

**T.C.
HASAN KALYONCU UNIVERSITY
GRADUATE SCHOOL OF
NATURAL AND APPLIED SCIENCES**

**BIM IMPLIMENTATION IN INFRASTRUCTURE
PROJECT: A CASE STUDY OF GAZIANTEP
UNDERGROUND PROJECT**

**MSc. THESIS
IN
CIVIL ENGINEERING**

**BY
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JANUARY, 2021**

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**BIM Implimentation in Infrastructure Project: A case
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MSc. Thesis

In

Civil Engineering

Hasan Kalyoncu University

Supervisor

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By

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JANUARY 2021



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Ahmet Kutalmis KOCOGLU

ABSTRACT

BIM Implimentation in Infrastructure Project: A case Study of Gaziantep Underground Project

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Project management process of infrastructure projects in public institutions is managed by traditional construction methods. Building Information Modeling (BIM) is an innovative project management approach to integrate the planning, design, construction, and operation of a building in 3D and beyond. The integration and implementation of public projects into BIM-based project management processes will facilitate the management of transportation projects from the design stage to the operating process. The aim of this study is to evaluate the advantages and disadvantages of developing effective BIM application methods in Gaziantep Underground project, which is a public project. It is aimed to investigate its usability in other public projects. BIM applications in infrastructure projects around the world have provided significant benefits in project management and field applications. The hypothesis in this study is that the BIM application to be applied correctly in a local public project will be an exemplary application in public projects at national level and in infrastructure projects for the private sector. Project method case study and quantitative methods will be applied. BIM applications enabled us to obtain information and performance based structures. Made significant contributions in terms of time and budget.

Keywords: Transportation, Building Information Modeling, Gaziantep Underground, Rail System, Engineering Application

ÖZET

Altyapı Projelerinde BIM Uygulaması: Gaziantep Metro Projesi

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Kamu kurumlarında altyapı projelerin proje yönetimi süreci geleneksel inşaat methodlarıyla yönetilmektedir. Yapı Bilgi Modellemesi (BIM), bir binanın planlama, tasarım, inşaat ve işletme sürecini 3B ve ötesine entegre etmek için yenilikçi bir proje yönetim yaklaşımıdır. Kamu projelerinin BIM tabanlı proje yönetim süreçlerine entegrasyonu ve uygulaması ulaşım projelerinin tasarım aşamasından işletme sürecine kadar yönetimini kolaylaştıracaktır. Bu çalışmanın amacı kamu projesi olan Gaziantep metro projesinde efektif BIM uygulama methodlarının geliştirilmesi avantaj ve dezavantajlarının değerlendirilmesi. Diğer kamu projelerinde kullanılabilirliğinin araştırılması hedeflenmektedir. Dünya'daki altyapı projelerinde BIM uygulamaları proje yönetimi ve saha uygulamalarında önemli fayda sağlamıştır. Bu çalışmada hipotezi, yerel bir kamu projesinde doğru uygulanacak BIM uygulaması ulusal düzeyde kamu projeleri ve özel sektör için altyapı projelerinde örnek uygulama olacaktır. Proje methodu vaka çalışması ve nicel yöntemler uygulanacaktır. BIM uygulamaları bilgi ve performans bazlı yapılar elde etmemize sağladı. Zaman ve bütçesel anlamda önemli katkılar sundu.

Anahtar Kelimeler: Ulaşım, Yapı Bilgi Modellemesi, Gaziantep Metro, Raylı Sistem, Mühendislik Uygulaması

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ABBREVIATIONS

AR	Augmented Reality
BHS	Baggage Handling System
BIM	Building Information Modelling
BOQ	Bill of Quantities
CAD	Computer Aided Design
CCL	Collaboration Communication and Learning
CM	Construction Manager
DCC	Document Control Center
DM	Design Management
FM	Facility Management
ICT	Information and Communications Technology
IFC	Industrial Foundation Classes
IGA	Istanbul Grand Airport
IM	Information Management
IT	Information Technology
LoD	Level of Detail
MAF	Material Approval Form
MEP	Mechanical Electrical Plumbing
MS	Method Statement
NWC	Navisworks Cache
NWD	Navisworks Document
PM	Performance Management
RFI	Request for Information
SAS	Special Airport Systems
2D	Two Dimensional
3D	Three Dimensional
4D	Four Dimensional
5D	Five Dimensional

6D	Six Dimensional
7D	Seven Dimensional
TBM	Tunnel boring machine
NATM	New Austrian Tunneling Method
GTMP	Gaziantep Transportation Master Plan
GOA4	Driverless Underground



CHAPTER 1

1.1 Introduction

BIM is a digital representation of the physical and functional characteristics of a facility. Therefore, it serves as a source of information where all data about a facility can be shared and a platform where all stakeholders can work together. It provides a reliable basis for decisions made throughout the life cycle from the start of the project. BIM is at the heart of the collaborative, next-generation project management approach supported by digital technologies, allowing more efficient methods to design, deliver and maintain assets to be physically constructed throughout the entire life cycle of the project. All stakeholders of a project, including employers, planners, designers, engineers, managers, occupational health providers, environmentalists, contractors, manufacturers, risk managers, first responders, and demolition contractors, can benefit by accessing BIM. Thanks to the software that enables the management of the process, everyone at different stages and layers, from employers to engineers, from contractors to architects, can easily access up-to-date information and details about the project process. The use of which is mandatory in many countries, particularly Britain, BIM, the utilization rate in Turkey is increasing everyday. BIM, which can be used actively in all steps from the planning and design phase of a project to the construction and finalization part, ensures that the construction teams are in communication with each other and the flow of information between different levels. In addition, BIM is not an architectural software or architectural program; is an information management system. In international construction projects, BIM applications are accepted as a common language where the cloud-based communication network is used to certain international standards. Countries have an obligation to deliver BIM-based projects in project delivery processes. The governments of countries such as the United Kingdom, the United States, Norway, Finland, and Singapore have made the use of BIM mandatory for contractors and designers in contracts for their contracting construction projects. Many governments outside these countries have started to emphasize the BIM requirement by supporting the industry with various BIM solutions.

In Turkey the use of BIM has become increasingly common in the last few years. For example, it has become mandatory to work with the BIM system in rail system projects in Istanbul. Thus, international construction and design companies that switch to BIM early have a competitive edge against their competitors who have not yet met BIM and are late to invest in this technology.

Benefiting from Building Information Modeling has advantages from different angles. It allows to identify problems that may occur in the later stages of the project before they occur at the design stage.

It allows all units working in the project to work synchronously and to progress the project process as a whole.

- It minimizes the margin of error in the cost calculation phase and maintains the controlled cash flow throughout the project.
- It saves time and extra expense by preventing repetition of jobs.
- It increases the motivation, efficiency and productivity of all units by making all the details of the project visible through architectural modeling and architectural visualization.
- It stores the data in the project so that it can be used in later stages.
- It facilitates the emergence and conclusion of the decisions that can be made regarding the project.
- It allows a transparent and clear work flow for all parties by removing uncertainties.
- It supports the minimization of possible waste and thus accelerates the increase of environmentally sensitive projects.
- Ensures that government contracts are complied with without any problems.

1.2 Underground Project Management and Field Applications

Project management is the discipline of planning, organizing, procuring and managing resources to achieve and complete a specific project's goals and objectives.

Projects are used to achieve specific specific goals and objectives, to bring useful change or to add value. Projects have a certain start and end date, with a margin of flexibility. Being temporary; makes them permanent, repetitive, different from the usual business operations for production and service purposes. In practice, the management of these two types of systems is quite different and requires different technical skills.

The main effort in project management does not go beyond the pre-determined project constraints while trying to achieve the project goals and objectives. Typical project constraints are scope, time and budget.

Generally, project management includes five stages. These stages are generally:

- Initiation,
- Planning,
- Execution,
- Monitoring and Control,
- Shutdown.

Starting the Project:

The initiation process determines the nature and scope of the project. If this phase is not carried out properly, the project will be unlikely to meet the needs of the organization. It is very important to understand the business environment well and to add the necessary controls to the project during the initiation phase. At this stage, any deficiencies in project design should be identified and corrected immediately.

The initiation phase should include a plan covering the following areas:

- Analyzing the needs and requirements of the organization according to measurable goals,
- Reviewing current operations,
- Financial analysis of benefits and costs including the budget,

- Shareholder analysis including users and support staff,
- A project contract including cost, tasks, products, and timetable.

Project Planning:

After the initiation phase, the project is planned to a suitable level of detail. The main goal is to estimate the costs and resources required for the project and effectively manage the risks in project implementation. Errors in the planning phase will also cause major obstacles to the success of the project, such as the initiation phase.

The planning phase generally includes:

- To determine how planning will be done,
- To improve the scope statement,
- Choosing the planning team,
- To define the products to be formed and to create a business separation structure,
- Estimating resource requirements for activities,
- Estimating the time and cost required for activities,
- To prepare the time schedule,
- To prepare the budget,
- Risk planning,
- Obtaining formal approval to start the business.

Project Execution:

The implementation phase consists of processes aimed at meeting the project requirements specified in the project management plan. This phase includes efforts to coordinate people and resources, as well as to bring their activities into line with the project management plan. The products are formed as the outputs of the processes realized according to the project management plan.

Project Monitoring and Control:

The supervision and control phase consists of processes aimed at detecting the problems in the project implementation on time and controlling the timely taking and implementation of corrective actions. An important benefit of this phase is the realization of differences in implementation from the project management plan, thanks to the monitoring and measurement of project performance.

Supervision and audit phase includes the following processes:

- To measure the completion of project activities,
- To monitor project variables such as cost, scope and compare them with the project management plan,
- Determining corrective actions for problems and risks,
- With Earned Value Analysis, it is possible to monitor the progress of the project in terms of time and budget, and to make estimates about the completion time and budget of the project.

Project Closing:

Closing includes the formal completion of the project. Administrative activities include archiving files and documenting lessons learned.

This stage includes the following processes:

- All activities in all process groups are terminated.
- Closing all contracts.

1.3 BIM Use in Underground Project in Turkey

In order to solve many problems encountered in the construction industry, a transition from the traditional to a more integrated project management is taking place all over the world. The most important innovation to achieve this transition is seen as Building Information Modeling (BIM).

BIM is a construction management tool that digitally combines all the components in a building and their relationships with each other on a 3-dimensional model. BIM allows stakeholders to work collaboratively on the same model throughout the project life cycle and to eliminate inconsistencies between models.

All stakeholders in the construction sector must first be informed about BIM from employer to designer, from contractor to supplier, and then to be involved in BIM applications. In addition, Istanbul Undergroundpolitan Municipality (IMM) has started the Smart City Project in line with its vision and strategic goals. This vision includes many different subjects such as city management, economy, finance, mobility, accessibility, energy and infrastructure management, education, environment, water and waste management, security, health, information technologies. All of these are combined in an integrated system with BIM support.

Likewise, Gaziantep Undergroundpolitan Municipality, with a decision taken in 2017, decided to use the BIM system in the Underground Project and took an important step to make Gaziantep a Smart City with the project. The project has been carried out BIM-based project management in the region's first and single rail system. BIM system has been adopted to be used in manufacturing, management and operation stages from the projecting stage. At the same time Gaziantep Undergroundpolitan Municipality for its support and make relevant presentations at universities in the region with BIM in various organizations gives support to Turkey's digital conversion.

Both public and private sectors play an important role in the spread of BIM. Our thesis is discussed both the theoretical and practical basics of BIM are offered both examples of current practices that took place in Turkey.

It is a fact that every innovation requires change and is not easy. The transition process to BIM will not be easy either. However, the determination and determination to be shown in this subject will be the basis for the success of BIM applications. It is for this reason that senior management in all institutions is expected to be supportive in this regard.

1.4 Research Questions

Research questions ‘define an investigation, provide direction, and set boundaries act as a frame of reference for assessing the research work. This research deals with proposing BIM roadmaps and an intelligent strategy for development BIM implimentation in infrastructure project. To achieve the research, aim and objectives, and based on the research gaps, the following research questions are identified to challenge in the research;

- How Digital Conversion is carried out in the construction sector in Turkey?
- In which infrastructure projects BIM was implemented in Turkey?
- How are engineering applications in infrastructure projects?
- What conditions should be established for successful BIM implementation in public infrastructure projects?
- How was BIM implemented in Gaziantep Underground Project?
- What is the importance and benefit of BIM in the operation of Underground projects?

1.5 Research Methodology

Will cover the research methodology approach that is applied in the study with a rigorous discussion and justifications. This will then pave the way in the research to better rationalization of the follow up chapters.

1.6 Thesis Guide

This section involves the entire structure guide to the thesis just as an introductory study overview to give a general knowledge or idea of what the chapter involve.

1.7 Discussion and Conclusion

The relevant chapters provide the general result of the thesis, provide a summary of the findings, and match the research objectives with the results in the research. It also makes recommendations for future research and also highlights how this research contributes to knowledge and practice.

CHAPTER 2

BIM APPLICATION IN INFRASTRUCTURE PROJECTS

2.1 Introduction

More and more infrastructure projects are modeled and managed with a building information modeling (BIM) system. Many companies in the industry have started the digital transformation process to compete and gain new business. Projects using the BIM-based approach are accompanied by a number of attractive advantages: less rework, fewer errors, improved collaboration, as well as design data that can be used to support operations, maintenance and asset management. Construction infrastructure owners, including government agencies, do not want to miss these advantages and are increasingly making the use of bim in their projects mandatory.

Even if companies want to switch to BIM, they face many obstacles during the transition process. Engineering companies and organizations that are considering transitioning to BIM want to apply it in their projects. There are tasks that the company must implement, such as training the company's own Technical staff, understanding the BIM project management philosophy, and implementing the digital transformation roadmap. In order to implement the project implementation plan, the field and the office should work in coordination. The implementation plan varies according to the project types. Process management is different in infrastructure projects. Due to the different conditions and different personnel involved in each project, the project-specific implementation plan and test processes are applied.

The purpose of this study is to identify the critical obstacles in implementing BIM in infrastructure projects. At the same time, it is to explain the application of BIM in digital transformation and infrastructure projects in the construction sector by making a comprehensive literature review.

2.2 BIM (Building Information Modeling) Applications in Infrastructure Projects

In the current wake of the digital revolution and information technology, the construction AEC industry towards an effort to respond to increase productivity, efficiency, value, sustainability and quality to reduce lifecycle cost. In order to increase the importance of digital transformation and information technology, construction industry aims to increase the industry efficiency, develop technology infrastructure and more sustainable buildings which help to reduce the life cycle costs and improve the quality of products. BIM embeds key product and asset data in a 3D computer parametric model that can be used for effective management of information throughout a building lifecycle from the earliest concept design through to operation (Arayici, et al 2012) that is illustrated figure 2.1.

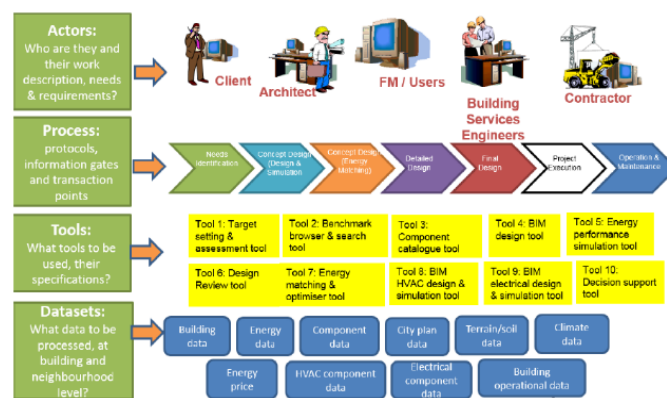


Figure 2.1 BIM Life Cycle

This is a type of transformation that cannot be made by one group of the industry sector or without involving the other, thus, in order to make these gains, they need to drive of corresponding shift in focus and process within the construction industry and involvement of the required stakeholders that take part in the building process, from building designers client, engineers and product manufacturers for effective transition management. This is a type of transformation that cannot be made by one group of the industry sector without involving the other, thus, in order to make these gains, the y need to drive of corresponding shift in focus and process within the construction industry and involvement of the required stakeholders that take part in the building process, from building designers client, engineers and product manufacturers for effective transition management. Afterwards, there is a non-

debatable perception of BIM as a means that may enable the building industry improve its productivity by means of providing an effective communication and collaboration between all the stakeholders involved in a project from the inception of all lifecycle projects. (Becerik-Gerber and Rice, 2010). Evidently, several stories have been reported by BIM researchers (Eastman et al., 2011) and there are many case studies that shows that the use of BIM makes the building process more effective and efficient to support the fact. Consistent, Succar, (defined as BIM has solidified its position as addressing the numerous inefficiencies in the AEC industry. Globally, Integrated Building Information Modelling delivery at different levels demonstrate a significant experience in growth and hence there are countless benefits as claimed by its users which include; the time and cost reduction and detection of clashes (Eastman et al., 2011), the improvement in collaboration, coordination and auto quantification, the improvement in visualization of design, project delivery and coordination of the construction documents (Olatunji et al, 2010; Sacks et al, 2010), the provision for efficient communication and data exchange (Nederveen et al., 2010).

Since its inception in the 1970s and its development in the 1980s and 1990s, building information modelling (is being increasingly implemented in the construction industry to produce data rich models of buildings and structures. BIM based processes are, therefore, gradually replacing the processes which create two-dimensional paper-based design and construction documents.

In order to assimilate this change in the construction industry, stakeholders including both the public sector and the private sector in different countries have initiated various BIM systems.

Turkish construction sector of the economy employing over one million people and with annual GDP of 784 million, the construction sector has historically and continues to have low levels of productivity. The construction industry the built environment is the last sector to fully exploit the advantages of information technology.

Rather than assuming the technology will percolate unguided through the industry, what must be done to accelerate the uptake of BIM technology in the national

interest? The lessons from the current technology 2D CAD are clear: after 20 years there are no common guidelines, a decline has occurred in documentation quality, there is no consensus in either industry or government on standards and no process improvement. Whereas in Turkey, there seems to be inadequate understanding of construction management by the majority of the parties in the construction industry even by some of the construction engineers themselves, which result in improper construction management practices regarding planning, cost, time, quality and safety management.

This study is aimed to prepare the adaptation of Building Information Modelling and Management roadmap to Turkish government, contributing to the development of a national BIM standard, BIM education and BIM policy initiatives. Republic of Turkey Ministry of Environment and Urbanization should support for BIM adoption is currently remaining at the level of encouragement with little financial incentives offered and a lack of introduction of BIM oriented standards and regulations. BIM standardization efforts and policy initiatives that ultimately influence the adoption varies significantly in Turkey. While industry is working on a variety of BIM initiatives to address specific immediate needs, a coordinated approach with industry and government collaborating to accelerate adoption of BIM would provide productivity benefits flowing to the entire economy. Turkish government and public sector base on the traditional construction methods which need to arrange BIM regulations so as to improve quality of whole process of the construction. Government projects are generally inception or pilot projects of these regulations. Especially for government projects, the bidders have to produce their competitive offers in accordance with the related BIM regulations. Thereby, the authority which must control and evaluate the projects through the regulations for approval will be able to execute the process easily and rapidly. When the Turkey decided to make a regulation about BIM, the Republic of Turkey Ministry of Environment and Urbanization will study to improve a compatible BIM regulation which require to using BIM can be a good support for a new one. It is possible that the clauses which are required for the Turkey's vision can be settled into the specific BIM regulation. BIM codes will need to define which are about drafting rules, scheduling properties, project delivery methods etc. It is required that detailed drafting rules and approved annotation styles must be put into the regulations. The speed of developing standards

should be accelerated. What the practitioners of BIM in construction urgently need is the BIM application standards to guide ways of using BIM tools. And the BIM tools developers are keen the foundation standards to unify the means of information exchanging format. Also, the BIM standards developers need strategy standards to develop all the BIM standards to be an organized and coordinated standard system.

2.3 BIM Applications and Sampling in Underground Projects

2.3.1 Mersin Underground

2.3.1.1 Project Information

Mersin Line-1 Underground design works tendered by Mersin Undergroundpolitan Municipality was carried out by Prota Mühendislik AŞ. Design studies were completed at the beginning of this year and Mersin Undergroundpolitan Municipality is preparing for the construction tender.

Mersin Line-1 Underground; It is a line that is 18.1 km long and consists of 15 stations. It is the first first underground Underground after the mega-cities such as Istanbul, Ankara and Izmir. It also stands out with being the first underground Underground in the Mediterranean. The Underground line is designed with BIM technology. It is the first Underground line tendered by Mersin Undergroundpolitan Municipality with BIM.

2.3.1.2 BIM Studies

Mersin Line-1 Underground design studies were carried out with BIM. It is the first Underground line awarded by the employer with BIM. BIM studies were carried out with Autodesk's Revit and Civil 3D software. The challenges experienced and the benefits achieved in the BIM process are summarized below.

2.3.1.3 Benefits of the BIM Process

BIM has been used since the first conceptual design phase of the project. Mersin Line-1 project station designs are quite aesthetic and optimum. The BIM scope of the project; Creating BIM models at LOD 300 level, ensuring interdisciplinary coordination with BIM and eliminating conflicts before the construction phase, obtaining the quantities from the BIM model and calculating the approximate cost with these data.

BIM technology has been very helpful in the development of designs. Design decisions were made quickly in the early stages of the project. In particular, thanks to the 3D (three-dimensional) presentations made to the Employer, critical issues in terms of design were discussed early, and time was saved in the final project and implementation project stages.

Drone shots were made on the project route and 3D BIM models were integrated with this data. In addition, the land on the route where the line passes were modeled with Civil 3D. This study has helped to determine the correct positions in the designs of the station entrances. In addition, the Infracore software made it easy to try out various design alternatives.

When the designs were detailed and the implementation phase models were created, three-dimensional coordination and overlap checks were made. Coordination studies in passenger areas have become important, especially since electrical and mechanical designs are used as design elements in architectural design. In addition, all rendering work was carried out from the models. Concrete, fine works (wall, floor, suspended ceiling, etc.), mechanical and electrical installation metrics were obtained from the application phase models and the approximate construction cost was calculated accordingly. For the elements that are not included in the BIM model, quantities have been obtained with the classical method. With these studies, it was aimed to obtain a more precise approximate cost. Studies prepared with the BIM model were understood more quickly by the employer.

Thanks to BIM, the design time is significantly shortened. In addition, these models were used together with VR technology at the launch of the project and the project was promoted through public models.

2.3.1.4 Challenges of the BIM Process

Since the BIM process is quite different from classical project production processes, it requires an adaptation process. Since the design firm was experienced in its previous projects, it did not experience any major problems in adapting to BIM. Nevertheless, the integration of all stakeholders into BIM (groundwork, mapping, infrastructure, etc.) has been challenging. It is also the employer's first BIM project.

At the beginning of the difficulties experienced in the process; Problems arise in all stakeholders such as the lack of habitual software, not being able to view the project, and not being able to use the software. For example; When the BIM model is sent directly to the team that carries out the map work, it cannot be opened and CAD export is requested. Another difficulty is the limits of software. Especially the BIM solutions currently used are suitable for superstructure designs such as buildings, residences, offices, etc., but are not very suitable for infrastructure projects such as Undergrounds, tunnels. Using BIM technology in such an infrastructure project creates requirements such as advanced design techniques, parametric design and model creation with the help of visual programming languages.

Mersin Line-1 Underground design works tendered by Mersin Undergroundpolitan Municipality have been completed with BIM. Despite the challenges, the benefits achieved during the design phase have been confirmed by both the employer and the design team. Mersin Undergroundpolitan Municipality aims to tender the new Underground lines planned in Mersin with BIM. The design group, on the other hand, completed the design of the Underground line in a very short time and emphasized that this would not be possible without BIM.

2.4 Kabataş Mahmutbey Underground

Kabataş, Mecidiyeköy, Mahmutbey Underground, run by the Istanbul Undergroundpolitan Municipality Rail Systems Department, consists of 19 stations and 2 viaducts with a length of 22.5 km. It is stated that BIM is the first public project in which 5D dimension has been implemented.

Istanbul Undergroundpolitan Municipality Rail Systems Department performs the tenders of all rail system projects on condition that 5D BIM size is created. They state that they minimize the problems encountered during field production with the BIM system, make the time and physical progress of the building more understandable, minimize the quantity and cost errors with the 5D BIM model, facilitate the construction of the project and prevent time and cost wastage (İMM, 2019).



Figure 2.2 Kabataş Mahmutbey Underground BIM Model view (İBB, 2019)



CHAPTER 3

PROJECTS AND THE USE OF UNDERGROUND IN TURKEY

3.1 Introduction

During the period from 1920s to the present, numerous dynamic changes caused the urban population to increase more than 100 times and caused the social and spatial structure to change rapidly. This change brought along many infrastructure problems. Transportation problems, air pollution, insufficient water resources, access and public health problems are the main problems. The share of the transportation sector in the emission of carbon dioxide gas, which is the most important factor in terms of climate change, to the atmosphere is 23% worldwide, and there is a continuous increase in emissions in the transportation sector. In many cities of the world, efforts are being made to create a sustainable transportation infrastructure by eliminating the problems caused by the intensive use of motor vehicles. In particular, within the scope of expanding renewable and clean energy options in public transportation, prioritizing the urban rail system and making the existing infrastructure most efficient with the use of new technologies is one of the popular efforts. In this study, we have mentioned the importance of rail systems in urban transportation as well as the importance of using BIM.

3.1.1 Underground System

It is an electric underground rail transportation vehicle that is generally established in large cities with high population density and quickly connects the city center to stops and suburbs. Having a road outside the city traffic and moving on a double line provides the opportunity to use many wagons in the Underground and reach a high speed. The Underground can be managed with very few personnel. The first Underground in the world was established in London. This Underground, which was opened in 1863, now carries about eight million passengers a day. Opened in 1900, the Paris Underground today carries more than five million passengers a day. Other cities in Europe with Underground; Budapest (1896), Berlin (1882), Hamburg

(1912), Leningrad (1915), Moscow (1935), Stockholm (1950), Vienna (1898), Madrid (1919), Barcelona (1923), Rome (1955), Lisbon (1959), Milan (1962).

The New York Underground, which was opened in 1868 with air lines passing over the street, was transformed into underground lines in 1904. Other cities with Underground in America, Chicago (1892), Philadelphia (1907), Boston (1901), Toronto (1921).

Tokyo in Japan in 1927 and Osaka in 1933, and Buenos Aires in Argentina in 1911 had their Underground systems. The air lines of the Undergrounds are at least 6 meters above the ground. The roof is metal or reinforced concrete. It rests on the soil with solid supports. Two systems are applied in underground lines. In the first, the galleries where the lines will pass are 6-8 meters deep just below the street level, and 35-40 meters below the other. The first method of Underground is cheaper. Because the excavation of the galleries in these is started by ditching deep from the street level, and a reinforced concrete wall is built on both sides of the ditch. Thus, after the gallery takes the form of a rectangular prism, it is closed and the street is re-paved. The biggest disadvantage of this method is that it follows the street plan, so it is long, indented and protruding.

Although the excavation was made at a medium depth of 6-8 meters, the walls in the double-line galleries show an elliptical shape. In deep networks the lines do not follow the plans of the streets, they are mostly straight lines. Thus, the distance between two points to go from one to the other becomes very short. The galleries in these networks are carved round. A single line passes through them. These galleries, with a circle diameter of 3.5-4.5 m, were paved with steel rings. Recently, however, these steel rings have been replaced by a prefabricated concrete floor system that can be screwed together.

Rail span is standard on almost all of them (1435 mm). There are no double lines in deep galleries. Two galleries can be found side by side, each with trains running in one direction. Deviations and rotations are only at the station points. Lines never cross. Stations are built by expanding galleries in underground networks and by installing a platform roof in air networks. There are 100-160 meters long platforms at the stations. Passengers are often brought out by escalators. Trains are the same as

electric trains. It is mostly bidirectional. The number and shape of wagons varies according to the network. Although Underground trains can run 90-100 km per hour, generally it is not exceeded 60 km. An average of 20 trains per hour moves in one direction. However, as in the London Underground, it can be reached up to 40 floors per hour.

3.2 Gaziantep Transportation Master Plan (GTMP) 2030

Efforts towards a solution on transportation, which is one of the most important problems of Undergroundpolitan cities today, do not yield the expected results due to the efforts to save the day in many cities. Because the studies for solving the problems should include long-term and sustainable approaches. However, while implementing these long-term approaches, one should not ignore the city's priorities and easily resolvable problems. For this reason, the primary target in transportation planning; Especially, the preparation of a "Transportation Master Plan" that takes into consideration the general characteristics, histories and traditions of developing cities, and the implementation of these plans prepared specifically for the cities should be. Transportation planning studies are grouped under two headings as short and long term planning. Long term planning studies; These are planning studies that take into account the city's development plan decisions, projection data such as the population in the target year, employment, as well as investments such as transportation, logistics and industrial investments in the city. In these studies, which plan the transportation infrastructure of the city in the long term, a demand forecast model is developed to make basic decisions such as the main routes the city will have in the future, public transportation systems (Underground, tram, bus, etc.), bicycle and pedestrian priority roads. The "Transport Demand Forecasting Model" is a mathematical model that simulates the city's transport mobility, which helps decision makers to develop transport strategies. With this model, it is possible to measure the performance of the current transportation system and determine its problems, as well as to test the developed policies and investments in the model without implementation, and to carry out feasibility studies. Within the scope of the "Transportation Master Plan", besides the long-term planning of the cities, bottlenecks and insufficiencies that can be solved in the short term are also analyzed and solution proposals are developed.

In this context, in addition to solutions such as public transport optimization, regulations including signalization at intersections, pedestrian crossings, pavement arrangements, problems such as infrastructure and superstructure disorders, problems in bicycle paTVS, transportation network failures (circulation) are studied and appropriate solutions are developed. Gaziantep Undergroundpolitan Municipality (GMM) prepared the Urban and Near Environment Transportation Master Plan targeted for 2025 in 2006, and this plan was carried out by the Transportation Coordination Center (UKOME) and the General Directorate of Infrastructure Investments (AYGM - DLH Directorate in the period when the plan was approved before 2011). It entered into force after its approval. In the second part of the "Regulation on Procedures and Principles for Increasing Energy Efficiency in Transportation", which was published in the Official Gazette dated 09.06.2008 and numbered 26901, in the 10th article titled "Urban Transport Plans", "The population of Undergroundpolitan municipalities and municipalities outside the borders of Undergroundpolitan municipalities over a hundred thousand prepare a transport master plan. Accordingly, these plans are made for a period of fifteen years and renewed every five years. " statement is included. The main purpose of Gaziantep Transportation Master Plan (GTMP) study is; It is the determination of the transportation investments and priorities to be realized by evaluating the travel demands expected to occur in the target year of the plan in line with the decisions of the Master Development Plan and the upper-scale strategic decisions for the city, and the basic planning decisions for the transportation and traffic system. With the GTMP, it is aimed to increase the comfort level of the people of Gaziantep in transportation, to evaluate urban mobility with an environmentalist approach, to produce solutions to macro and micro problems and to create sustainable solutions by using resources efficiently. In this context, within the boundaries of GTMPP and GMM; urban transport, for today and target year; The upper and lower scale plans of the city will be analyzed by taking into account the existing and expected transportation problems, and in parallel with this; Integration of public transport and inter-public transport types, their station and terminal areas will be arranged, planning will be made to ensure that different types of transport can be operated in a way that complements each other without competing, and transfer facilities will be developed.

