.00	$800.00
A1070	Foundation Mold Making	2d	$0.00	$5,000.00	$0.00	$5,000.00
A1080	Foundation Reinforcemn	2d	$0.00	$3,000.00	$0.00	$3,000.00
A1090	Foundation Concrete	1d	$0.00	$1,800.00	$0.00	$1,800.00
A1100	Basement Mold	4d	$0.00	$6,000.00	$0.00	$6,000.00
A1110	Basement Reinforcement	3d	$0.00	$4,000.00	$0.00	$4,000.00
A1120	Basement Concrete	1d	$0.00	$2,000.00	$0.00	$2,000.00
A1130	Priz Time	7d	$0.00	$0.00	$0.00	$0.00
A1140	Ground Floor Mold	4d	$0.00	$5,000.00	$0.00	$5,000.00
A1150	Ground Floor Reinforcement	3d	$0.00	$5,000.00	$0.00	$5,000.00
A1160	Ground Floor Concrete	1d	$0.00	$2,000.00	$0.00	$2,000.00
A1170	Priz Time	7d	$0.00	$0.00	$0.00	$0.00
A1180	First Floor Mold	4d	$0.00	$5,000.00	$0.00	$5,000.00
A1190	First Floor Reinforcement	3d	$0.00	$4,000.00	$0.00	$4,000.00
A1200	First Floor Cocrete	1d	$0.00	$2,000.00	$0.00	$2,000.00

Figure 2.3 Primavera P6 cost calculation

In the figure above, project activities are calculated in Primavera. It is a tool used in construction projects for effective and efficient cost management.

Budget is one of the important departments that should be managed since the construction sector has been continuously spending money since the beginning of the project. These expenditures are the parcel values of the amounts that must be paid as a result of correct analysis. One of the important issues in cost management is to make the right quantity. Human factors can make mistakes in the quantities made with traditional methods. Another issue is the visual assessment of the workflow and the risk assessment. Traditional cost management follows the workflow from paper and evaluates the actual project on paper. BIM technology is the solution to these problems. The project examines the activity progress in a 3-dimensional way. How much money will be spent depending on time is visually expressed. The digitalization of the construction sector will make cost management more efficient.

2.2.5 Project Quality Management

According to CMMA, quality is to meet the project's expectations, objectives and standards. quality is determined by compliance with certain standards. According to CMMA, the definition of quality is the process of planning, organizing, implementing and documenting to obtain an efficient, reliable, consistent product (Oral, 2010). Quality management is one of the most difficult issues in construction management. Where customer satisfaction is the main focus. planning and implementation planning and implementation in the process of continuously increasing the expectations of the customer offers an approach for management and quality increase (Shtub et al, 1994).

Quality management committee (QMC) was created by CMMA. Quality management procedures have been established to assist construction managers and practitioners (QM). Quality control system by using quality system inspection and documentation for design, supply and construction - quality control (QA-QC) is created. Total quality management (TQM) covers these two important quality standards. Contracts are important for the quality management of standards and specifications (Oral, 2010). Quality can be defined as the value of money for the customer (Flanagan and Taste, 1997). Quality is an ongoing organization and processes for continuous improvement of goods and services. The purpose is that the customer is satisfied. (Vincent and Joel, 1995). In manufacturing sector, manufacturing quality is very important. Project quality control teams make production controls according to the current project. Thanks to BIM technology, these controls give easier and better results. Intelligent objects are included in parametric modeled 3D projects. BIM projects can be done with the help of smart tablets in the field controls for QA / QC depeartings.

2.2.6 Project Comunication Management

One of the most important issues of the construction sector is communication. Regular communication problems in construction projects are stated by Latham (Latham, 1994) and DETR (DETR, 1998). In construction, communication could be achieved through letters, drawings, symbols, signs and word through which members of organizations send and receive information and also send information to the public at large. Continuous information flow from the relevant disciplines will be required for the building management. it is important to distribute this information quickly during construction (Soliman , 2017). Supplier communication is a very important issue for the execution of works in the construction sector. Supply-demand communication at the design stage and obtaining the requested materials during the construction phase are important issues for the projects. The importance of communication and the factors affecting communication have been the subject of discussion (Hoezen et al, 2006).

According to Balaban (Balaban, 2003), communication management includes communication planning, distribution of information, reporting of performance in order to make the most effective use of information. When traditional methods are preferred in construction projects, all communication network is provided by telephone and electronic mail tools. BIM tools collect all project stakeholders on the same platform. Revisions to the project are immediately communicated to all stakeholders. In this way, the project team can continuously integrate and communicate with each other at the design and manufacturing stage.

2.2.7 Project Risk Management

This standard specifies dynamic risks and static risks associated with risk management team decisions based on project management teams. Risk management safety is traditionally handled as cost, time and contract management. On the other hand, emergency policies, feasibility studies, tender policies and performance evaluations can be used (Han et al, 2008). Construction sector is among the most dangerous sectors for its employees. Therefore safety comes first. According to a study conducted by the National Institute of Occupational Safety and Health, 8% of the workers in USA died during construction. This ratio reaches 22% in industrial sectors (NIOSH, 2010). Construction management teams can provide safety planning and communication using BIM to reduce risks. construction security issues will be more clearly examined with the use of BIM. Safety will be more efficient by coordinating and visualizing the safety situation with the field (Sulavinki et al, 2010). Construction management teams can also use BIM to control cost and time risks (Yalcinkaya and Arditi, 2013). This issue will be discussed in chapter 3. Time and cost calculations and construction projects with BIM-based software can be cleared of these risks.

2.2.8 Project Human Resources Management

Human and physical resources determine project management, organization and use. resource management is the combination of these two (Yalcinkaya and Arditi, 2013). Human resources management is intended to be seen as the area of project management for BIM's team building and collaboration of this team (Rokooei, 2015). Although BIM technology has been used extensively in the visual field, this technology has come into contact with many different areas. Some researchers have investigated the integration of human resources management into BIM. For examaple (Babic et al, 2010) using BIM, the enterprise resource planning (ERP) software system is associated with the design data of the structure. Then the different stages of the project followed this situation (Wang et al 2004) a BIM-based system integrated into resource management was developed (Yalcinkaya and Arditi, 2013).

2.2.9 Project Procurement Management

Procurement management would be possible by quantity takeoffs which are produced by BIM. In addition, changes in any item can be easily reflected in cost and time and work needed for its procurement (Rokooei, 2015)

Chapter 3

Building Information Modelling (BIM)

3.1 Building Information Modelling

The construction sector is significantly dependent on the usefulness of using information in order to proceed within itself and to be successful. Collecting the information and presenting it consistently to the management will be time consuming and costly. On the other hand, information management will be ahead of companies that are ahead and will be different in terms of competition. Customers' satisfaction levels will increase (Arayici, 2015). Construction is a multi-disciplinary sector. The strong communication between these disciplines will increase the effectiveness of construction processes (Arayici, 2015). The increase in information technologies showed positive effects in the construction sector. Computer-integrated construction (CIC), the system will be successful and it will be called building information modeling (BIM) simultaneously. Below are the cases that can be provided:

- A dynamic base of information
- Quality assurance
- Management orientated value added services
- Advanced information and communications
- Progression towards integrated practices (Arayici, 2015).

Many construction companies have used information technologies for the following reasons:

- Poor management and communication
- Inadequate technical expertise
- A lack of software availability
- The fragmented natüre of the industry

- A lack of standadisation and uniform procedures

- The number of stakeholders involved in construction project

- The cost of implementation (Arayici, 2015).

Computer-integrated manufacturing (CIM) has been a pioneer in the use of information technology in the construction industry, and computer-integrated construction (CIC) has emerged. The CIC system is a system in which the stakeholders of the construction can work in harmony with the supply system and different geographical conditions. This system is given the name of building product models (BDP). Also modern nomenclature is structure information modeling (BIM). The suppliers of CAD systems are called Revit, ArchiCAD, Allplan for these BIM-based tools. These software, which emerged in the middle of the 2000s in the US, are able to make parametric modeling (Arayici, 2015). BIM is intended to provide a more secure environment to ICT users and to increase operational efficiency through the lifecycle of a structure (Arayici, 2015).

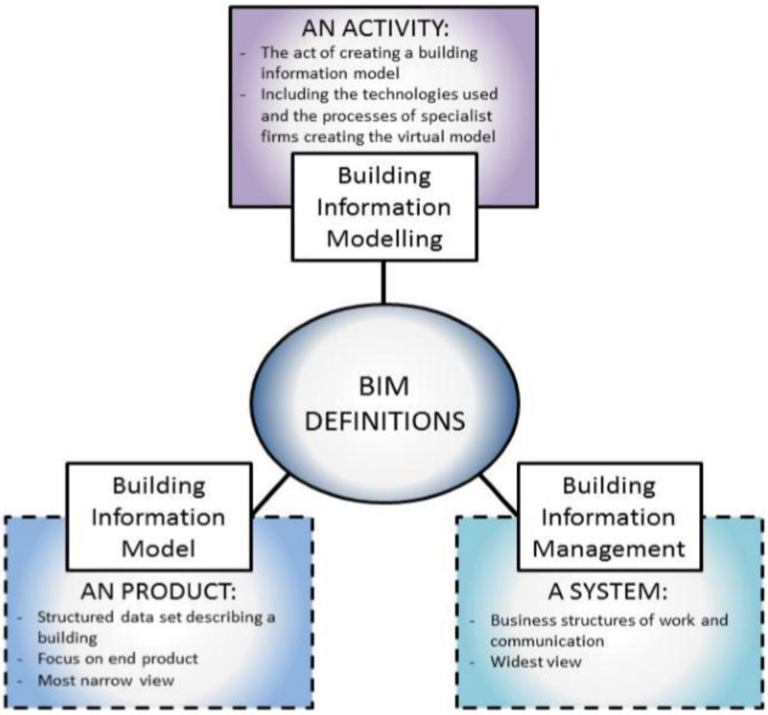


Figure 3.1 Different ways of looking at BIM, (Mauluna, 2008)

The database infrastructure is one of the most fundamental elements in the use of BIM. The digital expression of buildings will be fruitful for all stakeholders and the necessary estimates can be made throughout the life cycle of the building. BIM can provide more sustainable and more satisfying judgments to owners. While responding to the wishes of BIM owners, the impact on the natural environment is minimal (Arayici, 2015). BIM attempts to integrate all disciplines throughout the entire life cycle of a structure. The focus of BIM is the consistent use of information by all stakeholders throughout the life cycle of the structure. It is the methodology that is intended to be used throughout the life cycle of the building, based on the increased cooperation between stakeholders using information technologies. The fragmentation of the multi-discipline in the construction sector aims to combine with BIM technology (Arayici, 2015).

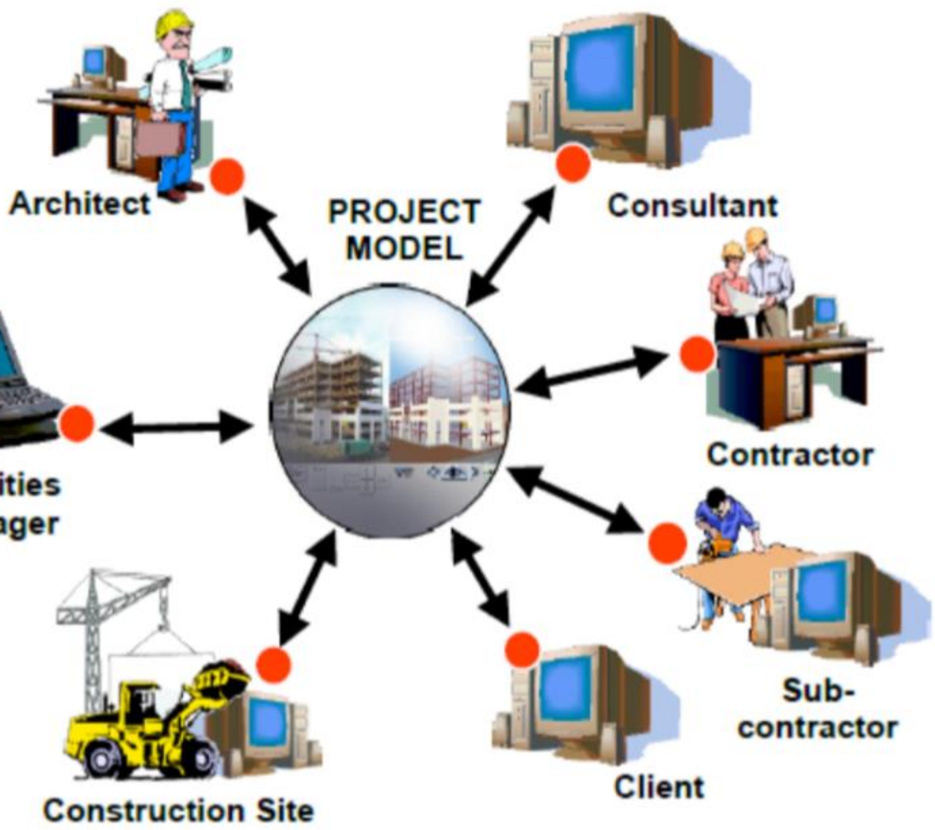


Figure 3.2 Communication and collaboration utilising BIM modelling, (Arayici, 2015)

3.1.1 Stage Of BIM

3.1.1.1 Stage 1

The first part of BIM refers to the transition from 2D to 3D drawing. This section involves object-based modeling (Arayici, 2015).

3.1.1.2 Stage 2

Stage 2 is the phase of co-operation with model assistance to workability. Designing and managing a structure is a very complex process. All stakeholders in this process are intended to cooperate with this model (Arayici, 2015).

3.1.1.3 Stage 3

At this stage there is a transition from cooperation to integration. Basic BIM philosophy is revealed at this stage. All players must obtain real benefits from the virtual workflow at this stage. At this stage, BIM models become the interdisciplinary nD model (Lee et al, 2015). At this stage, the model enterprise, the principles of lean construction, sustainability and the lifecycle of all the policies to determine the object becomes beyond a feature (Arayici, 2015).

3.2 Level of BIM

The British Government wanted BIM to be level. In this context they divided into 4 levels. They are level 0, level 1, level 2, and level 3. The UK Government aims to be in the second place until 2016. The purpose of these levels is the clear understanding of BIM for the supply chain and its classification in cooperation ethics (Arayici, 2015).

3.2.1 Level 0

Level 0 consists of projects drawn in DWG, DGN and DXF formats. Computer aided design (CAD) system is used at this stage. These drawings reflect the traditional style (Arayici, 2015).

3.2.2 Level 1

There are also 2D and 3D visualization projects in leve 1. Includes file-based partner data managed according to British Standart (BS1192). These models cannot produce useful information to other team members. There are commercial and non-integrated financial and cost packages (Arayici, 2015).

3.2.3 Level 2

Level 2 includes individual discipline-based BIM models. The full potential of a BIM model may not be complete even at this stage. Level 2 is called a proprietary BIM (pBIM). Cooperation between proprietary units is provided here. 4D construction simulation and 5D cost estimation can be performed at this stage (Arayici, 2015).

3.2.4 Level 3

All BIM data, including maintenance and operation at level 3, are shared in an integrated computer environment throughout the supply chain (CIC comes to mind at this point). At this level of BIM, we try to create a fully integrated and modern life cycle using Industry Foundation Classes-International Framework Dictionary (IFC and IFD codes). BIM level 3 is called the integrated BIM (iBIM) using concurrent engineering processes (Arayici, 2015).

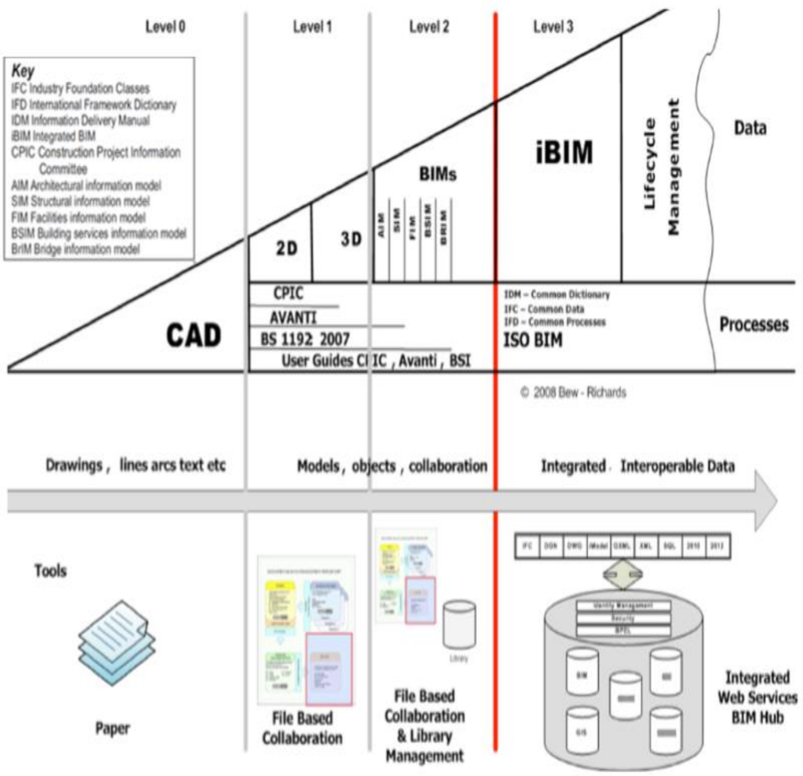


Figure 3.3 BIM levels, (BIM Task Group, 2012)

3.3 IFC (Industry Foundation Classes)

The IFC code provides a different way to the construction sector for information sharing. The common language is provided through this code. The IFC code uses object orientation and software technologies. Thanks to IFC, the designs have reached their goal during the construction period. The behavior of objects can be limited information because it will be controlled by applications (Arayici, 2015).

3.4 Parametric Modelling Technology With BIM

Parametric modeling offers more advanced information than CAD technology and requires less effort. Parametric modeling is more efficient than CAD technology. The Object CAD is more successful in than CAD technology. Figure 3.4 shows this 3 different situations (Arayici, 2015).

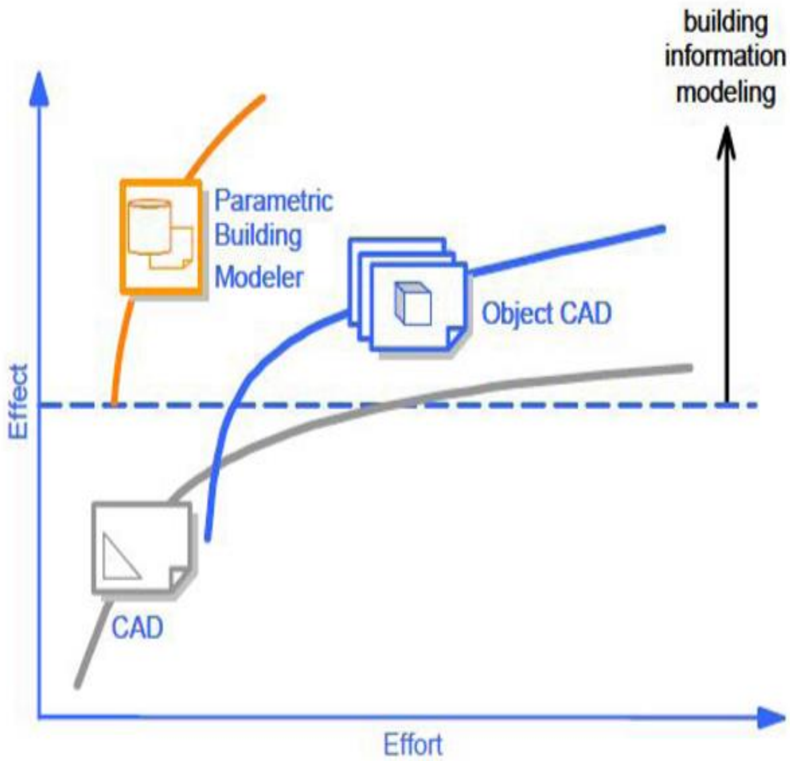


Figure 3.4 The effect/effort ratio of BIM Technologies, (Autodesk, 2003)

In parametric modeling, parameters are used to determine the properties of the objects and the relationship between them. This situation is shown in figure 3.5. It includes parameters such as price of objects, spatial relationship, geography, material type

(Jiang, 2011). In addition, 2D and 3D modeling only defines the form of the structure and is used to complete the design (Arayici, 2015).