3.2.1 Urban Rail System Current Status

The rail system line, including the 3rd stage, has a total line length of 22 km (in one direction). There are two different lines in the tram operation, Gar-Akkent and Gar-Courthouse lines. The Gar-Akkent line is 14 km in one direction and there are 18 stations on the line. Gar-Courthouse line is 10 km in one direction and has 15 stations. The tramway company has a warehouse area and an overnight stay area. Sector-based public transport passenger rates can be seen in Figure 2.2 prepared in line with the electronic card data obtained to cover the date range of 2-8 March 2015. The day-based distribution of the number of passengers obtained with the electronic card data within the tram company's own system is shown in figure 4.2 According to the table, a total of 313,000 passengers are transported on weekdays and around 85,000 on weekends. While the average number of passengers transported on weekdays is around 63,000, this value is in the band of 42,000 on weekends.

According to the data obtained, the daily average number of passengers is 56,849.

3.2.2 Railway Transport Status

The city of Gaziantep was connected to the national scale railway network in 1954. As in the road transport network, the city is located on important routes in the railway transport network. Adana - Malatya railway connects to Aleppo - Baghdad railway and Karkamış, Cerablus station. In addition, the Aleppo Express passing through Fevzipaşa provides the Syrian railway connection through the border gate of Gaziantep's İslahiye district. While continuing in the direction of Syria, the line proceeds from the north of the central region of Gaziantep to the east parallel to the D400 Highway.

The Republic of Turkey Railways (TCDD), according to information obtained, any mainline train to the city of Gaziantep is working. Among the regional trains, the Nusaybin line is currently out of service due to construction (TCDD, 2015).

3.2.3 Local Travel Data

The gross and net mobility rates determined in the household surveys are shown in the table below. According to this, according to the household survey data, the gross mobility rate determined in Gaziantep is 1.60 and the net mobility rate is 2.26.

According to the mobility rates of vehicle (private vehicle, public transportation and shuttle) and non-vehicle trips, the gross mobility ratio of the trips with vehicles is 0.85 and the net mobility rate is 2.14. The gross mobility rate of car-free journeys is 0.75, and the net mobility rate is 2.14. The district with the highest vehicle travel rate is Şehitkâmil (0.86), followed by Şahinbey (0.84). The highest rate in car-free journeys is in Oğuzeli district.

Home-based school journeys came to the fore in all three districts. Then, again, comes other home-based trips follow for all three districts. School trips in Gaziantep are seen more than other trips, as the population between the ages of 0-19 constitutes 44% of the total population.

The distribution of the journeys by vehicle types is shown in the graphic in figure 4.4. Pedestrian rides are in the first place with a rate of 46.2%. Automobile follows pedestrian travel with a rate of 18.7%. Shuttle journey is 16.4%, private public bus (Yellow) is 7.7%.

Considering the travel purposes, it is seen that 30% of business trips are made by automobiles and 29.5% by shuttle services. Automobile use is predominantly seen in home-work (41.7%) and home-other (43.5%) trips. While services are generally preferred for business and school purposes; public transportation vehicles (minibuses, midibuses, buses) are mostly used in other home-ended business trips.

Distribution of consolidated transportation types according to travel purposes is shown below. Accordingly, 41.9% of private vehicles are used for business purposes and 43.2% for home-other purposes. 48.5% of shuttle trips are for home-school purposes, 46.8% for home-business purposes. Public transportation is mainly used for home-other and home-business travels.

In the household survey, it was determined that the journeys in Gaziantep take 27.76 minutes on average. Pedestrian, bicycle, automobile, taxi and motorcycle rides are below average, while public transport trips such as shuttle, bus and minibus take above average

When the average of travel times was analyzed according to their goals, it was found that school trips were below the average and other trips were above the average.

Since most of the school trips are completed on foot and within the same zone, it is expected that the journeys made for this purpose will take a short time. Income and vehicle ownership are among the important factors affecting travel movements and characteristics in transportation studies. When vehicle use is analyzed by income group, pedestrian travel rates increase in the lower income group, while it decreases in the upper income groups.

3.2.4 Public Transport System

3.2.4.1 Planning Approach

Public transport systems are classified under various categories, taking into account the route, technology and service features. In this context, public transportation lines should be classified and graded in terms of type selection, fleet size and operational differences. By defining the roles and operating structures of the classified and graded lines in the transportation system, the lines should be operated in a hierarchy as complementary, not competitors to each other. Within the scope of GTMP, Gaziantep public transportation systems are classified into two sub-types: rail system and road wheeled bus system.

In order for a public transportation system to work efficiently, it must be adopted by users. For this reason, some facilitating practices for passengers should be implemented. In this regard, planning decisions were made regarding the implementation of practices such as obliging the use of the "Electronic Fare Collection System" in all modes of transportation, providing the opportunity to be used in parking lots and bicycle rental systems. Such applications facilitate public transportation for users and increase efficiency and speed in the public transportation system.

It is aimed to make the preference of public transportation in Gaziantep attractive with the plan decisions made for the development of "Passenger Information and Warning Systems", increasing the "Quality and Comfort Level in Transportation" and using "Environment Friendly Vehicles".

Establishing a usable system for "Disadvantaged Groups in Transportation" is one of the most important issues that the municipality is obliged to provide in public transportation. In this regard, laws and standards that have been enacted to eliminate

the problems faced by the disabled in urban traffic and transportation should be implemented. Decisions should be made regarding the features of public transportation vehicles that should be preferred, station arrangements and ease of access to the stops.

The main source of transportation problems in cities is the use of private vehicles. The biggest reason for the increase in the use of private vehicles and this increase in transportation problems is that the public transportation infrastructure is not planned and implemented in a quality and responsive way. Therefore, the reduction in the use of private vehicles can only be achieved by offering a quality public transport system as an alternative. In order to construct a quality public transport system, the basic principles adopted within the scope of the transport master plan should be considered. These principles are given below:

- By adopting that the focus of the transportation system philosophy is not vehicles, but people, a mass transportation planning will be made that takes into account the rights of disadvantaged groups, especially in terms of transportation in the city.
- Attention will be paid to the principles of adoption of public transport systems by the users and meeting the expectations of the users.
- Management will be integrated with transportation planning, investment, operation, management and control from a single source.
- A unified and integrated transportation system will be established.
- - Systems work as systems that complement each other, not compete with each other,
- - Private and public enterprises work as a whole system,
- - Integration of public transport with other types of transport (bicycle, automobile, etc.),
- - It will be ensured that the necessary transfer centers are built for the transitions between the transportation types, which are the other elements of integration.

- Existing transportation infrastructure will be used in the most efficient way.
- Business efficiency will be considered.
- - Service frequency will be increased,
- - A vehicle with a suitable capacity for the number of trips on the lines will be used,
- - Measures will be taken to minimize travel costs,
- Performance values for public transport systems will be measured periodically and compared with the previous period,
- - Practices will be made to reduce expenses economically.
- A route structure will be established to minimize the traffic burden caused by public transportation vehicles.
- Vehicles will be made suitable for the transportation of the disabled.
- Electronic toll collection systems will be provided.
- Ticket integration will be provided in all types of public transportation by installing applications that allow passengers to travel in all public transportation vehicles with the same card.
- Electronic fare collection system will be used in transportation types other than public transportation (rental bicycles and cars),
- Transfer discount will be applied,
- Statistical data will be collected.
- Intelligent transportation systems used in public transportation will be used.
- By providing detailed information about the transportation system, users will be enabled to use the system actively.

- Opinions of the affected stakeholders will be taken while making decisions regarding the public transportation system.
- The energy type that will minimize the environmental problems caused by public transport will be selected.
- Travel times will be shortened with route arrangements.
- Access to the city center will be facilitated by public transport.
- In bus transportation; Practices such as giving priority at intersections will be used as much as possible.

3.2.4.2 Arrangement of Public Transport Rail Lines

Certain conditions must be fulfilled in order to use the public transport system at the desired level, to meet the expectations of citizens and users, and to be economical and sustainable. While planning, it should be taken into consideration that transportation is a part of the social, economic, environmental and cultural system, and it should not be forgotten that planning is a stage where ideas are produced and basic choices are made to improve the quality of life of the future and to find effective solutions. Accordingly, it is estimated that 6 million trips will be made for Gaziantep according to the planned population for 2030. 1.2 million of these trips are expected to be public transport. In order to meet this travel demand, high capacity and integrated public transportation systems will be needed. It is predicted that the spatial development of Gaziantep will continue in a compact structure in the future as it is today. When the current and future spatial development trends are evaluated, it is seen that planning should be made in a way to respond to the transportation demand between the south of the city and the city center, again between the north of the city and the city center. Here, the main goal is to ensure that the mass transportation demand is aggregated in certain main corridors on these main axes.

While determining the lines that form the main backbone of the city's public transportation system on these main corridors in Gaziantep, it is essential to provide access to the most basic functions (city center, railway station, bus terminal, industrial sites and OIZs, hospitals and universities) that directly affect the reflection of travel demands to the space.

While planning the line, the main transfer points between the main backbone lines and rubber-wheeled lines within the public transportation system were established as “Transfer Centers” in a way that they also ensure the integration of all modes of the transportation system (pedestrian, bicycle, public transportation, automobile). Station Transfer Center is envisaged as the most important transfer point of the city. Within the scope of the Gaziantep Station Project, it is evaluated that this area is planned as a transfer center, considering the suitability of the area for the integration of different transportation types in terms of its location. This area is at an important junction point in urban transportation. Station Transfer Center is envisaged as the most important transfer point of the city. This decision will have an effect that will accelerate the development of the new CBD as a result of the major changes that the station and its immediate surroundings will experience with the planned transfer center. Accordingly, the total rail system line length for the 2030 target year is 105.13 km.

3.3 The Place of BIM Application in Public Projects in the Specifications

3.3.1 Gaziantep Underground Project Technical Specifications

The information of the BIM section in the technical specification of the Gaziantep Underground project is given below in summary.

3.3.1.1 BIM Definition

Building Information Modeling (BIM) is the name given to the system that enables 3D parametric and object-based models to be created by adapting information technologies to the building sector, to become 4D by entering time data into models, and to become 5D by loading cost data to objects. BIM alt yapısı kullanılarak hazırlanan bir yapının tasarımı için gerekli; plan, kesit, perspektif, liste ve diğer tüm gerekli bilgiler sayısal veri tabanında depolanır. Tasarım ve planlama sürecinde toplanan tüm veriler projenin her aşamasında kullanılabilir bir bilgi deposu oluşturur.

3.3.1.2 Aims

The main objectives of the BIM application within the scope of the project can be listed as follows;

- Creating a smart model of the project that includes all disciplines and ensuring coordination in order to increase the quality of implementation,
- Taking quantities according to the work items determined by the administration over the created model,
- Integrating the prepared model with the activity plan to be made in the stations and tunnels and planning the progress on the model,
- Preparation of As-Built projects in BIM model.
- To design the prepared BIM Model to be used in the operation and maintenance phase.

3.3.1.3 BIM Uses

Record Modeling

It is a process used to describe the physical condition of the building, its surroundings, and the nobility management. It includes but is not limited to architectural, structural, and EM information. BIM is at the center of the modeling process. Also; It includes links from Design, Build, and 4D coordination models to As-Built and Operation, Maintenance and Aset data After the construction is completed, the model is delivered to the facility manager.

Site Utilization Planning

It is the construction process that graphically shows the construction stages of temporary and permanent facilities during the construction phase.

Construction System Design (Virtual Mockup)

It is a process used to analyze and design the construction of a complex building system to increase planning.

3D Coordination

It is a process used to prevent conflicts in the field.

4D Planning (4D Modeling)

It is the process of planning the stages of construction, maintenance, renewal, strengthening, etc. by adding the time dimension to the 3D model.

Existing Conditions Modeling

It is the 3D modeling process of the current situation using laser scanning or traditional drawing techniques by choosing the most efficient method according to the desired model.



CHAPTER 4

ENGINEERING APPLICATIONS

4.1 Underground Tunnels Construction Methods

4.1.1 Tunnel Concept

Tunnel; In KTSŞ, it is defined as "underground structure built by excavating underground and creating and supporting a space in the desired cross section"

Tunnels are divided into transportation tunnels and transport tunnels according to their intended use:

- Transport tunnels; highway, railway, pedestrian road, Underground and approach tunnels,
- Transport tunnels; Tunnels built in dams, drinking and irrigation water tunnels, tunnels used to transport sewage water, tunnels opened in mines.

Today, tunnels have become an indispensable element of road, rail and urban rail systems.

4.1.2 NATM (New Austrian Tunneling Method)

First time put forward by Professor Lv Rabcewicz the New Austrian Tunneling Method (NATM) continues to be used widely in the world and in Turkey. NATM actually stands for "Neue Österreichische Tunnelbauweise" in its original German term, and this naming is more of a tunneling concept than a construction method.

- When Prof. LV Rabcewicz applied for a patent in 1948, he made the following definition for NATM:

“It is the reduction of rock pressure by placing a thin temporary bracing and allowing deformations and distributing this pressure to the surrounding rock. Thus, the final support will be less loaded and then the final support can be placed in an even finer

structure. Deformations should be observed with measurements and the results should be evaluated together with structural analysis and design. "

Although this definition has laid the foundations of NATM, which has been valid until today, other definitions have emerged after that.

For example, G. Sauer defined: "To create an underground void and to ensure the stability of the void, the use of all available means to maximize the self-supporting capacity of the rock or ground". Another definition is included in a brochure distributed by the Austrian Chamber of Engineers and Architects. According to this definition; "The New Austrian Tunneling Method is a method in which rock and ground formations surrounding a tunnel are combined into a ring-shaped supporting structure integrity. Thus these formations will be part of this supporting structure on their own. "

The emergence of different definitions is the result of the implementation of NATM in different countries and projects over time.

Although the first foundations of NATM appeared in 1948, upon the patent application of Prof Lv Rabcewicz, its main spread was made after the three-part articles published by Prof Lv Rabcewicz in Water Power magazine in November and December 1964 and January 1965.

These articles were taken from the papers presented by Prof Lv Rabcewicz at the 13th Geomechanical Colloquium held in Salzburg - Austria in October 1962. Sauer states that NATM's double bracing system (pre and post bracing), which is claimed by Prof Lv Rabcewicz, was actually implemented by Schmid in 1926 and based on Engesser's theoretical research in 1881.. "Allowing the rock to deform before placing the final support and thus reducing the loads", which forms the basis of the double bracing system concept, are the results of Engesser's theoretical research. Shotcrete was found in Chicago by Carl E. Akeley for the protection of dinosaur skeletons and its first application in tunnels was in the USA in the early 1920s.

- According to Sauer, the main contributions of Rabcewicz, Leopold Müller and other Austrians to this method were systematic bolting and on-site measurement.

- Although there are different opinions about NATM in terms of history and definition, its accepted main principles are still valid. These principles briefly;

The inner strength of the rock or ground surrounding the tunnel should be maintained and maximized as possible.

Controlled deformation is required in order to reach the full strength of the ground or rock safely. However, excessive deformations that may cause loss of strength or unacceptable settlement should be prevented.

These conditions can be achieved by systematic bolting, thin-semi flexible shotcrete coating. However, whatever bracing is used, this bracing system must be in full contact with the ground or rock mass surrounding the tunnel and must be deformed with it.

The timing of the bracing and closing of the pre-shotcrete ring is of great importance in controlling deformations.

4.1.2.1 Application of the New Austrian Tunneling Method

The main principle in this tunneling method; By selecting the most appropriate excavation and reinforcement methods, controlling and directing the secondary stresses and deformations that occur after excavation in a way that does not disturb the stability of the rock structure, and preserving the initial strength of the rocks as much as possible, it ensures that the surrounding area creates a static system that holds and carries itself.

The purpose of the method is not to counteract the mountain pressure that occurs after excavation with the reaction forces of absolutely rigid systems. Therefore, it is undesirable to use rigid support elements and thick coatings. They only come into play in plastic environments where the method cannot be applied with sufficient speed and care and therefore the bearing properties of the rock are completely lost or where excessive depTVS or high tectonic stresses are effective. During opening, the secondary deformations and stresses should be monitored with adequate measurements and observations, and the opening studies should be controlled and directed.

According to NATM, the environment to be tunneled is a living-living, dynamic structure, and a ductile structure / project that allows tunnel excavation-support and then the ability to adapt and sustain this environment where the prevalence of variability continues, thin and deformations within certain limits is essential.

From this point of view, the essence of NATM can be briefly summarized as "Project, build, observe, re-project". Figure 4.1 shows a comparison of a thick passive (passive) fortification (left) and the "reinforced ring" (right) of the NATM.

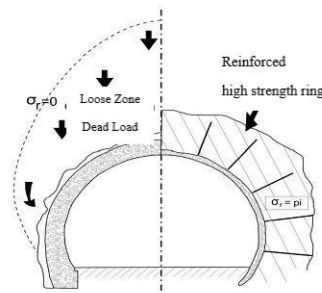


Figure 4.1 σ_r : Radial Stress

P_i : The ceiling pressure affecting the fortification in the plastic zone.

Comparison of a thick passive (passive) fortification (left) and the "reinforced ring" of NATM (right).

4.1.3 TBM (Tunnel Boring Machine)

It is a machine that is used to dig various soil or rock layers by drawing a circular section. It can dig all kinds of ground, from hard rocks to sand.

Tunnel Boring Machines are designed and manufactured depending on the geological and geotechnical characteristics of the ground to be tunneled, as well as the project requirements. A TBM generally consists of the cutter head operating with rotational drive and the inserts on the cutter head, the excavation chamber where the excavated earthwork is collected, the conveyor units that transfer the earthwork back from this chamber and a rotational segment crane that places the precast concrete in the excavated section. Behind this part of the TBM, which makes the excavation part, there are steel structures (gantry) consisting of various systems supporting the excavation units. TBM machine types are given in Figure 4.2.

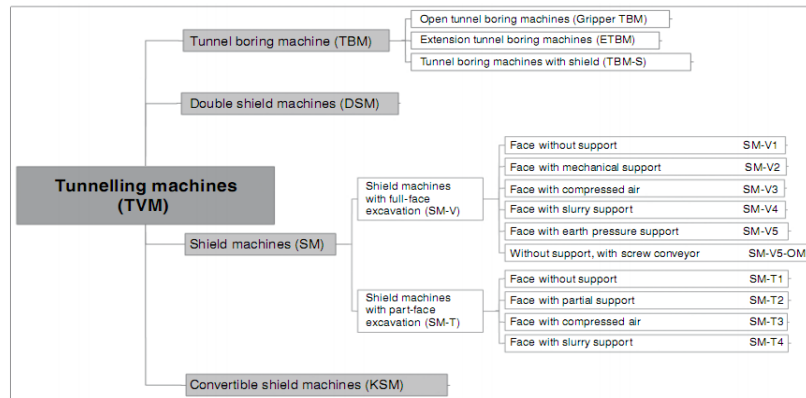


Figure 4.2 TBM machine types

4.1.3.1 TBM Working Principle

The TBM is designed to be able to excavate in variable soils due to the variable geological structures to be encountered along the tunnel route, the groundwater level and the structures in the impact area. It has the ability to excavate with the ground pressure supporting method (EPB) and open excavation method. Thanks to this feature, cutting discs, scrapers, nails and gravers can be placed on the machine, which has a variable floor type cutter head. The cutter head is driven by 9 (nine) electrically driven motors. There are 5 (five) foam lines on the cutter head and 6 (six) ground pressure sensors are available. Excavation in the tunnel mirror is done with the rotation of the cutter head. The excavated earthwork is taken into the plate from the excavation chamber by means of the spiral conveyor and transferred to the belt conveyor, in accordance with the EPB conditions. The belt conveyor transfers the excavation to the tunnel excavation transport vehicles in the back-up system. In Figure 4.3, there is a process diagram of the TBM machine.

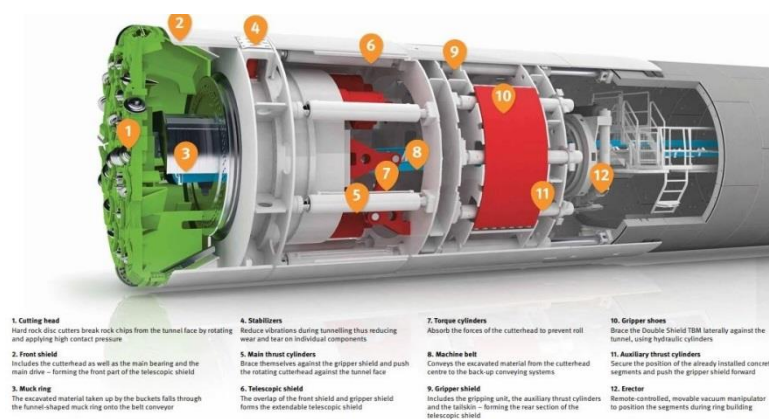


Figure 4.3 TBM process scheme

4.1.3.2 TBM Machine Equipment

Cutter Head: The variable ground cutter head is driven by electric motors and can dig in both directions with fully variable speeds.

Front Shield: It is the section that houses the TBM cutter head and the main drive unit, and this section is connected and directed through the Middle Mattress by 12 Active Articulation Pistons.

Middle Shield: Front Mattress is connected by Active Articulation Pistons, to the Tail Plate with Passive Articulation Pistons. There is a pressure chamber, pushing pistons and a screw conveyor inside the front plate for access to the cutter head.

Tail Shield: It is the section where the tunnel segment coating is carried out and the Middle Mattress is connected by passive articulation pistons. There are three rows of brushes to prevent water intake into the mattress, and the biodegradable grease oil is continuously pressed from the grease ports between these brushes.

At the same time, injection printing works are performed on the back of the segment ring, which is lastly assembled from the back of the tail mat.

Screw: It is mounted with a flange on the front part of the mattress in order to transport the excavation from the pressurized excavation chamber to the TBM belt conveyor. It has been manufactured to work under heavy loads.

Belt Conveyor: It is a system that enables the excavation taken from the screw conveyor to be transferred to the passage transport system in the tunnel by transferring it through the rear systems.

Mortar Injection System: It is a system used to fill the gap between the excavation diameter and the outer diameter of the segment, to ensure the permanent bonding of the segment concrete to the ground, and to inject mortar behind the installed segment ring to create a tightness inside the tunnel. A plasticizer chemical is used in order to transport the incoming mortar in the desired proportions outside the tunnel while remaining fluid and to have a high pumping capacity. When the tail is pumped in the mattress lines, a chemical additive is added to accelerate the set and the mortar sent to the back of the segment is rapidly solidified and strengthened.

Back-up System - Ground Conditioning System: By injecting pressurized foam with determined chemical-air-water ratios to the cutter head and the spiral conveyor, it provides the plasticity of the excavation excavated in the mirror, and provides easy transportation of the excavated excavation in the transfer systems, homogeneous maintenance of the ground pressure and the cutter head and protects the mechanical elements on the screw conveyor. Although the chemicals to be used vary according to the surface encountered, in general, polymer-added foam in gravel rocks with a high rate of sand-silt, clay separator foam in rocks with high clay content, foam reducing abrasion in order to reduce the abrasion of cutting heads and chisels in hard rocks and mirror cohesion in the region with high water income, gelling polymer is used to reduce the water content. In Figure 4.4, we can see the progress of the TBM while digging underground.

Other Systems

Besides the above mentioned key systems on the TBM, there are other systems below:

- Erector
- Tail Grease Pump
- Machine Grease Pump
- Hydraulic Tank
- Wastewater System
- Internal Ventilation Installation
- FanTube Cassette
- Closed Circuit monitoring system
- Communication System
- Fire curtain spraying system behind the last gantry
- Air Compressor

- Transformer
- Gas Detector



Figure 4.4 The advance of the TBM underground

4.1.4 Excavation Principles

A TBM is operated in two phases.

- Tunnel Excavation
- Tunnel Lining

4.1.4.1 Tunnel Excavation

Tunnel excavation starts by switching on the main drive power supply. The motors in the main drive unit transmit power to the pinion gear via reducers and drive the pinion gear cutter head. Thus, rotation of the cutter head is provided. Chisel equipment on the cutter head rotating on the mirror cuts the mirror and the scraper elements take the excavated excavation from the mirror into the head chamber. Meanwhile, the TBM pushing pistons press and push the TBM's head to the chuck continuously. Pressurized water and chemical mixture is continuously applied to the mirror during excavation from the cutter head. Thus, the earthwork becomes homogeneous and keeps the surface pressure constant by supporting the pressure of the excavated ground. The excavated earthwork is transferred to the back of the

machine via the screw conveyor and poured into the belt conveyor. The belt conveyor, on the other hand, allows the passage taken into the tunnel to be transferred to the excavation transport system.

- TBM continues excavating across the width of a tunnel segment. After this progress is completed, the excavation process ends.

4.1.4.2 Tunnel Lining

Segment Assembly: It is done by delivering the precast segments brought into the TBM by the tunnel train to the segment erector and placing the segment stones in their places in accordance with the curve of the excavation with the segment erector that can rotate 360 degrees. The pistons in the section where the first segment stone will be placed are closed. The segment stone placed in its place is fixed to both the adjacent segment stone and the segment ring assembled in the previous excavation by means of bolts and is compressed by means of pistons. By means of this compression, the gaskets of adjacent segments compress each other and provide sealing between segment stones. Then the next segment stone is placed. Bolts are torqued again after all segment stones are in place.

The segments used to support the excavation in TBM will consist of 6 universal type stones. In the system consisting of 5 main stones and one keystone, a full circular ring will be established when the keystone is in place. In order to ensure circularity, fiber connectors will make the connection at the right position on the radial faces of the segments by fitting into their slots on the opposite segment. By this means, sealing will be ensured radially by ensuring full contact and compression of seals with each other. It is very important that the segment gaskets are clean during assembly, and that they are not damaged or impacted. Segment gaskets will be lubricated with liquid soap during segment assembly, before the adjacent gaskets are compressed, reducing the risk of damage against impact. While assembling the segment stones; Until the distance between the previous stone and the adjacent stone is equal, the mounted stone will be brought closer to the neighboring stones radially and axially by means of the segment erector and from this position the segment will be brought to its correct position with a single cross movement. This situation is indicated visually in the figure below.

4.1.4.3 Map Measurement System

During the tunnel excavation, measurement and guidance systems installed on the TBM are instantly data analysis, control and integration into the system. There is a target unit (video target) moving together with the TBM in the TBM shield and a laser unit fixed in the tunnel. With the excavation, the position of the laser in the target unit is continuously transferred to the operator's cabin and the direction of the excavation and the status of the mirror are followed. By following this system, the TBM excavation direction is adjusted as desired. The pressures applied to the pushing and steering pistons are constantly regulated to adjust the direction of the excavation.

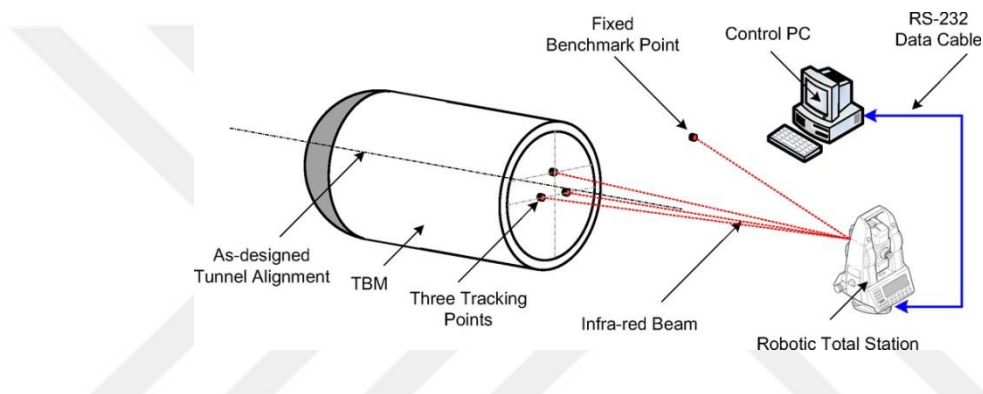
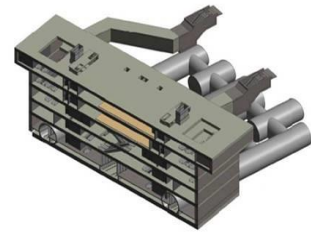


Figure 4.5 TBM map measurement system

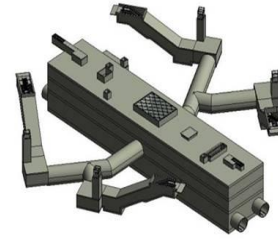
The measuring system also records the ring types and directions installed along the tunnel route and determines which type of ring will be placed in the excavated section by calculating from the piston openings. The data on the measurement system can be tracked from the monitoring station in the operation site and transferred to GPS records. Thus, the location of the TBM relative to the ground will be instantly monitored. (Figure 4.5)

4.2 Station Typologies

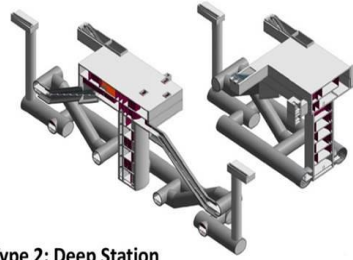
Station types are selected and applied depending on conditions such as ground conditions, depth excavations, station size. There are 4 Underground station types used in the Gaziantep project. In some stations, more than one typology was used together due to the conditions stated above. At the same time, in order to ensure the unity of language in design and implementation, and to construct our concept emerging from the context in the same way in all our stations, typicalization has been made. The station typologies used are shown in Figure 4.6.



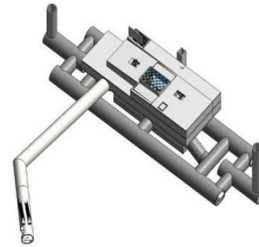
Type 1: Common Concourse



Type 3: Cut and Cover Station



Type 2: Deep Station



Type 4: Tunnel Type

Figure 4.6 Station Typologies

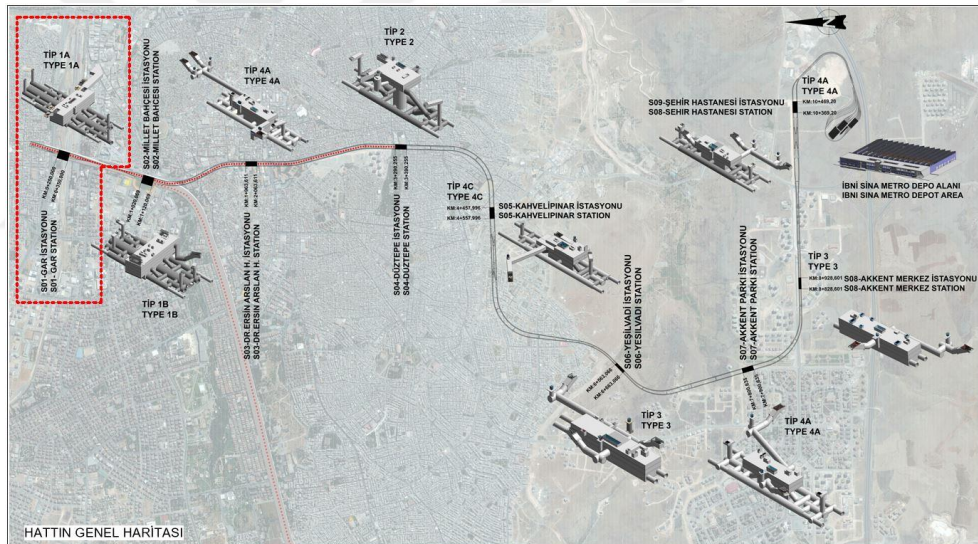


Figure 4.7 General view of the line and station typologies

4.2.1 Type 1 Common Station

It is the Station Type where both route lines are designed separately at the Platform Level and the Cut-Off Structure is shared on the lines.

These Stations are Gar Station and 15 Temmuz Demokrasi Stations.

Entry and exit building locations differ in terms of general situation and accessibility at both stations. (Figure 4.8).

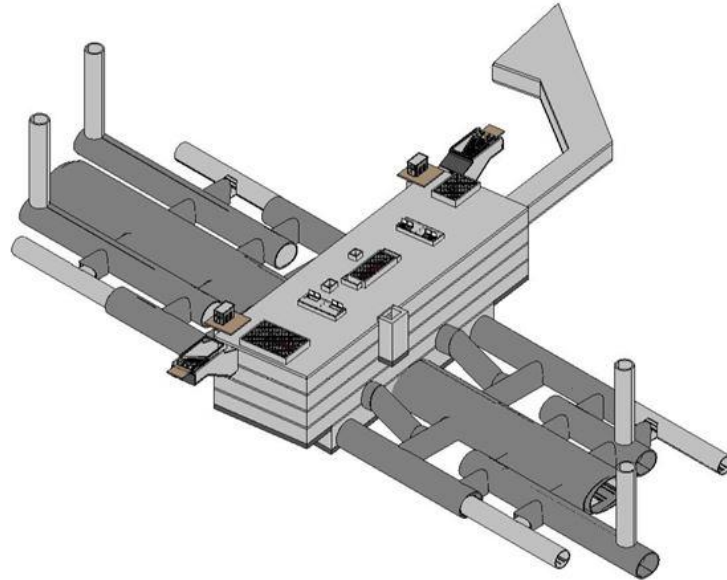


Figure 4.8 Common Station typology used in Gar Station and 15 Temmuz Demokrasi Square Stations

4.2.2 Type 2 Deep Station

The depth of the TYPE 2 station is between 40-53 m. Entry and exit building locations differ in terms of surface conditions and accessibility at TYPE 2 stations.

The deepest station on the route is Düztepe Station, which is called type 2. (Figure 4.9)

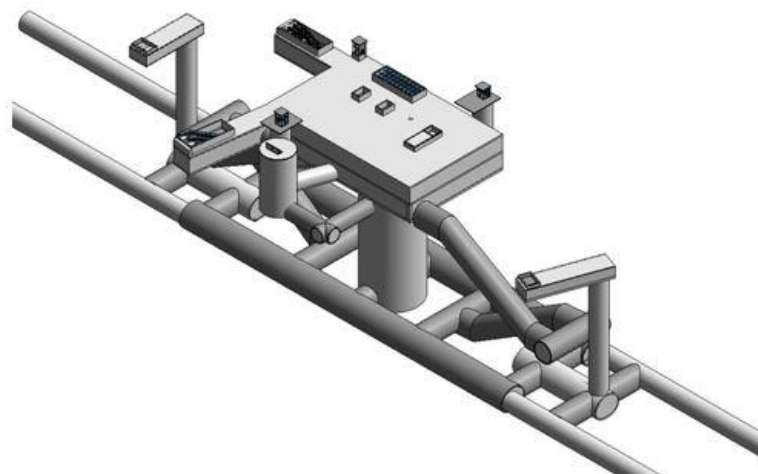


Figure 4.9 Deep station used in Düztepe Station

4.2.3 Type 3 Open-Close Station

TYPE 3 stations are about 23 meters deep and are solved with a full on-off system. Entry and exit building locations differ in terms of surface conditions and accessibility at TYPE 3 stations. 2 TYPE 3 stations are planned on the GDH line.

These variations are; Yesilvadi and Akkent Stations. (Figure 4.10)

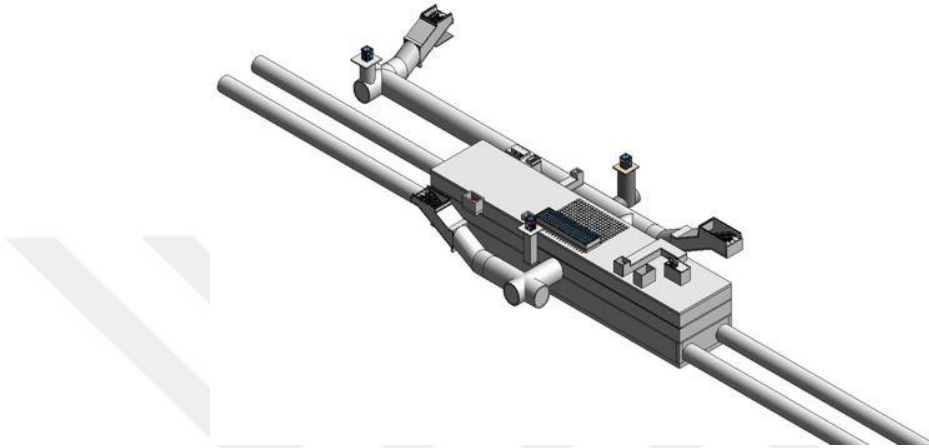


Figure 4.10 Open-close station type used in Yeşilvadi and Akkent Stations

4.2.4 Type 4 Tunnel Type Station

The depth of TYPE 4 stations is about 32 m deep. These are stations solved as a "boring tunnel" system. These stations are; Dr. Ersin, Kahvelipınar, Akkent Park and City Hospital Stations. (Figure 4.11)

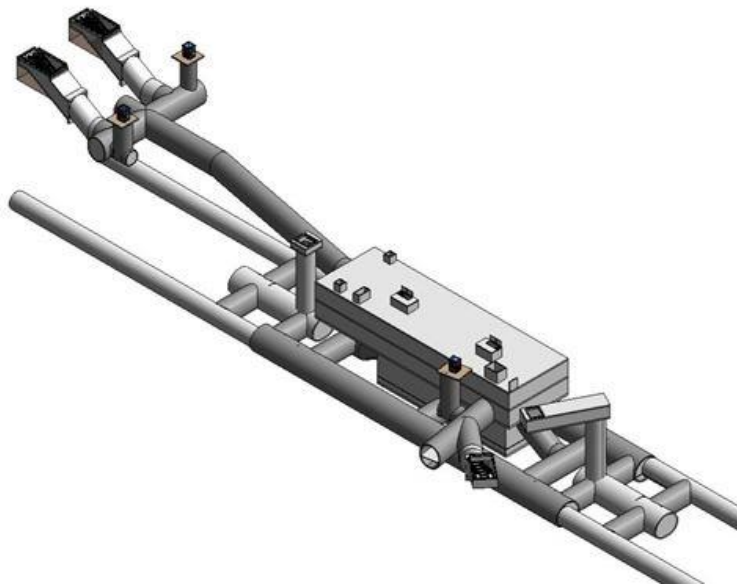


Figure 4.11 Tunnel type station to be used in Type 4 station

CHAPTER 5

BIM APPLICATION AND MANAGEMENT IN UNDERGROUND PROJECT

5.1 General Information about the Project

As a result of the Gaziantep Transportation Master Plan decisions, it is aimed to stratify the public transportation network and to transport the journeys faster and more efficiently. High capacity will also enable high comfort levels to be created.

- General principles regarding backbone lines are as follows.
- The development of Gaziantep city, which has a compact form, is towards the periphery of the city. For this reason, the main axes of the transportation system should be formed in a way to respond to the transportation demand radially from the city center to the periphery in order to ensure the sustainable urban development.
- While determining the backbone lines, it should be taken as a basis to provide access to the most basic attraction centers (city center, railway station, bus terminal, industrial sites and OIZs, hospitals and universities) that directly affect the reflection of travel demands to the space.
- While planning the line, the main transfer points between the main backbone lines and rubber-wheeled lines within the public transportation system should be established as “Transfer Centers” in a way that ensures the integration of all modes of the transportation system (pedestrian, bicycle, public transportation, automobile).
- Integration between transportation modes must be in the fare / ticket system as well as the Transfer Centers created.
- A mass transportation planning should be made that takes into account the rights of disadvantaged groups, especially in terms of transportation in the city, by

adopting that the focus of the transportation system philosophy is not vehicles but people.

With the Master Plan prepared within the framework of these general principles, the principles adopted for the main backbone public transportation line between Gar-Düztepe-Hospital, which is one of the priority lines within the scope of public transportation solution proposals developed to eliminate the future problems and deficiencies in Gaziantep's transportation infrastructure is as follows;

- To ensure the creation of line structures perpendicular to this backbone by creating a main backbone between traffic sectors and within districts,
- To be able to benefit from the general transportation infrastructure of the city,
- To ensure that it is adopted by users,
- To construct a public transportation system with acceptable travel time and cost,
- To reduce the traffic load on Özdemir Street, which is one of the most important axes connecting the city center and the city hospital,
- To contribute positively to urban values and environment,
- To create a sustainable line design in order to ensure compliance with planned land use decisions as well as the existing land use structure.
- Identifying station locations that can be integrated with the planned public transport network and transfer centers,
- Determining a public transportation system with a capacity to meet the estimated passenger demand on the route,
- To design a corridor completely separated from road traffic,
- To create a station in an average of 1 kilometer,
- To design a business structure with a density not exceeding 6 people / m² in vehicles,

- Creating a system using sustainable energy sources,

To design a structure that will keep the pedestrian flow uninterrupted on both sides of the streets where the line passes.

5.1.1 Coordination Meetings and Field Studies

Within the scope of the route determination and feasibility studies, a total of 20 technical trips were made, including international / domestic Underground construction sites. Based on the report issued in the light of technical visits, 35 coordination meetings were held in total. In addition, a total of 52 Institutions were contacted and their approval was obtained. There are photographs selected from the meetings held in Figure 5.1.



Figure 5.1 A photo of the meeting

5.2 New Design Technology "BIM"

Building Information Modeling (supported by physical technologies, is a collaborative work methodology supported by digital technologies that unlock more efficient ways to design, present and maintain physically constructed assets (Arayici et al., 2011) in a human-centered manner. Entity data that can be used in a 3D computer parametric model for effective management of information throughout a building lifecycle from early design concept to operation (et al 2012). Figure 5.2 shows the BIM cycle.

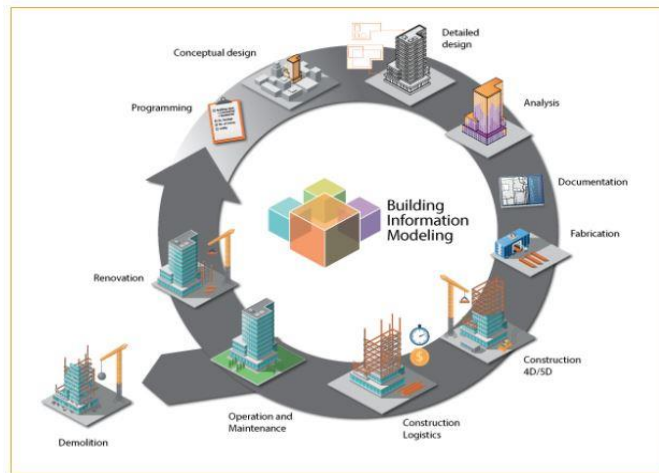


Figure 5.2 BIM cycle

It offers a new paradigm of work that offers strong perspectives for the integration and coordination of different areas and the processes involved in the design, construction and operation of buildings. The basic scheme for BIM data is IFC (Industry Foundation Classes), an international standard for the exchange of BIM data, and provides an overall data scheme covering architectural, construction service and structural elements, among others.

BIM is an information technology platform based on the 3D planning, design, construction and operation of a building to enable collaboration and integration between stakeholders in the construction project lifecycle. Digital transformation has taken place in many countries. Globally, some countries such as the UK, Denmark, USA, Norway and Finland are starting to recognize important opportunities and are now making large investments to develop their country capacities (Khosrowshahi & Seeker, 2012). BIM processes form the basis of project management in infrastructure projects and superstructure projects. BIM offers opportunities to use technological tools and techniques to simplify project process and management. By using digital construction technologies such as laser research techniques and realistic energy analysis, it can provide great value in building design, construction and renovation projects. Figure 5.3 shows the BIM usage rates by country.



Figure 5.3 BIM usage rates by country

Turkey is going through major urbanization process and economic development. Thanks to public projects, housing and urban transformation projects, the construction sector has a very high business capacity, the Turkish Architecture, Engineering and Construction sector plays an important role.

The design and construction companies in Turkey must adopt modern and efficient design collaboration and documentation methods. With this in mind, BIM use can not be ignored by stakeholders in Turkey. Research by Arayici et al. (2011; Navendren, Manu, Shelbourn, Mahamadu, 2014; Ramilo Embi, 2014) has shown that the adoption of BIM leads to efficiency gains, helps eliminate waste, and generates value in design and construction firms. Can BIM provide similar benefits to construction companies in Turkey? While this research addresses the issue of how it is possible for the adoption and implementation of BIM to become a knowledge-based sector within a knowledge-based economy in the Turkish construction industry, the use of BIM is maturing in developed countries such as the UK.

In international construction projects, BIM technology has become a world standard. The governments of countries such as the United Kingdom, the United States, Norway, Finland, and Singapore have made the use of BIM mandatory for contractors and designers in contracts for their contracting construction projects. Many governments outside these countries have started to emphasize the BIM requirement by supporting the industry with various BIM solutions.

In Turkey BIM usage is becoming increasingly common in the last few years. For example, it has become mandatory to work with the BIM system in rail system projects in Istanbul. Thus, international construction and design companies that switch to BIM early have a competitive edge over their competitors who have not yet met BIM and are late to invest in this technology.

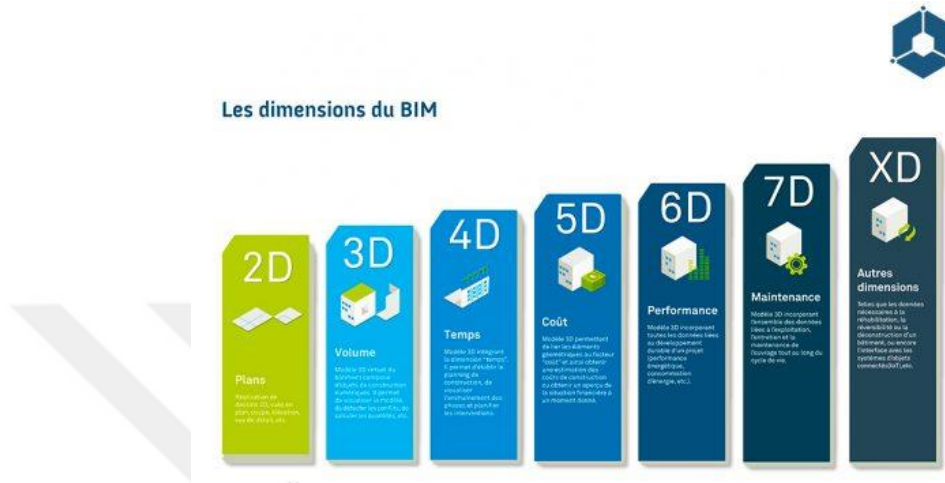


Figure 5.4 BIM Phases

Benefiting from Building Information Modeling has advantages from different angles.

- It allows to identify problems that may occur in the later stages of the project before they occur at the design stage.
- It allows all units working in the project to work synchronously and to progress the project process as a whole.
- Minimizes the margin of error during the cost calculation phase and maintains the controlled cash flow throughout the project.
- It saves time and extra expense by preventing repetition of jobs.
- It increases the motivation, efficiency and productivity of all units by making all the details of the project visible through architectural modeling and architectural visualization.
- It stores the data in the project so that it can be used in later stages.

- It facilitates the emergence and conclusion of the decisions that can be made regarding the project.
- It allows a transparent and clear work flow for all parties by removing uncertainties.
- It supports the minimization of possible waste and thus accelerates the increase of environmentally sensitive projects.
- It ensures flawless and seamless compliance with government contracts and offers the opportunity to transition to BIM 2.

Measurable benefits of BIM are given as a result of the researches below.

In the research of Stanford University's 'center for integrated facilities engineering (CIFE) unit on 32 large-scale projects in 2007, they list the benefits of BIM as follows;

- 40% reduction of changes in the budget
- Cost estimates can be made with 3% margin of error
- Over 80% less time spent in cost estimates
- 10% reduction in money losses arising from contracts resulting from overlapping structural elements
- It is seen that the entire project time is reduced by 7%. (Akkoyunlu, 2015)

In a study (Endeavor Hose - BSI, 2010), there was a 9.8% cost reduction while (Festival Place - BSI, 2010) a 9% cost reduction was observed. In the report prepared by McGraw Hill Construction - The Business Value of BIM by Europa 2010 by the Smart Market Report, 13 out of 35 projects examined had positive effects on time management and planning (Aylesbury Crown court - McGraw Hill Construction, 2010). The project was completed two months earlier than the estimated time. McGraw Hill Construction company is a U.S.-based research organization that collects, analyzes and publishes data for the building sector stakeholders worldwide. In a study conducted on Change Orders and changes in work programs, it was

observed that there was a 47% decrease in the work program and 67% less changes (Akkoyunlu, 2015; Barlish & Sullivan, 2012). McGraw Hill's BIM for Owners 2014 The positive impact of BIM on building projects was found to be 69% in the USA and 80% in the UK (McGraw Hill, 2014).

5.2.1 Long and short term benefits of BIM

In the research of "The Business Value of BIM in North America" prepared by McGraw Hill, they gathered 11 benefits of BIM under two headings as 5 long term and 6 short term with the data obtained from 30 projects examined between 2009-2012.

Long Term Benefits:

- Customer Satisfaction and repeat business with previous customers (Repeat Business)
- Reduce project Duration
- Increased consistency and usefulness (Increased Profit)
- Reduce Construction Cost
- Contract disputes are reduced in projects with BIM.
- Short Term Benefits:
 - Reduction of documentation-related errors and defects (reduce document error and omissions)
 - Providing new job opportunities (Market New Business)
 - Rebuilding is reduced as a result of Faulty Manufacturing (reduce rework)
 - Can provide new services (offer new service)
 - Reducing the running time of workflows that require special features and attention
 - Benefits in choosing and protecting human resources correctly

5.3 6D BIM Energy

In this dimension, the main issue is to protect the environment. By analyzing the energy consumption of the project to be built, the most appropriate model is created for the creation of a sustainable structure 37 of the obtained data. As reference, the standards of green building certification organizations such as LEED (Leadership in and Environment Design) and BREEM (Building Research Establishment Environmental Assesment Methodology) are taken.

With LEED Credit Manager working as add-ins (add-on software) in Revit, one of the BIM programs; The total credit and LEED certificate level can be reached by evaluating the project prepared with top titles such as energy and atmosphere, indoor environmental quality, innovation and design processes, materials and resources, regional priorities, sustainable areas, efficient water use.

In the organization of the United States Department of Energy, you can find suitable software from the website "Building Energy Software Tools", where building energy software is listed.

5.4 7D BIM Operation Phase

In the life cycle of the buildings, the operation and maintenance phases are as important as the design and construction phases. Because in the building sector, the working, operating phase of the building is the main contributor of the facility life cost, and 85% of the life cycle costs of the building are incurred after construction, and it is stated that two-thirds of the estimated cost is lost in the US due to inefficiency between the collaborative work, operation and maintenance phases (Lee et al., 2012; Jordani, 2010; Rundell, 2006). For an effective and efficient building life cycle management, it is necessary to increase the performance and efficiency as a result of the changes made in the usage process of the building. For many years, how structures can be managed efficiently and effectively has been an important research topic. Research has gained importance since the emergence of BIM processes and the prediction that BIM information captured throughout the life cycle of facilities can help facility management (FM) increase efficiency (Kelly et al., 2013).

While BIM plays an active role in the design and construction phases of the buildings, its adaptation in the facility management (FM) phase has remained in the

background (Teicholz, 2012). Facility Management; It is a multidisciplinary field that covers various fields to ensure the functionality of the built environment by integrating people, place, process and technology (Cotts et al., 2009). It is also the process of supporting an organization's core activities, including day-to-day operations, planned maintenance, and strategic decisions (Alexander, 1996). Facility management aims to increase business performance by privatizing areas and designing buildings in accordance with the needs of end users (Atkin & Brooks, 2014). These definitions highlight the multidisciplinary aspects needed to increase the performance and profitability of key businesses, among others. The International Facility Management Association (IFMA, 1998) further highlights the impact of facility management in accordance with the three P models in figure 5.5. The model shows the interdisciplinary nature of Facility Management and the level of participation in the different areas of an organization.

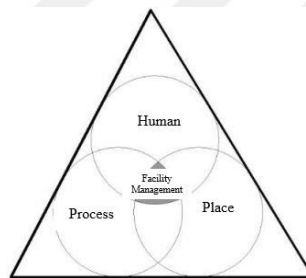


Figure 5.5 Three P models describing Facility Management integration in an organization (IFMA, 1998)

As seen in the three P models, facility management is a holistic and integrated approach that must coordinate people and processes (Atkin & Brooks, 2014). It was suggested that facility managers should be included in the design process in the design phase in order to minimize the problems arising during the facility management phase (Anker-Jensen, 2009). Facility managers operated and maintained the designed and constructed buildings throughout the life of the building. This building life cycle involves many occupational groups and it is difficult to establish communication and cooperation between these occupational groups (Cotts et al., 2009). It is not known what is needed for facility management during the design phase, on the other hand, knowledge and experiences about the use and operation of existing buildings are not transferred to the design phase (Jensen, 2008). The link between the design and facility management phases has not been

adequately established, often blocked (Erdener, 2003). Therefore, issues related to facility maintenance were excluded from the decision-making process (Pati et al., 2010). The most emphasized benefit of including facility managers in the design phase is to have valuable knowledge about facility operations to be explained at an early stage in order to reduce inefficient activities and to eliminate some design errors that interfere with the realization of operation and maintenance activities (Foster, 2011).

In his study, Emmitt (2007) emphasizes not only using the competence of facility managers but also using computer software to see important facility aspects to gain experience from past projects and take part in the design phase.

The main reason for the integration of BIM in facility management is to effectively exchange information between design, construction, operation and maintenance phases in projects. Actively accessing information is to reduce the time and effort required to reconstruct information and to prevent the emergence of thoughtless decisions that may result from lack of information. In recent years, BIM technologies have significantly impacted knowledge management practices across the entire building industry. With the development of BIM, communication, collaborative work and information sharing between facility management and design experts have become possible. BIM has shown the potential to eliminate problems arising due to insufficient access to information at all stages, including operation and maintenance phases (Sabol, 2008b). Facility owners by using BIM, such as reducing operating and maintenance costs, increasing performance and efficiency, improving service delivery, tailoring to the user's requirement, streamlining business processes, supporting and optimizing future building renovations and ultimately achieving higher ROI, seek a variety of business goals.

5.5 Obstacles and Challenges in the Use of BIM

With the development of technology, there may be many factors affecting the success of the new applications brought with it. For example, the attitudes of the staff towards the application of new technology, the risks of using unknown methods and tools, the difficulty of applying new technologies, financial risks, and the perception of other employees' attitudes towards new technologies (Tatum, 1989).

Since the construction sector covers different disciplines, companies that prefer to use BIM in order to ensure cooperation between stakeholders cannot be predicted exactly what the process will bring, lack of expert personnel, no customer demand in this direction, high initial investment and operating costs of software and hardware belonging to BIM are some obstacles and difficulties encountered due to issues arising from copyright issues and some other reasons (Eastman et al., 2011).

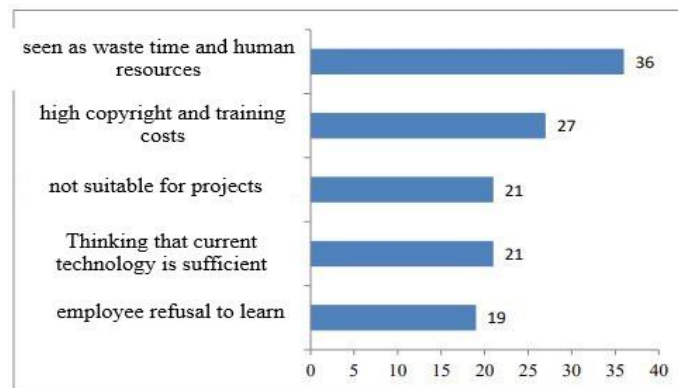


Figure 5.6 Obstacles and challenges for BIM use (Yan and Damian, 2008).

According to the results of the survey conducted by Yan and Damian (2008) on the obstacles and difficulties in the application of BIM; the participants see BIM as a waste of time and human resource. In addition, many participants state that BIM is not required to design their projects, and they are satisfied with traditional methods and existing technologies. It is seen that the participants resist accepting the changes in technology.

Liu et al. (2015) evaluated the factors that would hinder BIM implementation in the building sector in five main groups. These are; lack of national standards, high implementation costs, lack of qualified personnel, institutional and legal issues. Each obstacle is divided into two or three subgroups as shown in Table 5.1.

Table 5.1 Summary of barriers and challenges in BIM implementation (Liu et al., 2015)

Categories	Sub Categories
Lack of National Standards	<ul style="list-style-type: none"> • incomplete national standard • Lack of information sharing in BIM
High Implementation Cost	<ul style="list-style-type: none"> • high initial cost of software • high cost of the application process
Lack of Qualified Personnel	<ul style="list-style-type: none"> • lack of qualified personnel • education cost
Corporate Issues	<ul style="list-style-type: none"> • process problems • learning curve • lack of support from senior management
Legal Issues	<ul style="list-style-type: none"> • ownership • taking responsibility for mistakes • license problems

The absence of a national BIM-related standards in the building sector makes the information sharing and communication between all stakeholders ineffective during the implementation process. Despite all the BIM-related advances in the industry, interoperability between BIM software appliances is still problematic.

The initial investment cost of BIM is high, and the necessity of purchasing high-cost software and hardware by the company for the implementation of this technology, and the training cost to allow stakeholders to use the technology effectively are among the other important factors that prevent the use of BIM. Cost allows investors and potential BIM adopters to carefully consider options (Allen Consulting Group, 2010). In addition, the implementation cost, apart from the initial investment cost, often creates an obstacle to BIM implementation.

Lack of qualified personnel and training is a major obstacle to BIM applications. Although companies accept the value of BIM, they may have problems in providing integration. In this case, to integrate BIM, it can either select new personnel or train existing personnel to reach the required equipment and knowledge level. According to Pfitzner et al. (2010), staff training is mandatory to ensure effective use of BIM at the project level.

In the case of top management's support, some managers remain insensitive and resistant to new technologies, processes and change. In order to fully exploit the benefits of BIM, new processes must be used by companies and support from senior management is required (Eastman et al., 2008).

The problem of access to design data in BIM and how to protect copyright needs to be resolved (Azhar et al., 2008). According to Percio (2007), the ownership of the data should be considered in every project depending on the needs of the project stakeholders.

Another factor that prevents the use of BIM is the reluctance of project stakeholders to take responsibility for mistakes. Integrated BIM blurs the potential level of responsibility with increased risk and liability.

5.6 BIM System in Design and Engineering

5.6.1 BIM Model Managers and Their Roles

All parties that will contribute to the content of the modeling study should appoint a model manager to the project. Model managers should assume a range of responsibilities, including but not limited to:

- Managing interdisciplinary modeling studies,
- Checking the project detail level and validity of controls,
- Checking the validity of the content of the modeling study in each phase,
- To combine or link models,
- Participating in design review and model coordination meetings,
- Reporting problems to company teams or teams in other companies,
- Ensuring that the file names are given correctly,
- Managing version controls,
- Preserving the models in accordance with the common project management system.

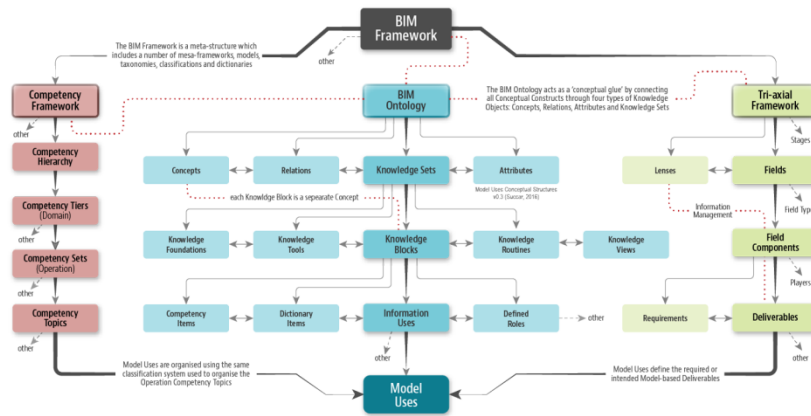


Figure 5.7 BIM Flowchart

5.6.2 Project Modeling

The projects prepared in the "Gar-Düztepe-Hospital Light Rail System (Underground) Line's Final Project Services Work for Implementation" will be modeled in accordance with the BIM infrastructure in architectural, static, mechanical and electrical disciplines.

5.6.3 Phase Planning (4D)

The work schedule will be based on the ideal construction process foreseen for the construction of the project in the main work items, and the model will be associated with the WBS codes and a 4D integrated model will be created. The work schedule will be made over the main work items as a base for the manufacturing work schedule.

4D simulations will be published at the end of the job.

4D Prepared model will be delivered in. nwd format. (* .avi or similar format can be added)

5.6.4 Project Evaluation

Prepared projects and documents produced will be submitted for the approval of the Administration.

Delivery of design / technical reports and similar documents with BIM model and CAD sheets; will be made together with the delivery sheets.

5.6.5 Dimensional Coordination

After preparing BIM Models, these models will be checked for conflict.

The main purpose of the coordination processes to be implemented in the project within the BIM processes is to reach a model without digital overlap. Since it will not be possible to reset the number of conflicts arising from the modeling of the systems with each other in the whole project (such as in-screed installation) in the digital report, it will be considered as a non-conflict model.

5.6.6 Uploading Operational Parameters to the Model

Since a certain brand and equipment cannot be specified on the prepared 3D BIM model in accordance with the tender specifications, the parameters to be filled in the required construction process will be placed on the model by category, but these lists will not be filled because the equipment and material decisions to be used have not been made.

5.6.7 Analysis Plan

For each type of analysis that can be performed for the project, the models used in the analysis to be carried out by the Project Delivery Team consultant, the required file format, the project stage and the software to be used in the analysis are as follows.

Table 5.2 Software to be Used in Project Phase and Analysis

Analysis	Analysis Tool	Model	Project Stages	File Format
Visualization	Revit-3dsmax	Revit	LOD 100,200,300	rvt
Structural	Sta4Cad, Robot	Revit	LOD 100,200,300	rvt
Conflict Detection	Navisworks	Revit	LOD 100,200,300	rvt, nwc, xlsx
BOQ	Excel	Revit	LOD 100,200,300	xlsx
Lighting	Dialux	Revit	LOD 300	
Pedestrian Simulation	Massmotion	Revit	LOD 200	.avi

5.6.8 Conflict Control

Conflict control is the stage of detecting and correcting the problems such as passing through each other and overlapping of the building elements belonging to the

disciplines that make up the building while modeling the building in the virtual environment. These conflict determinations are made via meetings held with relevant disciplines, and decisions are taken to resolve the conflict. The aim is to minimize the time cost losses caused by collisions during the construction phase (Altuni, 2019).

Contractors and decision-making mechanisms in the building industry prefer to use BIM to increase coordination and reduce conflict problems due to low efficiency of design coordination and collision checks with 2D drawings. In BIM projects, project stages are expected to take longer as a result of the analysis. In this way, all risks that may occur during the manufacturing and assembly stages are significantly reduced. The most important BIM goals in projects designed with BIM and where BIM case analyzes were carried out, such as the Hilton Aquarium with a budget of 46 million dollars and the 'One Island East Project' in Hong Kong with a budget of 300 million dollars, were to perform conflict checks and to perform '0' errors. These two big projects were completed with '0' conflict error (Azhar et al., 2008; Akkoyunlu T.).

Within the scope of the Gaziantep Underground Project, which is being carried out by Gaziantep Undergroundpolitan Municipality, conflict checks are checked by both the BIM consultant and the Technical personnel of the Transportation Department, through Navisworks and Revit software, and submitted to the contractor company after reporting.