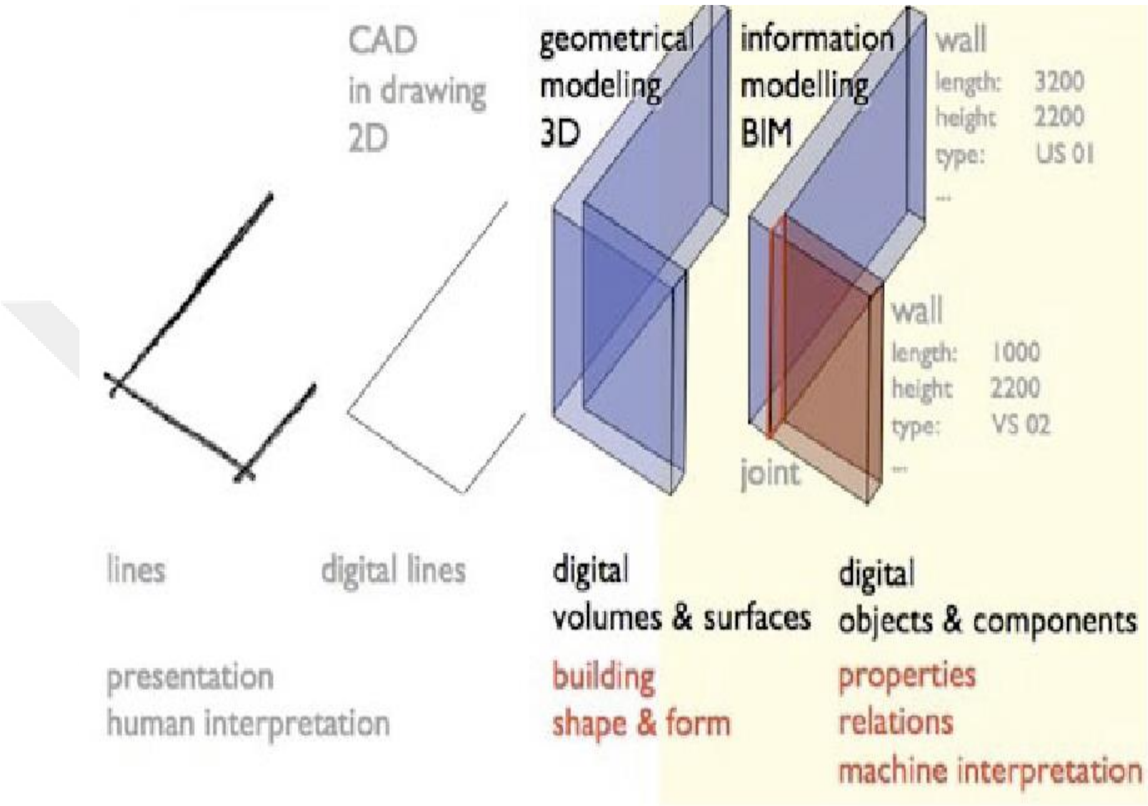
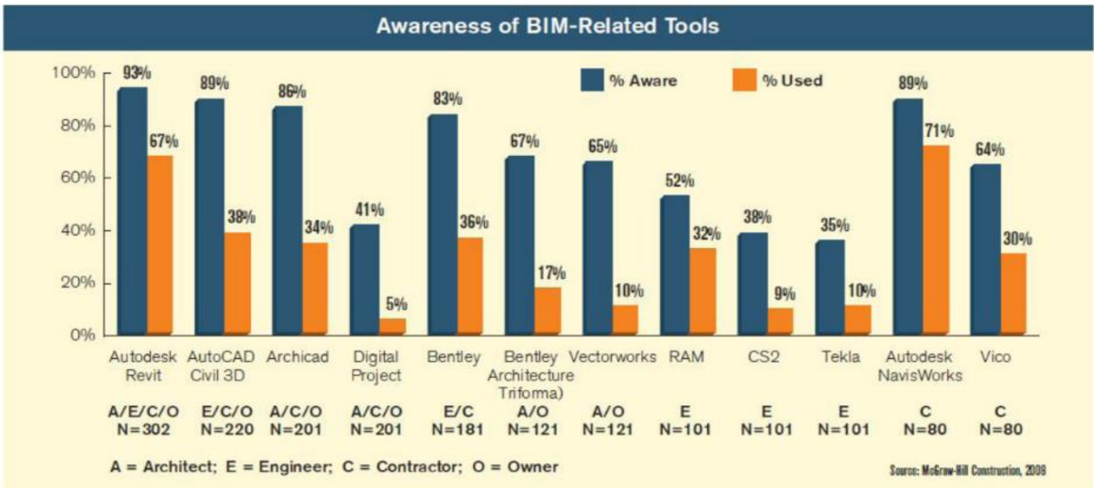


Figure 3.5 The evolution of CAD system, (Pentilla, 2009)

3.5 BIM Tools

Building information modeling is not dependent on one software. BIM model is integrated with different software for many disciplines (Thomassen, 2011). BIM software manufacturers include Bentley, Graphisoft's ArchiCAD and Autodesk's Revit BIM-based software (Brewer et al, 2012). Nowadays, a large number of BIM software are used in the construction headers. The most common uses are 67% Revit and 71% Navisworks. This result was determined by a survey conducted by McGraw-Hill Construction (2008). The use of ArchiCAD and Tekla was 34% and 10%, respectively (Arayici, 2015).



Figures 3.6 Awareness of BIM tools, (McGraw-Hill Construction, 2008)

Product Name	**Manufacturer**	**Primary Function**
Revit Architecture	Autodesk	3D Architectural modelling and parametric design
AutoCAD Architecture	Autodesk	3D Architectural modelling and parametric design
Revit Structure	Autodesk	3D Structural modelling and parametric design
Revit MEP	Autodesk	3D Detailed MEP modelling
AutoCAD MEP	Autodesk	3D MEP modelling
AutoCAD Civil 3D	Autodesk	Site Development
Cadpipe HVAC	AEC Design Group	3D HVAC modelling
Cadpipe Commercial Pipe	AEC Design Group	3D pipe modelling
DProfiler	Beck Technology	3D conceptual modelling with real time cost estimating
Bentley BIM Suite (Microstation, Bentley Architecture, Structural, Mechanical, Electrical, Generative Design	Bentley System	3D Architectural, structural, mechanical, electrical and generative component modelling and design
Fastrak	CSC(UK)	3D Structural modelling
SDS/2	Design Data	3D Detailed MEP modelling
Digital project	Gehry Technologies	CATIA based BIM system for Architectural, Design, Engineering and Construction Modelling
Digital Project MEP Systems Routing	Gehry Technologies	MEP Design
ArchiCAD	Graphisoft	3D Architectural Modelling
MEP Modeller	Graphisoft	3D MEP Modelling
HydraCAD	Hydratec	3D Fire Sprinkler Design and Modelling
AutoSPRINK VR	MEP CAD	3D Fire Sprinkler Design and Modelling
FireCAD	Mc4 Software	Fire piping Network Design and Modelling
CAD Duct	Micro Application	3D Detailed MEP Modelling
Vectorworks Designer	Nemetschek	3D Architectural Modelling
Duct Designer 3D, Pipe designer 3D	QuickPen International	3D Detailed MEP Modelling
RISA	RISA Technologies	Full Suite of 2D and 3D Structural Design Applications
Tekla Structures	Tekla	3D Detailed Structural Modelling
Affinity	Trelligence	3D Model Applications for early concept design
Vico Office	Vico Software	5D Modelling for generating cost and schedule data
PowerCivil	Bentley Systems	Site Development
Site Design, Site Planning	Eagle Point	Site Development
Solibri	Solibri Technologies	Design review, clash detection, code checking

Table 3.1 List of BIM tools and technologies based on their specific application areas (Arayici, 2015)

3.6 Level of Developmet (LOD)

The development level of the BIM model is determined by the extent of its integrity and is called the level of develepment (Velasco, 2013). The steps taken by the LOD to logically advance a BIM model from its lowest level of conceptual approach to its highest level (Brewer et al, 2012).

AIA has defined 5 levels of development. They are used for a better understanding of LODs. LOD 100, LOD 200, LOD 300, LOD 400 and LOD 500 are shown in table 3.2 below. These stages determine the geometric level of the structure, the level of the manufacturing phase (Velasco, 2013). These components determine who is responsible for each development. The coordination between the stakeholders can be done in detail on the BIM model (Gaudin, 2013).

- LOD 100 Conceptual: The model will consist of overall building massing including orientation, volume, height, location and area

- LOD 200 Approximate geometry: generalized systems or assemblies with approximate size, shape, location, orientation and quantities

- LOD 300 Precise geometry: specific assemblies accurate in terms of size, location, orientation, shape and quantities

- LOD 400 Fabrication: specific assemblies accurate in terms of size, location, shape, orientation and quantities with complete fabrication

- LOD 500 As-built: constructed assemblies that are accurate and actual in terms of shape, location, size, orientation and quantities.

LOD	Model Content Requirements	Authorised Uses	
LOD 100	Overall building massing indicative of area, height, volume, location and orientation is modelled in 3D dimensions	Analysis	The model is analysed based on volume, area and orientation by application of generalised performance criteria assigned to the representative BIM model
		Cost Estimating	The model is used to develop a cost estimate based on current area, volume or similar estimating techniques
		Schedule	The model is used for project phasing and construction
LOD 200	Model elements are modelled as generalised systems or assemblies with approximate quantities, size, shape, location and orientation. Non-geometric information can also be attached to the BIM model	Analysis	The model is analysed for performance of selected systems by application of generalised performance criteria assigned to the representative BIM model
		Cost Estimating	The model is used to develop a cost estimate based on approximate data provided and conceptual estimating techniques
		Schedule	The model is used to show ordered, time scaled appearance of major elements and systems
LOD 300	Model elements are modelled as specific assemblies accurate in terms of quantity, size, shape, location and orientation. Non geometric information is also attached to the BIM model	Analysis	The model is analysed for the performance of selected systems by application of specific performance criteria assigned to the representative BIM model
		Cost Estimating	The model is used to develop a cost estimate based on specific data provided and conceptual estimating techniques
		Schedule	The model is used to show an ordered, time scaled appearance of detailed elements and systems
		Construction	Suitable for the generation of traditional construction documents and shop drawings
LOD 400	BIM model components are modelled as specific assemblies accurate in terms of quantity, size, shape, location and orientation with complete fabrication, assembly and detailing information. Non-geometric information is also attached to the BIM model.	Analysis	The model is analysed for performance of approved systems based on specific BIM model
		Cost Estimating	Costs are based on the actual cost of specific elements at buyout
		Schedule	The model is used to show an ordered, time scaled appearance of detailed specific elements and systems including construction means and methods
		Construction	BIM model is the virtual representation of the proposed element and are suitable for construction.
LOD 500	BIM Model is modelled as constructed assemblies, actual and accurate in terms of size, shape, location, quantity and orientation. Non-geometric information may also be attached to the modelled elements	General Usage	The model is utilised for maintaining, altering and adding to a project but only to the extent that is consistent with any licences granted in the agreement or in a separate licensing agreement

Table 3.2 Level of Development, (Gaudin, 2013)

3.7 Use of BIM

In order to achieve the desired results in the BIM structure, the planning, design, construction and operation of the building throughout the life cycle of the structure to be driven. The use of BIM refers to computer-integrated construction (CIC, 2012). The use of BIM is a set of activities throughout the life of the structure to produce, operate and manage the structure. As defined by BIM (2012), the widespread use of BIM is classified into four main categories: Planning, Design, Construction and Operation. These categories are described below (Arayici, 2015).

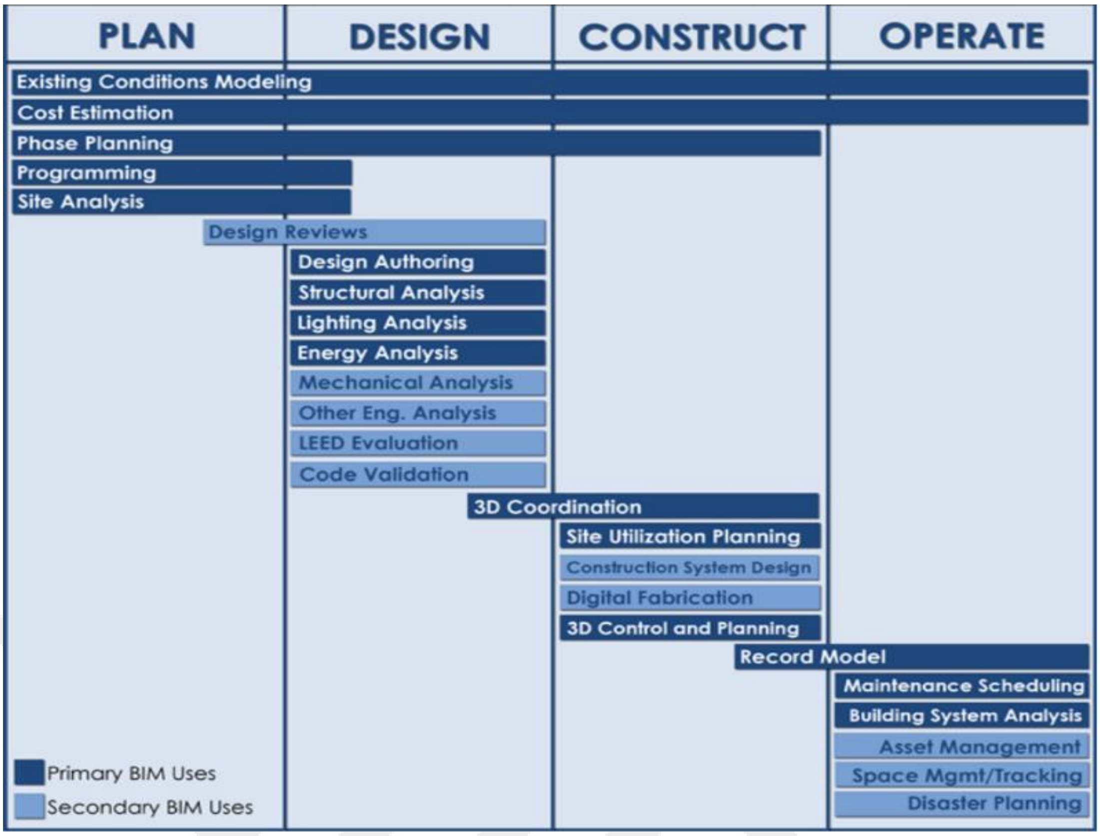


Figure 3.7 Use of BIM lifecycle, (CIC, 2013)

3.7.1 Planning Phase

Any factor that may affect the design should be determined by feasibility study at the planning stage. Among the factors affecting the design are topography, wind direction, daily and annual solar path. These factors play an important role in the design. BIM plays an important role in integrating all of these factors in the same environment. Makes design analysis, organizes information, makes quick cost estimation and integrates all information in the BIM model (Arayici, 2015).

3.7.2 Design Phase

Architects should advance the design process in a balanced way by considering the needs and budgets of the customers. changes other than plans may result in loss of time and money. When using traditional methods to make time and cost estimation requires much time and effort. Design documentation and other vital information is used from a single source through the use of BIM. In this way, the design teams are made with the right design construction control in a more efficient and efficient way without manual controls. Design teams find time to work on architectural projects. Building design and documentation can be done at the same time (Autodesk, 2003). By using

BIM, less time and effort can be achieved. thus the delivery speed increases, coordination improves and costs decrease. As a result, more production, better quality work and increases in profitability are seen (Arayici, 2015).

3.7.3 Construction Phase

With the development of accurate designs in a synchronized manner with BIM, construction teams provide effective progress. Therefore BIM is inevitably needed in the field. The improvement of construction information and the acceleration of the logistics business will be a huge gain for contractors. Spending less time and money can be reduced to overall costs by making better quality planning (Arayici, 2015).

3.7.4 Management Phase

BIM supports management teams by providing important information such as performance and operation for the management of a facility. BIM through use, the equipment, rental space is kolyacabelirlen and is controlled by the facility manager. With the use of this information, the overall operation of the building becomes more advanced (Arayici, 2015).

3.8 BIM & Sustainable Design

Ozone depletion and global warming led to awareness about energy consumption. At this point, the energy consumption of buildings has become an agenda that needs attention. To achieve more sustainable results, building energy performance must be controlled. BIM examines the energy use of a building's life cycle (Arayici, 2015). more efficient building because of global warming has become an important issue all over the world. To reduce the carbon emissions of buildings and to design more sustainable structures and to create green buildings are important developments but the desired level has not been reached yet (Arayici, 2015). Sustainable solutions are important for the welfare levels of societies. Sustainable living can be considered as waste control and improvement of general life. BIM helps provide sustainable solutions for project teams. The integration between BIM tools ensures better quality during design and during construction (Arayici, 2015). Design and construction have always been a part of human activity. All through history, sustainability has, in one form or another, been applied to design, in spite of the fact that, centuries ago, advanced technology did not exist. In order to convey their ideas, architects and engineers put pencil or pen to paper; this process of creating drawings made project progression move quite slowly (Arayici, 2015). There is no definite time line of when sustainability began. According to (Krygiel and Nies, 2008) sustainable thinking implementation is, in many ways, ancient. Buildings, designed and constructed on sustainable lines, were not only made from natural resources found in the environment but were also designed and constructed to exist within the environment (Arayici, 2015). Master builders and architects used to convey their instructions to traders on paper via hand drawn drawings until (Levy, 2012). Computer Aided Design (CAD) tools came into play. CAD made designers and engineers able to draft their drawings using computer systems which aided in the creation, modification and analysis of designs. The CAD system was used to improve design quality, to develop communication between project stakeholders through proper storage and documentation, to increase overall project efficiency, as well as in the construction of a catalogue for fabrication and manufacturing (Sarcar et al, 2008). BIM is the present-day technological acronym that has established itself in the AEC industry and has given CAD 'a run for its money. BIM has grown into an emblem of change for participants in the AEC industry (Arayici, 2015). Kibert (Kibert, 2013) stated that the initial stride taken forward in thinking and methodology first occurred in the United Kingdom with the initiation of a building assessment system known as the Building Research Establishment Environmental Assessment Method (BREEAM). BREEAM was instantly recognised by the AEC industry because it was a means of evaluating a building's performance and proposed a standard definition for a green building. BREEAM presented the first effort to successfully evaluate buildings on a widespread variety of factors that encompass not only the energy performance of a building but also the consumption of water, location, indoor environmental quality, environmental impacts, use of material, and contribution to ecological system health, to mention just a handful of the general classifications that can be incorporated into the assessment. Table 5.1 shows a list of twenty-nine of the sixty countries that have sustainable assessment bodies (Arayici, 2015).

Australia	Nabers/Green Star	Mexico	LEED Mexico
Brazil	AQUA/LEED Brazil	Netherlands	BREEAM Netherlands
Canada	LEED Canada/Green Globes/Built Green Canada	New Zealand	Green Star NZ
Czech Rep	SBToolCZ	Philippines	BERDE/Philippine Green Building Council
China	GBAS	Portugal	Lider A
Finland	PromisE	Taiwan	China Green Building Network
France	HQE	Singapore	Green Mark
Germany	DGNB/CEPHEUS	South Africa	Green Star SA
Hong Kong	HKBEAM	South Korea	KGBC
India	Indian Green Building Council (IGBC)/(GRIHA)	Spain	VERDE
Indonesia	Green Building Council Indonesia	Switzerland	Minergie
Italy	LEED/Italy/protocollo Itaca/ GBCouncil Italia	United States	LEED/Living Building Challenge/ Green Globes
Japan	CASBEE	UAE	Estidama
Jordan	EDAMA	UK	BREEAM
Malaysia	GBI Malaysia		

Table 3.3 Sustainability assessment bodies in different countries, (Kibert, 2013).

Sustainable and environmentally sensitive designs can be created by reducing the negative effects of construction practices (Autodesk, 2003) Knowing what will be needed now and in the future should be built sustainable buildings (Arayici, 2015). Sustainability is an interesting aspect of the Architectural, Engineering and Construction (AEC) industry and is part of Green Design and Construction. According to Krygiel and Nies (2008), sustainable design is seen as better than green design. This is because sustainable design takes into consideration a larger range of impacts (social impact, economic impact and environmental impact) while the term green design is used to describe designs that only have less impact on the natural environment (Arayici, 2015).

The need for sustainable design and construction has become a common aim for building design in general. According to the Oxford Dictionary, the meaning of sustainability is preserving anything at a certain level or rate. McLennan (2004) explained that the dictionary meaning of the word “sustainable” or “sustainability” does not describe what a sustainable design is because, in the sustainable design domain of today, most designers want the term to mean more than just “preservation” or ”maintaining”. Therefore, it means much more than a dictionary definition (Arayici, 2015). McLennan (2004) believes that it is philosophically based on how buildings should be designed to be more environmentally responsible, how they should be built and how they should be operated. to maximize the quality of the environment by minimizing the negative effects on the environment and creating the philosophy of sustainable design (Arayici, 2015). Studies on sustainable design did not rapidly disseminate between 1980s and 1990s. In the design and construction processes, the use of resources and time loss has become more efficient thanks to technology (Arayici, 2015). In order to achieve the purpose of sustainable design, it must fulfill some principles. Mclennan (2004) states the following six principles:

1 People – The Human Vitality Principle

2 Wisdom of Natural Systems – The Bio-mimicry Principle

3 Place – The Ecosystem Principle

4 Energy and Natural Resources – The Conservation Principle

5 Cycles to come – The Seven Generations’ Principle

6 Process – The Holistic Thinking Principle

3.8.1 Benefit of Sustainable Building Design

From the design stage onwards, sustainable design is taken into account and all the benefits of sustainable design can be utilized (AnCor, Inc, 2014). Collaborative studies should be conducted to increase productivity throughout the entire life cycle of the building. In order to achieve its sustainability goals, the design team gives priority to life cycle and environmental issues during the design and construction phases. The three dimensions of sustainability in individuals and companies, social, environmental and economics are very valuable (Enterprise Europe, 2010). These substances are described below (Arayici, 2015).

3.8.1.1 Environmental/Ecological Benefit

Protecting the environment and protecting the natural resources of the ecosystem is the main aim of sustainability (Arayici, 2015).

1. Reduce waste
2. Reduce carbon emission
3. Protect the environment through the reduction of greenhouse gas emissions and the preservation of various existing ecosystems
4. Improve air and water quality
5. Control temperature in a building to assist in energy use reduction
6. Preserve and restore natural resources by requiring less energy and water

3.8.1.2 Economic Benefits

Increased water efficiency, sustainable use of materials and reduction of energy consumption provide economic benefits in sustainable building design. Some of these are shown below:

1. Reduction in building operation cost
2. Enhancement of the life cycle of a building
3. A rise asset value
4. Helping develop the expansion of the sustainable/green market
5. Improvement of occupants' productivity, well-being and attendance

3.8.1.3 Social Benefits

Social benefits can be seen as less important besides economic and environmental benefits. Designers and owners can improve the quality to:

1. Improve the productivity of workers or people working-living in a building
2. Create an aesthetically appealing environment both internally and externally
3. Decrease pressure on local Infrastructure
4. Increase occupants' overall morale
5. Increase cccupants' comfort and health improvement (Arayici, 2015)

3.8.1.4 Business Benefits of Sustainable Design

Sustainable designs appear to be expensive and laborious for owners but cost savings in the medium and long term will be ensured. The benefits for a business are as follows:

1.Short and long haul cost decreases from waste and transfer costs, and expanded vitality and asset efficiencies

2.Focal points when acquiring new work and tendering for contracts, particularly open division contracts where minimizing ecological harm is specified in the acquisition rules

3.Better consistency with building, ecological, wellbeing and security regulations

4.Better relations with nearby groups and media

5.Better staff relations on the grounds that staff feel more esteemed, better encouraged and better prepared (Arayici, 2015)

3.9 BIM for Facilities Management

Facility Management The British Standard (BS EN 15221-1: 2006 Facility Management-Part 1) is defined as the facility management of the integration of the activities of processes within an organization. To manage the plant effectively and to ensure its efficient operation. The main responsibilities of facility management are as follows by the International Association of Facility Managers (IFMA):

- Long-range and annual facility planning
- Facility financial forecasting
- Real estate acquisition and disposal
- Work specification, installation and space management
- Architectural and enginnering planning and design
- New construction and renovation
- Maintenance and operations’ management
- Telecommunications’ integration, security and general administrative services (Arayici, 2015).