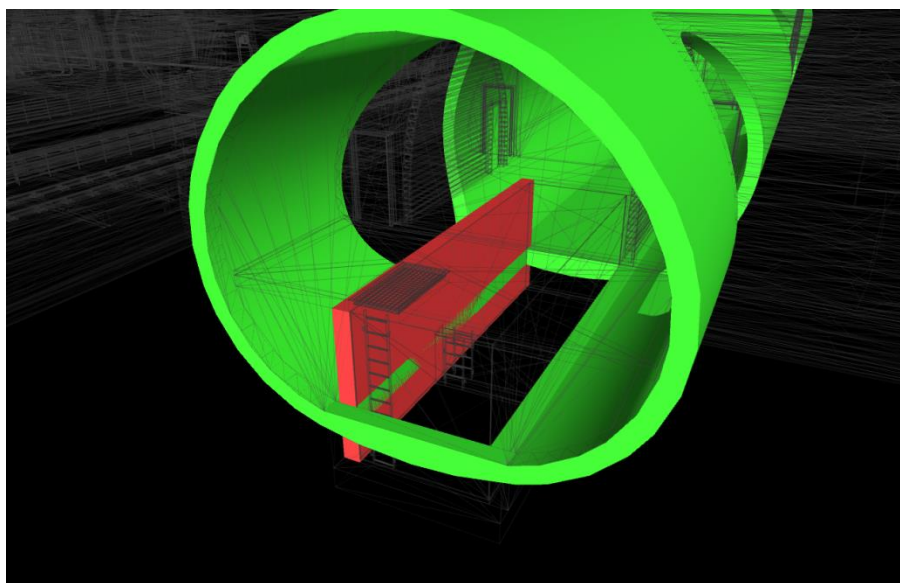


Figure 5.8 Conflict check in Navisworks software

In the light of the submitted report, the contractor company makes the necessary arrangements on models and presents them to the BIM consultant and related technical personnel for approval.

Below is the report prepared by the Technical Staff of the Transportation Department (Ahmet Kutalmis KOCOGLU).

5.6.9 Project Information

Table 5.3 Project Tag

The name of the job	GMM GDH UNDERGROUND LINE
Employer	GMM TRANSPORT DEPARTMENT
Report Preparer	AHMET KUTALMIS KOCOGLU
Evaluated Projects	S06 (ARCHITECTURAL-STATIC-ELECTRIC-MECHANICAL)

BIM models of architectural, structural, electrical and mechanical projects of S06 Station belonging to the Underground project prepared by the contractor (IDOM) within the scope of the technical specification were examined. The published BIM models were examined through Revit and the opinions about the models are reported below.

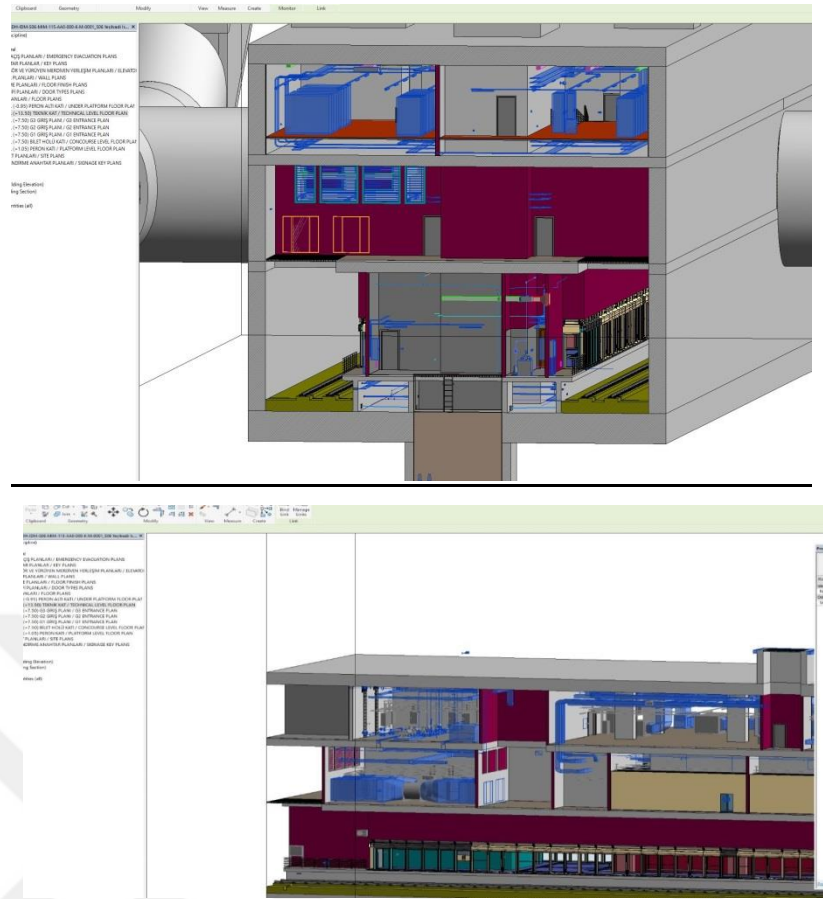


Figure 5.9 Conflict images of mechanical and electrical equipment in Revit software

5.7 BIM Competency Evaluation Study of the Design Process of Gaziantep Undergroundpolitan Municipality Infrastructure Project (Underground Project):

BIM competence assessment of the architectural, structural, mechanical, electrical and electronic design processes of an infrastructure project (Underground project for example) belonging to Gaziantep Undergroundpolitan Municipality (GMM) has been made. Building Information Modeling (BIM) Competence Assessment Model (BIM / YBM-YeDeM), which was developed within the scope of my doctoral study, was used to make this assessment.

Three levels of BIM competencies are defined in the BIM Competency Dimension of BIM-YeDeM. These; BIM Competency Level 1-Implemented BIM, BIM Competency Level 2-Integrated BIM and BIM Competency Level-Optimized BIM. For the Underground project of GBB, BIM Competency Level 1 evaluation was carried out as an example. By using two attributes (metrics) belonging to BIM

Competency Level 1, BIM competency evaluations of the design processes have been completed. The definitions of these metrics are given below:

- BIM Competency Level 1- Implemented BIM: Processes are operated using BIM and BIM outputs are produced as a result of the process.

BIM Attribute 1.1 Measures whether the defined BIM outputs of the BIM Implementation process have been achieved

BIM Attribute 1.2 BIM Skills measure whether the organization is working with BIM trained / experienced staff.

Evaluation results are presented below in summary form.

5.7.1 GMM Underground Project BIM Competency Level 1 Assessment Findings

A case study was conducted with the Transportation Department to evaluate the BIM competence of the architectural, structural, mechanical, electrical and electronic design processes of the GMM Underground project. Data were collected through surveys and remote online meetings, and the accuracy of the findings was confirmed through bilateral interviews.

There are approximately 20 technical personnel throughout the project and all of the technical personnel have received BIM training at the beginning of the project. In addition, 2 technical personnel in the technical staff have BIM experience of 3-10 years. BIM-related processes are assigned to BIM experienced staff.

5.7.2 BIM Attribute BIM Implementation-Architectural Design (ARCH D)

BIM competence of four architectural design processes (ARCH D2-Program development, ARCH D 3-Pre-project creation, ARCH D4-Application project development, and ARCH D5-Record modeling) were measured. According to the findings at what level the BIM outputs of these processes were made, it was scored as 1- Not done, 2- Partially done, 3- Mostly done, 4- Completely done.

The scores of the BIM outputs are given according to the findings below.

ARCH D2 Program preparation: The building program is made on the model. The aim of the project, in which technical details are processed on the models, is to create the infrastructure so that the details can be seen on the tablet when the QR code is read during the construction phase. Calculations were made considering the forward-looking change predictions and these predictions were transferred to the model. In the BIM contract made with the architectural design company, all infrastructures on the Underground route are processed into the model.

ARCH D3 Pre-project creation: Architectural models are created using the Revit tool. The stations are modeled and tunnels are designed using CAD as a tube passage. 3D coordination has been achieved. Interior designs are also made on the same model. Conflict checks are carried out through three different channels: the firm that performs the architectural design, the project team in the municipality, and the BIM consultant. It is added to the model as a comment. Code verifications (metering item numbers) are not made on the model. Also, Models are archived.

Table 5.4 Scores of BIM outputs of architectural design processes.

Architectural Design Processes	BIM Outputs	Scoring All (4) / Mostly (3) / Partially (2) / None (1)
ARCH D2 Program preparation	ARCH D2-1. Building program and requirement list is prepared (indoor areas, volumes, quality, etc.)	4
	ARCH D2-2. Creating a program: The functionality of the building program (building design, if any) is evaluated in terms of the existing land environment and customer requirements.	4
ARCH D3 Pre-project creation	ARCH D3-1. Architectural model development: Conceptual project model alternatives are created and one of them is selected together with the customer.	4
	ARCH D3-2. Architectural model development: Conceptual project model is detailed.	4
	ARCH D3-3. Architectural model development: Pre-project model is created.	4
	ARCH D3-4. 3D coordination (Conflict check): 3D coordination is performed to detect conflicts between the architectural model and the models of all disciplines (STR, BS and GEO).	4
	ARCH D3-5. Code (ground codes, independent section codes, etc.) verification is done.	2
	ARCH D3-6. Architectural model development: Architectural exact project model is developed.	4
	ARCH D3-7. An application is made for a building license.	2

Table 5.4 (more)

Architectural Design Processes	BIM Outputs	Scoring All (4) / Mostly (3) / Partially (2) / None (1)
ARCH D4 Application project development	ARCH D4-1. Design review: A design review is made for the preliminary project and final project model created.	4
	ARCH D4-2. Architectural model development: An application project model is created.	4
	ARCH D4-3. 3D coordination: 3D coordination is made between the application project model and the application project models of other disciplines (STR, BS, GEO).	4
	ARCH D4-4. Architectural model development: The application project model is updated and a manufacturing project model is created for the construction phase.	4
	ARCH D4-5. Cost estimation: 5D cost estimation is created over the quantities extracted from the model.	4
	ARCH D4-6. 4D phase planning: 4D planning is prepared in order to follow progress during construction.	3
	ARCH D4-7. Engineering analysis: Engineering analysis such as energy analysis is done on the model.	4
	45	
	ARCH D4-8. Engineering analysis: Sustainability (LEED) evaluation is made on the model.	4
	ARCH D4-9. Tender documents containing BIM protocols are created.	4
ARCH D5 Registration modeling	ARCH D5-1. Record modeling: Record model (as-built model) is created for use in facility management.	N/A

ARCH D4 Application project development: Design reviews are carried out on the model. Architectural application model is developed using Revit and auxiliary tools. 3D coordination has been achieved. 4D planning simulation was done using Navisworks for the construction of a station. Passenger simulations were carried out. 5D cost estimation is made by taking quantities over the model. Passenger movements, CCTV, business, CFD, accessibility, CER and fire simulations were made.

ARCH D5 Record modeling: Since the construction phase has not passed yet, there is not enough evidence to enable an assessment of record modeling. Therefore, it was not included in the evaluation.

5.7.3 BIM Attribute Performing BIM-Structural Design (STR D)

BIM competence of three processes (STR D3-Pre-project creation, STR D4-Detailed structural model creation, STR D5-Record modeling) of the structural design phase was measured. The level of BIM outputs of these processes was scored according to the following findings (Table 5.5).

Table 5.5 Scores of BIM outputs of structural design processes

Structural Design Processes	BIM Outputs	Scoring All (4) / Mostly (3) / Partially (2) / None (1)
STR D3 Pre-project creation	STR D3-1. Structural model development: Alternative structural frameworks are developed according to structural possibilities.	4
	STR D3-2. 3D coordination: The 3D coordination of MEPF models and bearing structures and the 3D coordination of structural design alternatives (ARCH, BS, GEO) with the proposed design solutions of all disciplines are checked and a structural model is selected by proposing a structural solution.	3
	STR D3-3. 3D coordination: 3D coordination is made between the selected structural model and models from all disciplines (ARCH, BS and GEO).	4
	STR D3-4. Structural model development: The structural model is detailed to create the final project model.	4
STR D4 - Building detailed structural model	STR D4-1. Structural model development: Detailed structural model is created based on structural calculations.	4
	STR D4-2. Engineering analysis: Structural analysis is done.	4
	STR D4-3. Cost estimation: 5D cost estimation is prepared over the quantity extracted from the model.	4
	STR D4-4. 4D phase planning: 4D planning is prepared in order to follow progress during construction.	3
STR D5 - Registration modeling	STR D5-1. Record modeling: Record model (as-built model) is created for use in facility management.	N/A

STR D3- Pre-project creation: Static calculations were made using structural calculation programs (Sap2000, Tekla, Plaxis) and the structural model was developed using Revit. 3D coordination is made between structural models and models from other disciplines.

STR D4- Creating a detailed structural model: Models are created in accordance with the LOD 300 level specified in the contract. All the accessories of the project have been created using the CAD program. 4D planning was carried out using Navisworks. 5D cost estimation was made by taking the quantities over the model.

STR D5- Record modeling: Since the construction phase has not started yet, there is not enough evidence to make an assessment about record modeling. Therefore, it was not included in the evaluation.

5.7.4 BIM Attribute Performing BIM- Mechanical, Electrical and Electronic Design (BSD)

BIM competencies of three processes (BS D3-Pre-project creation, BS D4-Detailed ME model creation, BS D5-Record modeling) belonging to the mechanical, electrical

and electronic (ME) design phase were measured. The level of BIM outputs of these processes was scored according to the following findings (Table 5.6).

Table 5.6 Scores of BIM outputs for Mechanical, Electrical and Electronic design processes

Mechanical, Electrical and Electronic Design Processes	BIM Outputs	Scoring All (4) / Mostly (3) / Partially (2) / None (1)
BS D3 - Pre-project model building	BS D3-1. MEP model development: Recommended MEP models (HVAC, AUT, TEL, ELE) are created.	4
	BS D3-2. 3D coordination: 3D coordination is carried out between proposed MEP models (HVAC, AUT, TEL, ELE) and suggested models from all disciplines (ARCH, STR, GEO).	4
	BS D3-3. 3D coordination: 3D coordination is made for MEP models (HVAC, AUT, TEL, ELE) and MEP design solutions are selected and approved.	3
	BS D3-4. MEP model development: Definitive MEP models are created and approved.	4
BS D4 - Creating detailed MEP models	BS D4-1. MEP model development: Detailed MEP models (HVAC, AUT, TEL, ELE) are developed.	4
	BS D4-2. 3D coordination: 3D coordination is made between detailed MEP models (HVAC, AUT, TEL, ELE).	3
	BS D4-3. Cost estimation: 5D cost estimation is prepared over the quantity extracted from the model.	4
	BS D4-4. 4D phase planning: 4B planning is prepared in order to follow progress during construction.	3
	BS D4-5. Engineering analysis: Energy analyzes (heating energy consumption, cooling energy consumption, electricity consumption, water consumption, lighting analysis, etc.) are	4
BS D5 - Record modeling	BS D5-1. Record modeling: Record model (as-built model) is created for use in facility management.	N/A

BS D3- Pre-project creation: Mechanical, electrical and electronic models have been developed using Revit. 3D coordination is made between ME models and models from other disciplines.

BS D4- Detailed mechanical, electrical and electronic model creation: Detailed mechanical, electrical and electronic models were created using Revit. 3D conflict checks were done using Navisworks. 5D cost estimation is made by taking quantities over the model. 4D planning was carried out using Navisworks. Lighting, ventilation, line-long sound, announcement, radio simulations were made.

BS D5- Record modeling: Since the construction phase has not started yet, there is not enough evidence to make an assessment about record modeling. For this reason, it was not evaluated.

5.7.5 BIM Attribute BIM skills - Architectural, Structural and Mechanical, Electrical and Electronic Design

In order to measure the BIM skills of the personnel carrying out architectural, structural, mechanical, electrical and electronic design processes, the level of BIM skills outputs of the following BIM skills attribute was scored. The scores shown in Table 5.7 are based on the following findings obtained as a result of our evaluations.

Table 5.7 Scores of the outputs of the BIM skills attribute in architectural, structural, mechanical, electrical and electronic design processes

BIM Attribute 1.2 BIM skills outputs	Scoring All (4) / Mostly (3) / Partially (2) / None (1)
1. 1. Personnel with BIM training and / or BIM experience are employed.	3
2. Employees are supported in BIM training.	4
3. BIM-related processes are assigned to BIM-trained and / or BIM-experienced workers or teamwork BIM learning is encouraged.	4

BIM trained personnel are employed. BIM consultancy has been received for 3 years. BIM trainings were also provided to employees when necessary (especially at the beginning of the project). BIM-related processes are assigned to BIM experienced staff; Teamwork is carried out within the company and mutual BIM learning is encouraged.

5.7.6 Phase 1 BIM Competency Level Scores

According to the findings given above, it has been concluded that the architectural, structural, electrical and electronic design phases are at the Level Implemented BIM level (Figure 510).

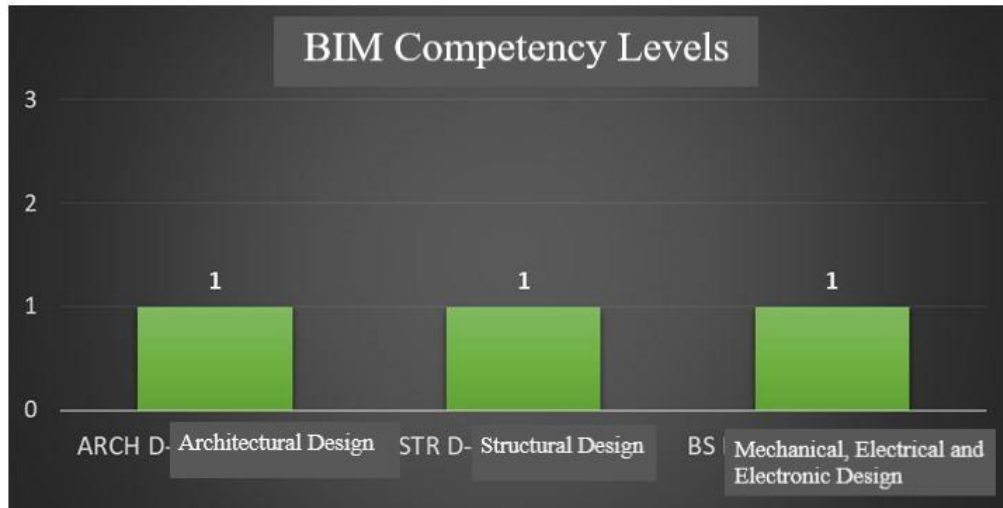


Figure 5.10 Architectural, structural, mechanical, electrical and electronic design BIM competency level

5.8 Route and Station Locations

5.8.1 Route

As a result of the Gaziantep Transportation Master Plan decisions, it is aimed to stratify the public transportation network and to transport the journeys faster and more efficiently. High capacity will also enable high comfort levels to be created.

General principles regarding backbone lines are as follows.

- The development of Gaziantep, which has a compact form, is towards the periphery of the city. For this reason, the main axes of the transportation system should be formed in a way to respond to the transportation demand radially from the city center to the periphery in order to ensure the sustainable urban development.
- While determining the backbone lines, it should be taken as a basis to provide access to the most basic attraction centers (city center, railway station, bus terminal, industrial sites and OIZs, hospitals and universities) that directly affect the reflection of travel demands to the space.
- While planning the line, the main transfer points between the main backbone lines and rubber-wheeled lines within the public transportation system should be established as "Transfer Centers" in a way to ensure the integration of all modes of the transportation system (pedestrian, bicycle, public transport, automobile).

- Integration between the modes of transport must be in the fare / ticket system as well as the Transfer Centers created.
- A mass transportation planning should be made that takes into account the rights of disadvantaged groups, especially in terms of transportation in the city, adopting that the focus of the transportation system philosophy is not vehicles but people.

With the Master Plan prepared within the framework of these general principles, the principles adopted for the main backbone public transportation line between Gar-Düztepe-Hospital, which is one of the priority lines within the scope of public transportation solution proposals developed to eliminate the future problems and deficiencies in Gaziantep's transportation infrastructure. is as follows.;

- To ensure the creation of line structures perpendicular to this backbone by creating a main backbone between traffic sectors and within districts,
- To be able to benefit from the general transportation infrastructure of the city,
- To ensure that it is adopted by users,
- To construct a public transportation system with acceptable travel time and cost,
- To reduce the traffic load on Özdemir Street, one of the most important axes connecting the city center and the city hospital.,
- To contribute positively to urban values and the environment,
- To create a sustainable line design to ensure compliance with planned land use decisions as well as the existing land use structure,
- To determine station locations that can be integrated with the planned public transport network and transfer centers,
- To determine a public transportation system with a capacity to meet the estimated passenger demand on the route,
- To design a corridor completely separated from road traffic,

- To create a station in an average of 1 kilometer,
- To design a business structure with a density not exceeding 6 people / m² in vehicles,
- Creating a system using sustainable energy resources,
- To design a structure that will keep the pedestrian flow uninterrupted on both sides of the streets where the line passes.

5.8.1.1 Route of the Line and Area of Influence Land Use Structure

City Hospital is planned in the south of the city. There is a dense residential texture from the station towards the south. The City Hospital to be built will be an important attraction. For this reason, it is aimed to open the Gar-Düztepe-Hospital Line, which will connect the city center to Gaziantep City Hospital, within the Gaziantep Transportation Master Plan until 2020.

Since all elements of the transport system of cities are related and interacted with the uses around them, the transport network infrastructure can never be considered alone. Therefore, the decision to make a transportation investment will also affect the uses around the specified route. Likewise, the land use character of the city is among the evaluation criteria that stand out along with physical and financial evaluations in determining the routes of transportation investments. Therefore, it is important to evaluate a transportation investment or land use change decision within this framework.

When the land uses around the route of Gar-Düztepe-Hospital Line in Gaziantep city are examined, it is seen that it has a structure that will ensure the continuity of the demand.

When the land uses in the immediate vicinity of the Gar-Düztepe-Hospital Line route are evaluated, the prominent uses are as follows.

- Center Uses
- Commercial Uses

- Education Facilities
- Health Facilities
- Recreative Uses
- Residential Uses
- Transfer Center Uses

The route of the line starts from Gaziantep Gar station and continues along the Özdemiir Avenue route from the Democracy Square on July 15th. From here, due to land reasons, the line curves towards the west of the city and reaches Akkent and from there to the City hospital.

This main backbone line connects Gaziantep city center with the residential and hospital areas in the south. Özdemiir Caddesi, which is the main service route of the line, also hosts important urban activity areas, commercial and business areas.

The line will be integrated with other systems thanks to the proposed transfer areas on the route within the scope of Gaziantep Transportation Master Plan. These transfer centers;

- Gar Main Transfer Center,
- Düztepe Transfer Center
- City Hospital Main Transfer Center

Gar-Düztepe-Hospital Line starts from Gaziantep Gar and passes through Özdemiir Avenue breaking the Green valley in the west direction. From here, it reaches the City Hospital after Akkent.

Gaziantep Gar, Düztepe, and City Hospital Transfer Centers will be located on the Gar-Düztepe-Hospital Line, which are proposed in the Transportation Master Plan decisions and which are an integration point where many public transportation lines intersect.

5.8.2 Station Locations

The growth rate of population and economy in Gaziantep continues above the average of Turkey's population and economic growth. With economic, industrial, health, education, cultural and social investments, the transportation problems brought by the increasing population of Gaziantep City are one of the important problems in the city as in our country. As a result of the studies carried out in the city of Gaziantep within the scope of GTMP 2030, sustainable urban transportation policies have been developed for sustainable economic development. In this context, short, medium and long term transportation policies have been determined in Gaziantep City.

The most important lines planned in Gaziantep within the scope of GTMP, Gar-Düztepe-Hospital light rail system Underground line, Gar-GAUN Campus-15 Temmuz light rail system Underground line, Şehirgösteren-Airport light rail system Underground line, Gar-Yeniotogar-Stadium light rail system Underground lines are planned.

With this planned light rail system Underground lines, Gaziantep Undergroundpolitan Municipality has determined a vision that will ensure 24-hour access to the main travel centers of the city by targeting a fast, reliable, economical, environmentally friendly and modern transportation infrastructure that connects the main travel centers and the city center.

In this context, starting from the Gar area, passing through "15 July Democracy Square, Dr. Ersin Arslan State Hospital, Düztepe, Kahvelipınar, Yeşilvadi, Akkent Park and Akkent stations, a total of 9 stations, 1 warehouse area and 11.3 km, Gar-Düztepe-Hospital light rail system Underground line is planned to be constructed within the short-term planning, and it is aimed to provide transportation from the city center to the City Hospital with 1875 bed capacity, which is planned to be completed in 2019 and is built on an area of 638.000 m². The transportation model approved by Gaziantep Undergroundpolitan Municipality has been studied and determined.

The first station of the line is planned in the Gar area. With the station to be built in this region, integration with Gaziray, the planned high-speed train, Gar-Gaün- 15 Temmuz, Şehirgösteren-Airport light rail system lines will be provided. The Gar

Station Gar-Gaün is projected together with the 15 July light rail line. Infrastructure lines were taken into consideration while positioning the stations.

In addition, the concept project of GAR TRANSFER CENTER has been prepared within the scope of this project in the Gar area. GAR TRANSFER CENTER Gaziray is planned to provide integration with high-speed train and rail system Underground lines, as well as to meet the daily needs of passengers in a more comfortable and modern transportation network with its social, cultural and commercial functions. The general location of this station on the current satellite photo is given in Figure 5.11.



Figure 5.11 Gas Station

The second station of the line, 15 Temmuz Demokrasi station, is located in the social and cultural center of the city. It is a planning that completes the cultural road project planned in the region. Just like the Gar station, Gar-Gaün is designed in partnership with Station 2 of the 15 Temmuz Underground line at the 15 Temmuz Democracy station.

In this way, passengers of both lines will be able to transfer easily to both Underground lines. In addition, work is being carried out in coordination with the 15 Temmuz Demokrasi Station Millet Bahçesi project, and the Millet Bahçesi and the New Governor's Office are continuing on the basis of the draft development plans.

Infrastructure lines were taken into consideration while positioning the stations. The general location of this station on the current satellite photo is given in Figure 5.12.

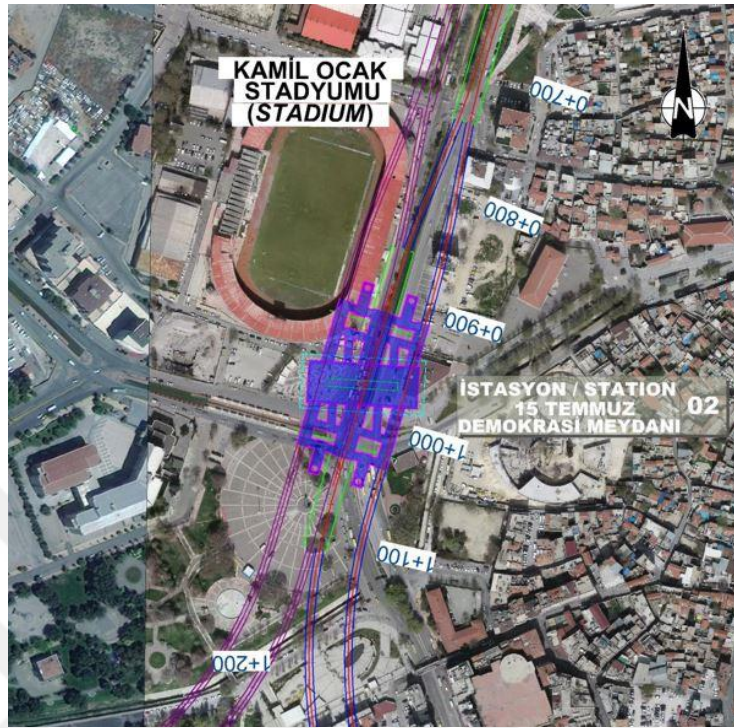


Figure 5.12 15 Temmuz Demokrasi Square Station

The third station of the line is Dr. Ersin Arslan station which is located between İnönü street and Balıklı square. The station's proximity to travel production centers such as İnönü Caddesi, Karagöz, Bey Mahallesi, Balıklı Square has increased the attractiveness of the station. While determining the location of the station concourse, the lines of GASKI in the region and the current traffic situation of Hürriyet Street were taken into consideration.

There are serious elevation differences between the Gar district of the city and Karataş and Akkent regions in the south. The maximum slope allowed by the rail system line from Dr Ersin, which is the 3rd station of the line, to the Düztepe station area is 4.5%. In this case, it is technically not possible to plan a separate station between Dr Ersin and Düztepe. Currently, Düztepe station is the deepest station of the line with 53 meters. In the Düztepe region, there are areas with serious urban transformation potential on the NORTH-SOUTH-EAST AND WEST axis. The fast, reliable and comfortable transportation provided by the station to be located in this

region will accelerate the urban transformation of the region and add value to the region, the stations are shown in Figures 5.13 and 5.14.

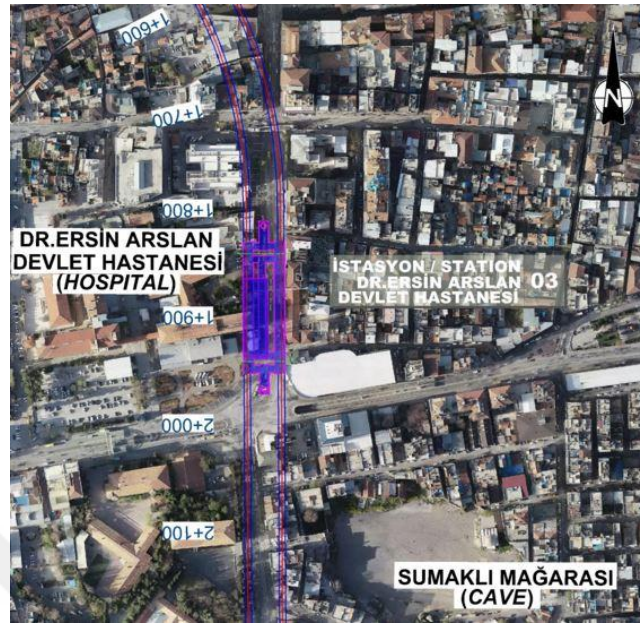


Figure 5.13 Dr Ersin Arslan Station

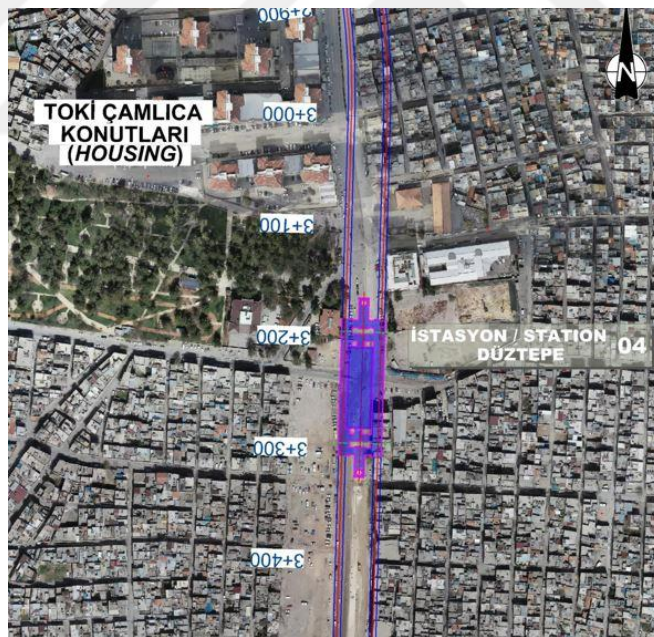


Figure 5.14 Düztepe Station

The 5th station of the line, Kahvelipınar station, will again accelerate the urban transformation projects within the impact area and will enable the urban design projects to be planned in the region. The station, which is located on 77th Street designated as the main supply bus line corridor within the scope of GTMP, serves

Kahvelipınar, Geylani, Güneş, Geylani and Mimar Sinan neighborhoods on the east-west axis with a wide coverage area. (Figure 5.15)



Figure 5.15 Kahvelipınar Station

The 6th station of the line Yeşilvadi station is planned at the intersection of the 160th street and Yeşilvadi Boulevard where residential and commercial areas are planned together. The station serves Bülbülzade, Geylani, Güneş and Ertuğrulgazi neighborhoods with its coverage area. (Figure 5.16)

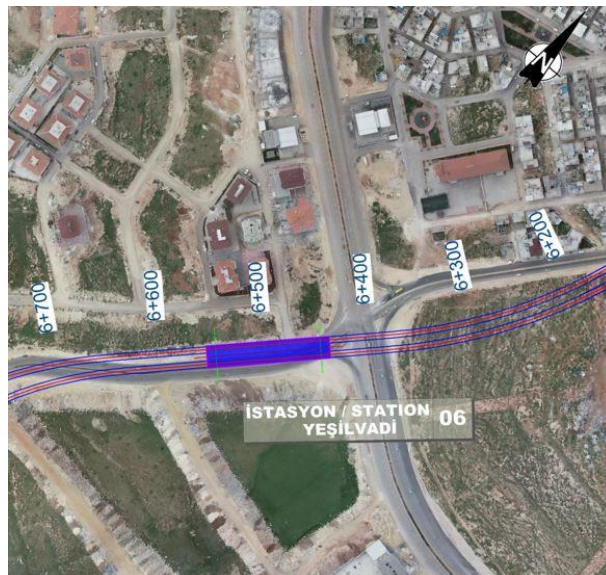


Figure 5.16 Yeşilvadi Station

The 7th Station of the line Akkent Park station serves the neighborhoods of Bülbülzade, Ertuğrulgazi, Karataş and Şahintepe. (Figure 5.17)

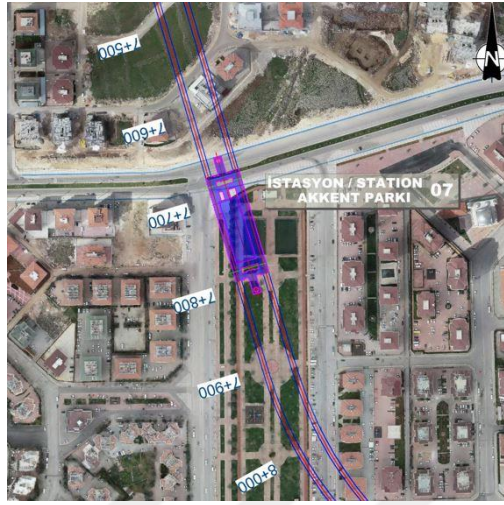


Figure 5.17 Akkent Station

The 8th Station of the line Akkent Mosque is located in front of the Prophet Abdullah Mosque, where 15 thousand people can pray at the same time, which is built on an area of 10 thousand 182 square meters on an area of 100 thousand square meters, and has a seating area of 6 thousand square meters. Akkent district is in the coverage area of the station. (Figure 5.18)



Figure 5.18 Akkent Park

The 9th Station of the line City Hospital station is located in the region of Gaziantep City Hospital, which will be established on an area of 638,089 m², has a capacity of 1875 beds, an open and closed car park with a capacity of 3082 vehicles and the

Provincial Health Directorate Building in the health campus area. While station positioning, coordination meetings were held with city hospital officials. (Figure 5.19)

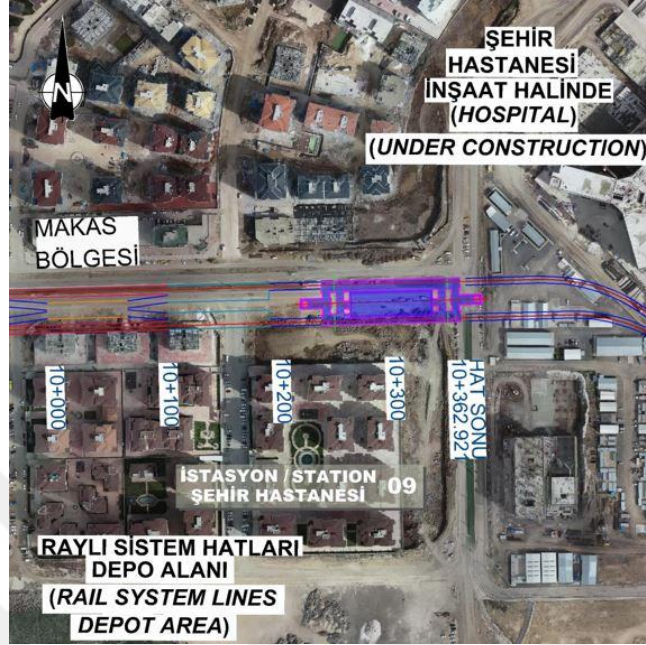


Figure 5.19 City Hospital Station

One of the main storage areas planned to meet the needs such as parking, periodic maintenance and heavy maintenance of the rail system Underground lines planned within the scope of short, medium and long term planning in Gaziantep city in the works carried out within the scope of GTMP 2030, was planned on the GAR-DÜZTEPE HOSPITAL light rail system Underground line. Unless the warehouse lines are required as a technical preference, it is preferred to be at the beginning and end of the rail system lines. Rail system lines are investments with approximate km costs of up to 40,000,000 Euros, planning the warehouse areas away from the line will increase the initial investment costs of the rail system lines and cause serious energy consumption by increasing the dead kms of trains under long-term operating conditions expenses, vehicle and line maintenance expenses. Within the scope of GTMP 2030 approved by AYGEM, at the end of the GAR DÜZTEPE HOSPITAL rail system line, as the rail system area in the zoning plans in the region below, GAR-DÜZTEPE-HOSPITAL, GAR-GAUN 15 TEMMUZ and GAR DÜZTEPE HOSPITAL Underground line is planned to be put into operation in 2033. The space reserved for the rail system lines in the zoning plans should be arranged in line with

the proposed project layout, in the most optimum conditions needed to include train parking, heavy maintenance, periodic maintenance and washing facilities. Figure 5.20 shows the general view of the station locations along the line.

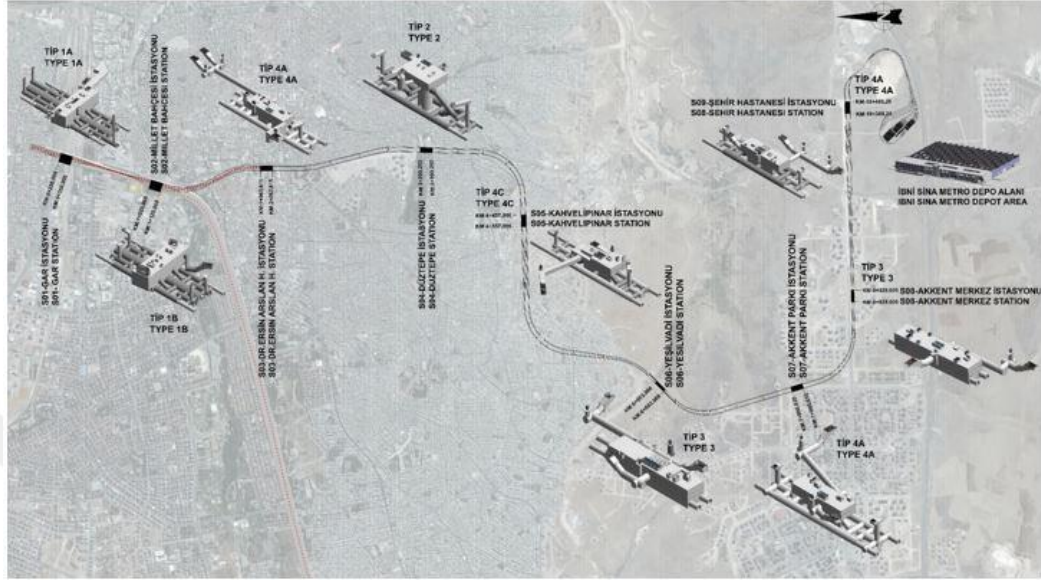


Figure 5.20 Stations settled along the line and their locations

5.9 Transfer Centers

5.9.1 Station Main Transfer Center

Gar Main transfer center has been prepared in order to ensure the integration of all transportation types in the city center. These types of transportation are;

Gaziray and High Speed Train Lines, Underground Lines, Bus Platforms, Indoor Parking and Taxi will be used.

The transfer center also includes scaled trade and service functions.

The planned Gar Main Transfer Center is expected to host at least 877,540 passengers per day in 2030. (Figure 5.21)



Figure 5.21 Gar Station main transfer center where urban transportation lines meet

5.9.2 Dr Ersin Arslan Transfer Center

When the Transfer Centers are considered within the transportation setup, they mainly function to organize the system elements within the transportation system and to ensure that the users benefit from the system in the most efficient way possible, with increased comfort quality. (Figure 5.22 shows architectural visuals)



Figure 5.22 Dr Ersin Arslan Transfer Centre

The Dr Ersin Arslan Transfer Center, which is included in the Gaziantep Gar-Düztepe light rail system project, is also the transfer function of the passengers in connection with the Dr Ersin Arslan Underground station and bus stops, as well as

the underground car park with a capacity of approximately 300 vehicles and the users described as "park - continue". It is planned as a structure that will provide services in terms of providing more economical and comfortable transportation to their destination in a shorter time by switching to public transportation vehicles after coming to certain centers by private vehicles. In addition, parking areas have been created for bicycle use supported in terms of urban transportation.

As an architectural fiction, it is aimed to contribute to the city location in which it is located in addition to meeting the specified functions of the Transfer Center structure. First of all, city residents and visitors who are or are not users of the Transfer Center in this location encounter a physical environment that is physically processed with good qualities, perceive and adopt this structure as a city building and urban life, where they face difficulties by taking advantage of the transportation-based necessities as well as the developed cafeteria and shopping areas. It is aimed to find places where you can have a pleasant time.

In this context, the above ground part of the building; The upper floor was designed as open and closed spatial formations connected to the overpass on İnönü Caddesi, forming a holistic formation starting from the square where it is located together, consisting mostly of green areas. On the upper level, a cafeteria that will function mostly for the open area is located.

Green areas in the form of a ramp function as open spaces where you can freely walk around and sit. In the green areas, it is aimed to create a reference awareness with the replicas of the Hittite sculpture workshop sculptures in this area by making a mental reference to the ancient ruins of Yesemek, located within the province of Gaziantep.

5.9.3 Düztepe Transfer Center

When the Transfer Centers are considered within the transportation setup, they mainly function to organize the system elements within the transportation system and to ensure that the users benefit from the system in the most efficient way possible, with increased comfort quality.

The Düztepe Transfer Center, which is included in the Gaziantep Gar-Düztepe Light rail system project, has the function of transferring passengers in connection with the nearby Düztepe Underground station and bus stops, as well as the underground car

park with a capacity of 115 vehicles. It is planned as a structure that will provide service in terms of providing more economical and comfortable transportation to their destination in a shorter time by switching to public transportation vehicles after coming with their private vehicles. In addition, parking areas have been created for bicycle use supported in terms of urban transportation.

As an architectural fiction, it is aimed to contribute to the city location in which it is located in addition to meeting the specified functions of the Transfer Center structure. In the location of Düztepe Transfer Center, there are densely residential settlements. There is a primary school in the neighboring parcel. For these reasons, it has been predicted that departments especially for children will provide the best use in the formation to take place in this field.

As the above ground part, a plain looking structure consisting of a single storey closed and partially covered open areas is proposed. Closed areas in this structure; It is a hobby and art workshop and a cafeteria. It is foreseen that activities for women or age groups, especially children in the district, can be held in the hobby and art workshop. (Figure 5.23)

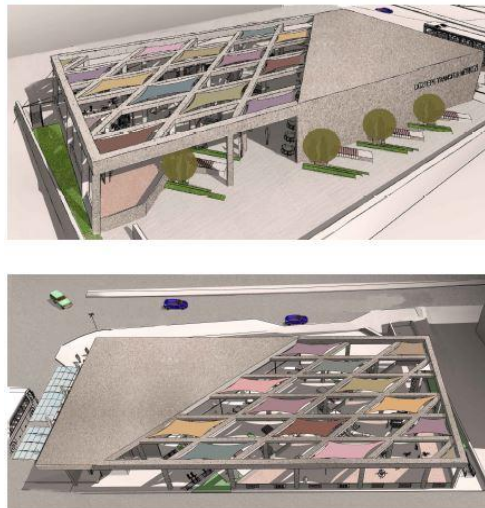


Figure 5.23 Düztepe transfer center

While the area in the middle part of the partially closed open space arrangement provides the opportunity to sit and rest within the landscape organization, a playground for children is created on the other hand. We anticipate that the functions we have specified in the context of the immediate environment can be evaluated as a structure that can contribute positively to the region with an increase in the quality of life.

5.10 Gaziantep Underground Project Ground Geology

Gar-Düztepe-Hospital Light Rail System (Underground) Line station structures and tunnel route; It is within the borders of Gaziantep province and Şahinbey and Şehitkâmil districts.

Gaziantep province is located in the Southeastern Anatolia Region, adjacent to the Mediterranean Region, between 36 ° 28 'and 38 ° 01' east longitudes and 36 ° 38 'and 37 ° 32' north latitudes. Gaziantep covers 1% of the country's territory with a surface area of 7642 km². Considering the location of the province in geographical regions, it is seen that it is located at the intersection of the Mediterranean Region and the Eastern Anatolia Region. Gaziantep is neighbors with Kahramanmaraş and Adıyaman in the north, Kilis in the south, Şanlıurfa in the east, Osmaniye and Hatay in the west.

9 station structures are planned along the Gar-Düztepe-Hospital Underground line. The line starts from T.C.D.D Gar location, goes south and ends at Şehir Hastanesi location.

5.10.1 Geology of the Study Area

General information about the formations encountered along the route is given below. The generalized stratigraphic section of the units seen in the study area is shown below.

5.10.2 Gaziantep Formation (Tmga)

The description and naming of this unit consisting of clayey limestone, limestone and chalk was first made by Wilson and Krummenacher (1957).

The formation outcrops in the form of clayey limestone and chalky limestone showing a soft topography. In some places, instead of these clayey and chalky limestones, thick bedded limestones are found. Clayey limestones are whitish gray-cream-dirty yellow colored, thin to medium bedded, with little chert nodules. Limestones, on the other hand, are gray-beige-yellowish gray, medium-thick in places, very thick bedded, grained, abundant benthic fossils, algae and coral in places. Clayey limestones, chalky limestones were deposited in the basin edge or deep shelf edge environment, while limestones were deposited in the turbulent

shallow water environment. The thickness of the formation varies between 100-250 meters and it comes over the Ardiçlitepe formation with a harmonious contact. The Fırat formation and Yavuzeli basalt are located on it with an incompatible contact.

Terlemeç et al. (1992) stated the age of the formation as Late Eocene (Priabonian) - Late Oligocene (Stampian).

5.10.3 Gaziantep Formation Limestone

It is located in the upper levels of the Gaziantep formation, transitionally with it. The border of the two units is not clear in many places, as there are chalky additives at the base or inside.

The closest outcrops of this unit to Birecik region are in Kalazan Mountain, Arat Mountain and high areas to the west of Zeugma. Limestones are composed of thick bedded, karstic cavity, sparse silexite lined limestone, clayey limestone and chalky limestone. Chalky limestone gains a hard massive feature with the increase of limestone ratio towards the top. Karst systems that developed due to discontinuities in this Eocene-Oligocene unit caused the discharge of large flow rate resources.

5.10.4 Fırat Formation (Tmf)

R. Krauset (1958) named the unit Pirin formation in his study in Midyat District of Mardin province. H. H. Wilson and R. Krummenacher (1957) named the unit as the Karadağ formation (Ulu et al. 1991). For the first time, Maxon and Tromp (from Tuna, 1973) named it a member (member of Fırat) of Midyat formation. Duran et al. (1988) presented it under the name of Fırat formation (from Şafak and Meriç, 1996).

The formation starts with cream-whitish-dirty yellow colored, medium-thick bedded limestones with no layers at the bottom, and above these limestones with dirty yellow color, medium-thick bedding, plenty of chert nodules and abundant fossil shells. The uppermost part is composed of whitish cream-dirty yellow colored bioclastic limestones with thick to very thick layers, few chert nodules, abundant echinids, ostrea, gastropods and lamellibranch.

The limestones that make up the unit have been deposited in the turbulent shallow water environment. The thickness of the formation varies between 0-150 meters and it overlies the Gaziantep formation with an inconsistent contact. On it, the Şelmo

formation and Yavuzeli basalt are located with an unconformable contact with an angle.

In the samples taken from the limestones that make up the unit, *Victoriella* sp., *Miogypsius* sp., *Operculina* sp., *Elphidium* sp., *Globoigerinoides* sp., *Rotalia* sp., *Amphistegina* sp., and *Lepidocyclina* spp. fossils have been found. *Miogypsina* and *Lepidocyclina* from this foraminifera assemblage indicate that the age of the limestones is between Late Oligocene and Early Miocene (Erdoğan and Yavuz, 2002).

5.10.5 Yavuzeli Basalt (Ty)

Tuna (1973) named the unit as Karacadağ basalt. This unit consisting of basalt lava was named by Yoldemir (1987). The definition and naming was made outside the map area, around Yavuzeli District.

Yavuzeli basalt consists of generally reddish-dark brown-dark gray and blackish colored, non-layered, occasionally very thick bedded, porous, pores filled with calcite-filled lava flow. In addition, there are agglomerate and tuff outcrops under this lava flow. These pyroclastics are observed especially in the parts of Gaziantep-Kilis road close to Kilis. The thickness of the basalts varies between 0 and 50 meters and they come over the Şelmo formation and other older units with an angular unconformity.

The formation age of Yavuzeli basalt is 12.1 ± 0.4 million years (Middle Miocene) according to Yoldemir (1987) and 7-8 million years (Late Miocene) according to Ulu et al. (1991). According to its stratigraphic position in the map area, the age of basalt is Late Miocene.

5.10.6 Alluvium (Qa)

They are unattached gravel, sand and mud deposits in the valleys and plains of large streams.

5.10.7 Geological and Geotechnical Surveys

Field and laboratory studies were carried out in order to reveal the ground features and geological structure of the Underground route within the scope of the Gaziantep

Transportation Master Plan, "Gar-Düztepe-Hospital Light Rail System (Underground) Line's Final Project Services for Implementation". 53 boreholes with a total depth of 2464.00 meters were drilled. Pressuremeter test and pressurized water test were performed on the boring samples taken.

Information on geophysical studies carried out throughout the project area are as follows:

- 9 MASWs,
- 17 2D Vp Refractive Tomography,
- 9 Microtremors,
- 30 Georadar (GPR) measurements were made

5.10.8 Geological Risks

- The effect of groundwater on tunnel excavation
- Excavation / hybrid mirror
- Karstification
- Rock block insensitivity

5.10.9 Geological Data:

The geological results of Gaziantep Underground Project, approximately 11 km long route, 9 station structures and 1 warehouse area, which were tendered by Gaziantep Undergroundpolitan Municipality in 2017 within the scope of Gaziantep Transportation Master Plan are given below.

Clayey limestone, chalky limestone and limestone units of the Eocene-Oligocene aged Gaziantep Formation, limestone of the Oligocene-Miocene Fırat Formation, shelled limestone unit, basalt unit of the Miocene aged Yavuzeli Formation, Quaternary aged Alluvium unit and Quaternary artificial on the route filling unit is included.

Fırat Formation consists of 3 different levels.

Firat Formation;

It starts with cream-whitish-dirty yellow colored, medium-thick bedded limestones with no layers at the bottom, and above these limestones with dirty yellow, medium-thick bedded, chert nodules and abundant fossil shells. The uppermost part is whitish cream-dirty yellow, thick-very thick bedded, less chert nodular, abundant echinid, ostrea, gastropod and lamellibranch bioclastic limestones.

Gaziantep Formation is; It outcrops as clayey limestone and chalky limestone showing a soft topography. In some places, instead of these clayey and chalky limestones, thick bedded limestones are found. Clayey limestones are whitish gray-cream-dirty yellow colored, thin to medium bedded, with little chert nodules.

Limestones, on the other hand, are gray-beige-yellowish gray, medium-thick in places, very thick bedded, grained, abundant benthic fossils, algae and coral in places.

The most distinctive feature between these two formations is that the fractures and cracks in the upper levels of the Firat formation where it is exposed are filled with red colored terra rosa material. Due to the absence of terra rosa material in the Gaziantep Formation and the presence in the Firat Formation, these two units could be distinguished on the plan.

However, these two formations could not be distinguished visually in terms of depth, since they are located in the cream-whitish-dirty yellow, chert nodular and fossil shell unit within these two limestone units and the ages of these two units are very close.

Because of this similarity, these two units could not be separated in terms of depth while creating the geological profile. In order to differentiate these formations, it is necessary to determine the age of fossils within the limestones or to determine the geological age determination method according to the cutting great rule.

Lithological, mechanical and hydrogeological properties of the formation are important in such construction works. Therefore, it was not considered necessary to separate the units on the basis of formation and the geological profile was evaluated lithologically and detailed according to the separation.

Based on the data obtained from the drillings carried out in the tunnel excavation, it is seen that the limestone unit, which is mostly of weak strength-strength rock, and the strength-multi-strength basalt unit towards the end of the route.

In order to determine the engineering characteristics of the units along the route, 53 boreholes were drilled, in-situ tests such as SPT, pressiometer and Lugeon were carried out in these wells, and laboratory tests were carried out on damaged samples taken from the boreholes. In addition, 9 MASW, 17 2D Vp Fracture Tomographs, 9 Microtremors, 30 Georadar (GPR) measurements were made along the route.

The field and laboratory data obtained were compiled for each different lithology and their average values were found. According to these results, design parameters were determined and excavation classes were determined. (Table 5.8)

Table 5.8 Design Parameters

Zone	Mileage Range		Length [m]	RMR _{final}	1994
	Start	End			
1	-0+075	0+450	525	36.6	B3
2	0+450	0+925	475	44.8	B3
3	0+925	1+200	275	28.8	C2
4	1+200	1+575	375	46.4	B3
5	1+575	2+525	950	44.2	B3
6	2+525	3+025	500	35.4	B3
7	3+025	3+375	350	39.5	B3
8	3+375	3+650	275	34.5	B3
9	3+650	4+000	350	31.4	B3
10	4+000	4+350	350	43.4	B3
			64		
11	4+350	4+675	325	43.0	B3
12	4+675	5+675	1000	44.3	B3
13	5+675	6+275	600	28.7	C2
14	6+275	7+125	850	28.9	C2
15	7+125	7+625	500	35.7	B3
16	7+625	8+050	425	47.9	B2
17	8+050	8+550	500	45.6	B3
18	8+550	9+075	525	47.6	B2
19	9+075	9+400	325	47.5	B2
20	9+400	10+325	925	38.1	B3
21	0+000	0+325	325	39.9	B3
22	0+325	0+575	250	40.2	B3

5.11 Gaziantep Underground Project Architectural Design

Located at the entrance of Mediterranean Region and Southeastern Anatolia Region, Gaziantep is located in southern Turkey. The province is surrounded by Şanlıurfa in the east, Kahramanmaraş and Adıyaman in the north, Osmaniye in the west, Hatay in the southwest and Kilis and the Syrian state in the south. The area of the province is 6,222 km². According to data of 2017 TSI (Turkey Statistical Institute) population of Gaziantep is 2,005,515 people.

Developing organized industrial zones, geopolitical location, domestic and international migration, growing trade volume, increased investments in higher education, universities, city hospitals, historical and natural, social-cultural areas, and the rapid growth in Gaziantep with the existing and rapid growth. Solution of expected transportation problems require proper transportation planning.

Efforts towards a solution on transportation, which is one of the most important problems of many Undergroundpolitan cities, have not yielded the expected results due to the efforts to save the day in many cities. It is as important as the correct determination of transportation problems that the solutions required to solve the problems include long-term and sustainable planning. Based on this fact, the Gaziantep Transportation Master Plan, which is a very comprehensive target year 2030, has been prepared, which takes into account the projection data such as the city's zoning plan decisions, the population in the target year, employment, as well as the investments in the transportation, logistics and industry fields in the city.

Within the scope of GTMP 2030, permanent solutions were brought to the transportation problems of the city of Gaziantep in line with the sustainable transportation policies in order to keep up with the developing economy of the city, and short term, medium term and long term plans were made.

In this context, backbone railway lines have been created with the Gaziantep Transportation Master Plan, the target year of which is 2030. These lines are:

- Gaziray
- Gar Station - GAÜN 15 Temmuz Campus Rail System Underground Line

- Gar - Düztepe - Hospital Rail System Underground Line
- GAÜN - Karataş - City Hospital - Güzelvadi Tramway
- GAUN - Abdulkadir Aksu Street - İbrahimli - Budak Tram Line
- Railway Station - Bus Station - Stadium Rail System Line
- Şehircösteren - Gar - Airport Rail System Line.

These lines come from different parts of the city and are joined at the train station.

In this context, GAR-DÜZTEPE-HOSPITAL light rail system Underground lines, whose projecting studies are ongoing, are designed to have the highest automation system GOA4 (driverless Underground) when today's technologies are evaluated.

The GAR-DÜZTEPE-HOSPITAL Light Rail System (Underground) Line (OMURGA-4 line GTMP 2030), passing through the two major districts of Gaziantep, Şehitkamil and Şahinbey districts, continues the development centers in the city's Gar-Düztepe-Kahvelipinar-Yeşilvadi-Karataş-Akkent regions was planned to connect the 1875-bed Gaziantep City Hospital to the city center.

Gar-Düztepe-Hospital Light Rail System (Underground) Line is one of the most important vision projects in the near future, which aims to provide a safe, comfortable and attractive public transportation system of Gaziantep Undergroundpolitan Municipality, to encourage people to travel by public transportation and to facilitate traffic studies.

"Final Project Services for the Implementation of Gar-Düztepe-Hospital Light Rail System Line", starting from Gaziantep Station area, GAR Station, MİLLET BAHÇESİ Station, DR ERSİN ARSLAN H Station, DÜZTEPE Station, KAHVELİPİNAR Station, YEŞİLVADİ Station, AKKENT PARKI Station reaches to the City Hospital by passing through the AKKENT CENTER Station and ŞEHİR HOSPITAL Stations. The light rail system line, whose design has been completed, has 9 stations approximately 10 km and above. On the route, preliminary projects of inter-stations transport transfer centers planned in the region of GAR MAIN

TRANSFER CENTER, DÜZTEPE and DR ERSİN ARSLAN Hospital are being studied.

Within the scope of the report, it is explained which typologies the 9 stations on the GAR-DÜZTEPE-HOSPITAL light rail system Underground line were designed in terms of Architectural Design and the design decisions affecting the Interior Architectural Design.

5.11.1 Brief Information on the Historical and Cultural Values of Gaziantep City

Turkey's sixth and Southeastern Anatolia Region's largest city Gaziantep; is a Undergroundpolitan city with its population, economic potential, cultural wealth, historical texture and Undergroundpolitan status.

Located at the intersection point of Mesopotamia, one of the first settlements of Anatolia, and the Mediterranean Region, the city has hosted many civilizations and has preserved its importance in all periods of history.

Gaziantep, which has a mysterious history where different civilizations, cultures and religions come together and synthesized within each other; Paleolithic, Neolithic, Chalcolithic, Bronze, Hittite, Hurri-Mitanni, Assyrian, Persian, Alexander the Great, Seleucid Kingdom, Roman, Byzantine, Seljuk, Mamluks, Dulkadiroğulları and Ottoman periods carry the traces / artifacts to the present day.

Since the historical Silk Road has passed here, it has been a haunt of civilizations and has preserved its feature of being a cultural and commercial center in every period of history. The diversity of historical artifacts found in Gaziantep is an indicator of the cultural wealth of the city.

In addition, the studies carried out at the point of bringing the underground water facilities (KASTEL) and water distribution systems (LİVAS), which are located only in Gaziantep in Anatolia and have the title of the oldest in the world, to tourism have yielded results and as a result of the positive application of Gaziantep Undergroundpolitan Municipality it was included in the UNESCO tentative list.

5.11.2 Context and Concept Relationship in Design

It is impossible to separate a building from its context. Accordingly, Station Interior Architecture design is considered as a search for a suitable solution for a specific problem for a special area.

The building belongs to its location and it is clear that there is a definite link between the originality of the design and the features of the location of the building. Architectural design is fed by features of the Place. The relationship established with the place has often provided the conceptualization of the concept and played a decisive role in shaping the design. It has been a prerequisite to solve the design problem with the data coming from Gaziantep's elements. In this sense, the architectural design process has been considered as a dream-based performative process that feeds on ground features, and the Architectural Concept has emerged accordingly.

This design approach aims to analyze the relationship between the contextual conditions of Gaziantep and the concept concept in the architectural design process. In this context, first of all, the concept concept and its components (designer, problem and context) are defined correctly. In the light of the information obtained, the process of the formation of the concept in architectural design was conceptualized and finalized as Concept Production and project design in Architectural Design.

5.11.3 Concept

With the responsibility and awareness given to us by all this underground and aboveground cultural heritage, the Underground Station Interior Architecture concept, which will be built in Gaziantep, the city where the first underground structures in Anatolia are located, has been achieved by integrating the Local Architectural Elements of Gaziantep into the project.

5.11.4 Local Architectural Elements and Design Impact

5.11.4.1 Hayat (Courtyard) Ticket Hall (Concourse)

Looking at the history of Gaziantep from past to present, it is seen that it has a deep-rooted and rich architecture. In the formation of the functions of the buildings,

the understanding of courtyard is dominant in the architecture due to the climate of the region and the very hot summers. Since most of the time is spent in the courtyard, it is called "life". (Figure 5.24)



Figure 5.24 Hayat ticket hall design in old Gaziantep houses

Ticket Hall: The Ticket Hall (CONCOURSE) design at the stations was inspired by Life and a skylight was used to get daylight in all Ticket Halls.

5.11.4.2 —→ Bedesten Peron (Platform)

Bedesten are thin and long covered bazaars where shopping life beats in the past, and where shopping is done. As a structure with its geometric form and intensive human circulation, Bedesten has been a structure inspired by our Tunnel Type Platform design. (Figure 5.25)



Figure 5.25 Bedesten style bay holl design

Platform: Although there is a PAKS system in the design of the platform where the landing and boarding movements are made (mechanically, the ceiling is more intense), the maximum height has been obtained by inspiring from the Bedesten form.

5.11.4.3 —→ Kastel | Livas Platform Hall

Gaziantep historical water system consists of underground water channels that bring water to the city from the main source, which is far from the settlement area, and water structures where the water coming from these channels is opened to use. Underground water channels are called LİVAS in local language. The most important of the water structures such as wells, pools and fountains where the water transported to the settlement by LİVAS in Gaziantep is opened to the public use, the

most important are the underground water structures called KASTEL in local language. (Figure 5.26)

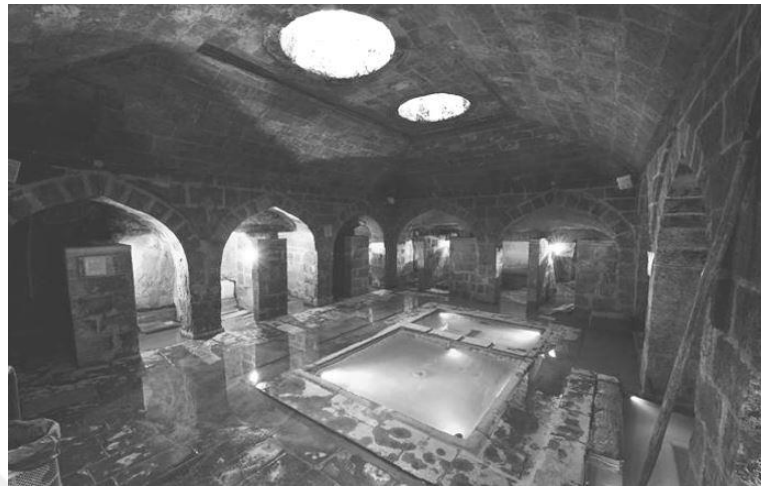


Figure 5.26 The design made in the lighting style in the Livas.