There two main types of computer FM systems which support FM functions. These are Computer Maintenance Management Systems (CMMS) and Computer Aided FM (CAFM) systems (Arayici, 2015). CMMS facilitates the management of operations and the maintenance of properties in terms of the physical and financial aspects and makes that information accessible in order to support facility-related decisions (NIST, 2007), for example, this system manages equipment and product assets relating to building services such as HVAC, electrical, water and other utilities. The system is used to record, manage and communicate day to day operations and helps to evaluate the effectiveness of facilities operations (Sapp and Eckstein, 2013). On the other hand, a CAFM system is an information rich database system which is used to manage spaces (Excitech, 2011). The CAFM system is described by Watson and Watson (Watson and Watson, 2013) as the combination of Computer-Aided Design (CAD) and/or relational database software with specific abilities for Facilities Management in order to ensure that an asset is fully utilised at the lowest possible cost at every stage of its lifecycle (Arayici, 2015). CAFM systems support the operational and strategic facility management of all the activities that are associated with administrative, technical, and infrastructural FM tasks when a facility is operational and supporting strategic planning (Arayici, 2015). Overall the two systems have different functions yet both intended to support the total FM processes. However, there are still challenges in supporting these FM processes with these existing tools and technologies (Arayici, 2015). The cost of operations and maintenance over the life of a building far outweigh any initial investment (Excitech, 2011) and, therefore, BIM and FM integration is seen as a solution to assist in the operations phase. BIM will provide a fully populated asset data set that can be transferred into CAFM systems, will reduce the time wasted in obtaining and populating asset information, will enable the achievement of optimum performance much quicker, and will reduce running costs and refine target outcomes (BIMTG, 2013). (Eastman et al, 2013) suggested that owners can realize significant benefits on projects by using BIM processes and tools to streamline the delivery of higher quality and better performing buildings at the handover stage.

Such benefits include:

- Improved space management
- Streamlined maintenance
- Efficient use of energy
- Economical retrofits and renovations
- Enhanced lifecycle management (Arayici, 2015).

Chapter 4

BIM Implemantetion Of Residential House

4.1 Introduction

In the chapter 2, we emphasized the importance of project construction management for the construction sector. Engineers and architects should be integrated into BIM technology to improve project efficiency. Today, BIM technologies have gained an important place in supporting the building performance in the manufacturing and usage stages of the buildings and creating an efficient product.

We will conduct a case study to examine how difficult to understand construction projects by traditional methods and to investigate time-cost management problems of projects. A real construction project design (3D), time management (4D), and cost management (5D) stages will be examined in order to understand the benefits of BIM technology on construction management. In the study, quantitative and qualitative data will be included in the study and project modeling and simulation. With Autodesk Revit software, the project will be transformed into 3 dimensions and time and cost analysis will be done with Oracle Primavera P6 software.

4.2 Case Study Description

The project is 247 islands, 7 layouts, 1633 parcel of building project in Kılavuz neighborhood in Sivas Turkey. The number of floors of the project is 5 and ıt has 371.16 square meters of land area. 2D architectural drawing of the building is as follow.

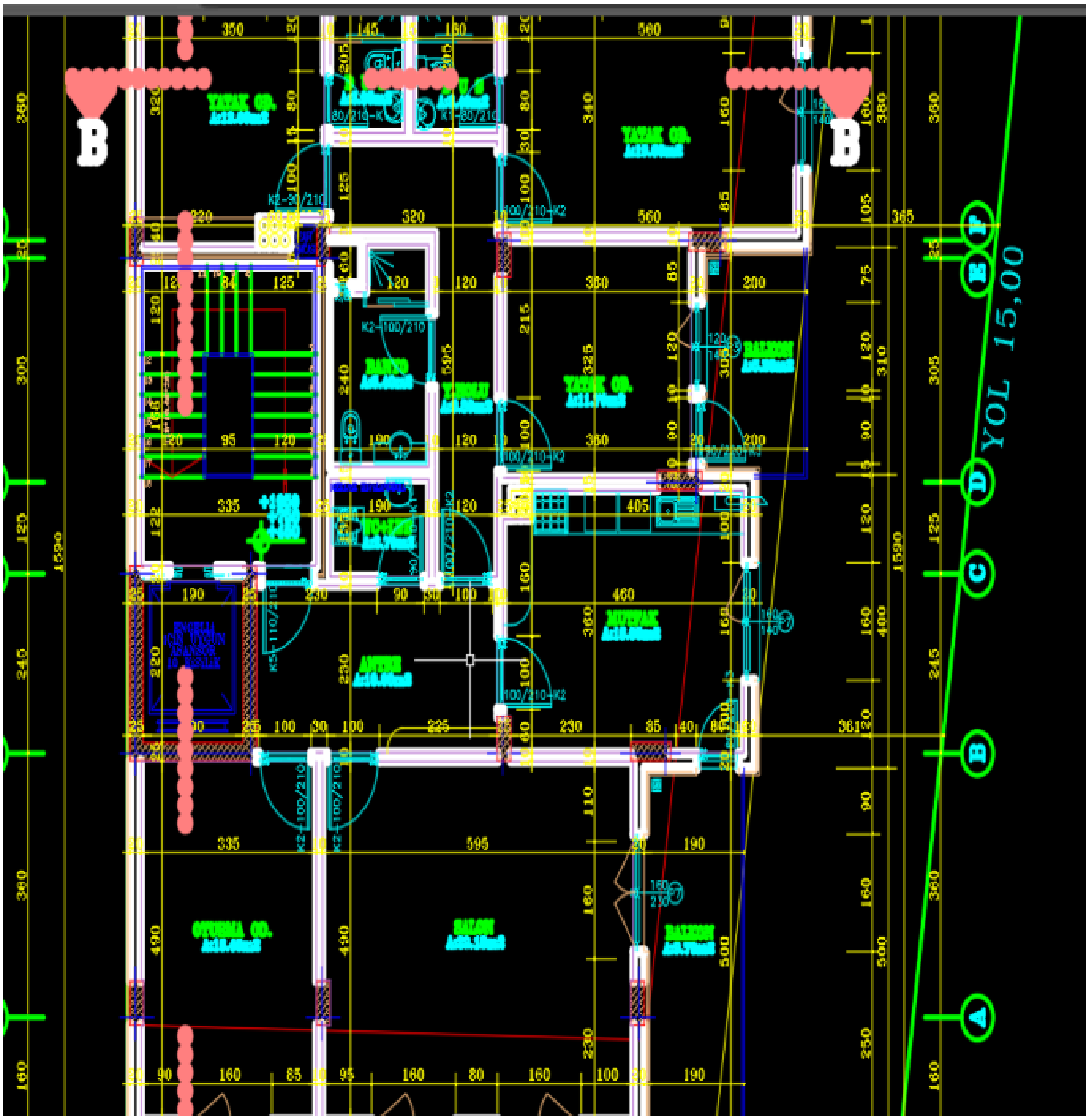


Figure 4.1 2D drawing

4.3 Projet Design with BIM (3D)

The CAD project, drawn above by conventional methods, has only mixed lines. If the project is not carefully examined during the manufacturing phase, faulty productions may occur.

To integrate this project into BIM technology we first, close unnecessary layers in a CAD environment and create a simple CAD format. After this CAD format is taken Revit with import CAD link tool.

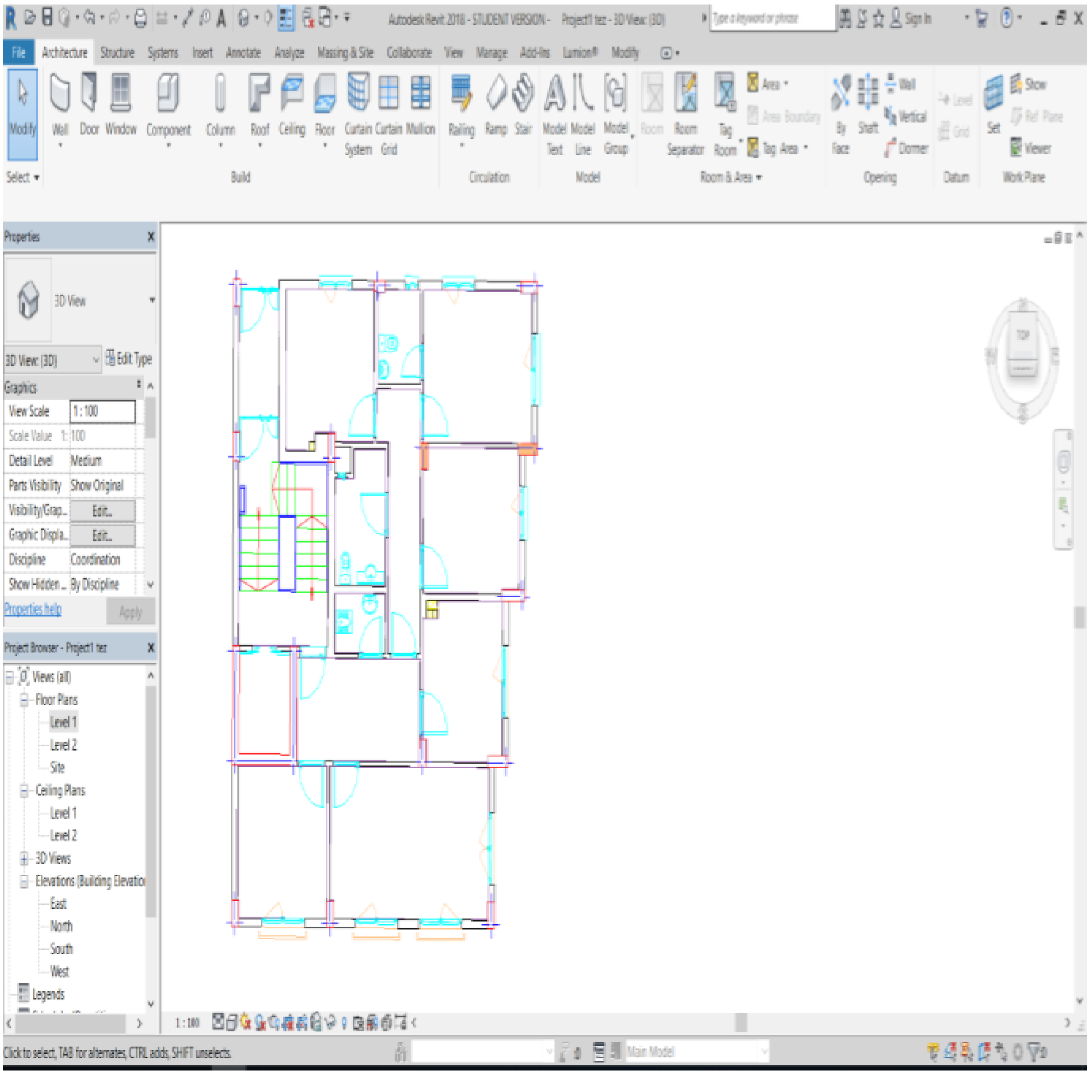


Figure 4.2 CAD base

The CAD base we import in Revitin will serve as a guide in the project process. Carrier columns and walls are placed in the project in Revit environment. The columns are 25-50 cm in diameter and the walls are 20 centimeters wide. The objects available in the project are selected from the BIM library and the ground floor is created. BIM library door, window, wall and other material selections are made.

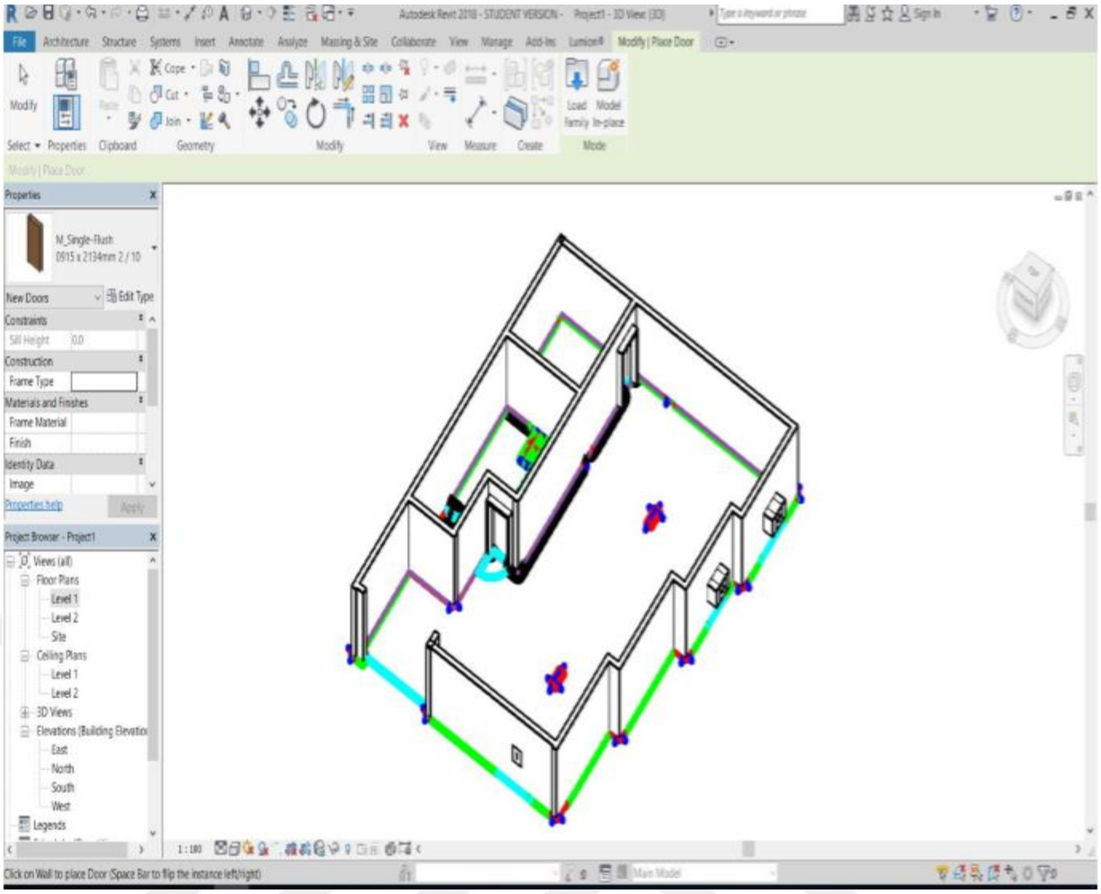


Figure 4.3 Material insertion

After this step, the Autocad drawing of the first layer is import as a Revit CAD base. Plan of ground floor and plan of first floor are different from each other. BIM library is selected from the required materials for dimensioning with CAD aid.

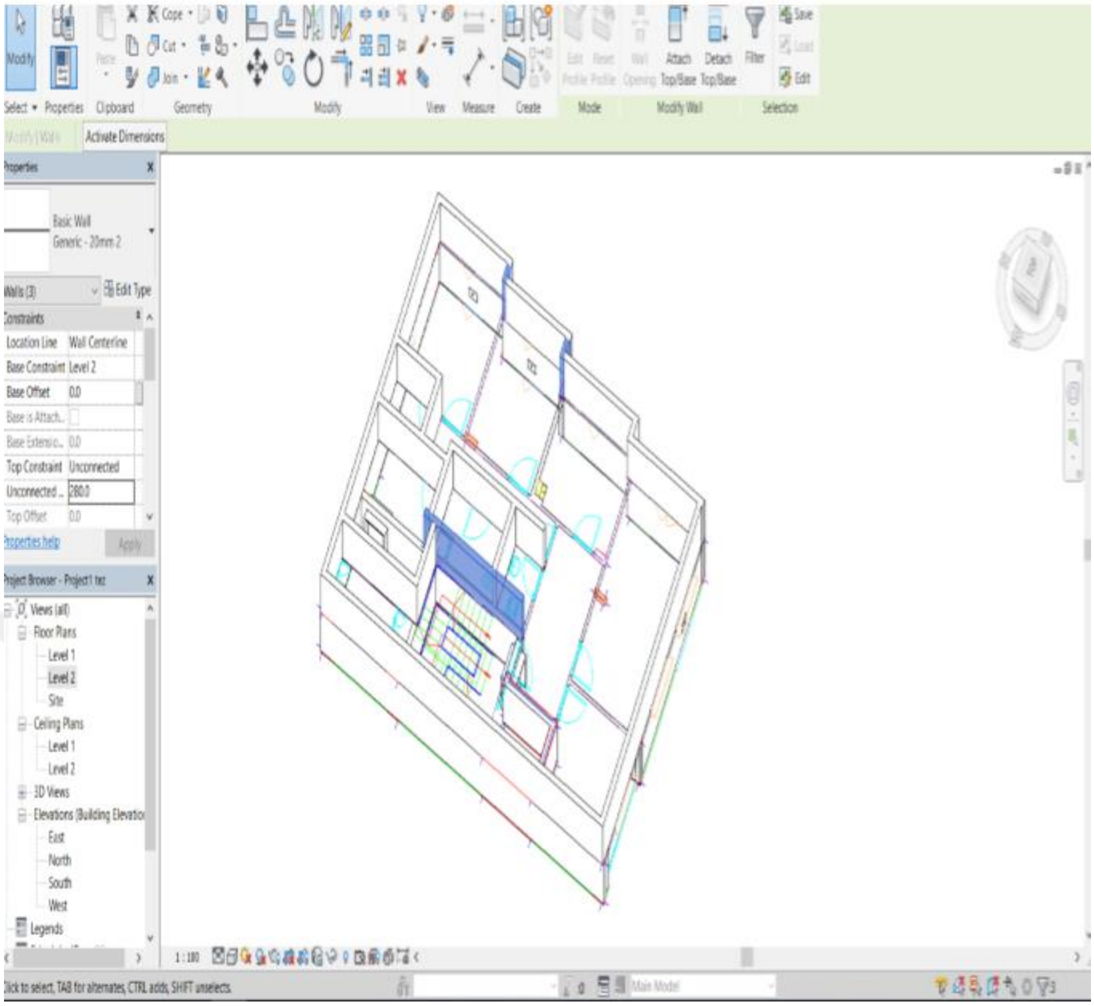


Figure 4.4 3D drawing of the first floor

In the current project all floors after the first floor have the same architectural features. After making a correct design up to this stage, the design is continued with fold copy command for the next floors. This automatic fold making process prevents errors in the design phase. The three-dimensional structure of the building with all its floors is as follows:

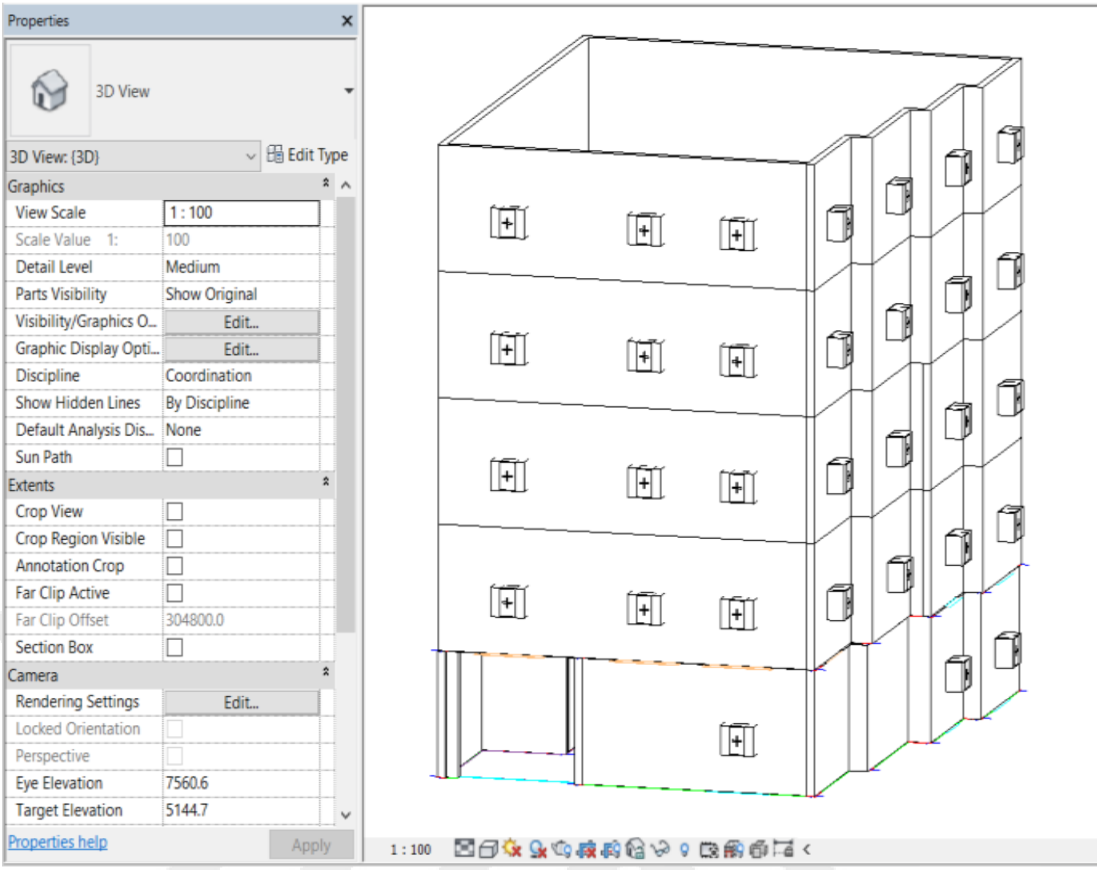


Figure 4.5 Building with all floors

After all floors are formed, the roof of the structure is designed. The roof of the Autocad Project has been given as 4 pieces and needs to be resized. The roof plan drawn by traditional methods is given below. As shown in the figure 4.6, the project has only lines and the imagination must be developed for understanding.