Platform Hall: In the design of the Platform Hall, which is the junction point of the passenger connection tunnels, which is located on the Platform floor in the tunnel type stations, it was inspired by the KASTEL area, where the Livas are opened to the public use. This area is also a gathering place in terms of passenger circulation.

5.11.4.4 —→ Kabalti Entrance Canopy

The architectural mesh element consisting of CURVED surfaces or surfaces constructed using knitting techniques in the provinces of the Southeastern Anatolia Region is called abbara or KABALTI. (Figure 5.27)

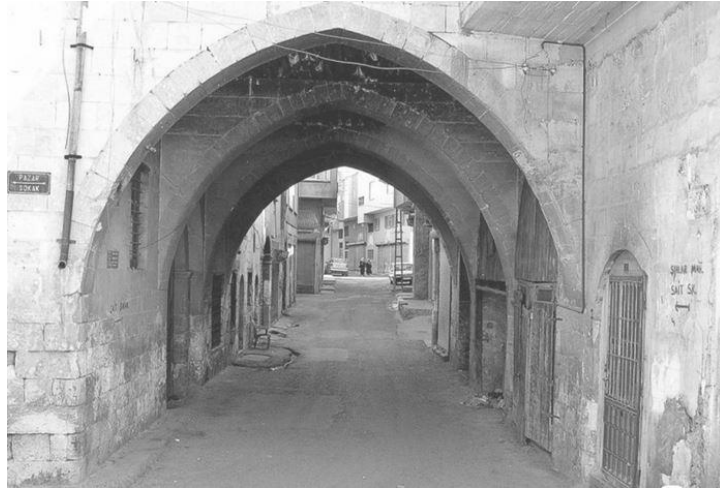


Figure 5.27 Kabalti style entrance canopy design

Entrance Canopy: The Entrance Canopy, inspired by the textural symbol of Gaziantep, KABALTI, is used at the Stations determined by the Administration. KABALTI has been modernized in our design of the Entrance structure, the gateway between the Passengers coming from the surface and the Underground station.

5.11.5 Design Elements

The elements used in the interior setup of the Gar-Düztepe-Hospital Underground line are handled as Color, Texture, Shape, Illumination.

5.11.5.1 Color

The station types are inspired by the mosaic colors extracted from Zeugma Ancient City. Glass Coating colors used in the stations have been selected considering these colors. (Figure 5.28)



Figure 5.28 The colors used in the project are inspired by the Gypsy Eye

5.11.5.2 Texture

Gaziantep is a city with a traditional architectural texture that has been hosting many different cultures and ethnic groups for centuries. The neighborhood that summarizes the architectural texture in Gaziantep, which is a self-formed city with an organic texture, is the Bey District. The texture and color of the HAVARA stone used in the Bey Mahallesi, which was formed in the 1500's, was chosen as the coating in the stations. GFRC (Glass Fiber Reinforced Concrete) is preferred in terms of both its multiform feature and its ability to reflect the desired texture.

5.11.5.3 Form - Venue

Formally, it is aimed to preserve the structural forms of the stations. Based on this, platform tunnel sections will be covered with material suitable for the form while preserving their structural forms. Thus, it will be possible to obtain spaces with function, form and aesthetic integrity.

5.11.5.4 Lighting

Since natural light cannot generally be used in underground stations, "artificial lighting" becomes necessary. Since underground Underground stations are closed areas, various negative psychological situations may occur in people. Lighting is very important to eliminate these negative effects such as fear, anxiety, insecurity and claustrophobia. With good lighting, it is possible to make the underground

Underground stations more spacious, more attractive and more comfortable. In our design, we aimed to include natural light in our stations by using LIGHTING in our ticket halls, which is the cultural heritage of Gaziantep and locally natural light. Thus, identity and more aesthetic spaces were created. The light source is LED and the color temperature is projected as 4000K. (Figure 5.29)

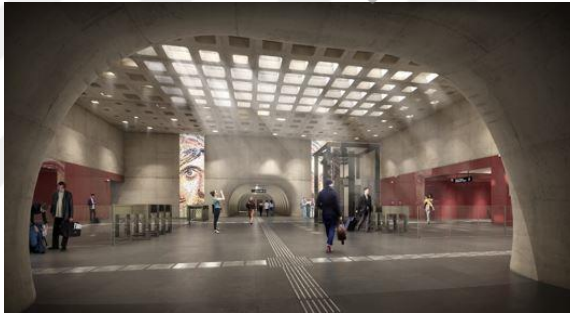


Figure 5.29 Lighting

5.12 Gaziantep Underground Project Structural (Static) Design

5.12.1 Tunnel Type Sections

There are 4 types of tunnel type sections (A.1.1, B.1.1, B.3.1, P1), among them A.1.1 general design information of the tunnel type section.

5.12.1.1 A-A1.1 Type Tunnel General Information

A and A1.1 Type tunnels planned to be made within the scope of "Gar-Düztepe-Hospital Light Rail System (Underground) Line Implementation Final Project Services Work" will be made. Since there is not much difference in cross-sectional dimensions between A and A1.1 tunnels, it is expected that the supporting elements will not differ from each other. For this reason, relatively large section A type tunnel

section will be taken into account in the calculations and the expression "A" will be written for both of the tunnel sections.

Analytical and numerical analyzes were carried out considering the anticipated support type A2 and A3. Although the primary support system (shotcrete, bolt and steel beam) is a semi-permeable system, water force can occur on the interface in areas where the groundwater level is effective. For this reason, this water effect has been taken into account in the analysis as in impermeable systems.

5.12.1.2 Tunnel Type Section

The A-type tunnel section depends on the excavation area, which varies depending on the multi-center cross-section fixed internal shape and the primary support shotcrete thickness. In determining dimensions, it is important to define and consider the limits of the primary support and permanent coating.

In the figure below, the general scheme of support and permanent pavement detailed according to different excavation lines and layers is given. (Figure 5.30)

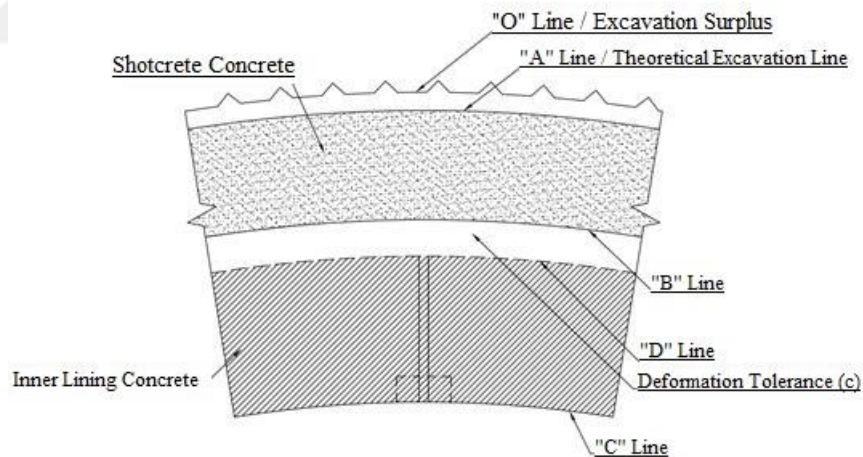


Figure 5.30 Defining the Excavation Profile

Geometric properties are as presented in the drawings specified in the Technical Specification. The dimensions for A2 and A3 support are as follows;

Class A2: The excavation height is 6.81 m and the excavation width is 6.66 m, and this means approximately 36.84 m² excavation area considering the A line in Figure 5.38.

Class A3: The excavation height is 6.91 m and the excavation width is 6.76 m, which means approximately 37.93 m² excavation area considering the A line in Figure 5.31.

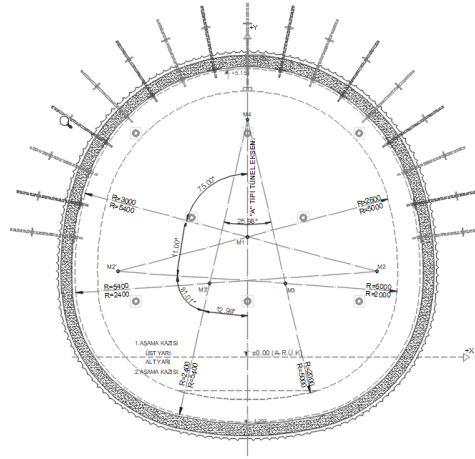


Figure 5.31 A Tunnel Type Section - A2 Support Type

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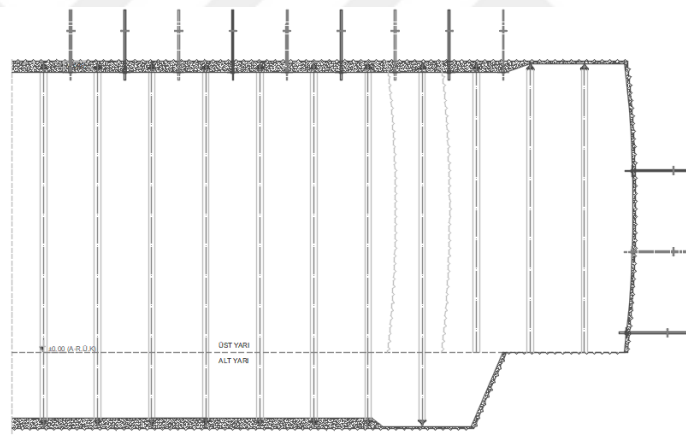


Figure 5.32 A Tunnel Profile - A2 Support Type

5.12.2 Excavation Support Systems

A type tunnel section is designed considering the A2 and A3 support categories depending on the geology specified in the Geological-Geotechnical report. Depending on the geology and convergence measurements at the site, the most appropriate support required by the actual geological situation will be decided.

Table 5.9 Pile Support Class Selection Table

Average Unsupported Duration	Max Unsupported Span (m)	CSIR (RMR)	AFTER OCTOBER 1994 ÖNORM B 2203	UNDERGROUND SUPPORT TYPE	ADDITIONAL INFORMATION
20 years for 15 m span	4 - 6 m	81-100 (I) VERY GOOD QUALITY ROCK	A1 SOLID	A1	Difficulty digging, blasting may be required.
1 year for 10 m span	2 - 4 m	61-80 (II) GOOD QUALITY ROCK	B1 - A2 CRISPY - LESS SPILLED AFTER	A1 , A2	The ceiling rock may be in a thin crust. Due to the difficulty of excavation on the ceiling and sides, blasting may be required.
1 week for 5 m span	2 - 4 m	60-41 (III) MEDIUM QUALITY ROCK	B1 - B2 - B3 CROSS - MULTI-CRUDE - GRAIN	A2	The ceiling rock may be in a thin crust. Due to the difficulty of excavation on the ceiling and sides, blasting may be required..
10 hours for 2.5 m span	1	40-21 (IV) POOR QUALITY ROCK	C1 - B3 MOUNTING – GRAIN	A3	Excessive detachments are expected in fault and dyke zones. Excessive detachments are expected in fault and dyke zones.
30 min at 1 m span.	0,3	< 20 (V) VERY WEAK ROCK	C2 - C3 - C4 - C5 PRESSURED – HIGHLY PRESSURED - FLUID ve EXPANDING	A4 , A5 Umbrella Arch	Excessive dismantling and collapsing should be expected with water leaks.

Table 5.10 Excavation and Support Systems According to Geological Classes (For A Type Tunnel)

A Type Tunnel Support System		
Rock	Good –A2	Weak –A3
RMR	>40	20-40
Shotcrete	200 mm	250 mm
Steel mesh	2 row Q221/221	2 rows of Q221/221
Lattice beam shoring	H=120 mm 1,5 m	@1,0- H=150 mm @0,75-1,2 m
Pipe driving / pre-fastening steel pipes	Not necessary	1 sıra. L=3-4 m
Bolts	L=4 m, @1,0-1,5 m	L=4 m, @0,75-1,2 m
Shotcrete on the ground	50-100 mm* (as required)	50-100 mm* (as required)
Bolts on the ground	6-8 bolt L=6 m $\phi=26$ (as required)	6-8 bolt L=6 m $\phi=26$ (as required)
Lattice beam shoring on ground	1 sıra çelik hasır Q221/221 (as required)	1 row of steel mesh Q221 / 221 (as required)
Geçici invert	Not required	Not required
Subroutine Truss beam	Where any cross section is less than 1 tunnel equivalent diameter	Necessary
Permanent coating	400 mm	400 mm

If steel mesh is used on the ground, 100 mm shotcrete should be used, and if steel mesh is not used, 50 mm shotcrete should be used on the ground.

Consider the following details before deciding on the type of support.:

- Shotcrete resistance f_{ck} , cube = 21 MPa.
- Lattice beams, 2 reinforcement $\phi 20$, 1 reinforcement $\phi 26$.
- 2 rows of Q221 / 221 welded mesh steels correspond to $\phi 6,5$ mm reinforcement and its grid is 150x150mm.
- For A3 type fortification, the front strut steel pipe is inclined at 8.5° for the tunnel section.

5.12.3 Structural Design Report

In the structural analysis model, flooring and walls are shell elements, beams and columns.

It was modeled as a (bar) element and calculations were made accordingly.

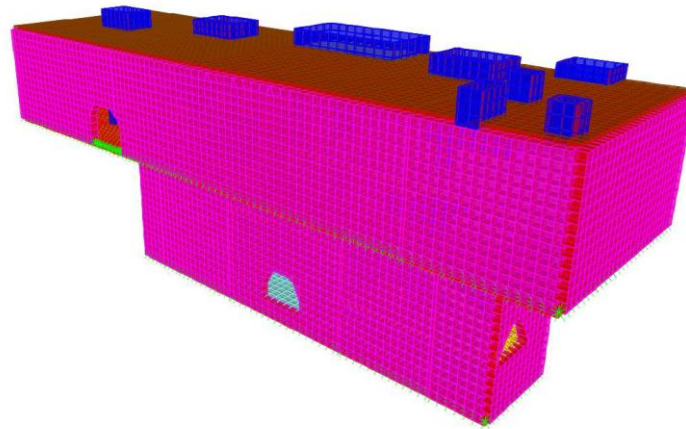


Figure 5.33 Structural Analysis Model

5.12.3.1 Software Used

SAP2000, Static & Dynamic Finite Element Analysis of Structures, Computers & Structures Inc. Berkeley, California.

Excel, Microsoft

Autocad, Autodesk

Revit, Autodesk

SAFE, Slab Analysis by the Finite Element Method, Computers & Structures, Inc.

5.12.3.2 Material and Design Parameters Concrete

Table 5.11 Concrete Classes and Strength Properties

Concrete Class	Characteristic Cylinder (150 mm x 300 mm) Compressive Strength, fck	Equivalent Cube (150 mm) Compressive Strength, fck	Characteristic Axial Tensile Strength, fck	28 Day Elasticity Module, Ec	Concrete Unit Volume Weight	Classes of Concrete Used
	MPa	MPa	MPa	MPa	t/M3	
C16/20	16	20	1,4	26000	2,5	+
C20/25	20	25	1,6	28000	2,5	
C25/30	25	30	1,8	30000	2,5	
C30/37	30	37	1,9	32000	2,5	
C35/45	35	45	2,1	33000	2,5	+
C40/50	40	50	2,2	34000	2,5	
C45/55	45	55	2,3	36000	2,5	
C50/60	50	60	2,5	37000	2,5	

C16 class concrete will be used as lean concrete in the project. C35 class concrete will be used for column, beam, curtain, floor and foundation.

The partial safety factor of the material for concrete will be 1.5.

Shear Modulus: $G_{cj} = 0,40 E_{cj}$

Poisson ratio: It will be taken as $\nu_c = 0,2$.

Steel

Table 5.12 Reinforcement Steel and Strength Properties

REINFORCED STEEL	Characteristic Yield Strength, f_{yk}	Design Yield Strength, f_{yd}	Material Partial Coefficient for Steel	Elasticity Module, E_c	Unit Volume Weight
	MPa	MPa	-	MPa	t/m ³
S420a	420	365	1,15	200000	7,85

5.12.3.3 Loads

All loads and effects that may occur during the service life of the stations are the characteristic loads specified in AASHTO TS498 and TS9194 are Youssef MA Hashash-Seismic design and analysis of underground structures documents.

The loads based on the design and used in the analysis model are given below. Capitalized abbreviations are the load vector names used in the analysis model.

5.12.3.4 Dead Load + Coating Load (G)

The individual weights of the elements of the structural system of the building are calculated automatically by the program according to the material information given in Section 2 and the sections entered into the structural system. Persistent coating loads; Soil loads, floor covering, screed, plaster, partition walls, suspended ceilings, installation pipes, etc., non-bearing elements on the building are included in this load definition. Unit weight of the elements for these loads will be given under the heading of load effects.

5.12.3.5 Lateral Earth Load (HT)

Lateral static soil pressures affecting the structure will be calculated using Coulomb's Soil Pressure Equations. This load includes the loads acting on the structure from the

ground in the parts where the building is embedded in the ground. Soil unit volume weights given in the ground study will be used to calculate these loads.

5.12.3.6 Moving Loads (Q)

Static loads that affect the building element from time to time and change its location (objects, people and vehicles) are included in this scope.

These loads according to the Structural Design Handbook:

Table 5.13 Loads acting on the building element

Ticket Halls and General circulation areas	6.0 kN/m ²
Staff rooms, Toilets, Offices	6.0 kN/m ²
Warehouse and Spare Rooms	10.0 kN/m ²
Pedestrian Roads and Pedestrian Ramps	6.0 kN/m ²
Technical Volumes	10.0 kN/m ²
Highway Moving Loads *	15.0 kN/m ²

5.12.3.7 Temperature Load (T ±)

Station buildings are buried structures. Temperature differences that will occur in buried structures will be much lower than in aboveground structures. However, there are no statistical data on this.

In addition, the temperature differences that the structures may be exposed to during the manufacturing process may differ from the predicted. For this reason, the temperature change used for aboveground structures will be taken into account in the heat calculations of underground structures by reducing them a little:

- $T (+) = + 15 \text{ }^{\circ} \text{C}$ ”
- $T (-) = -15 \text{ }^{\circ} \text{C}$ ”will be reflected in the calculations.

5.12.3.8 Horizontal Surcharge Effects (HS)

The static surcharge effects of highway loads on the perimeter walls of underground structures will be considered as 15 kN / m² uniform live load equivalent to H30-S24 truck load.

5.12.3.9 Groundwater Loads (WH-WV)

Water effects affecting the structure from under the foundation and / or from the side will be defined under this loading.

5.12.3.10 Shrinkage Effect (TR)

In case shrinkage is expected to occur, necessary precautions should be taken by calculating additional stresses and displacements (shortenings). Shrinkage effects will be calculated and affected separately for each element.

5.12.3.11 Earthquake Load (SSI ± 72 and ± 2475 years)

The earthquake that will affect the station will be examined for two separate cases.

5.12.4 Temporary Excavation Support and Shaft Solutions of Stations

5.12.4.1 Shaft

5.12.4.1.1 Akkent Park Station Shaft Information

The "Akkent Park Station shaft" planned to be carried out within the scope of the "Final Project Services for the Implementation of the Gar-Düztepe-Hospital Light Rail System (Underground) Line" will be manufactured in the form of cut-off. The land where the station will sit is at +835.52 elevation.

Since the land is not inclined, it was deemed appropriate to create a single platform. Elevation excavation consists of +942.99 elevation as the upper level. Final excavation level is modeled as +918.84.

Shaft excavation mainly; Shotcrete and rock bolt, as shown on it, were planned to create an excavation support system during the construction phase and the system was designed to be supported by the bottom floor.

Main characteristics of the support members:

Shotcrete 30 cm

- Rock bolt $\varnothing 28$ (1m Vertical / 1.6m Horizontal)
- L: 6.0m Barbakan Manufacturing (2 mx2 m) (if water is observed during excavation)

Groundwater has been detected at a depth of 2m at the site, and effective drainage measures (drain pipes and holes) must be taken to manage water attacks that may occur during excavation. Barbakan settlement is given in detail in the application sheets.

5.12.4.1.2 Construction Phases

The main construction stages can be summarized as follows:

- Bringing the ground to the specified excavation level,
- Excavation with 2 m progress up to the shaft foundation level,
- Production of shotcrete (30 cm) and Ø28 rock bolt

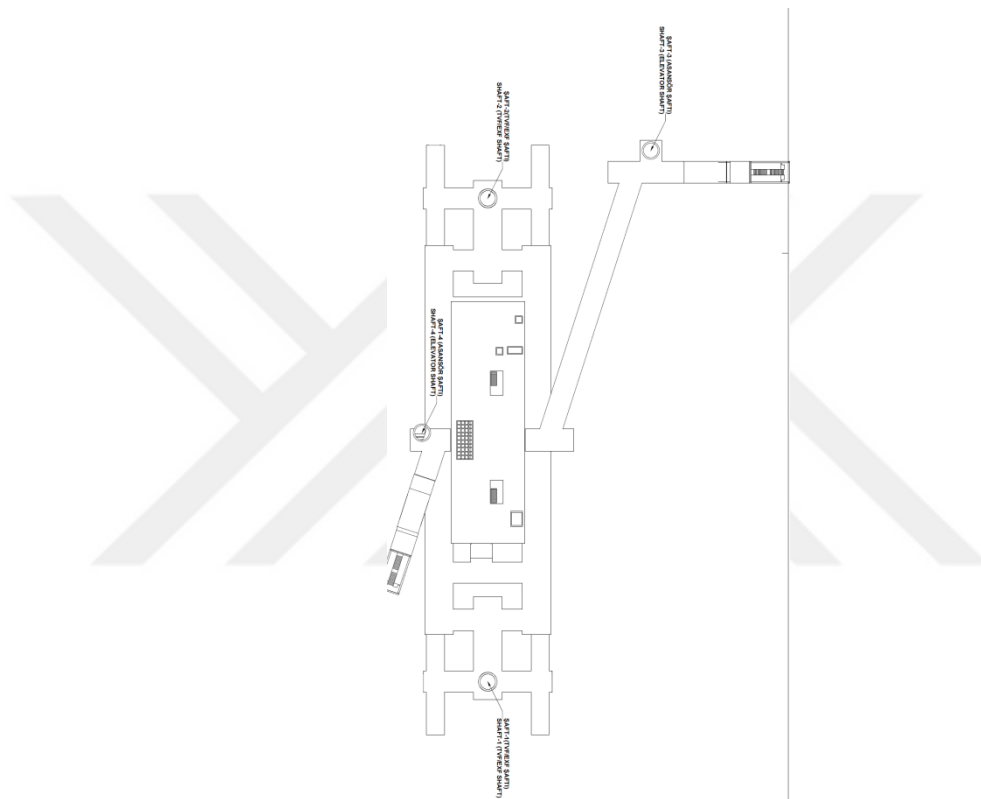


Figure 5.34 Shaft Plan view

- The soil / rock parameters used in this report were obtained by evaluating the information obtained from field studies and laboratory tests during the projected excavation work.
- In the excavation support system of the shaft structure, it is aimed to complete the temporary support system of the shaft structure by manufacturing a 30cm thick double row of Q589 / Q589 double row of mesh steel, as well as the intermediate horizontally 1.6m vertical and 1.0m long rock bolt. Bolt diameter is chosen as $\text{Ø} = 28\text{mm}$.

- When the shaft excavation is completed, the total lateral displacement expected to occur in the shoring system is approximately 0.81 mm. The displacement field control should be carried out during the entire excavation and construction period
- and the control and the project payer should be informed in case of any movement beyond the expected displacement amounts.
- In order to provide the drainage of the groundwater level and possible surface water during the shaft excavation, Barbakans of 6.0m length with 2.0m intervals in vertical and horizontal axis should be manufactured. Barbakan lengTVS should be decided after the observations to be made during manufacturing.
- Instrumental observations must be made in the project area during the construction period. In this direction, by using 1 Inclonometer around the shaft structure, the values obtained with regular readings will be checked and the project will be revised if necessary and the project author should be informed to take additional measures. The placement of the proposed measuring instruments is shown in the plans and sections on the application sheets.
- The projected shoring system is given in detail in the annex of this report.

5.12.4.2 Temporary Excavation Supports

Within the Gaziantep Transportation Master Plan, it is foreseen that the Underground line tendered by Gaziantep Undergroundpolitan Municipality in 2017 will be manufactured within the scope of the "Gar-Düztepe-Hospital Light Rail System (Underground) Line Implementation Final Project Services Work". The project includes an approximately 11 km long route, 9 station structures and 1 warehouse area. This line to be built is also planned to be integrated with the "Gar-GAÜN-15 Temmuz Campus Light Rail System (Underground) Line", which is being planned.

These two lines intersect approximately 1km long.

A foundation excavation up to 33m is required for the "Akkent Park Station", which is planned to be built within the scope of "Gar-Düztepe-Hospital Light Rail System (Underground) Line Final Project Services Work for Implementation". In order to

reach the excavation level safely, a system supported by bored piles and steel pipes was planned and numerical analysis was performed and calculation report and application sheets were prepared for the application project.

Some of the content of the excavation support report of Akkent Station, one of the 9 stations, can be seen below.

5.12.4.3 Akkent Park Station Information

The "Akkent Park Station" planned to be made within the scope of the "Gar-Düztepe-Hospital Light Rail System (Underground) Line Final Project Services for Implementation" will be manufactured in cut-and-cover form. The land where the station will sit is at +943.67 elevation. Since the land is not inclined, it was deemed appropriate to create a single platform.

The elevations consist of +943.67 elevation as the head beam top elevation. Final excavation level +910.66 final pile bottom elevation is modeled as +905.16.

5.12.4.4 Project Area Geology

2 drillings were made within the scope of Akkent Park station (GDH-35, GDH-36). The total drilling depth is 102m and the groundwater level has been seen at 33m and 2m. Although Basalt / Basalt (W2-W3) unit is dominant in the constitutive model of the bedding, the Limestone / Limestone unit is also seen from the drillings.

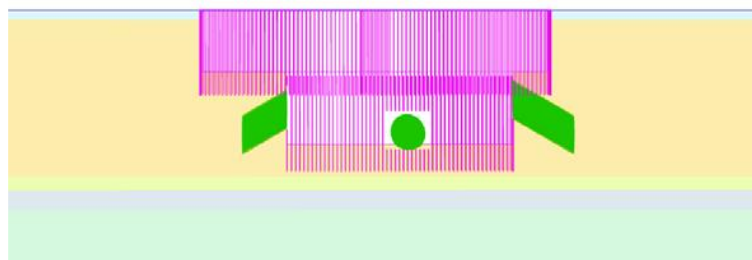


Figure 5.35 Akkent Parki Station Geological Profile

5.12.4.5 Support Elements

The excavation planned for the station structure is mainly; diameter $\varnothing = 80\text{cm}$; piles with spacing $s = 100\text{ cm}$; It will be supported by struts and foundations of varying diameter and length.

Main characteristics of the support members:

- Ø80cm diameter pile
- Head beam 100cmx100cm
- Ø813 mm diameter; strut with wall thickness D: 20,6mm

Analyzes have been made in order to reach the final excavation level safely.

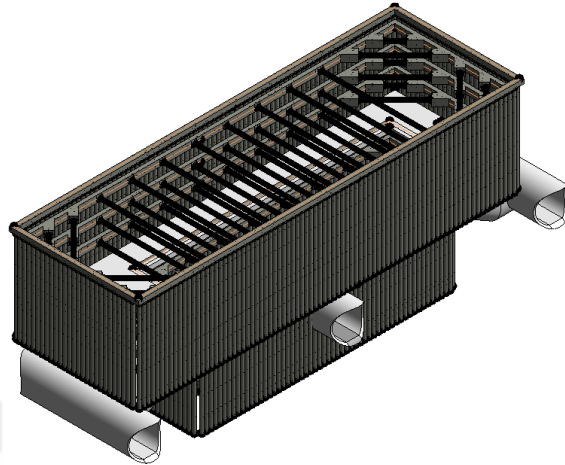


Figure 5.36 Panoramic View of Station Structure Excavation Support System

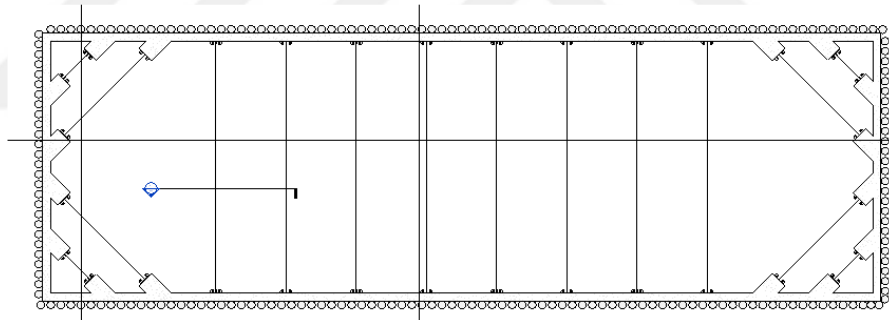


Figure 5.37 Station Structure Excavation Support System Plan View

In the field, the ground water level was seen at 33m and 2m. It is recommended to take effective drainage measures (drain pipes and holes) in order to manage water attacks that may occur during excavation.

A foundation excavation up to 23m is required for the "Akkent Park Station, which is planned to be built within the scope of the" Gar-Düztepe-Hospital Light Rail System (Underground) Line's Final Project Services for Implementation ". 2 drillings were conducted in the study area. After the field and laboratory tests, a geological ground profile was created. In order to reach the excavation level safely, a system supported by bored piles and steel pipes was modeled and analyzes were made on these models. The work done is as follows;

- Soil Investigations and Geotechnical Works Evaluation Report of the Gar-Düztepe-Hospital Light Rail System (Underground) Line submitted to the administration in this report”(GMM-GDHG00-AL-G-000-AA0-000-KT-0003 - A), using field, laboratory studies and field observations, geotechnical evaluations and analyzes were made.
- The final excavation level for the construction of the station structure has been determined as +910.66. Models have been made in order to reach this quota safely. According to the modeling, it has been suggested that the piles with a diameter of $\varnothing = 80\text{cm}$ should be manufactured in $s = 100\text{cm}$ intervals. The pile length was determined as $L = 20$ and $L = 23$ and the piles were socketed with $L_{\text{socket}} = 5.22\text{m}$ and $L_{\text{socket}} = 5.77\text{m}$.
- By providing horizontal supports with steel pipes, it is aimed to minimize the deformation caused by the section effects on the piles. Steel piles; diameter is $\varnothing 80\text{cm}$, wall thickness is determined as $d = 20.6\text{mm}$.

As a result of the analysis, the lateral deformation limits were determined as "0.002h console". It was seen in the analysis that this value was not exceeded. The displacement field control should be carried out during the entire excavation and construction period, and the control and the project author should be informed in case of movement exceeding the expected displacement amounts.

5.13 Gaziantep Underground Project Mechanical Design

It is a summary of the information taken from the Mechanical Design Guide of the Underground Project being carried out by Gaziantep Undergroundpolitan Municipality.

Gar-Düztepe-Hospital Rail System Project; It will be designed considering the local conditions of the stations and their relations with other structures in the vicinity. This report has been prepared independently of the different architectural design needs of the stations in order to form a basis for all station structures.

All equipment that will serve the station structures will be selected in the high efficiency class and thus, efforts will be made to reduce the total carbon emission.

The applicability of the heat recovery ventilation strategy in the ventilation of station auxiliary areas and especially office spaces will be evaluated on a station basis. Variable speed drive technology and building automation will be used optimally to reduce system engine loads. By establishing an integrated automation system, it will be ensured that the system works by minimizing the energy loss throughout the entire working life of the system by using various techniques such as proportional control, decommissioning of inoperative equipment, programming of optimum working times, remote control, outdoor weather compensation.

5.13.1 Design Conditions

The design conditions of the Gar-Düztepe-Hospital Light Rail System are given below.

Table 5.14 Design Conditions

Outdoor (Winter)	-9 °C, (TS 2164 / Chart-1)
Outdoor (Summer)	23 ° C Wet Bulb Temperature, 39 ° C Dry Bulb Temperature 13.5 ° C Daily Temperature Difference (TS 3419)
Latitude	37°, 05' N (TS 3419)
Longitude	37°, 22' E (TS 3419)
Sea level	849 m

5.13.2 Tunnel Ventilation System

5.13.2.1 General

It describes the basic principles of the tunnel ventilation system (TVS) and the analysis activities that should be carried out to guide architectural / structural design.

Tunnel ventilation system (TVS) will be used to control tunnel ambient conditions in normal, congested and extraordinary situations. This is primarily an emergency ventilation system that creates an acceptable evacuation route for passengers in case of fires likely to break out in the tunnel or in the stations. During normal, congested or maintenance operations in tunnels, the TVS will be capable of providing the natural

ventilation position (all fans off, piston relief shafts open) or reduced speed to provide acceptable temperatures and air quality. The stations will not have any air conditioning-based cooling system. Therefore, TVS will be the main mechanism that provides the temperature change of the environment by free ventilation.

5.13.2.2 System Description

At the stations, in case of train fire on the platform, the tunnel ventilation fans will "pull-pull", and if needed, the tunnel ventilation fans in the neighboring stations can be operated in compression.

The tunnel ventilation system will be designed to control the effects of high-speed train movement (possibly leading to high air flow in the passenger compartments) and heavy traffic (leading to high heat loads).

The tunnel ventilation system should have ventilation shafts, escape tunnels and entrance structures at both ends of the station in order to provide ambient conditions in various operating situations. At least 2 fans (2 main) should be considered for each half station. Jet fans will be added to the system together with all their equipment when jet fans are used in the scissor areas required to assist tunnel ventilation fans.

Mechanical equipment in each tunnel ventilation shaft; will consist of fans, inlet-outlet dampers, shutters and silencers. The fans will have a fully reversible axial flow that can operate in either supply or suction state. A piston relief damper will be placed in each piston relief shaft. In normal operation, the piston relief damper will be open, with the emergency activation of the fans, the piston relief dampers will turn off. Fan dampers will be placed on both sides of the fan and will be opened when the fans are activated.

The tunnel ventilation equipment will be controllable both locally (from the Fan Control Room) and from the Control Center by remote control in order to reach the appropriate fan operation and damper position for every activity situation. The status of the fan and the damper position will be shown with signals to be sent back to the Control Center.

5.13.2.3 Scope of Work

The tunnel ventilation system will control the underground environmental conditions in the following operating situations.

Normal Activity:

Under normal conditions, where train activity complies with the predicted schedule, the control of environmental conditions requires the ventilation shaft dampers to be adjusted so that hot air can be taken from the tunnels and fresh air can be drawn in to ensure that the train piston movement is at the comfort level described in the design criteria of the passenger compartments.

During the normal operation of the railway, the ventilation in the tunnels will be provided by the piston effect of the train. Positive pressure created in front of the train approaching the station;

It will expel the hot and dirty air in the tunnel from the tunnel ventilation shaft. The negative pressure created behind the train moving from the station will allow the outside air to be taken in through the same openings. In addition, in the systems with PAKS, the heat that will be generated by train acceleration and braking will be removed with the piston effect of the train. In systems without PAKS, the heat generated by train acceleration and braking will be discharged through the under-platform exhaust system.

Although most of this air flow will be used at the station entrances, ventilation shafts should be placed at both ends of the station for additional fresh air intake and exit of train heat.

If the temperature in the tunnels increases excessively in hot weather, tunnel ventilation fans will be operated to draw in fresh air and evacuate the hot air in order to reinforce the air changes caused by the train piston effect.

5.13.2.4 System Layout

The main elements of tunnel ventilation will be:

Air draft shafts at both ends of the stations will assist the train piston impact pressure. Each air shaft will have a clean cross section of approximately 20 m². Such

shafts should provide an air passage as easily as possible. 2 (2 main) reversible fans and insulation dampers will be mounted on each shaft. Fans will have equal performance in terms of both feeding and drawing. In simulations, the inoperative state of 1 fan and the openness of 1 cross-passage doors on the line will also be examined.

Piston relief dampers will be placed to provide air flow between the rail and the surface during normal operation. Tunnel ventilation dampers will be placed in such a way that they completely prevent air flow between the railways in case of emergency. Tunnel temperature detectors will be installed approximately 20 m away from the two ends of the stations and ventilation shafts and buildings to detect the air temperature of the tunnel. If the average tunnel air temperature exceeds the design temperature, the tunnel ventilation fans at the stations will operate to cool the tunnel to its design temperature.

5.13.2.5 Modeling and Simulation Tools

Aerodynamic and thermodynamic analysis simulation program by modeling the whole tunnel network in one dimensional. SES 4.1. It will be determined using.

The main purpose of ventilation modeling at this stage of the project is to determine the capacities and configurations of the tunnel and stations' emergency ventilation systems. Results of these simulations; It is used to inform station designers about the appropriate provisions to be made for the equipment of tunnels, shafts and stations. The outputs of the SES software will also be used to define boundary conditions for computational fluid dynamics simulations of train fire scenarios at the station in the later stage of the design.

SES modeling for this stage of the design does not include all of the scenarios required to complete the detailed design of the system and the approval of the authorities.

The aim is to define tunnel and station emergency ventilation systems with sufficient details to approve spatial and interface provisions. Advanced SES analyzes will be carried out during the construction phase of the project to produce the detailed design and obtain the approval of the relevant authorities.

Detailed computational fluid dynamics (CFD) modeling will be evaluated and applied for heat and smoke movement in a given station for multiple train fire scenarios and single baggage / waste fire. Modeling will be applied to two different prototype stations as a cut-and-cover, bored tunnel.

5.13.2.6 Tunnel Ventilation System Design Assumptions

The capacity should be sufficient to prevent reverse stratification in the tunnel perimeter area. The capacity of the ventilation system will be selected to adequately provide critical air flow at the time of a train burning, even when a fan is not operating.

The following parameters will be considered in simulation studies.

Doruk Train Fire Thermal Load (FHRR) = 12 MW (for stations and tunnels) (It will be evaluated with the vehicle specification. It is predicted to be 12 MW at this stage.)

Train Fire Growth Rate = Medium Suitcase Fire Heat Release Rate = 1.0 MW
Suitcase Fire Growth Rate = The summary of the main assumptions made for Medium SES is as follows: Maximum number of trains in a ventilation zone: 1 in emergency mode; For compressed scenarios, 2 will be envisaged at a frequency of 90 seconds. Fans will be assumed to be reversible. In a fire, 80% convection heat transfer, 20% radiation heat transfer will be considered. The smoke heat dissipation coefficient of train fire = 0.2 Tunnel pedestrian connection tunnels (cross-passage) will be assumed to be closed in normal operations. In emergency scenarios, the passage pedestrian connection tunnel to the fire situation will be deemed open. It will be assumed that the maintenance of TVS systems will be made during non-operational hours (night).

The weights and dimensions of train brake resistor grids (Brake Resistor Grids) temperatures (starting at 430 ° C) are typically not provided by rolling stock designers. They will therefore be determined using an iterative approach to ensure that the temperature rise as in train brakes and the temperature drop as in inter-station travel are consistent across the entire line.

The regenerative braking efficiency of the overall system will be assumed to be 20% based on experience. (Ashrae- Handbook of HVAC Applications Chapter 15 - Enclosed Vehicular Facilities 2015)

5.13.2.7 Simulation Report

Many simulations are made for all stations of the Gaziantep Underground Project. The Number of Passengers simulation is just one of them. Below are the results from the passenger simulation report of Duztepe Station.

5.13.2.8 Peak Time Normal Case Operation Scenario Simulation Results

The Service Level to be experienced by passengers who will use Duztepe Station in 2048 and at the peak time will be predicted. The term service level (HS) represents the service quality and status of one or more facilities based on passenger experience. It covers the period from the moment the passengers to use the Underground station enter the station until they get on the train and leave the station. During this period, parameters such as the arrival time of the passengers to the ticket hall, waiting time, processing time, walking time, waiting time on the platform, etc. are determined by the intensity experienced by the passengers, delays, congestions, etc. The level of service is determined by correlating them with the factors. A grading system from SL = A (best) to SL = F (unacceptable) is used to determine the level of service. Table 5.16 describes the service level standards determined according to flow, delay and comfort levels (Fruin, 1972). The Fruin Service Level Standards given below are also used in the coloring of the capacity analysis to be given in the following sections.

Table 5.15 Fruin Service Level Standards

SERVICE LEVEL STANDARDS FOR CORRIDORS	SL	Density (Person /m2)	Area (m2/person)	Color
	A	$X \leq 0,309$	$X \geq 3,24$	Blue
	B	$0,309 < X \leq 0,431$	$3,24 > X \geq 2,32$	Light Blue
	C	$0,431 < X \leq 0,719$	$2,32 > X \geq 1,39$	Green
	D	$0,719 < X \leq 1,075$	$1,39 > X \geq 0,93$	Yellow
	E	$1,075 < X \leq 2,174$	$0,93 > X \geq 0,46$	Orange
	F	$2,174 < X$	$0,46 > X$	Red
SERVICE LEVEL STANDARDS FOR STAIRS	SL	Density (Person /m2)	Area (m2/person)	Color
	A	$X \leq 0,541$	$X \geq 1,85$	Blue
	B	$0,541 < X \leq 0,719$	$1,85 > X \geq 1,39$	Light Blue
	C	$0,719 < X \leq 1,076$	$1,39 > X \geq 0,93$	Green
	D	$1,076 < X \leq 1,539$	$0,93 > X \geq 0,65$	Yellow
	E	$1,539 < X \leq 2,702$	$0,65 > X \geq 0,37$	Orange
	F	$2,702 < X$	$0,37 > X$	Red
SERVICE LEVEL STANDARDS FOR PLATFORMS, WAITING AREAS	SL	Density (Person /m2)	Area (m2/person)	Color
	A	$X \leq 0,826$	$X \geq 1,21$	Blue
	B	$0,826 < X \leq 1,075$	$1,21 > X \geq 0,93$	Light Blue
	C	$1,075 < X \leq 1,538$	$0,93 > X \geq 0,65$	Green
	D	$1,538 < X \leq 3,571$	$0,65 > X \geq 0,28$	Yellow
	E	$3,571 < X \leq 5,263$	$0,28 > X \geq 0,19$	Orange
	F	$5,263 < X$	$0,19 > X$	Red

As can be seen in the figure above; A, B, C, D levels are absolutely acceptable for passenger circulation in Underground stations during peak hours, level E is acceptable for stations with high passenger capacity, and level F is absolutely unacceptable. Service level standards are determined specifically for the area used by passengers.

Therefore; Standards defined for areas such as corridors etc. where passengers walk, and those defined for areas such as stairs, platforms etc. where they wait or stand still differ from each other.

In order to simulate the passenger and determine the Service Level, some pre-acceptances must first be made. These pre-acceptances, which are frequently used by Istanbul Undergroundpolitan Municipality in station capacity calculations, have been prepared based on national (TS 12127) and international (NFPA 130) standards. The table containing the values determined by the line design and station design teams and the pre-acceptances is given below.

Table 5.16 Values and Pre-Assumptions Used in Passenger Simulation

Values Used		
Vehicle Capacity	275	person / vehicle
Number of Wagons	4	
Peak Time Range	105	second
Peak Hour Factor	1,25	
Platform Capacity (Normal)	0,5	m ² / person
Platform Capacity (Crowded)	0,2	m ² / person
Ticket Hall Capacity	1	m ² / person
Walking Speed (Platform, Corridor, Ramp)	37,7	m / min
Walking Speed (Conkors)	61	m / min
Upward Walking Speed	14,6	m / min
Escalator Capacity (Normal Condition)	120	person / min
Escalator Capacity (Emergency)	75	person / min
Emergency Ladder Capacity (Upstream)	55,5	person / min / m
Emergency Ladder Capacity (Downward)	40	person / min / m
Normal State Ladder Capacity (Bi-directional)	28	person / min / m
Normal State Ladder Capacity (One Way)	35	person / min / m
Turnstile Capacity (Arm - Entrance)	30	person / min
Turnstile Capacity (Arm - Exit)	40	person / min
Emergency Escape Door Passing Capacity	50	person / min / m
Disabled Gate Passing Capacity	89	person / min / m
Service Door Passing Capacity	89	person / min / m

Using these values and presumptions, a 3D passenger simulation study has been performed in Massmotion software and the results are given below. The simulation study with the results was carried out not on the initial state of the station, but on its revised final version. In order to better understand the results, first the pedestrian circulation on each floor is shown schematically, then the average density analysis results are shared and finally the density analysis and pedestrian flow are combined on the same map. As a result of the simulation study carried out for all floors, no problems were encountered in the entrance and exit areas of the station. Circulation is extremely comfortable in these areas. The simulation results of the station are given below.

Concourse Solid Passenger Simulation Results show that;

There is no problem in terms of passenger density and circulation on this floor. The passengers are well distributed in the concourse floor and this has prevented congestion in certain areas.

The increase in the number of both entrance and exit turnstiles has prevented possible accumulations in the tourniquet area and provided a relaxation of the

circulation. The location and number of elevators are sufficient. Escalators and fixed stairs that provide entry and exit to the station are at a level to meet the number of passengers without any problems and provide an adequate level of service. The landing to the platform floor and the landing to the platform floor areas were expanded by the architectural design team after the problems seen in the first design and this final form was used in the simulation study. According to the simulation results, there are no problems in the access area covering escalators and elevators. The number of elevators and escalators is sufficient. Passengers experience very short waiting times in these areas and there is no serious congestion. Passengers passing through the corridors reach the platforms according to the direction they will travel and wait for the trains with a 1.75-minute time interval. Platform widths have sufficient capacity for both waiting passengers and passengers getting on and off the train. On the platform floor, there are only orange areas in front of the train doors, which is very normal. The results of the 3D passenger simulation carried out are given below, showing all floors together.

5.13.2.9 Peak Hour Emergency Scenario Simulation Results

An Emergency Station Evacuation Simulation was carried out for an emergency scenario that could occur during the Summit Hour. The preliminary assumptions determined within the scope of this study, which simulates the evacuation time of the platform floor first and then the time for all passengers to reach the safe area are given below. In case of emergency;

- In addition to the passengers currently on the platform, all passengers in the trains on both platforms will also exit the train and evacuate the station.
- The evacuation time of all passengers from the platform floor should not exceed 4 minutes in total.
- The exit time of all passengers to the safe area should not exceed 6 minutes. The safe area in DÜZTEPE station is designated as the concave floor.
- Elevators will not be used.

- All escalators in the station will be run in the upward direction, but one escalator on the platform floor will not be used in the simulation, assuming it is out of order or under maintenance. Passengers will not be able to use this escalator.
- In accordance with NFPA 130-5.3.5.3 article, the capacity of all escalators to be operated upwards will be calculated as 75 person / minute on average.
- In accordance with NFPA 130-5.3.5.3 article, the upward exit capacity of fixed stairs will be calculated as 56 person / minute / meter on average.
- The pre-acceptance and standards given in Table 5.4 will be valid here as well.

In summary, the results obtained as a result of the simulation study for the Emergency Evacuation Scenario carried out in line with these pre-assumptions are as follows:

- Number of Passengers on the Platform Floor: 2446
- Platform Floor Discharge Time 3:50 <4:00 SUITABLE
- Exit Time to Safe Area: 5:20 <6:00 SUITABLE
- Time for Station Complete Evacuation: 13:51

The entrance and exit areas of the station, ticket hall, concourse floor, balcony floor, platform floor and platforms provide the necessary areas for passenger circulation. Same time; The number of elevators, escalators, fixed stairs and turnstiles throughout the station is sufficient. Although the station has a compact structure, it provides passengers with the necessary areas for circulation and emergency evacuation.

Passenger simulation and capacity analysis studies carried out in line with 2048 peak hour travel values for Duztepe Underground station located on the Stadium - Gar - Duztepe - Hospital Underground line show that the station is suitable for both the peak hour normal operating scenario and the emergency evacuation scenario.

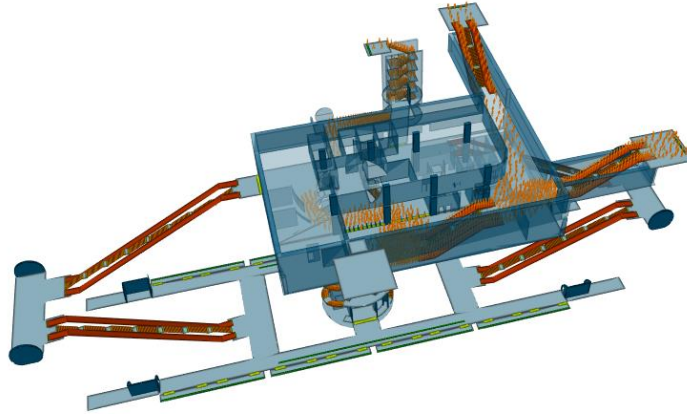


Figure 5.38 Station Overview During Emergency Evacuation

5.14 Storage Area

The warehouse area will start with the warehouse connection tunnel at +10,441,558 km of the line after the Hospital station; warehouse and workshop area with parking lines, transformer building (underground), recreation, parking areas and basketball court, is planned on an area of approximately 124.500 m². Architectural general view is shown in Figure 5.39.



Figure 5.39 Warehouse Area General View

Driverless operation will be carried out in the warehouse area with a total capacity of 39 series trains (156 vehicles), excluding the maintenance area. The Ibn-i Sina Warehouse Facility has been designed in such a way that the operation, parking and maintenance of the vehicles that will serve the Gar-GAÜN Underground line, which is planned to be built within the scope of both Gar-Düztepe-Hospital and GTMP.

In the warehouse area, there is a 97-vehicle car park, 1 VIP entrance, 1 football-basketball field.

After the city hospital, the line tunnels end and access to the warehouse is provided through the warehouse connection tunnels.

Line tunnels end at the end of Line 1: at Km 10 + 499.215, at this point the Warehouse Connection Tunnel Line -1 starts and ends at Km 0 + 868.605 in the warehouse area..

Line tunnels end at the end of Line 2: at Km 10 + 441.558, at this point the Warehouse Connection Tunnel Line -2 starts and ends at Km 0 + 896.321 in the warehouse area..

The Warehouse and Workshop Area is planned on an area of approximately 124.500 m² with parking lines, transformer building, recreation, parking areas and basketball court.

There is a total of 97 car parking spaces.

There is 1 football-basketball field.

GOA4 business will be provided.

After the city hospital, the line tunnels end and access to the warehouse is provided through the warehouse connection tunnels.

Line tunnels end at the end of Line 1: at Km 10 + 499.215, at this point the Warehouse Connection Tunnel Line -1 starts and ends at Km 0 + 868.605 in the warehouse area. (Figure 5.40)

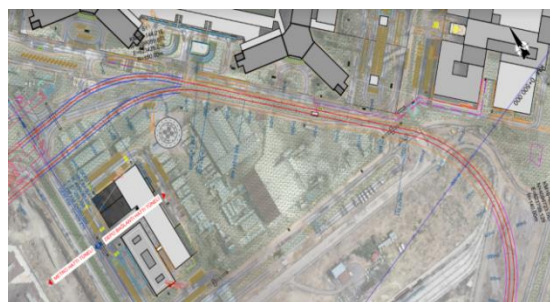


Figure 5.40 Warehouse connection tunnel line

Line tunnels end at the end of Line 2: at Km 10 + 441.558, at this point the Warehouse Connection Tunnel Line -2 starts and ends at Km 0 + 896.321 in the warehouse area. (Figure 5.41)

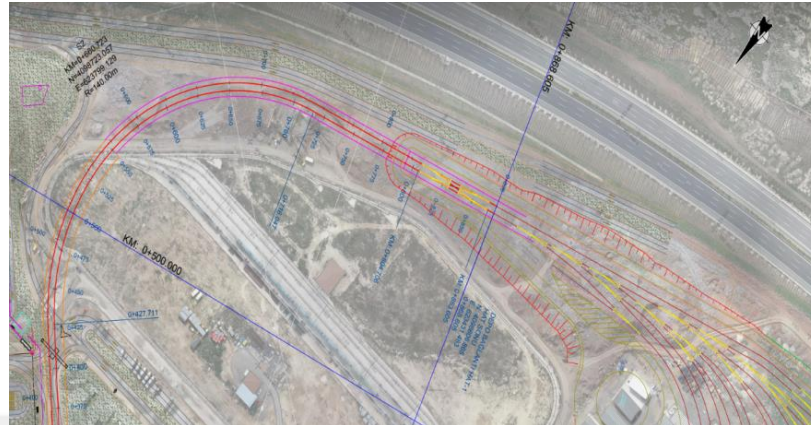


Figure 5.41 Warehouse line tunnels part 2

5.14.1 Places to be located in the workshop and administrative building:

Maintenance lines for vehicle periodic maintenance and heavy maintenance needs,

Turning line,

There will be a total of 21 lines, including painting line, and administrative sections.

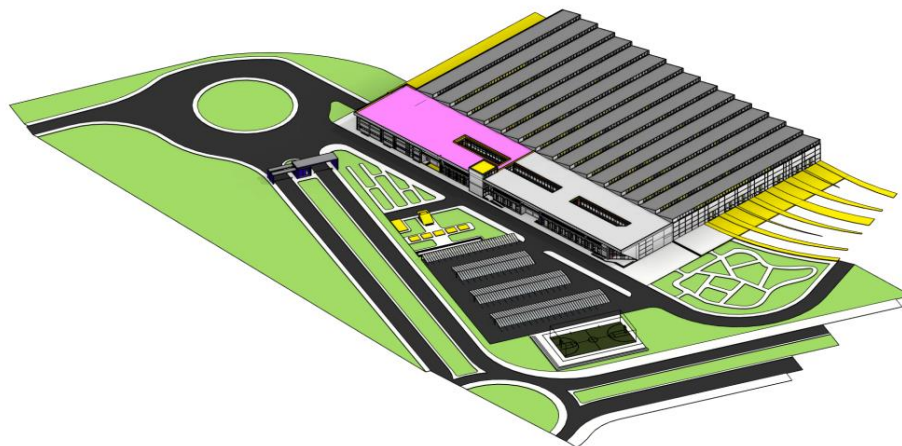


Figure 5.42 Warehouse area revit overview

5.15 Fully Automatic Driverless Underground Goa4

5.15.1 What is Underground Automation?

Automation in Underground systems refers to the process of transferring the responsibility of the operation management of trains from the driver to the train control system.


There are various degrees of automation (or Automation Classes, GoA); these are defined according to which basic functions of train operation are the responsibility of the staff and which are the responsibilities of the system. For example, Automation Grade 0 corresponds to the operation at sight, like a tram running in street traffic. Automation Class 4 refers to a system in which vehicles are started fully automatically without any operating personnel. Table 5.17 shows Underground automation tools.

Table 5.17 Underground automation tools

Grade of automation	Train operation	Setting the train in motion	Driving and stopping the train	Opening and closing the doors	Operation in the event of disruptions
1	ATP with a driver	Driver	Driver	Driver	Driver
2	ATP and ATO with a driver	Driver / Automatic	Automatic	Driver	Driver
3	Driverless	Automatic	Automatic	Automatic / Attendant	Attendant
4	Unattended	Automatic	Automatic	Automatic	Automatic

The work of Shift2Rail from 2016-2019 is associated with grades 1 and 2. The work of Shift2Rail from 2019-2022 is associated with grades 3 and 4.

ATP - Automatic Train Protection
ATO - Automatic Train Operation



5.15.2 What Makes Automation Possible?

Technical progress has provided the train control systems with the ability to supervise, operate and control the entire operational process. Key elements for this:

5.15.3 Automatic Train Protection (ATP)

System and all equipment responsible for basic security; By applying the brakes automatically, it avoids collisions, red signal overrun and speed limits being exceeded. A line equipped with ATP (at least) corresponds to a GoA1.

5.15.4 Automatic Train Operation (ATO)

Guarantees partial or fully automatic train piloting and driverless functionality. The ATO system performs all the functions of the driver, with the exception of closing the door. The driver only needs to close the doors and if the road is open, the train will automatically move to the next station. This corresponds to a GoA2. Many new systems are fully computer controlled; Most systems still choose to protect a driver or some type of train attendant to reduce the risks associated with breakdowns or emergencies. This corresponds to a GoA3.

5.15.5 Automatic Train Control (ATC)

Automatically performs normal signaling operations such as route adjustment and train regulation. ATO and ATC systems work together to keep a train within a certain tolerance of the timeline. The combined system will marginally adjust operating parameters such as the ratio of power to shore and station standby time while on the move to bring the train back to the timetable slot defined for it. The driver corresponding to a GoA4 and there are no personnel to accompany the train.

In the Automation 4 Class, ATC systems operate in a general signal system with locking, automatic train control, gap detection and communication functions.

5.15.6 Why Underground Automation?

Unattended Train Operation has many benefits and many beneficiaries: customers, operators, funders and staff.

The implementation of UTO systems allows operators to optimize the running time of trains, increase the average speed of the system, shorten the headers to 75 seconds, and reduce the waiting time in the stations (in optimum conditions) to 15 seconds.

5.15.7 More flexibility in operation

By removing the human factor from the driving equation, operators gain flexibility and better exploit assets. UTO systems offer a more specialized scope of service that reduces the supply of overcapacity during off-peak hours and allows operators to inject trains in response to sudden fluctuations in demand, for example in major events.

5.15.8 Impressive security records

UTO systems also offer safer operations by reducing the human-risk factor; Well-designed UTO systems have proven to be more reliable than traditional Undergroundpolises and maintain an impressive safety record. Platform and runway incidents aside, there was only one operational incident in Osaka in the late '80s, when a train did not stop at the terminal and hit a bumper stop, injuring several dozen passengers.

5.15.9 Increase in service quality

In general, passengers perceive higher quality of service, thanks to the improved reliability of the trains and shorter waiting times on the platforms. Relocation of personnel to stations also increases the subjective level of safety and security of passengers.

5.15.10 Financial feasibility

For new lines, automation costs have a relatively low comparative weight in the total budget.

5.15.11 Operational cost factors: personnel and energy savings

While factoring in operational costs, automatic lines clearly stand out from traditional lines; some studies show that operational costs are halved. Even in the case of line conversion, personnel costs are drastically reduced by de-functioning drives when personnel are likely to be retrained and deployed to other functions. The acceleration and deceleration patterns can be adjusted to reduce energy consumption and maximize energy recovery, thus significantly reducing energy costs. Maintenance costs have slightly increased due to the introduction of platform and pallet guard systems, while the overall balance is positive thanks to staff gains and energy costs.

5.15.12 Holistic productivity and organizational opportunities

The implementation of the UTO (as a new system or a strengthening of an old line) is an important milestone in the life of the operating company. The introduction of a more sophisticated computerized system and the Operations Control Center (OCC) should be an opportunity to review most transactional processes and evaluate how

the system can be optimized and "stuck" in order to gain maximum benefit from data processing capabilities. And it also provides better performance at optimized costs. The main areas of operation likely to be affected are: operations resource planning, staff training, railway stock management, maintenance management, quality management.

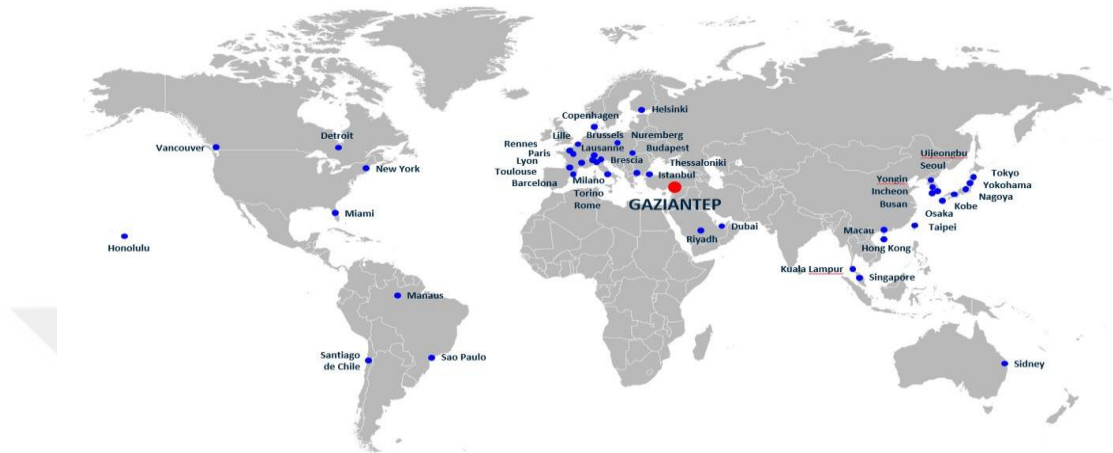


Figure 5.43 Country names using GOA-4

CHAPTER 6

DISCUSSION AND CONCLUSION

6.1 Discussion

The study is an answer to how and to what extent BIM is implemented and what benefits it provides in an infrastructure project for digital construction, especially in infrastructure projects in Turkey, by identifying the main obstacles to BIM adoption.

To develop a study of BIM adoption in the Turkish construction industry, the literature review is crucial to focus on explaining what BIM encompasses. Case studies of BIM implementation in the Turkish construction industry are also necessary for accurate diagnosis in pre-framework business development. As a result, the following questions were sought within the scope of the study and specifically:

1. How is digital transformation carried out in the construction sector in Turkey?
2. What infrastructure projects have BIM been implemented in Turkey?
3. How are engineering applications in infrastructure projects?
4. What conditions should be established for successful BIM implementation in public infrastructure projects?
5. How was BIM implemented in Gaziantep Underground project?
6. What is the importance and benefit of BIM in the operation of Underground projects?

1) Transformation is the transition of the sector to a level that is accepted in the world, leaving aside the traditional solutions that form the basis of the business. After the field of industry in Turkey, it is time for digital transformation for the construction sector, which is the focus of investment. In many countries of the world, the transformation in industry and construction has been completed, and even

innovations continue to follow. This process, which started with Industry 4.0, is already moving towards Industry 5.0. But unfortunately, in our country, the transition to Industry 4.0 has not been fully achieved. The transformation of the construction sector, which likes to move forward with traditionalist solutions from the past, is not easy, while the industry, which is better and ahead than the construction sector, is the state of the field.

In countries, the public takes the lead on issues of total sector concern (regulations, change, etc.). Because of this, the transformation in the construction sector should begin in the public sector. It will play an important role in the transformation of local companies by providing digital transformation in investment projects that are important throughout Turkey and issuing regulations in accordance with it.

2) BIM is currently used in infrastructure Underground projects in Istanbul in Turkey, both at the project stage, at the field implementation stage and at the operation stage. It has been a good example of participation by other cities and the private sector. In this way, BIM has been used in the Mersin Underground project and the construction tender is about to come out. It is envisaged that BIM will be used as Istanbul again at the construction site stage and operation stage.