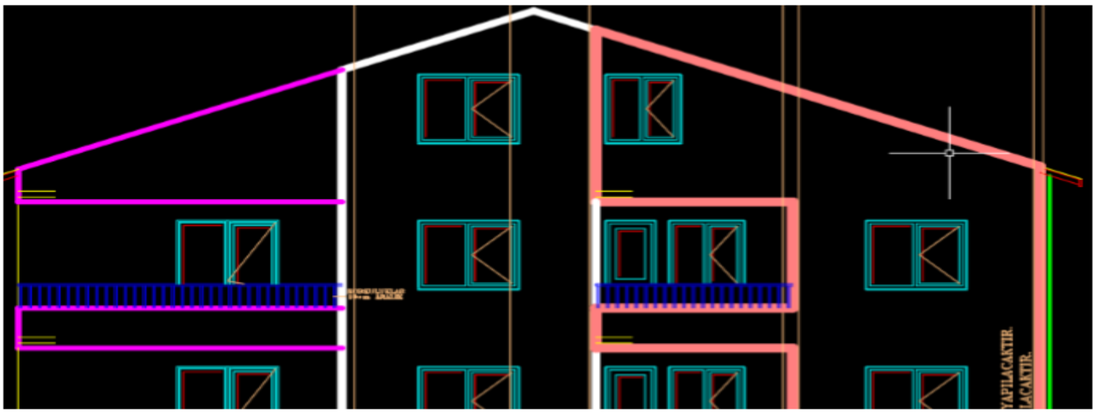


Figure 4.6 Autocad roof plan

The manufacturing errors of 2-D projects can be due to the difficulty of understanding or misunderstanding. The roof project in the same way is more difficult to understand than BIM projects.

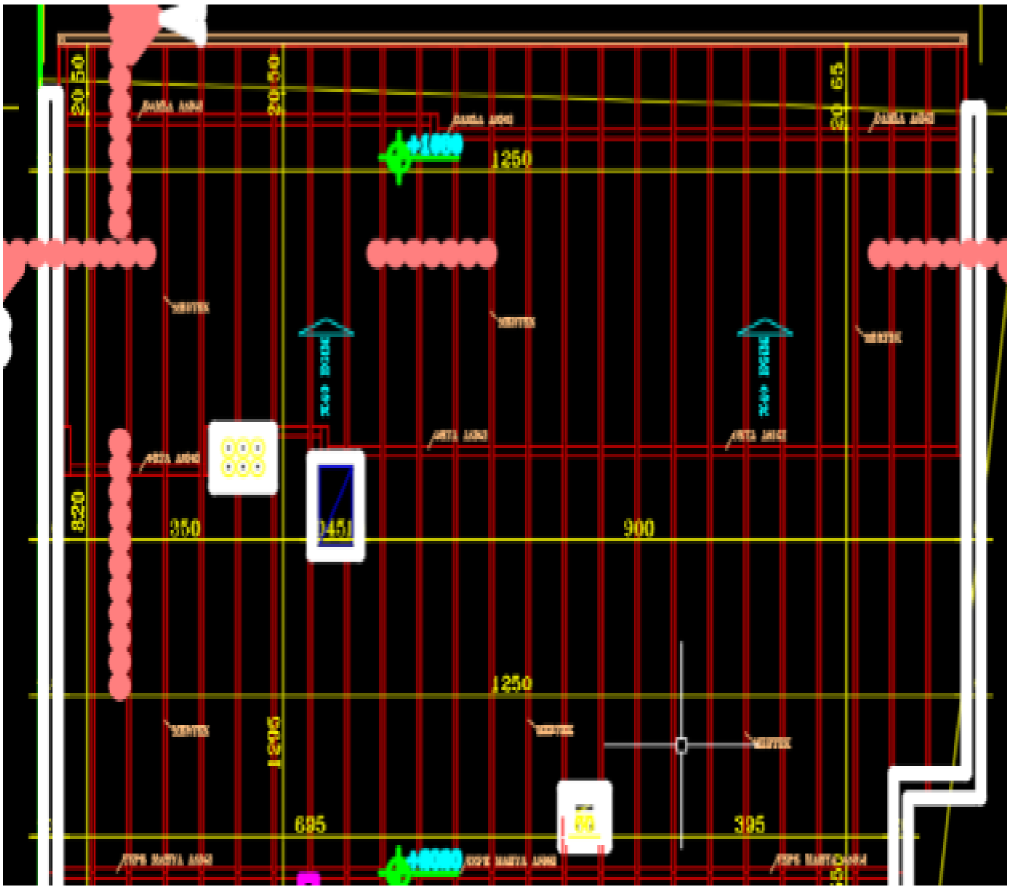


Figure 4.7 Autocad roof plan

After the creation of all the floors of the project created on the roof as shown in figure 4.8.

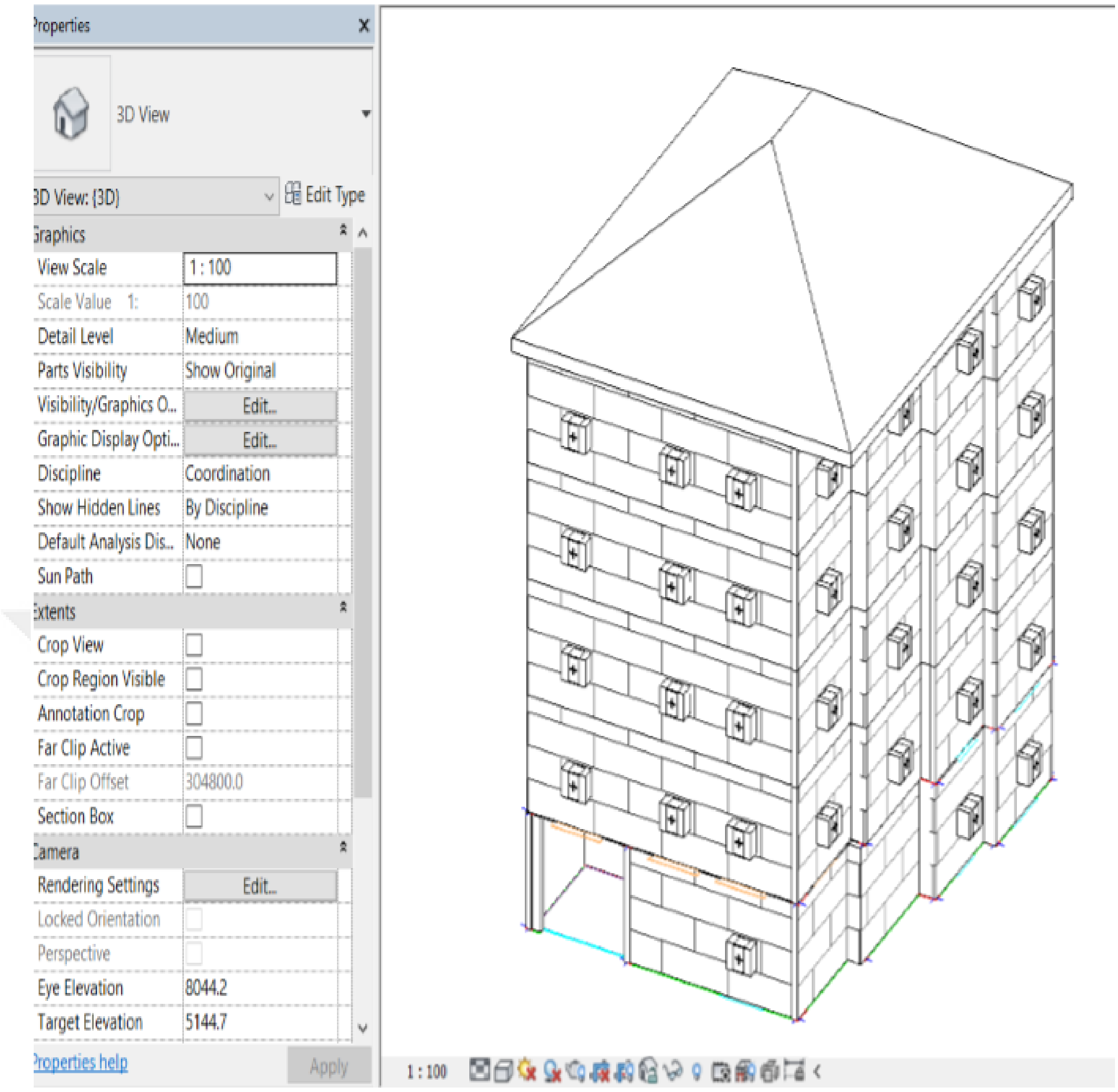


Figure 4.8 3D design

All the materials formed in the structure recognize each other and are integrated. For example, if the wall recognizes the door, the door cannot be made if there is no wall. The roof was completely placed in the coordinates on the structure and the roof and the building became familiar and integrated.

When material identification is required, the size and properties of the materials with Revit are made by selecting the Material toolbar from the "Manage" tab.

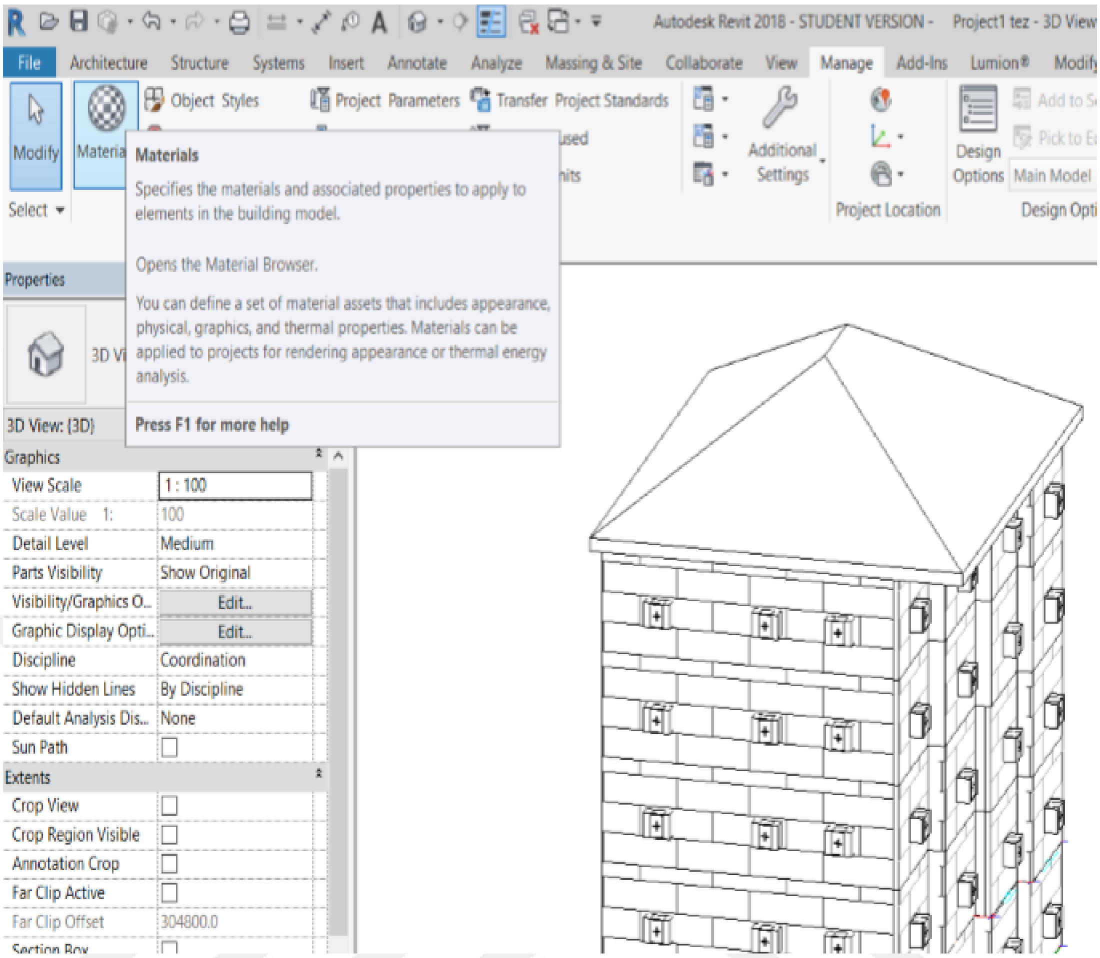


Figure 4.9 Materials tool

With the pop-up window, the list of materials is displayed and the materials to be replaced are copied and added to the BIM library. A copy of the material to be assigned is selected and the material is assigned. Thanks to this process, design teams have achieved great convenience by using BIM-based Revit software.

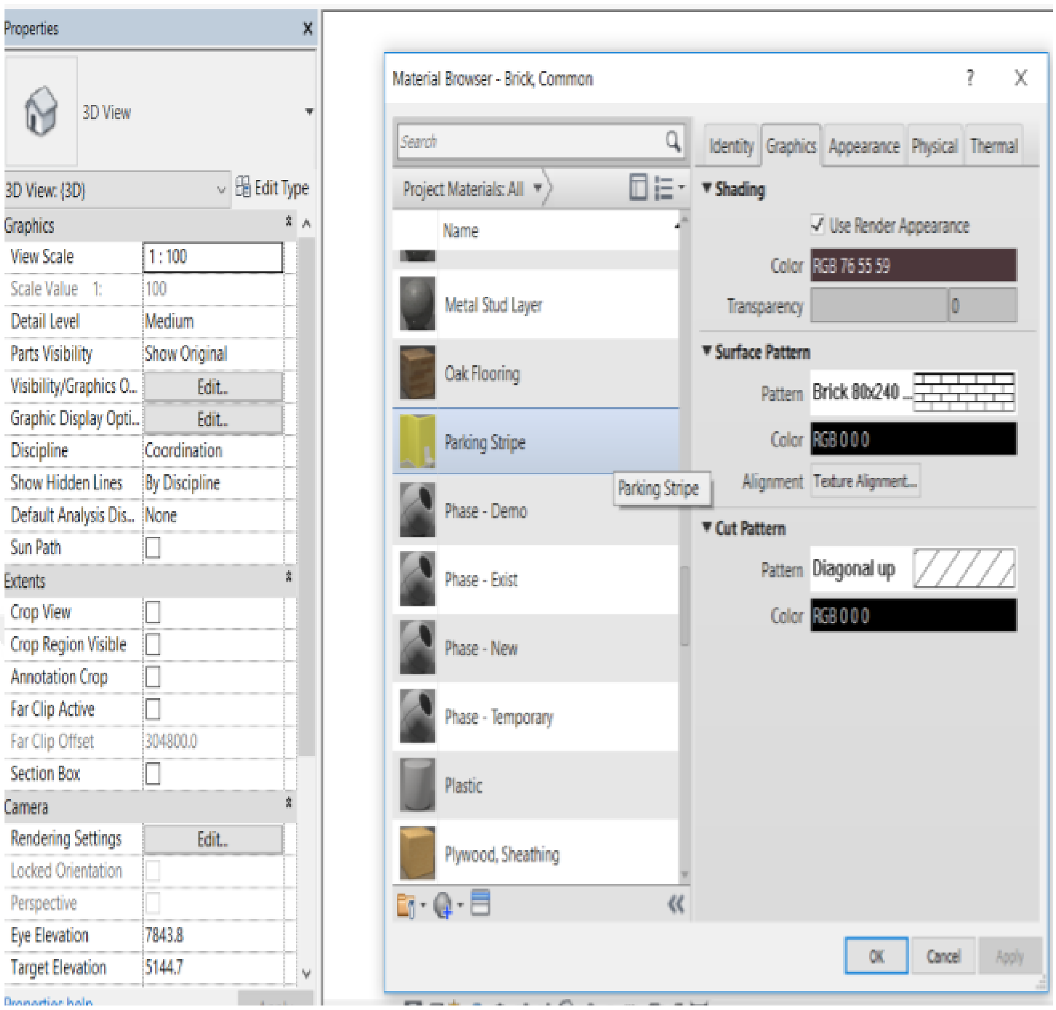


Figure 4.10 Material Browser

With the architectural project created in the BIM model, it is automatically drawn by the software in views from all fronts. Drawing the facade views in projects drawn with traditional methods wastes extra time for architects. The appearance of the facade created with Revit is as in figure 4.11.

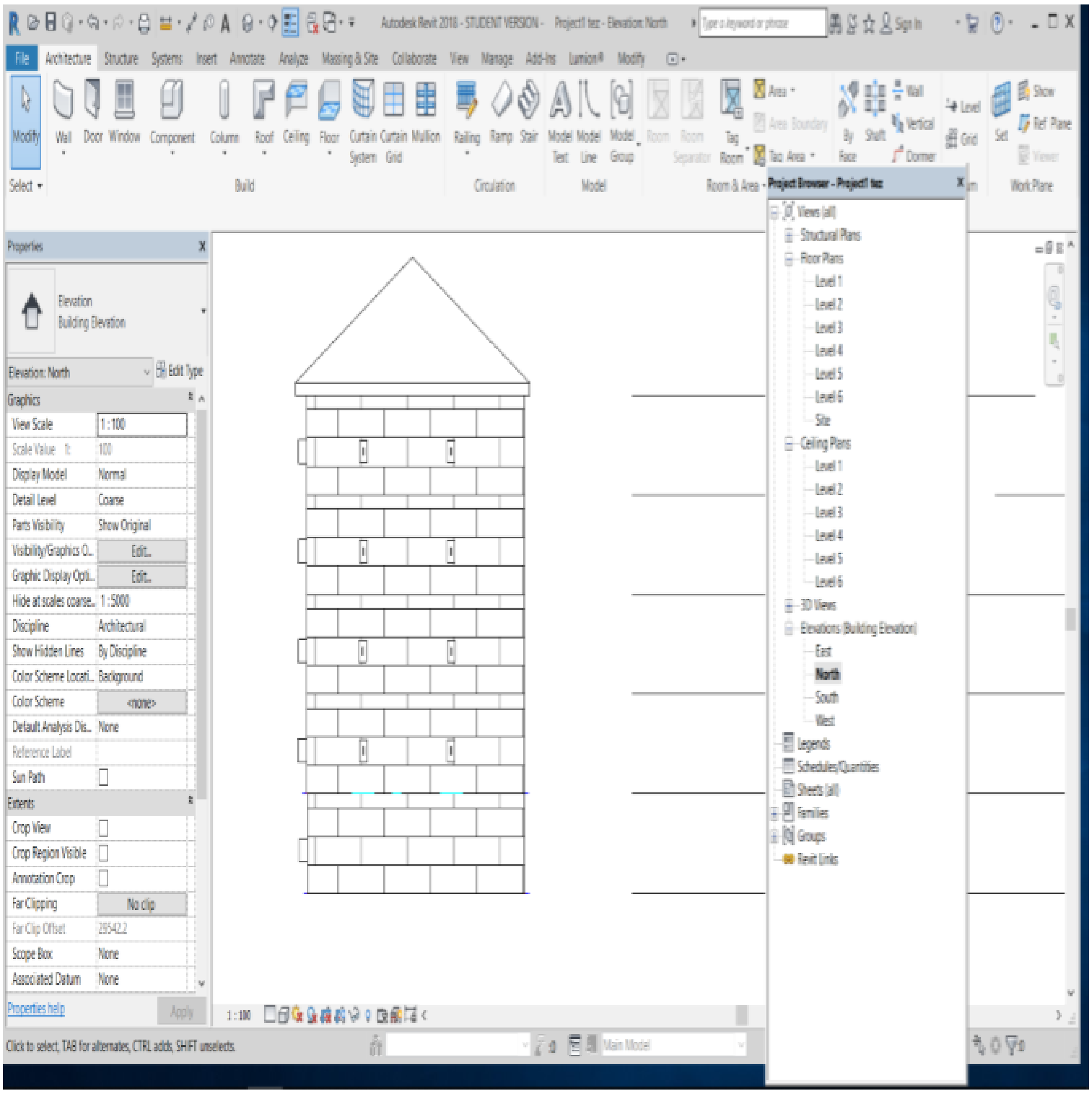


Figure 4.11 View of north facade

The building's floor heights are 2.8 meters and consist of 5 floors. There is no need to specify the height once for each floor. Again, BIM-based software design teams offer one of the convenience of each floor does not need to show a separate height.

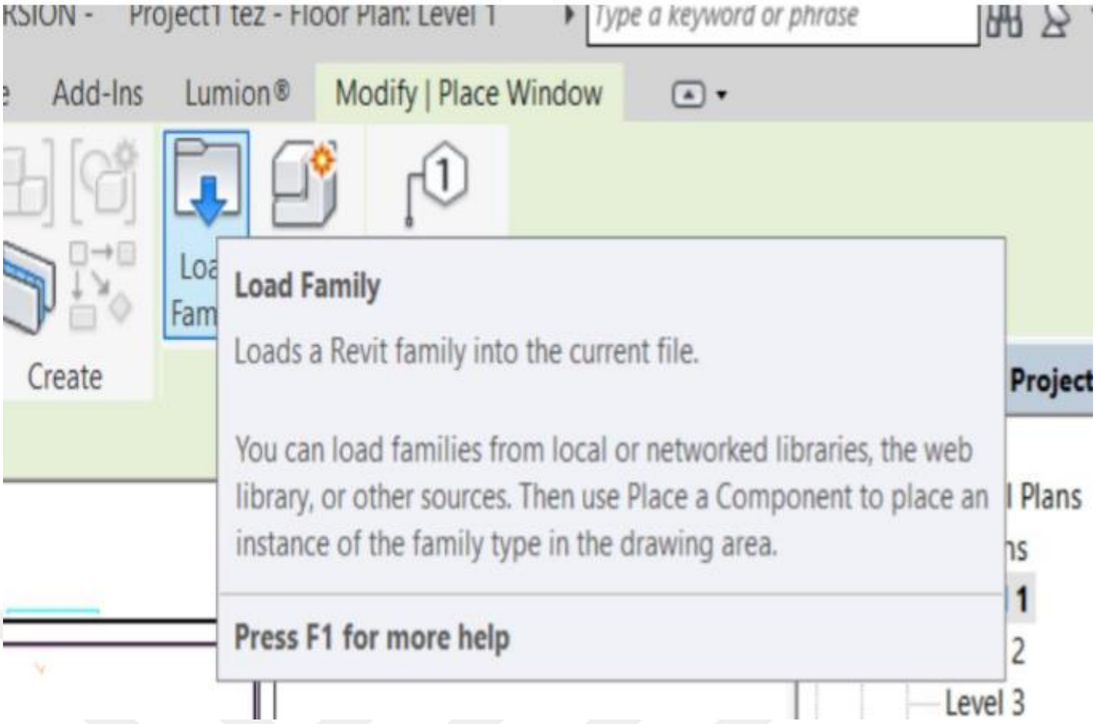


Figure 4.12 Load family

Material selection is made from the load family toolbar. Projects are created and drawn with selected materials from this library. The material library includes columns, walls, glass, suspended ceilings, light and all materials that come to mind. Since the design of each project will be different, the BIM material library that will be created by each design team will be different. It is quite normal that the material libraries for the housing, shopping center or hospital will differ. All these emerging libraries are a gain and wealth for construction sector. Thanks to this material library, we can easily build a building project. Various designs were made thanks to the material library when creating this project. In this respect, BIM gives architect a chance to create a design with many different shapes and think about it.

We may need to see the internal structure from the external perspective to make the necessary investigations in the project we have created. There are several ways to do this with Autodesk Revit. One of them is to select wireframe from the toolbars down. With this selection, we can see what is happening in our project. Shown in figure 4.13 below:

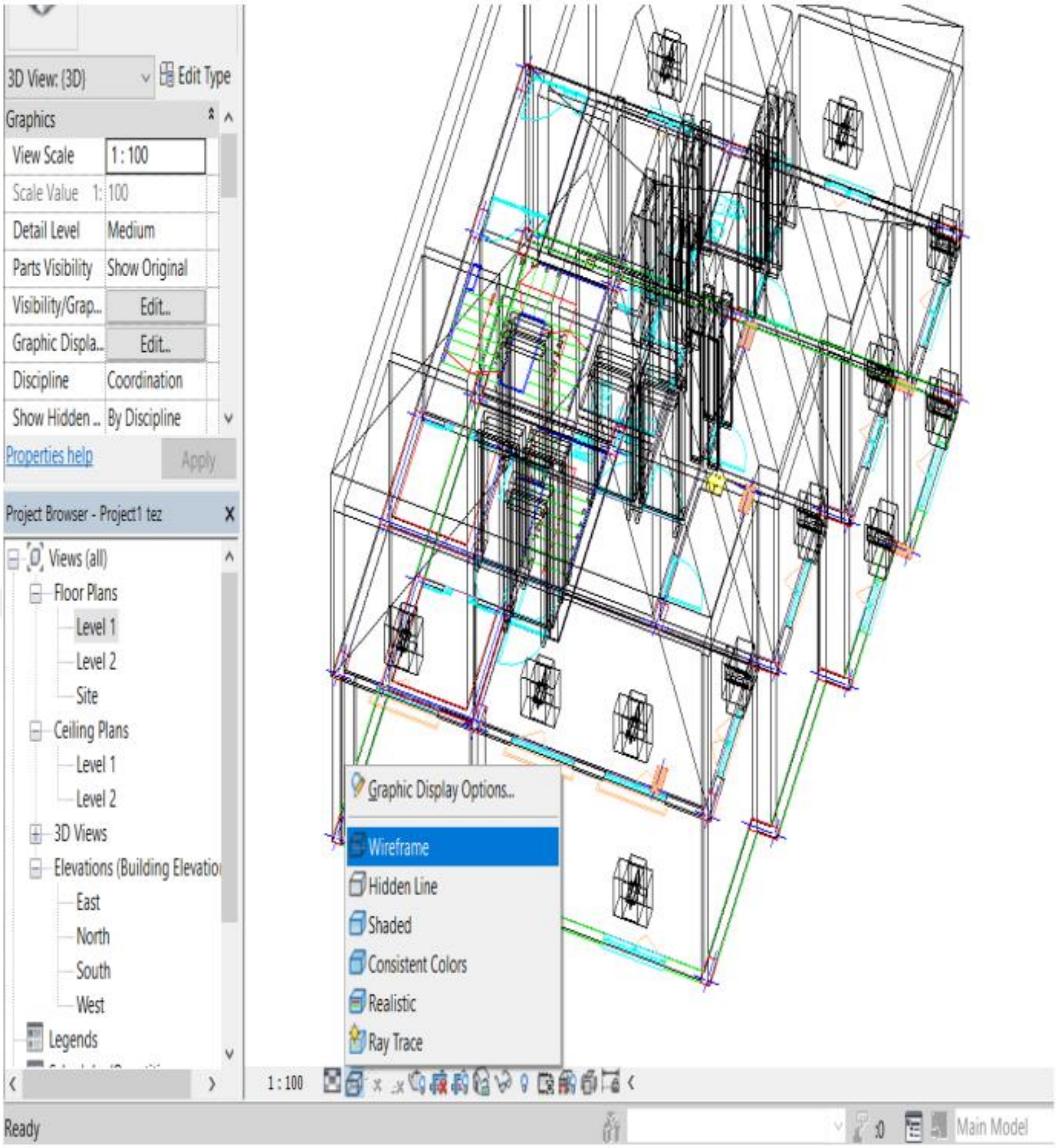


Figure 4.13 wireframe system

Figure 4.13 shows the internal and external details of the project at the same time is possible to see.

To take a cross-section in one of the most difficult stages of architectural projects. Should take into account the structure while taking the cross-section and they should do this while dreaming. But with this method architects imagine the possibility of making mistakes. However, a cross-section of the project drawn with Revit takes place within a few seconds. With the "section" toolbar selected, the section is moved to the desired position and the automatic sectioning.

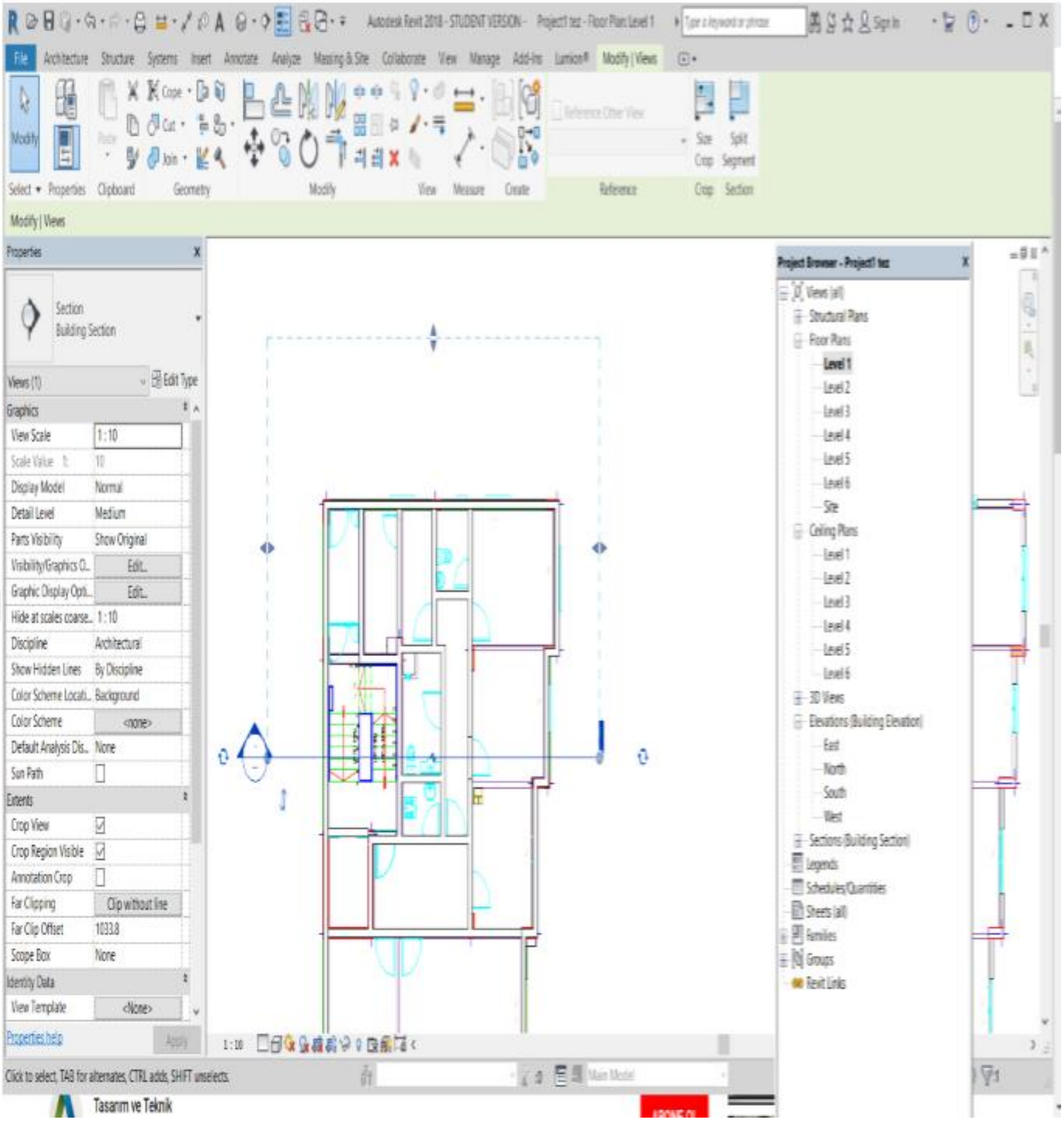


Figure 4.14 Sectioning

Blue colored cross section in the figure above is displayed by selecting the section toolbar from the view tab. The dot is the square section of the section where it wants to be seen.

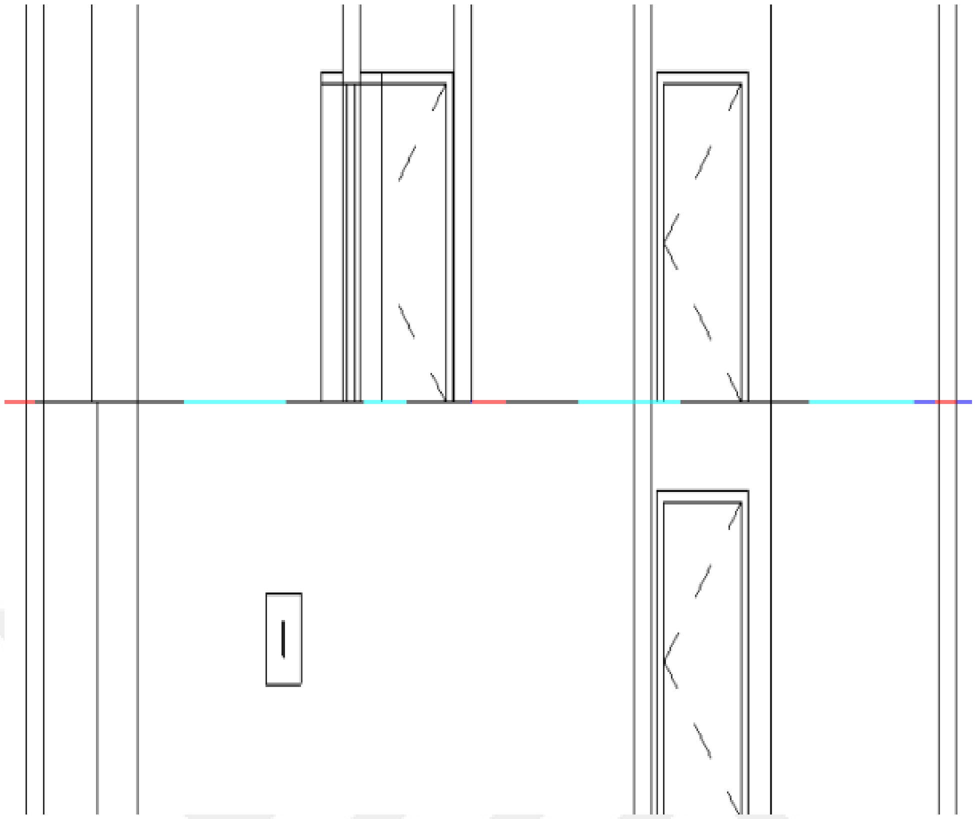


Figure 4.15 View of sectional

Shown in the figure above shows a section taken from the project. The projects drawn by traditional methods have a complex meaning. As all drawings are made up of lines, meaning confusion can be experienced. With this architectural drawing we created, this confusion was largely prevented. Below is the autocad of the project :

Figure 4.16 Traditional architecture

Figure 4.17 below BIM model, architectural features were created with. The BIM model is designed in 3D and clearly identifies what needs to be done. This architectural model was created in less time than the autocad drawing. This is the most important factor in making this process using CAD pad. CAD base system is a commonly used method in the market. The complexity of 2-D drawings and the creation of more time-consuming shows the inefficiency of traditional methods.

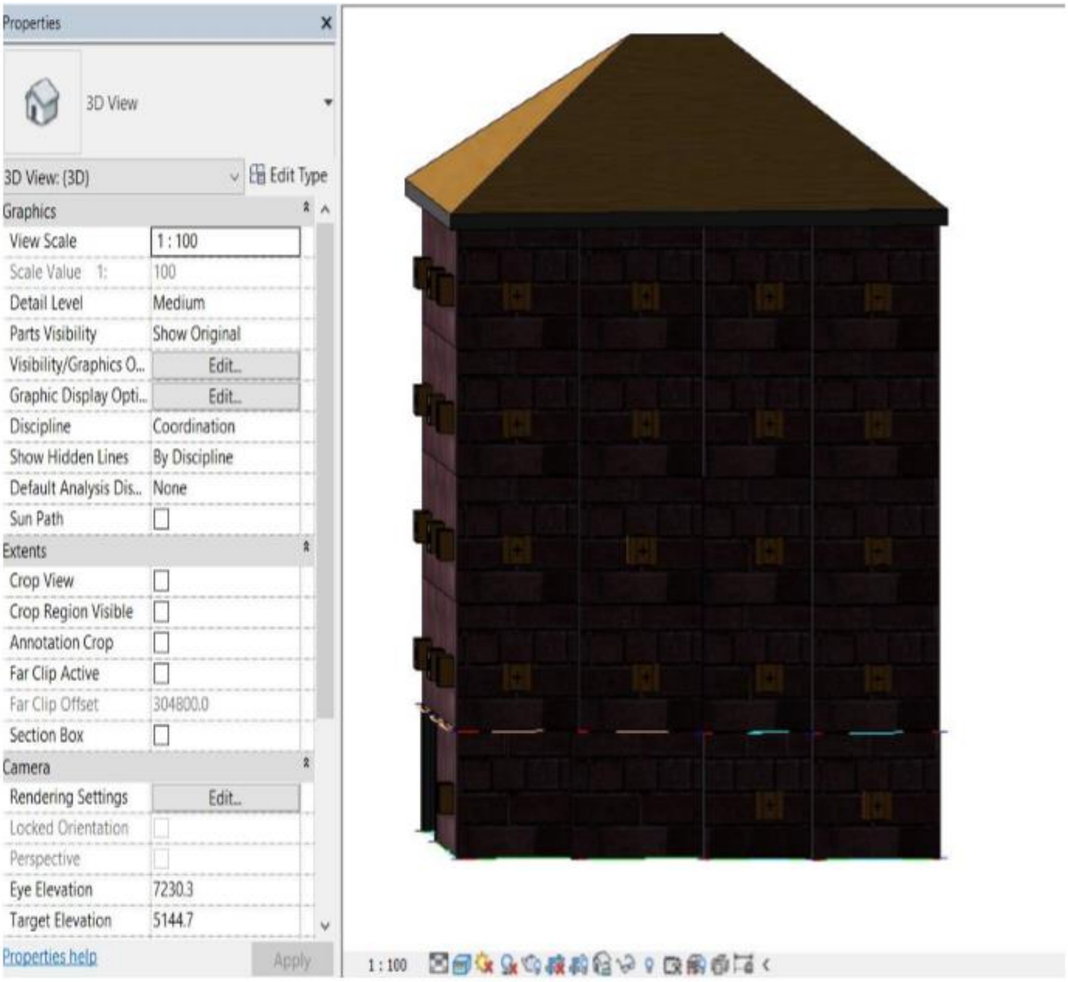


Figure 4.17 Total Building

4.4 Project Time Managemet With BIM

In the project whose design phase is completed, the stages of time and cost management will be evaluated. This process will use the BIM-based software Oracle Primavera P6. This tool consists of time management (4D) and cost management (5D) scenarios in construction projects. The first project is started by creating the enterprise project structure (EPS).

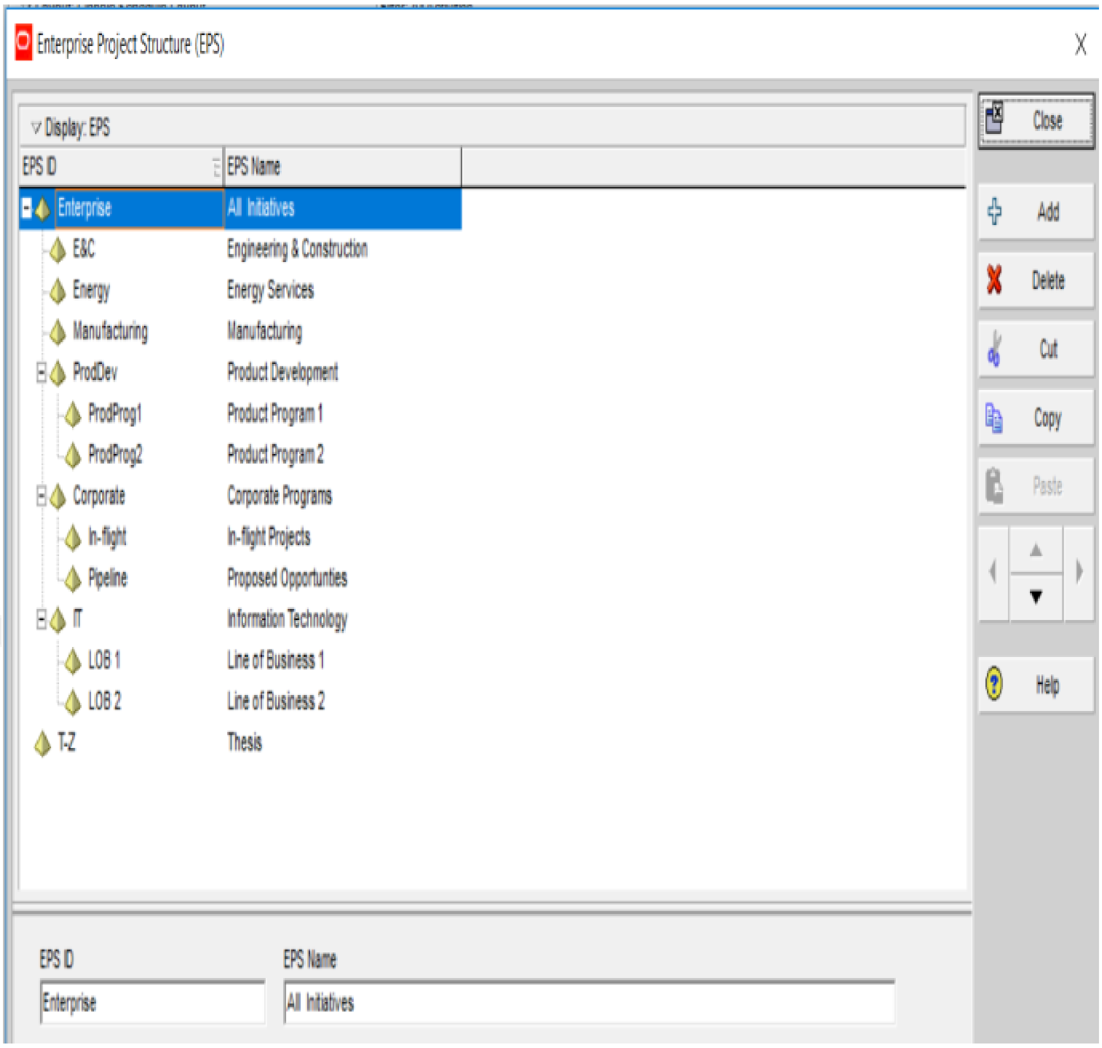


Figure 4.18 Enterprise Project Structure (EPS)

EPS is the structure of the companies in which the projects are grouped in parallel with the organization chart of the company. Pyramid shaped expressions are the name of the group headings of projects.

Figure 4.19 EPS root

Created EPS projects are automatically sent to section projects. The new project opens by pressing the plus (+) or insert section in the generated EPS section. So the project will be defined in. After this process, the project comes to create a work breakdown structure (WBS). Click on the projects tab to open the WBS window. WBS is added with the (+) key on the right toolbar.

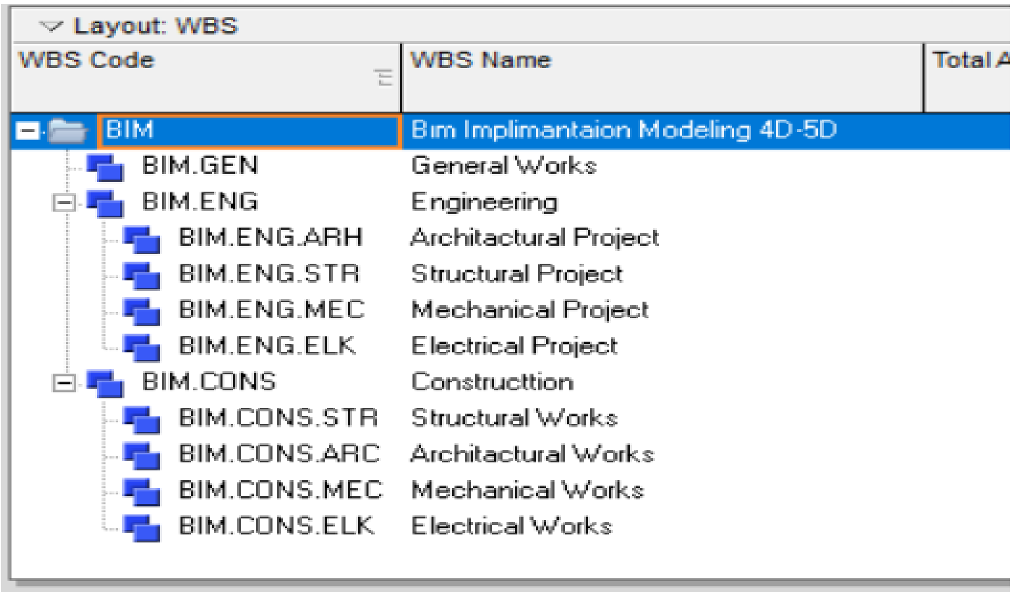
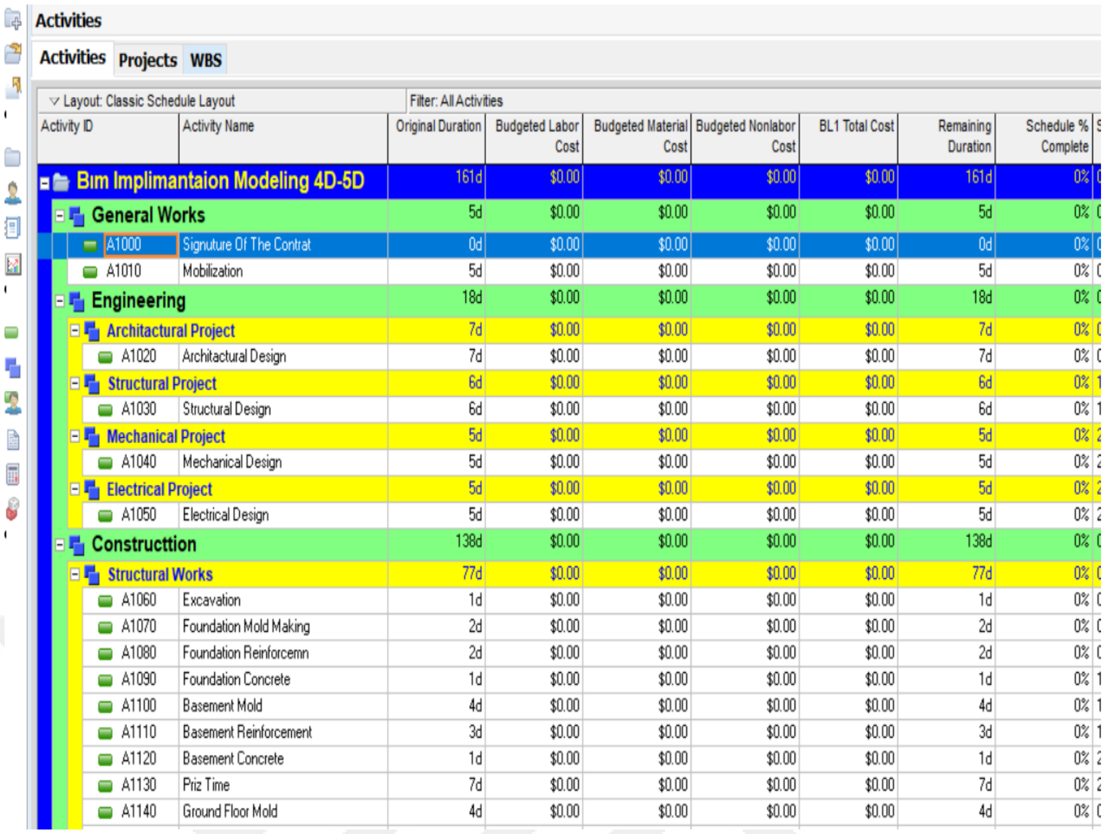


Figure 4.20 Work Breakdown Structure (WBS)

WBS formation will be a common language created within the project itself and will facilitate the classification of activities in the project. Activities of projects where WBS is completed. Activities section is selected in the projects menü.



Activities

Activities | Projects | WBS

Layout: Classic Schedule Layout — Filter: All Activities

Activity ID	Activity Name	Original Duration	Budgeted Labor Cost	Budgeted Material Cost	Budgeted Nonlabor Cost	BL1 Total Cost	Remaining Duration	Schedule % Complete
Bım Implimantaion Modeling 4D-5D		161d	$0.00	$0.00	$0.00	$0.00	161d	0%
General Works		5d	$0.00	$0.00	$0.00	$0.00	5d	0%
A1000	Signuture Of The Contrat	0d	$0.00	$0.00	$0.00	$0.00	0d	0%
A1010	Mobilization	5d	$0.00	$0.00	$0.00	$0.00	5d	0%
Engineering		18d	$0.00	$0.00	$0.00	$0.00	18d	0%
Architactural Project		7d	$0.00	$0.00	$0.00	$0.00	7d	0%
A1020	Architactural Design	7d	$0.00	$0.00	$0.00	$0.00	7d	0%
Structural Project		6d	$0.00	$0.00	$0.00	$0.00	6d	0%
A1030	Structural Design	6d	$0.00	$0.00	$0.00	$0.00	6d	0%
Mechanical Project		5d	$0.00	$0.00	$0.00	$0.00	5d	0%
A1040	Mechanical Design	5d	$0.00	$0.00	$0.00	$0.00	5d	0%
Electrical Project		5d	$0.00	$0.00	$0.00	$0.00	5d	0%
A1050	Electrical Design	5d	$0.00	$0.00	$0.00	$0.00	5d	0%
Constructtion		138d	$0.00	$0.00	$0.00	$0.00	138d	0%
Structural Works		77d	$0.00	$0.00	$0.00	$0.00	77d	0%
A1060	Excavation	1d	$0.00	$0.00	$0.00	$0.00	1d	0%
A1070	Foundation Mold Making	2d	$0.00	$0.00	$0.00	$0.00	2d	0%
A1080	Foundation Reinforcemn	2d	$0.00	$0.00	$0.00	$0.00	2d	0%
A1090	Foundation Concrete	1d	$0.00	$0.00	$0.00	$0.00	1d	0%
A1100	Basement Mold	4d	$0.00	$0.00	$0.00	$0.00	4d	0%
A1110	Basement Reinforcement	3d	$0.00	$0.00	$0.00	$0.00	3d	0%
A1120	Basement Concrete	1d	$0.00	$0.00	$0.00	$0.00	1d	0%
A1130	Priz Time	7d	$0.00	$0.00	$0.00	$0.00	7d	0%
A1140	Ground Floor Mold	4d	$0.00	$0.00	$0.00	$0.00	4d	0%

Figure 4.21 Project Activities

The activities of the project are given in Figure 4.21 above. There are two ways to do this, the first one to enter the activity under the WBS and the second to export to excel. In this project we entered all activities starting from mobilization of our activities. We have written how many days of activities will take place in the original duration section. Time is calculated for all disciplines and time management calculation is done. Where the critical path method is used, and primavera performs this process automatically.

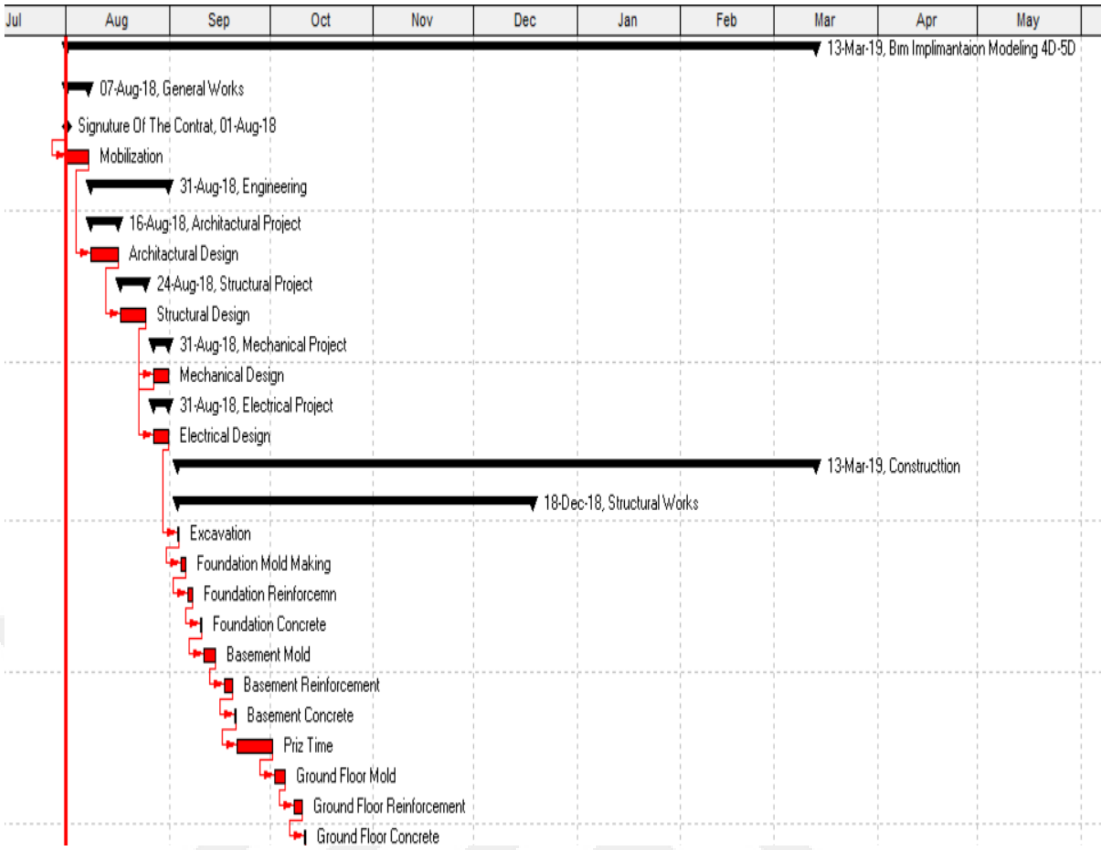


Figure 4.22 Critical Path Method

Activities with red form the critical path. If an activity in the critical road account is delayed it means the project will change at the end date of the project. In this project, a delay in excavation works, for example, will directly block the end date of this project. Managing time is so important. Delayed projects are crushed under increasing cost loads every day. This leads to a budget deficit for owners of goods and this cost reflects the cost to contractors contractors. Customers do not have to pay for this time management error. In order to avoid such mishaps, the project will determine when the production is to be made and the probability of error is minimized.

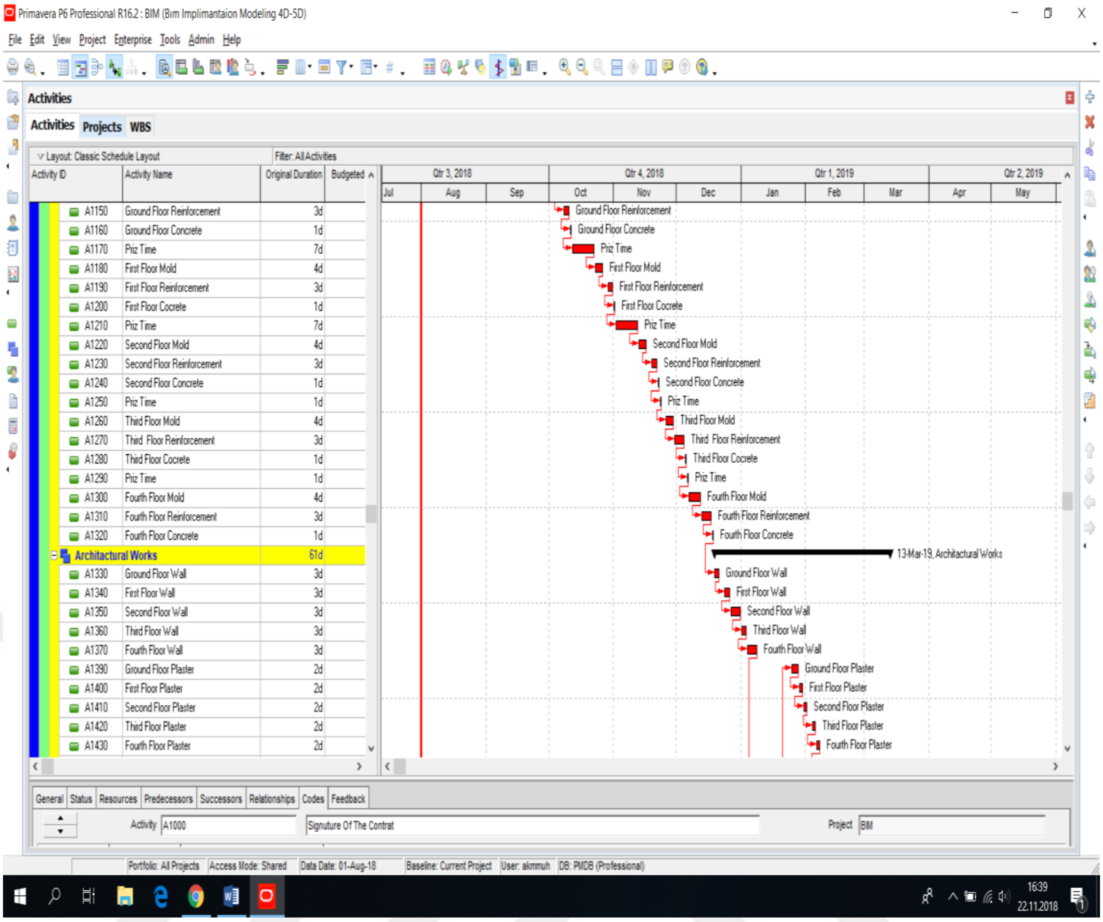


Figure 4.23 Activities and critical path

The duration of manufacturing is evident as in Figure 4.9 and is seen above the critical path. The production period of the project is 138 days, project time is 18 days and other works are programmed for 5 days. What to do every day for these days and how much work will be finished. Schedule and roadmap of my project is prepared and aware of what should not be disrupted. This gives us the opportunity to create new roadmaps in case of a possible business failure. Already these processes are mathematical control and planning of data.

Time analysis is completed, now the cost analysis will be examined through the same software. In the project, earthmoving, iron production, mold manufacturing, wall manufacturing and fine work were calculated and the cost of the project was calculated. Prices of materials and workmanship are priced according to the prices of these works. Resources must be specified first when calculating this cost. Then resources are assigned to activities and pricing is made.

Structural Works		77d	$0.00	$44,800.00	$800.00	$45,600.00
A1060	Excavation	1d	$0.00	$0.00	$800.00	$800.00
A1070	Foundation Mold Making	2d	$0.00	$5,000.00	$0.00	$5,000.00
A1080	Foundation Reinforcemn	2d	$0.00	$3,000.00	$0.00	$3,000.00
A1090	Foundation Concrete	1d	$0.00	$1,800.00	$0.00	$1,800.00
A1100	Basement Mold	4d	$0.00	$6,000.00	$0.00	$6,000.00
A1110	Basement Reinforcement	3d	$0.00	$4,000.00	$0.00	$4,000.00
A1120	Basement Concrete	1d	$0.00	$2,000.00	$0.00	$2,000.00
A1130	Priz Time	7d	$0.00	$0.00	$0.00	$0.00
A1140	Ground Floor Mold	4d	$0.00	$5,000.00	$0.00	$5,000.00
A1150	Ground Floor Reinforcement	3d	$0.00	$5,000.00	$0.00	$5,000.00
A1160	Ground Floor Concrete	1d	$0.00	$2,000.00	$0.00	$2,000.00
A1170	Priz Time	7d	$0.00	$0.00	$0.00	$0.00
A1180	First Floor Mold	4d	$0.00	$5,000.00	$0.00	$5,000.00
A1190	First Floor Reinforcement	3d	$0.00	$4,000.00	$0.00	$4,000.00
A1200	First Floor Cocrete	1d	$0.00	$2,000.00	$0.00	$2,000.00

Figure 4.24 Project cost calculation

As shown in figure 4.24, it is stated how much the activities will cost against them. According to these calculations the cost of this building is 750 thousand Turkish Liras. Calculations in the program were made as dollar accounts. The dollar equivalent of this cost is $ 141.5 thousand according to the exchange rate of the day of this study.

Chapter 5

How to Execute 4D – 5D Simulation

After the analysis for time and cost management, we will examine the progress of the project by using Autodesk Navisworks. A BIM-based program, Autodesk Navisworks analyzes the projects that have been drawn up in all disciplines and shows the analysis of time and cost values according to the progress of the project. It is an important tool for the comparison of planned projects with construction projects. In the case analysis, the formation process of all floors starting from the ground floor was simulated. The progress of the project is shown in 3 dimensions and the project progress is examined in virtual environment before the project starts and offers the opportunity to take measures for possible risks.

The first 3D project we created with Revit is associated with Autodesk Navisworks. Navisworks is not a project creation environment, it is the software that is used to control the project and perform various analyzes. Therefore the previously created project is imported into the Autodesk Navisworks environment. Project Revit can be exported from Navisworks.

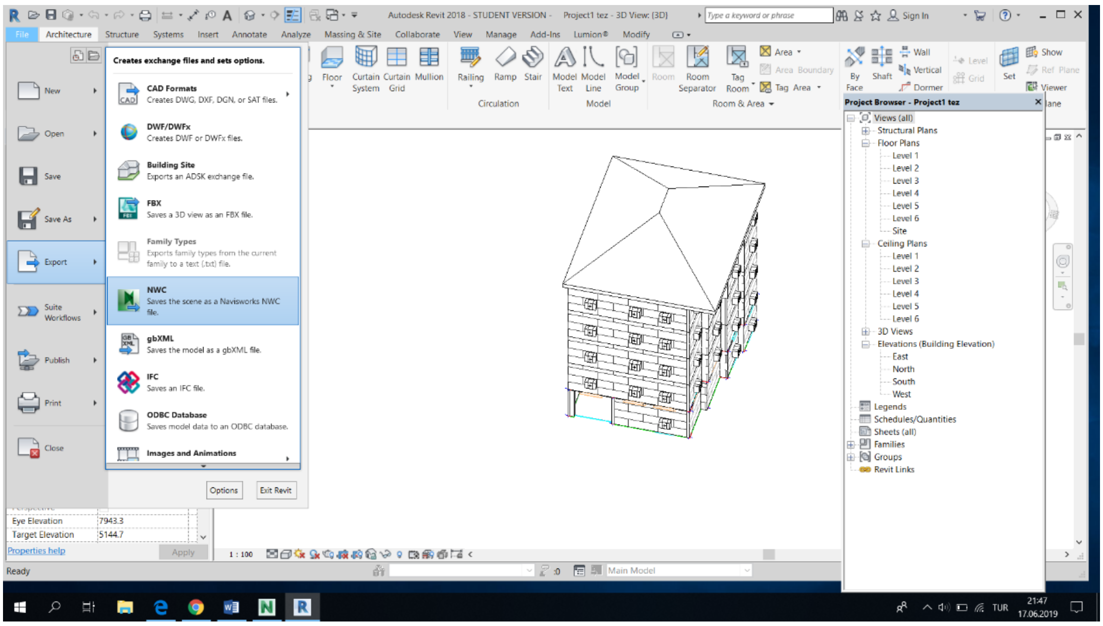


Figure 5.1 Project export Navisworks

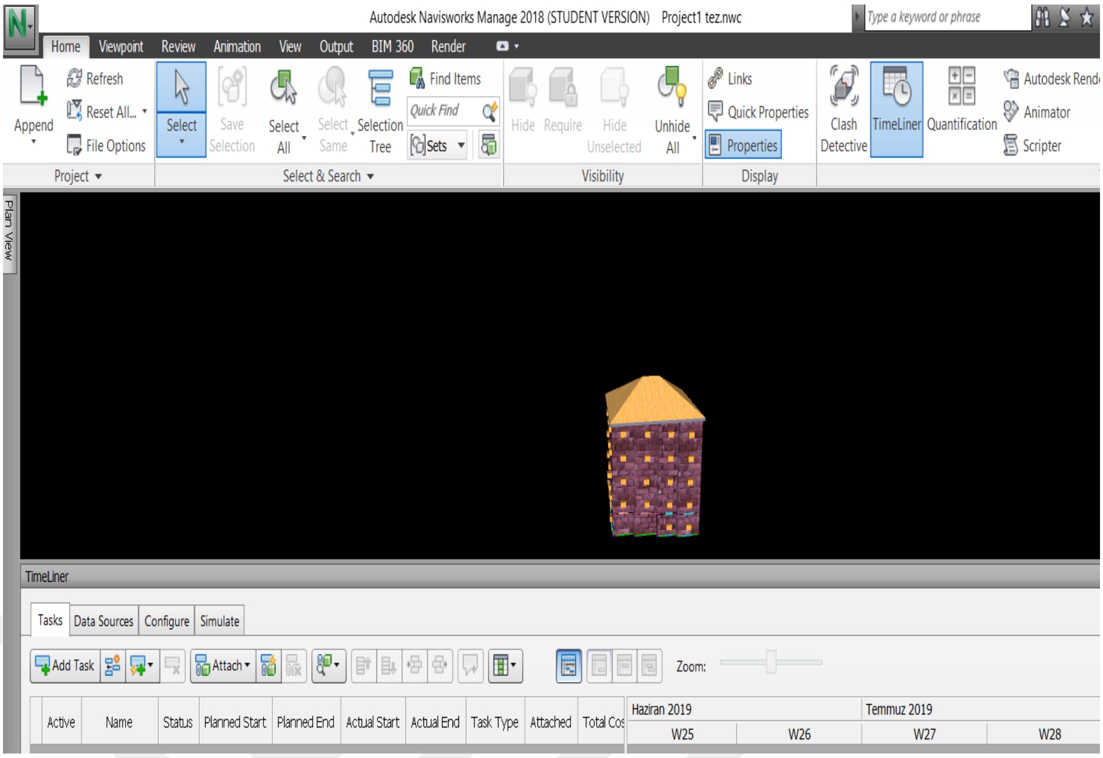


Figure 5.2 Navisworks

Figure 5.2 is also included in the project Navisworks environment. The time schedule to be created is added to the project in the Naviswork environment. This can be done in Naviswork. In addition, the work program in the previously created Primavera P6 software can be integrated into Naviswork.

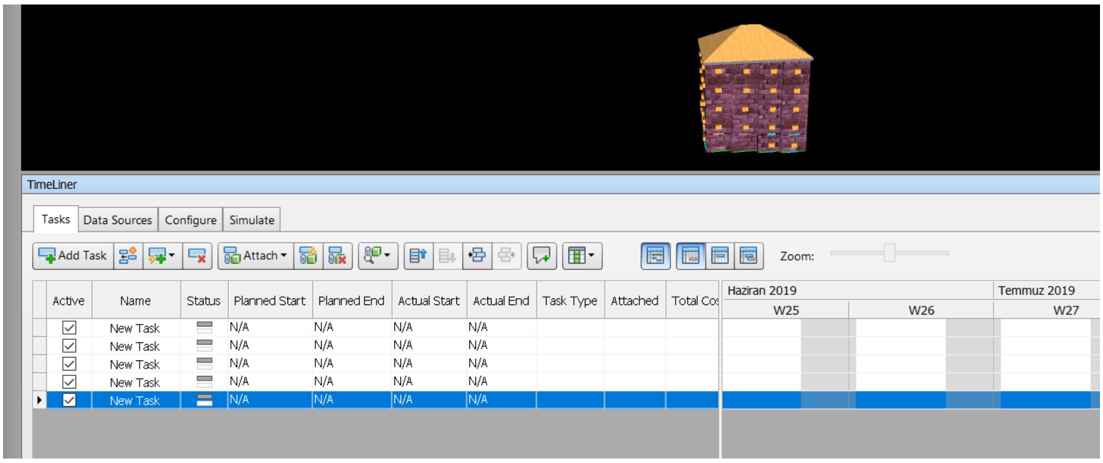


Figure 5.3 Add Task

In Figure 5.3, ıt can add activities with the Add task option. Time and cost calculations can be made.

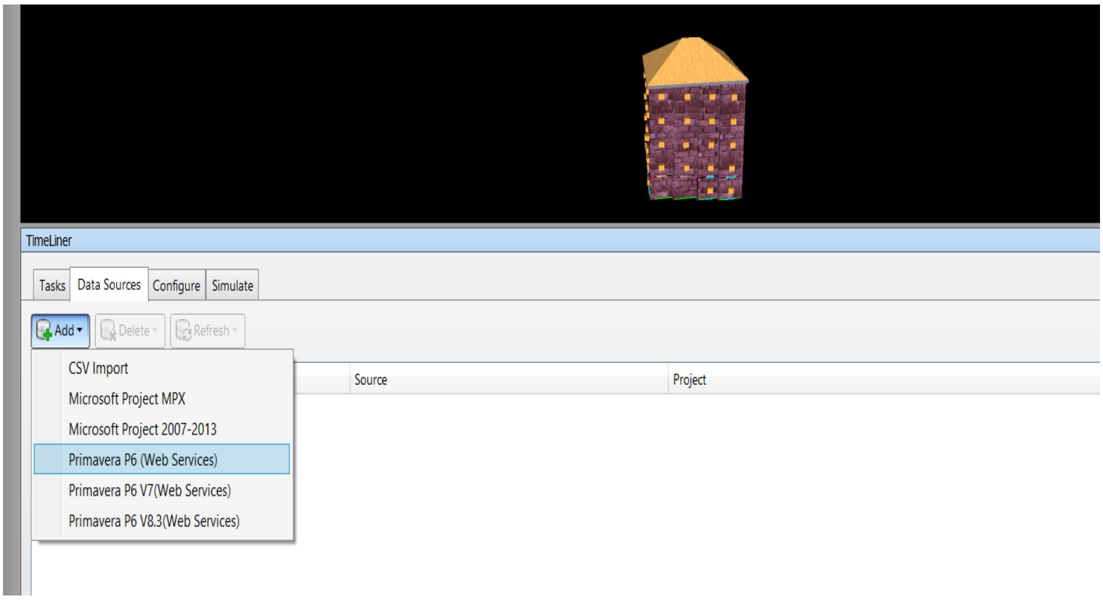


Figure 5.4 Navisworks Add Task

With Primavera and Ms Project programs, previously made plans can be imported into the Naviswork program.

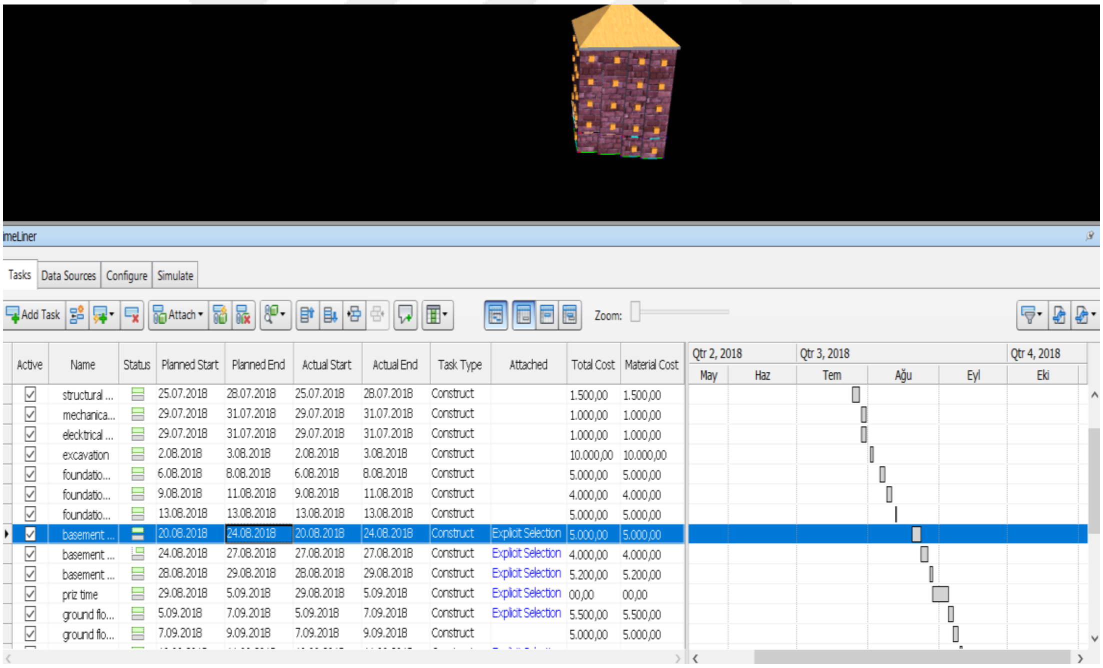


Figure 5.5 Project Activities

As shown in Figure 5.5, the project activities were transferred from Navisworks to Primavera.

Project planning created with Naviswork can be viewed as animation. Simulation moves according to the productions dates in the project.

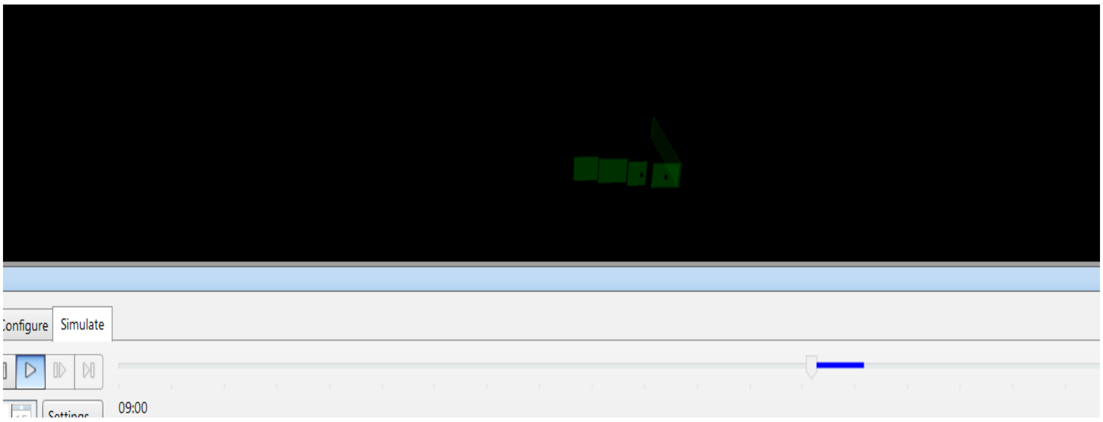


Figure 5.6 Ground Floor Simulation

The formation of the ground floor with green color began. All phases of the project will be shown in the respectively. The activities performed in the project are shown when they will be finished and how long.

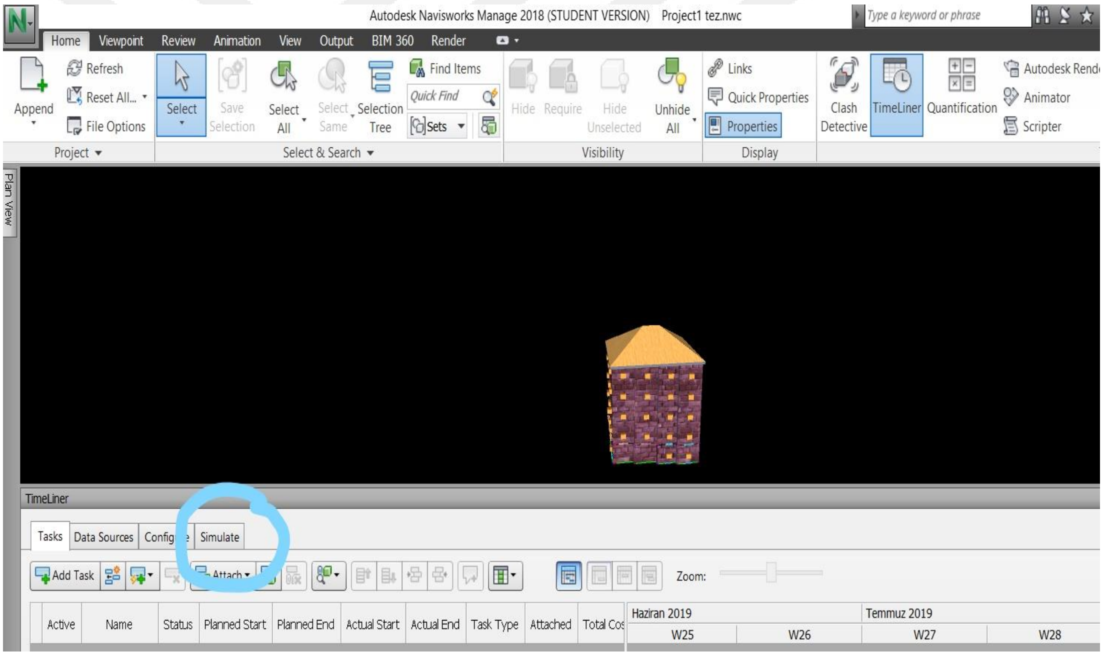


Figure 5.7 Simulation Tool

Start of the project simulation shown above is started with the animation toolbar in figure 5.7. All activities of the projects are monitored visually. This is visually comparable if it lags behind the program. With this visual planning follow-up, all project stakeholders follow the workflow more efficiently. This is an advanced planning.

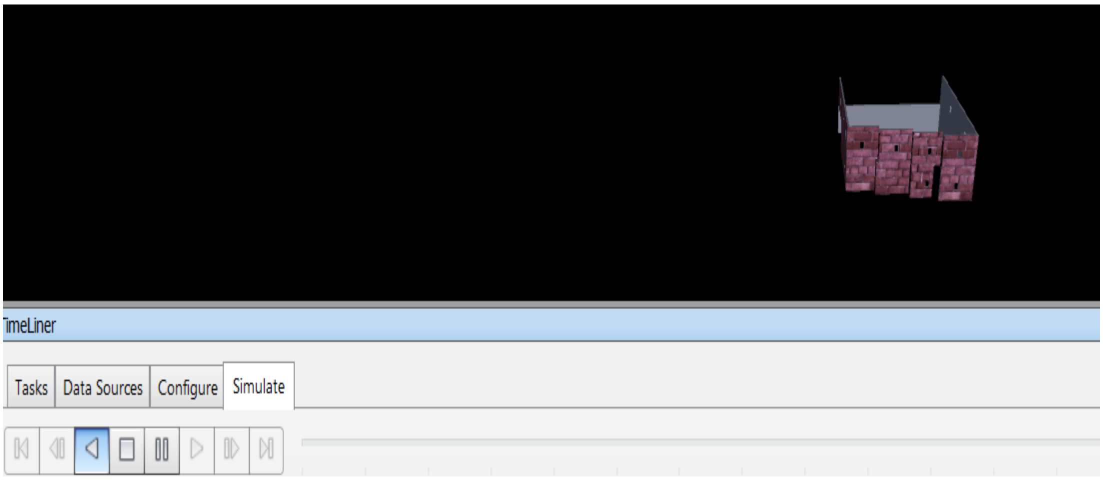


Figure 5.8 First floor simulation

Figure 5.8 shows the first floor simulation of the project using Autodesk Navisworks software. The materials to be used in the project, the productions that need to be made and the identified risks are determined and simulated.

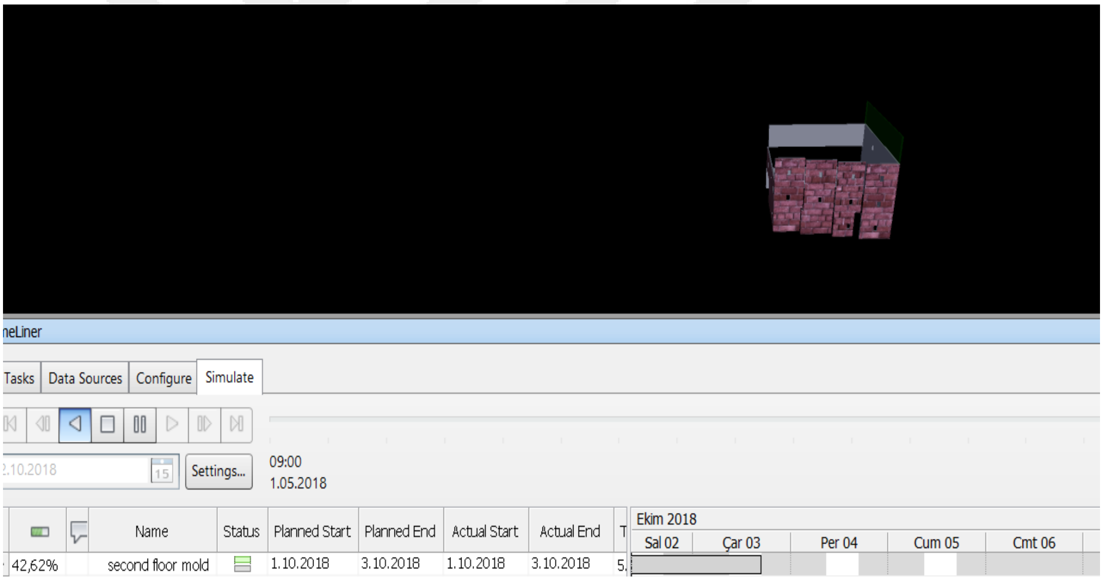
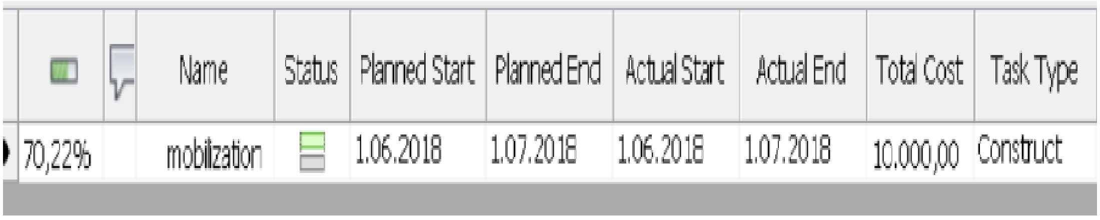


Figure 5.9 Second floor simulation

Figure 5.9 shows the formation of the third floor of the project. The planned start for this phase of the project is shown when the planned end dates are simulated. Against this, the project has actual start and end dates for deviation from this plan. In the case analysis performed, the time schedule and the actual time are programmed together.



		Name	Status	Planned Start	Planned End	Actual Start	Actual End	Total Cost	Task Type
70,22%		mobilization		1.06.2018	1.07.2018	1.06.2018	1.07.2018	10.000,00	Construct

Figure 5.10 Cost calculation

Figure 5.10 shows how much money the mobilization activity

Navisworks can easily be done to take the quantities of productions made in the project. To do this, use the Navisworks Quantification toolbar.

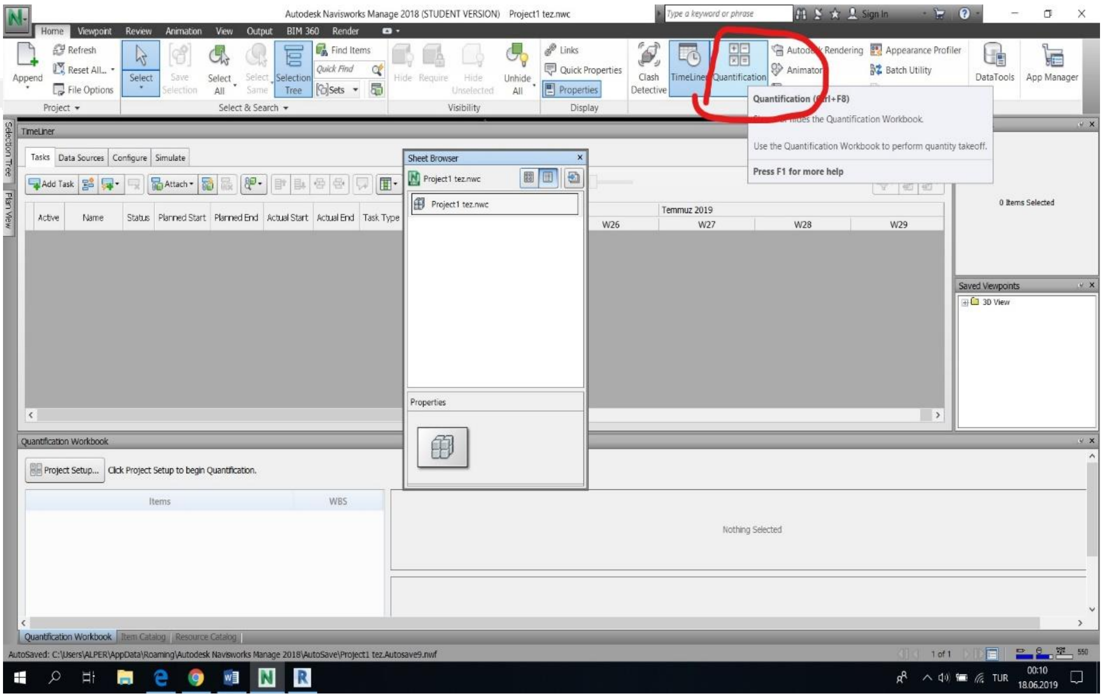


Figure 5.11 Quantification

Then the project quantities are created together with the WBS. This data can be retrieved in excel environment.

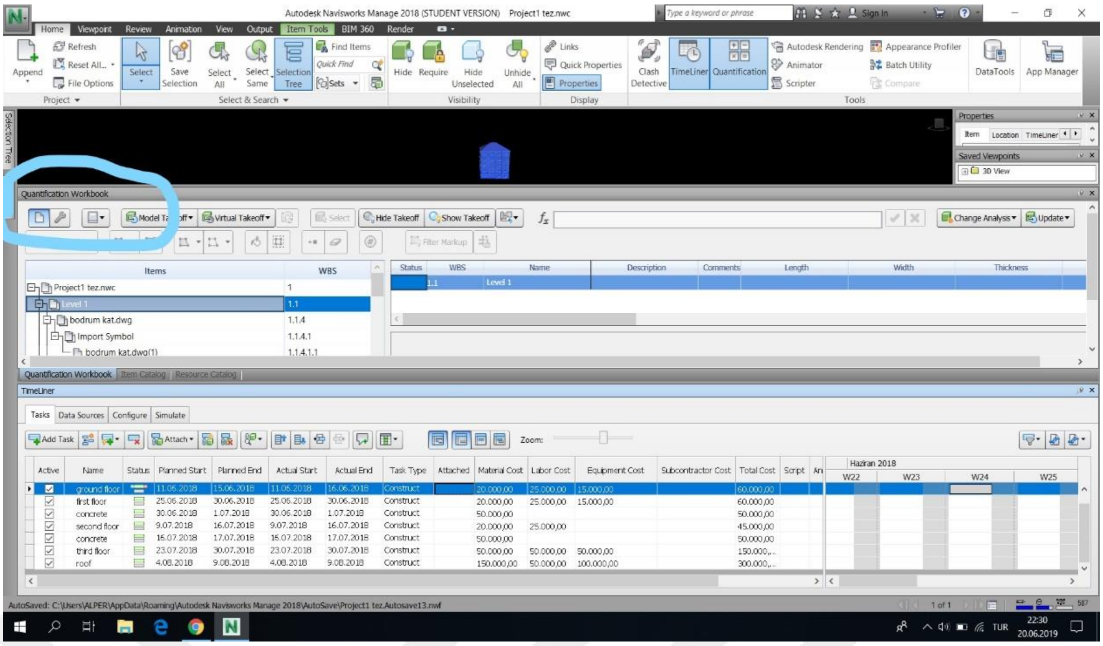


Figure 5.12 Quantity-WBS

The figure below shows how to transfer the project quantity-takeoff from Naviswork to Excel.

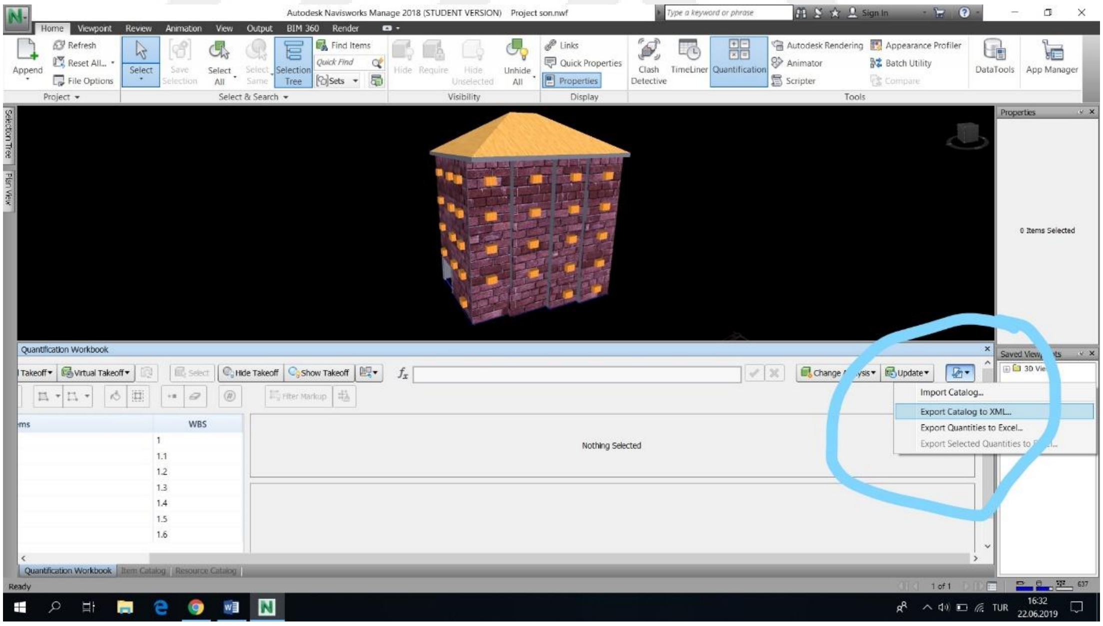
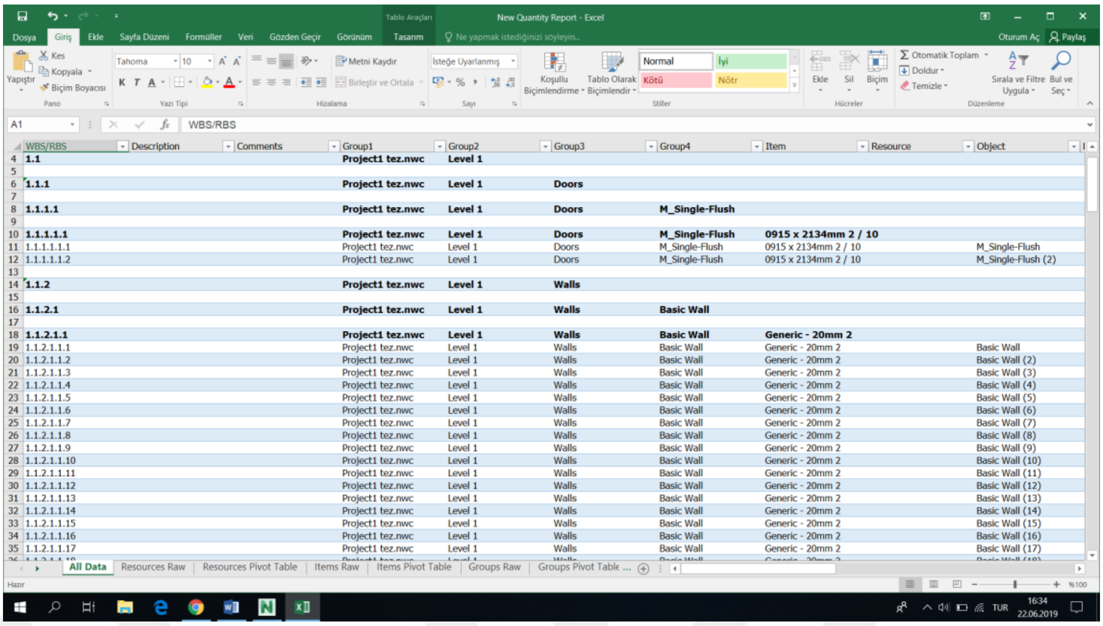


Figure 5.13 Export to Excel

As shown in Figure 5.14, project quantity information has been transferred to Excel.



	WBS/RBS	Description	Comments	Group1	Group2	Group3	Group4	Item	Resource	Object
4	**1.1**			**Project1 tez.nwc**	**Level 1**					
5										
6	**1.1.1**			**Project1 tez.nwc**	**Level 1**	**Doors**				
7										
8	**1.1.1.1**			**Project1 tez.nwc**	**Level 1**	**Doors**	**M_Single-Flush**			
9										
10	**1.1.1.1.1**			**Project1 tez.nwc**	**Level 1**	**Doors**	**M_Single-Flush**	**0915 x 2134mm 2 / 10**		
11	1.1.1.1.1.1			Project1 tez.nwc	Level 1	Doors	M_Single-Flush	0915 x 2134mm 2 / 10		M_Single-Flush
12	1.1.1.1.1.2			Project1 tez.nwc	Level 1	Doors	M_Single-Flush	0915 x 2134mm 2 / 10		M_Single-Flush (2)
13										
14	**1.1.2**			**Project1 tez.nwc**	**Level 1**	**Walls**				
15										
16	**1.1.2.1**			**Project1 tez.nwc**	**Level 1**	**Walls**	**Basic Wall**			
17										
18	**1.1.2.1.1**			**Project1 tez.nwc**	**Level 1**	**Walls**	**Basic Wall**	**Generic - 20mm 2**		
19	1.1.2.1.1.1			Project1 tez.nwc	Level 1	Walls	Basic Wall	Generic - 20mm 2		Basic Wall
20	1.1.2.1.1.2			Project1 tez.nwc	Level 1	Walls	Basic Wall	Generic - 20mm 2		Basic Wall (2)
21	1.1.2.1.1.3			Project1 tez.nwc	Level 1	Walls	Basic Wall	Generic - 20mm 2		Basic Wall (3)
22	1.1.2.1.1.4			Project1 tez.nwc	Level 1	Walls	Basic Wall	Generic - 20mm 2		Basic Wall (4)
23	1.1.2.1.1.5			Project1 tez.nwc	Level 1	Walls	Basic Wall	Generic - 20mm 2		Basic Wall (5)
24	1.1.2.1.1.6			Project1 tez.nwc	Level 1	Walls	Basic Wall	Generic - 20mm 2		Basic Wall (6)
25	1.1.2.1.1.7			Project1 tez.nwc	Level 1	Walls	Basic Wall	Generic - 20mm 2		Basic Wall (7)
26	1.1.2.1.1.8			Project1 tez.nwc	Level 1	Walls	Basic Wall	Generic - 20mm 2		Basic Wall (8)
27	1.1.2.1.1.9			Project1 tez.nwc	Level 1	Walls	Basic Wall	Generic - 20mm 2		Basic Wall (9)
28	1.1.2.1.1.10			Project1 tez.nwc	Level 1	Walls	Basic Wall	Generic - 20mm 2		Basic Wall (10)
29	1.1.2.1.1.11			Project1 tez.nwc	Level 1	Walls	Basic Wall	Generic - 20mm 2		Basic Wall (11)
30	1.1.2.1.1.12			Project1 tez.nwc	Level 1	Walls	Basic Wall	Generic - 20mm 2		Basic Wall (12)
31	1.1.2.1.1.13			Project1 tez.nwc	Level 1	Walls	Basic Wall	Generic - 20mm 2		Basic Wall (13)
32	1.1.2.1.1.14			Project1 tez.nwc	Level 1	Walls	Basic Wall	Generic - 20mm 2		Basic Wall (14)
33	1.1.2.1.1.15			Project1 tez.nwc	Level 1	Walls	Basic Wall	Generic - 20mm 2		Basic Wall (15)
34	1.1.2.1.1.16			Project1 tez.nwc	Level 1	Walls	Basic Wall	Generic - 20mm 2		Basic Wall (16)
35	1.1.2.1.1.17			Project1 tez.nwc	Level 1	Walls	Basic Wall	Generic - 20mm 2		Basic Wall (17)

Figure 5.14 Excel Table of Quantities

The time dependent monetary change of the project (5D) is as follows :

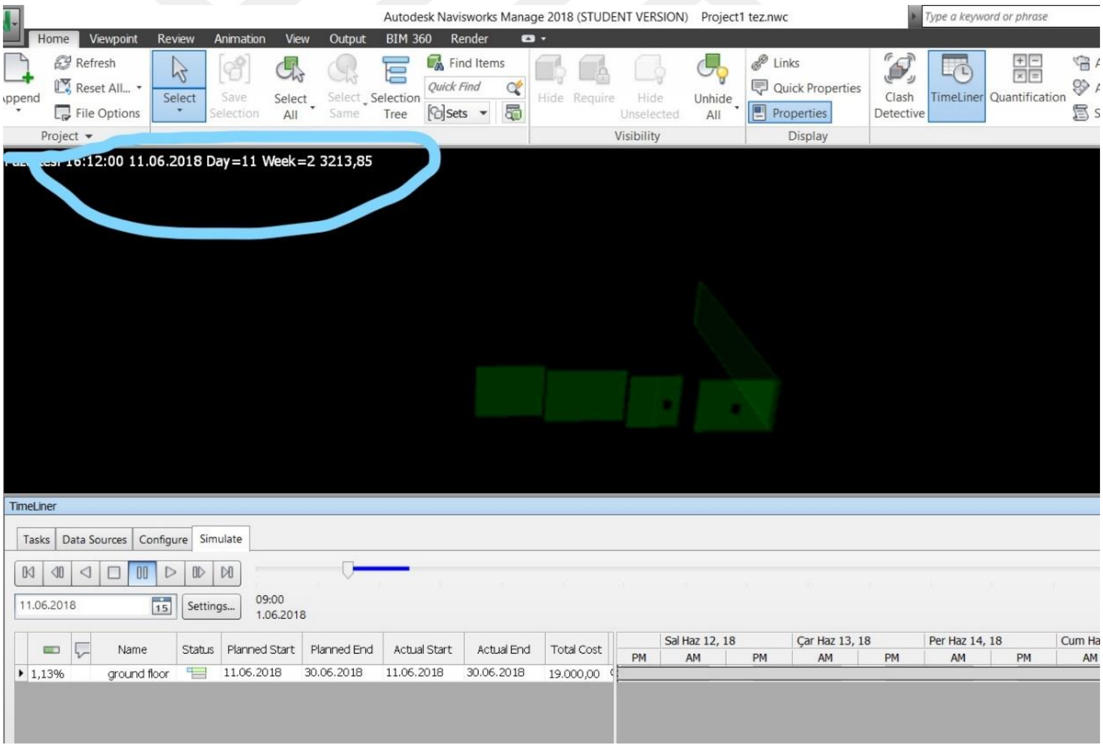


Figure 5.15 Cost simulation

In figure 5.15, the cost of the basement floor in the project is shown together with time simulation. As the project relates, the monetary values for each activity and for all activities are shown.

The progress of the project in another phase is shown in figure 5.16 below. Historical and monetary change is shown step by step in the simulation of change depending on time. This process continues until the end of the project. At the end of the simulation, the project cost and how long it will last is observed.

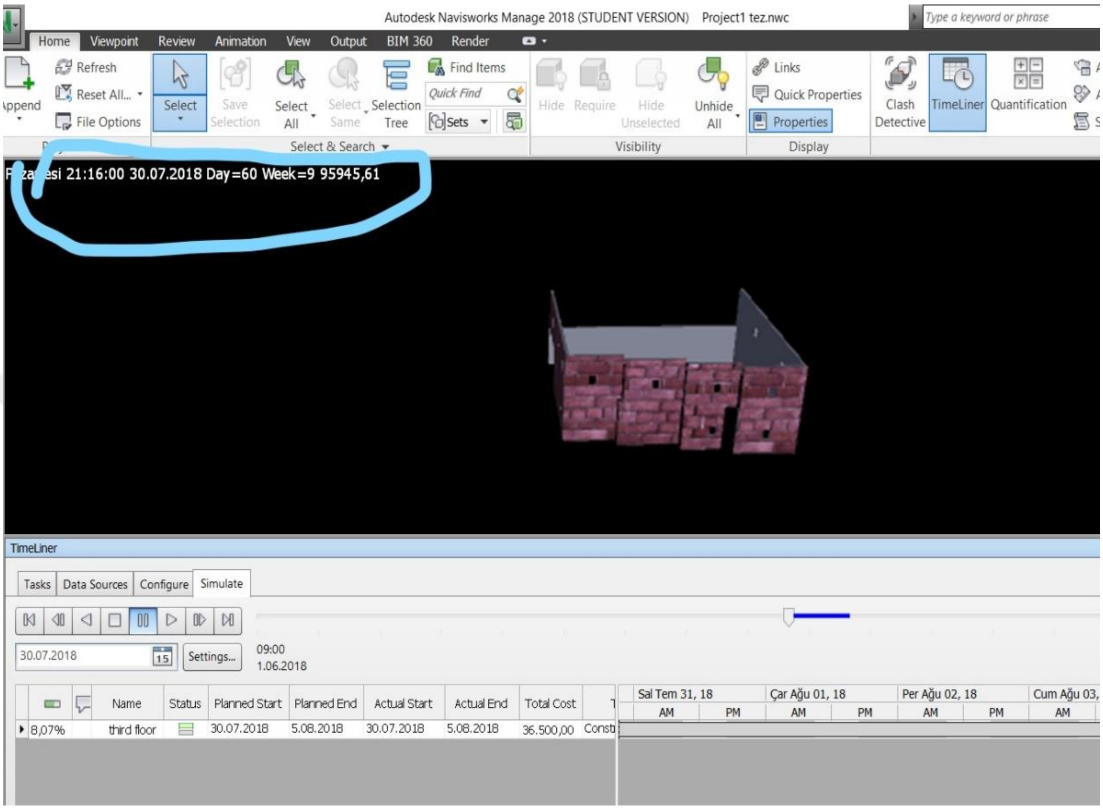


Figure 5.16 Cost progress of the project

The figure below shows how much money will be spent when the project is finalized. The marked sections show the time and monetary progress of the project. The progress of the project in stages can be monitored.

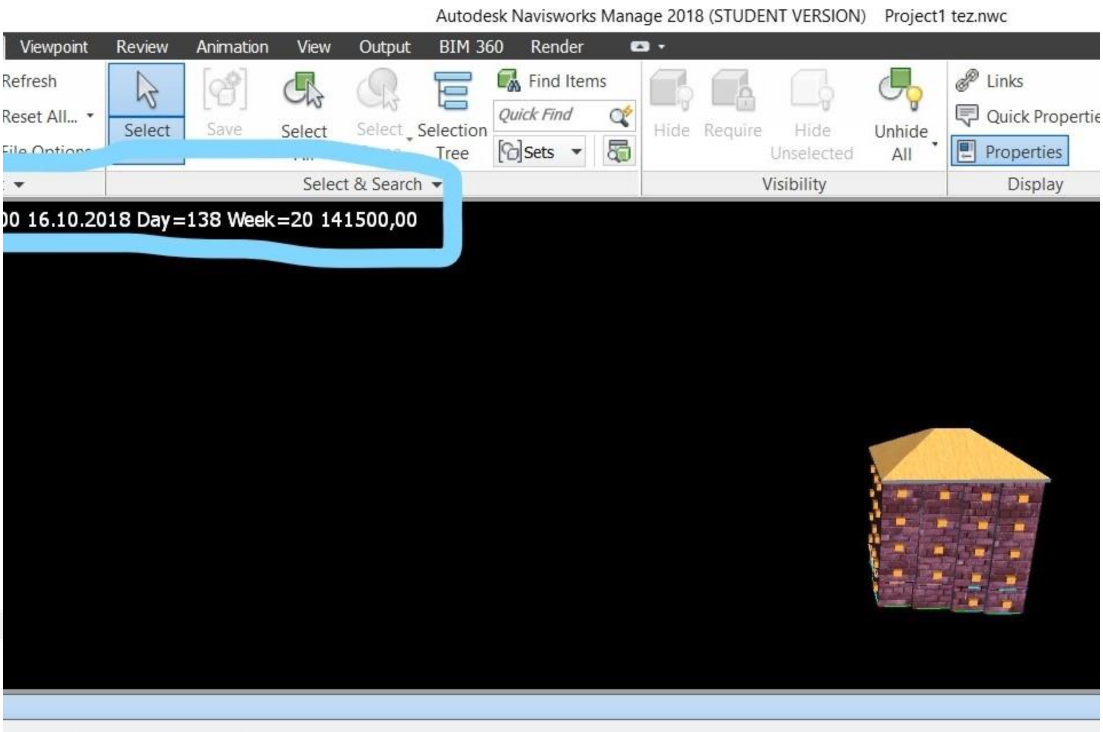


Figure 5.17 Total Simulate

The temporal and monetary simulation of the whole project is shown in Figure 5.17 below. On the other hand, monetary values of project activities are stated. Autodesk Navisworks is used step by step to determine when activities will take place and how much money will be spent on the project.

It would be an important privilege to see this time and money flow at any time in the project. In a multidisciplinary and complex sector such as construction, BIM-based software enables more accurate and accurate analysis. More accurate time and cost management will be provided by project management teams, and accurate analysis will be done by simulating step by step progress.

As mentioned in Chapter 2, the problems of traditional time management are among the administrative problems of not being able to visualize the stage of the project and how it will proceed. The ability to visually observe the activities of a structure is key to identifying problems. Problems detected in the virtual environment can be prevented in real life or faster solutions can be developed. We mentioned that budget management is one of the most important issues. When a building starts manufacturing, money is constantly spent. All these expenditures have different meaning for each discipline. In construction, which is a multidisciplinary sector, money is paid to different dispensers. As mentioned in Chapter 2, money flow control, which is one of the major problems for budget management, is controlled more efficiently than paper and traditional methods by 5D simulation. One important issue in cost analysis is to make incorrect quantity-takeoff and make unnecessary expenditures. In this study, thanks to BIM-based software integrated to each other, error-free quantities are made on the model. In this way, the monetary values to be spent in the activities performed are generated correctly. In this study, the value of money spent against time was determined correctly with 5D simulation. Time and cost management problems mentioned in chapter 2 can be solved by using BIM technology.

Chapter 6

Discussion And Conclusion

6.1 Case study of Rezidential Building Project

Design and engineering phases across the residential house project were provided in the inter-disciplinary communication BIM environment. In the study, it was seen that the 2D project was difficult to understand and imagined by the manufacturing and project teams. A fast dimensioning process was implemented in the project using a 3D design CAD pad. These processes were made easy with Autodesk Revit and the use of objects was achieved through the BIM library. By means of parametric modeling technology, all objects have recognized each other and provided a harmonious merger. Thanks to these automatic combinations, the objects are very clearly placed in their coordinates and their production becomes clearer. Proper modeling during the design phase plays an important guideline for the transition to the construction phase.

Time management is a vital discipline for construction projects. In this case analysis, we focused on this section because many of the small budget housing projects are not scheduled. all activities starting from the basic excavation stage of the project were programmed with Primavera software. A critical line of the project was created and activities that could not be postponed in the project were determined. In the event of a possible program failure, the current program can be revised in a short time to create a new work schedule. It is of particular importance to supply the materials required for the project and to provide the logistics of these materials. When to supply the material is one of the critical steps for time management.

Time management, which has a 5th dimension (5D) perspective, is one of the most important aspects of project management. In the case analysis, cost management was evaluated starting from the rough structure and evaluated all activities of the project. The project will be worth 750 thousand Turkish lira. This indicator is an criticalindicator for the contractor and for the health of the project. The price of the product before the analysis is not determined. Currently, small construction projects do not carry out cost analysis. When we look at the project from a 5D perspective, budget management will become more efficient. With this case study, we had the opportunity to see the monetary equivalents of all activities of the project. The costs and salaries to be paid have been determined and thus the employer creates the cost policy.

6.2 Conclusion

It has been seen that BIM model projects provide efficient opportunities for all stakeholders. It undertakes the task of solving a significant problem such as lack of communication in the construction projects. Project technical team working on the same platform, instant communication is possible with BIM technology. One of the issues in which traditional methods are incomplete is lack of in project communication. At this point, BIM technology supports the communication efficiency positively.

3-D drawings are easy to understand, clearly identifying project details and very clear material definition, accelerates the construction works by project manufacturing teams. The BIM software for architects and engineers in the Project Dimensioning section offers considerable convenience for analysis and proye design. Constructed with traditional methods, construction projects can be designed in more time and cause more errors. The reason for this is that architects imagine their projects in 3D and transfer them to 2D drawings. In the case analysis project, which is dimensioned by Revit, all the objects are designed in their coordinates without causing an error. It is expected that the design will be 3-dimensional and the ease of automatic cross-section can be easily provided for architects. As a result of these facilities, aesthetic and fast projects can be developed by using BIM software in the following days. The creation of project objects in the traditional way for architects is a waste of time. BIM librarycreated with BIM software enables object libraries to save time for each project. In the case analysis project examined, the risk of error occurrence during the design phase is less than that of traditional methods because objects recognize each other as data. The selection of materials, which is an architecturally important subject, will facilitate the work of designers when using BIM. Thanks to the parametric design, the communication of materials with each other provides a useful infrastructure in energy analysis. Thanks to BIM-based software, they approach more accurate results in the design and analysis phases of architectural and engineering professions.

In the case study in which the timetable was created, it was concluded that the project would be completed in 138 days. Which day was determined which activity to do. In the light of this information, the critical path of the project was created and it was revealed that there was no float of activities. Construction projects with a complex structure as a result of these mathematical data have the opportunity to plan a time management plan. Projects with a critical line are readily available because a new roadmap can be created when an undesirable situation develops, and the critical line can be redesigned. Time management, which is an important pillar of construction management, was created with Primavera P6 software. It is planned how much the daily production of the project should go and that the product should come out after 138 days.

The determination of project costs is another critical step for construction management. Failure to make cost planning can cause severe injuries in the construction sector. In the case study, it was concluded that the project would cost 750 thousand Turkish Liras. The evaluation of all disciplines and the analysis of the data revealed the amount of money to be paid to the activity. As a result of this calculation, any supplier or subcontractor money and the service they provide shall be clearly defined in both parties. The expected amount of work and the amount of money to be paid in a professional manner makes the definition of the work clearer. This cost analysis of the Primavera P6 software provided guidance on how to use resources in the project. Provides the opportunity to transfer resources and to see the front of the project when needed.

As a result of the investigations carried out in this study, it has been revealed that the construction sector should benefit from the blessings of BIM technology. This study aims to create an awareness for the use of this technology, which makes project management more efficient than traditional methods. As a result of the literature studies and case analysis, it was understood how necessary for BIM construction sector. The digital transformation of the construction sector will develop under the leadership of BIM technologies.

6.3 Future Work

This research has prepared an area for further research and development. These are as follows:

- The addition of BIM training to the curriculum in engineering and architecture will be useful for training technical staff.

- The positive impact of BIM on the construction sector is that it is necessary for the responsible government agencies to do their job.

- Defining BIM libraries in building material companies.

- That the time and cost calculation for the efficient use of resources should be done by the professional assistance of the contractors themselves.

- That many structures are transferred to future generations as a sustainable work and control of wasted energy in facility management is possible with BIM Technologie

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