In addition, the project design phase using BIM is continuing in Gaziantep Underground project. In addition to BIM system solutions, the BIM competence level measurement (BIMYeDeM), which was started to be implemented in our country and is newly developing, was commissioned and the first phase was made. In short, BIMYeDeM is a system tool that scores the degree to which the BIM system is applied starting from the project, during the construction phase and operation phase. At the moment, the first phase, that is, the project phase, has been evaluated, and in the later stages, the Phase 2 and Phase 3 parts will also be scored. The first phase BIMYeDeM report of our project is available in the thesis content. In addition, the aim of the Gaziantep Underground project is to use BIM both in the implementation phase and in the operation phase. All preparations continue in this direction.

3) In engineering applications in infrastructure projects, the project occurs as a result of many analyses, especially CFD ‘Computational Fluid Dynamics’ analyses at the

project stage. At the construction stage, there are two known and most commonly used methods: CPC and NATM. In Chapter-4, this question is examined in detail.

4) BIM is the name of a system. It is not a program or product by itself. And like any system, the BIM system has many titles, chapters and topics. There are several issues that need to be done primarily on behalf of both the integration and solution of the BIM system. The system must operate as a whole. It is the purpose. To be included in the system, a BIM implementation plan must first be created. In light of the implementation plan, progress must be made according to the phases contained in the BIM system.

3D, 4D, 5D, 6D, 7D .. 3D, which is the beginning, should start with obtaining the necessary BIM-based programs that will be used in all project disciplines, starting with the ground Study Section at the beginning of the field work. All disciplines should be determined, although the names of the disciplines are separate, care should be taken to form a whole thanks to the programs and staff used.

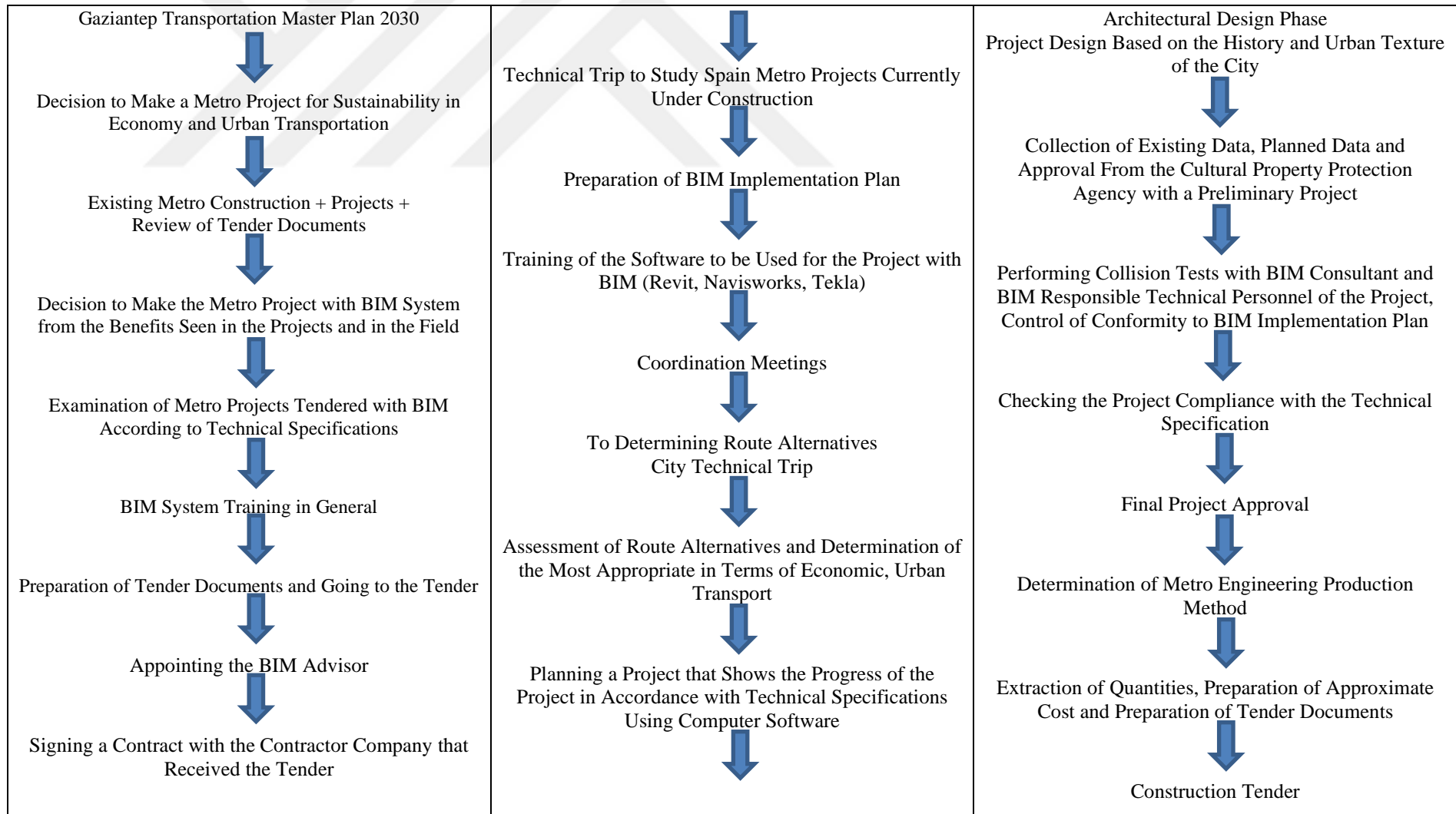
A business program should be created in the 4D phase, cost should be activated in the 5D phase, sustainability and business management should be activated in the 6D and 7D phases.

5) BIM implementation plan and example by giving technical training to the staff about the process that began with infrastructure projects, and then visit began, and continued with field studies, as envisaged in the implementation plan the phases are respectively applied, the Lod levels are created by considering the details of the project, quality control and conflict control corresponding to the simulations carried out in the name of the construction project being included in the cost and time to simulate was increased.

6) Unlike paper storage, which is the classic method for municipalities and public institutions, one of the main goals of the BIM system, which allows all data to be stored digitally and creates a database, is to help find solutions that eliminate problems by anticipating them in advance, to ensure sustainability in the business. In this way, the minimum revised phenomenon that started at the project stage continues in the construction site and ensures sustainability in business management.

6.1.1 BIM Adoption Roadmap for Gaziantep Municipality

Government agencies should be the leading force for digital transformation in the construction industry. In defending this view, the fact that Gaziantep Metropolitan Municipality undertook the first and only infrastructure project of Southeast Anatolia with BIM is an important argument. For this reason, the proliferation of infrastructure projects that make life easier in every sense and the creation of BIM system are important for the digital transformation of the sector. As part of the Gaziantep Metro project, the process table in which we describe the stages that begin with the Gaziantep Transportation Master Plan, which will result in the project phase and the construction tender is below. This table, which is a summary of the thesis, is also a guide for other government agencies that want to make a metro project. From beginning to end, the steps taken in this process are described in detail in the thesis. In order to determine the subject of the thesis, which should not be extended and which is essential, some titles have not been explained.



Figür 6.1 BIM Adoption Roadmap for Gaziantep Municipality

6.2 Conclusion

The amenities provided by BIM in Gaziantep Underground project, which is an infrastructure project in Turkey, are listed below:

- Minimization of conflicts and disagreements within design and applications on the basis of all disciplines,
- Obtaining realistic figures and construction timing before the tender process with realistic planning and cost analysis,
- Maximizing design efficiency as a result of training of BIM-based programs used in in-house projects,
- As a result of collision analysis, preventing project revisions that may occur during construction and minimizing the risk of faulty manufacturing,
- Prevention of delays that may occur during the manufacturing phase with realistic time planning,
- Making project decisions quickly by predicting with 3D models produced across all disciplines,
- Preventing the differences that may occur during the construction phase with the models delivered with real and current coordinate data,
- Creating realistic models thanks to simulations made across all disciplines and creating digital twins of the structures that are the essence of BIM,
- Preventing the problems that may occur during the construction phase as a result of the reinforcement sheets delivered in 3D in the structural discipline,
- Quick solving of material problems that may occur during business management thanks to the material information processed on the models,

- Saving time and providing convenience to the technical staff working as a result of on-site controls in digital environments (tablets etc.) during the construction phase,
- Providing energy efficiency during the operation phase with the materials preferred in the models during the project phase,



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APPENDICES

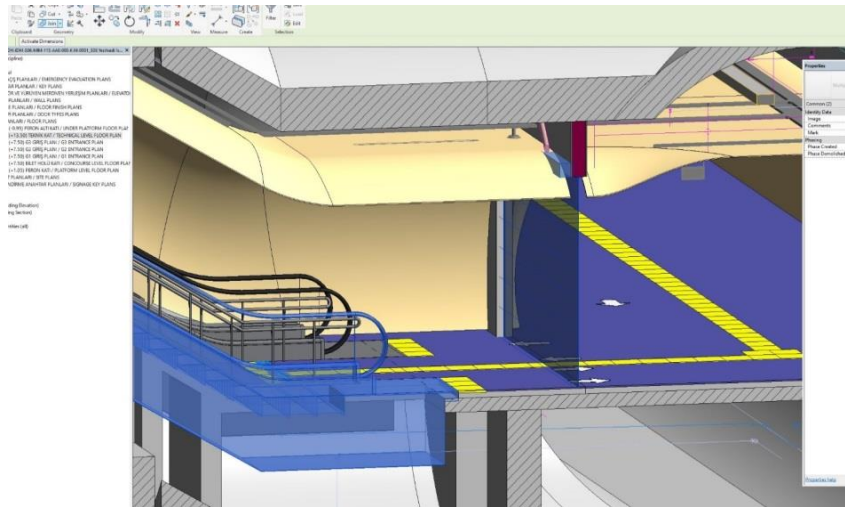


Figure 7.1 The mechanical elements of the hinged doors in the entire station should be arranged in the architectural project.

The relationship between the escalator and the structural element should be reviewed.

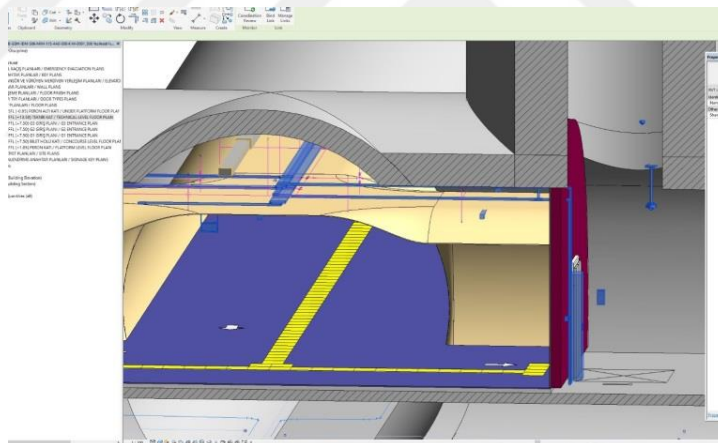
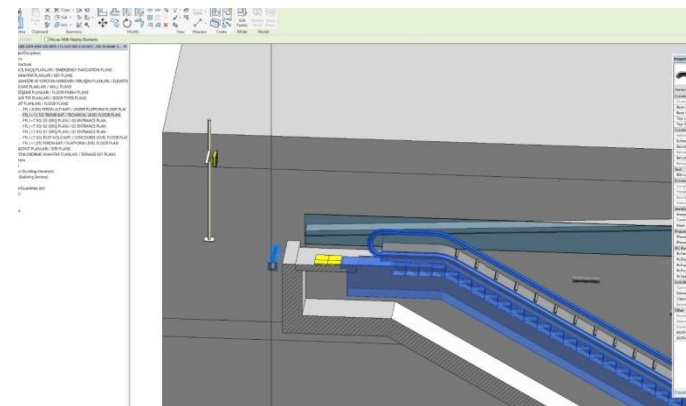


Figure 7.2 The locations of the electrical elements in the entire station should be reviewed in the architectural project.



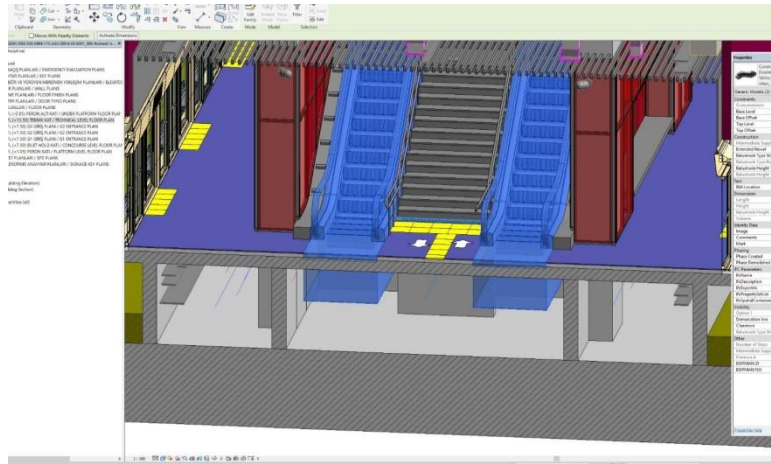


Figure 7.3 The relationship between the escalator and the structural element should be reviewed.



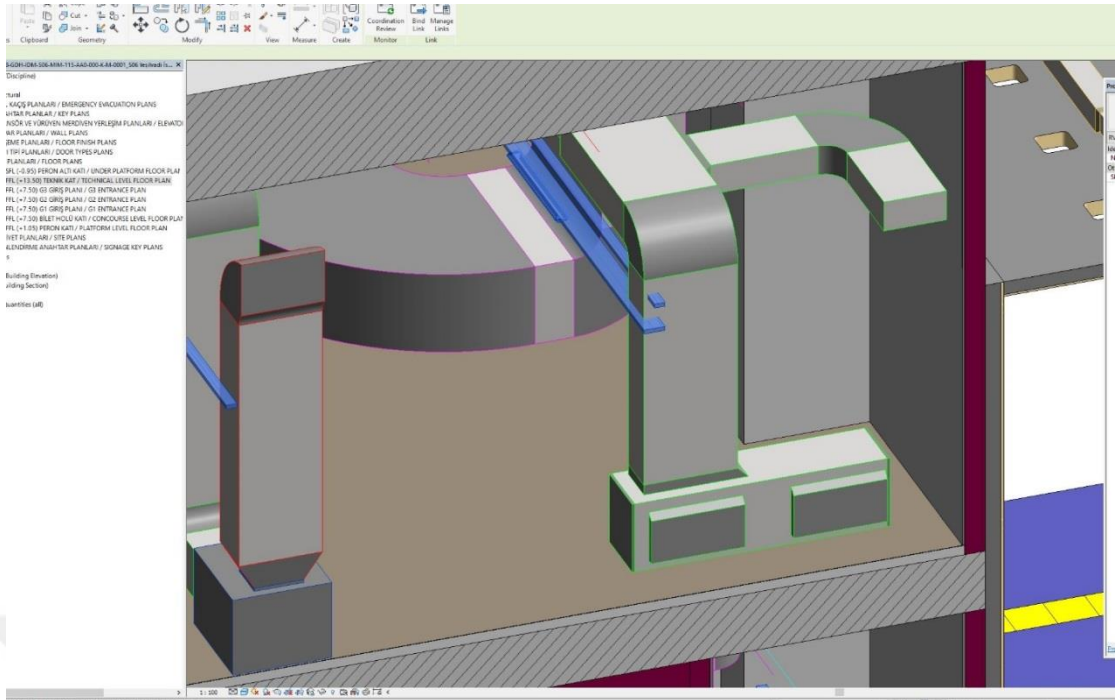


Figure 7.5 The relationship between electrical equipment and mechanical elements should be reviewed.

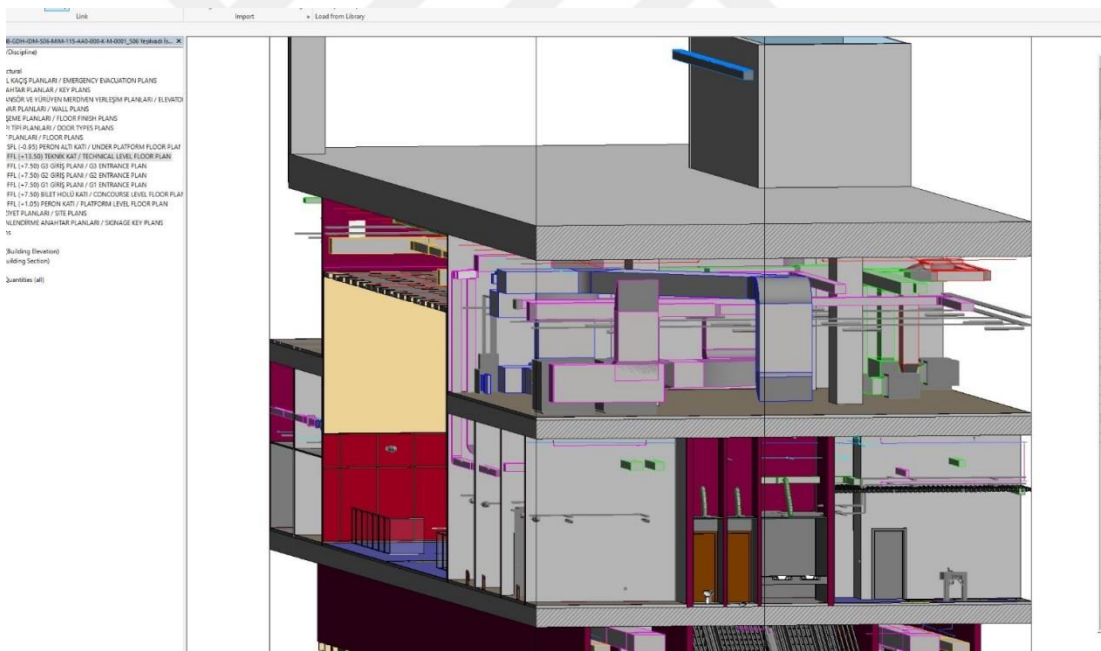


Figure 7.6 Mechanical equipment should be rearranged in the project by looking at their relationships among themselves.

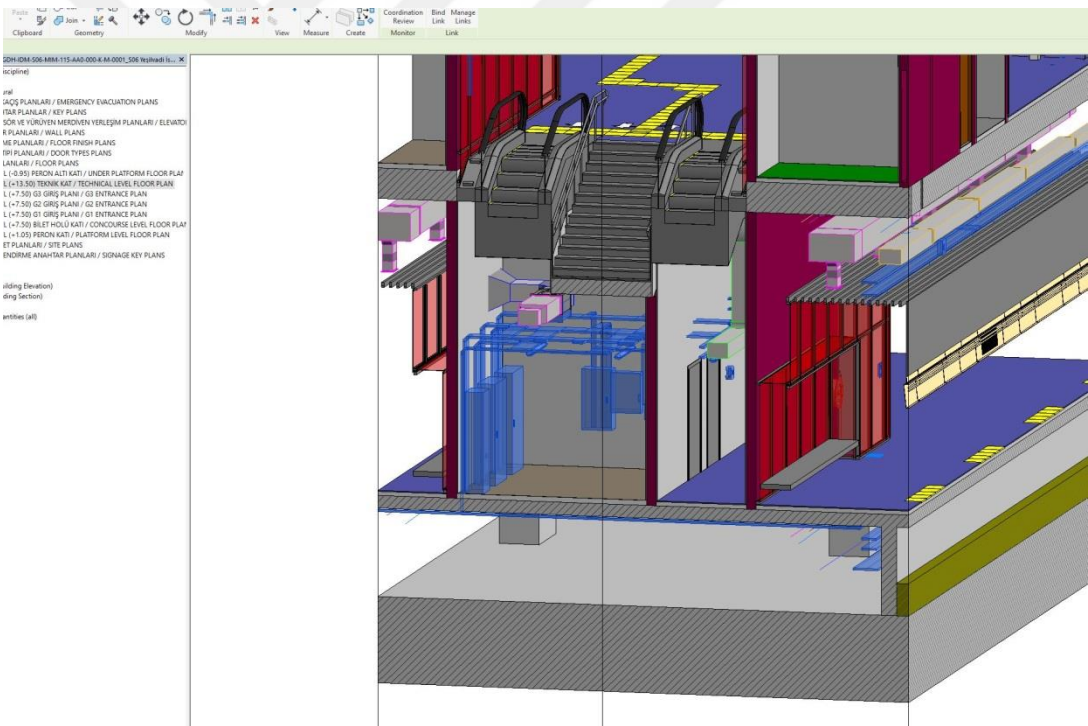
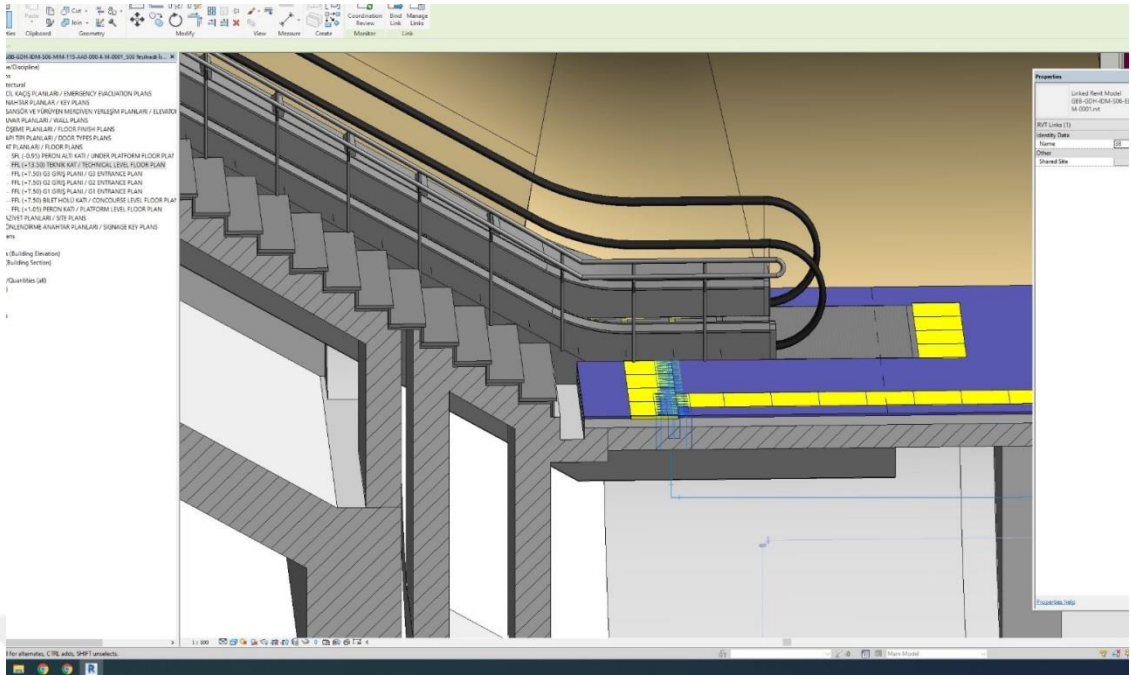


Figure 7.7 Sufficient gaps should be opened in the projects for electrical and mechanical elements in the entire station.

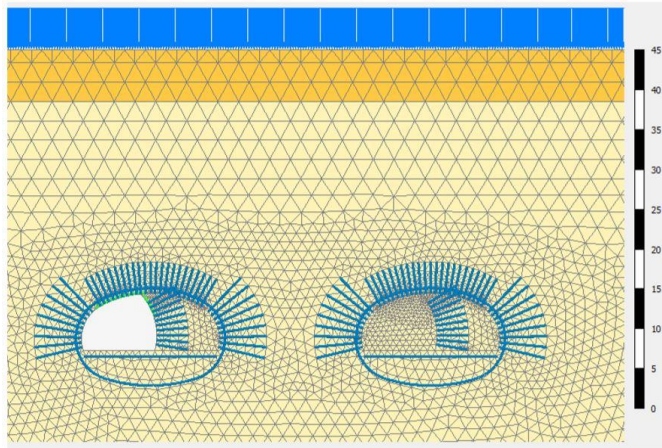


Figure 7.8 Pipe drive manufacturing

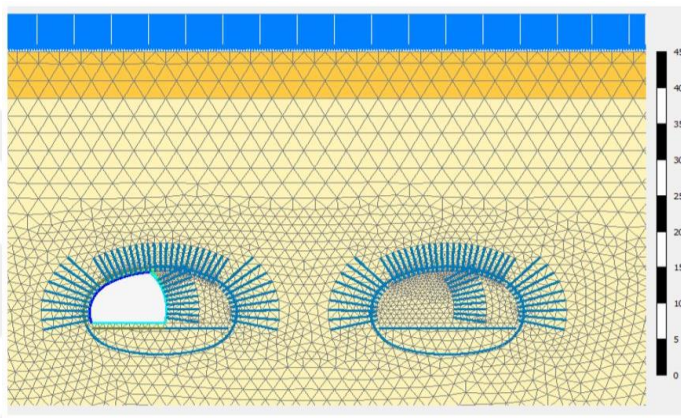


Figure 7.9 Stage 1 excavation stress reduction

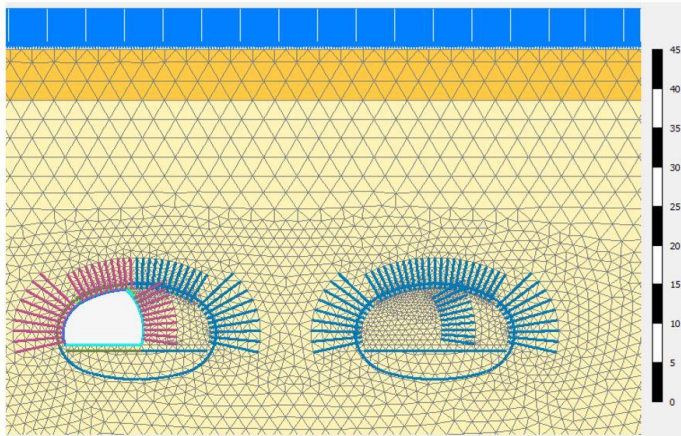


Figure 7.10 Shotcrete manufacturing

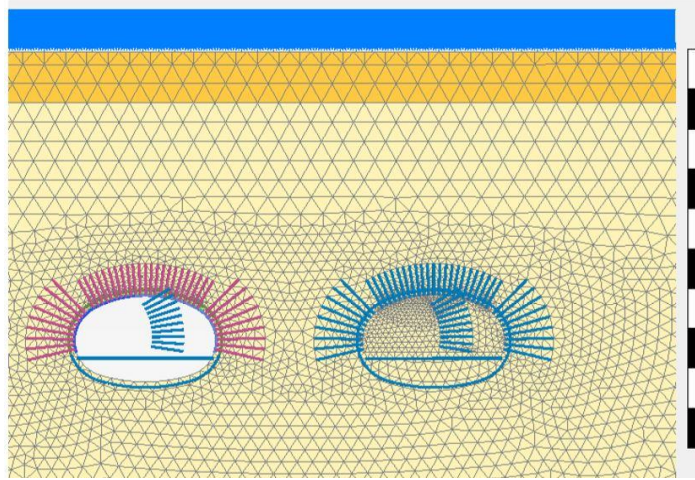


Figure 7.11 Rock bolt application

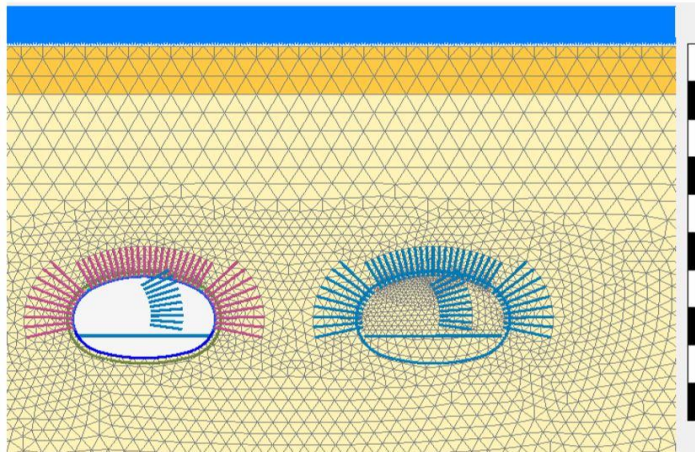


Figure 7.12 Lower half stress reduction



Figure 7.13 Lower half shotcrete and fortification fabrication



Figure 7.14 Site Manufacturing Photos of NATM Construction Method

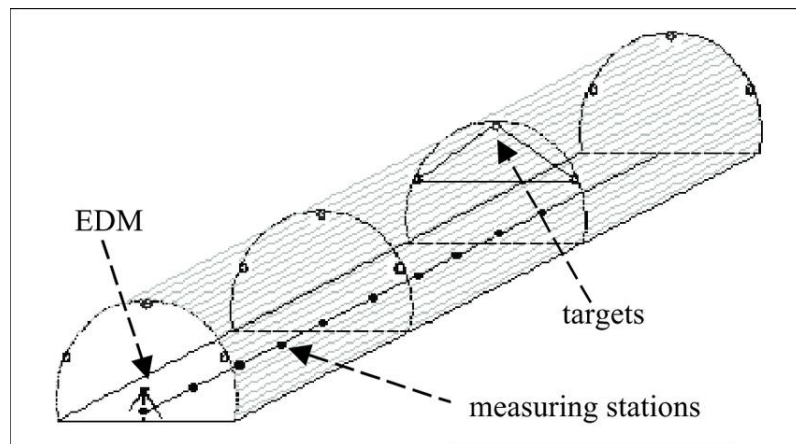


Figure 7.15 NATM Laser Map Measurement



Figure 7.16 Warehouse Revit Images

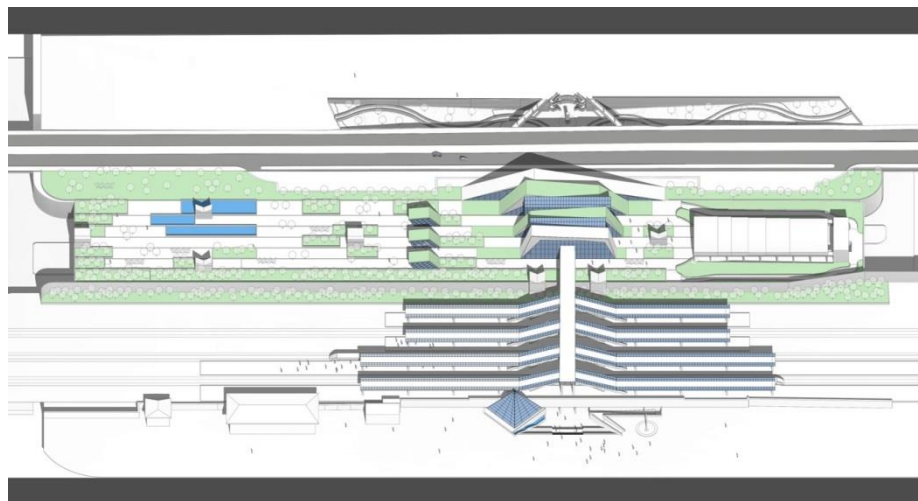


Figure 7.17 Station Main Transfer Center 3D Rendering Images

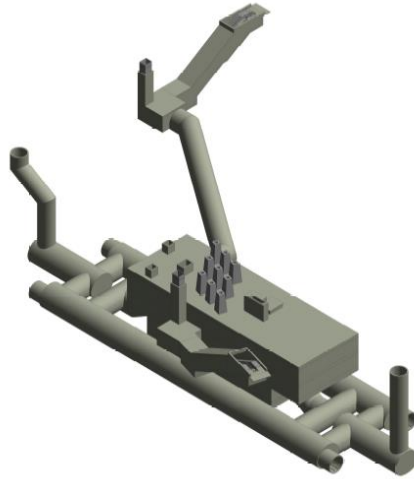


Figure 7.18 Akkent Station Model 3D image

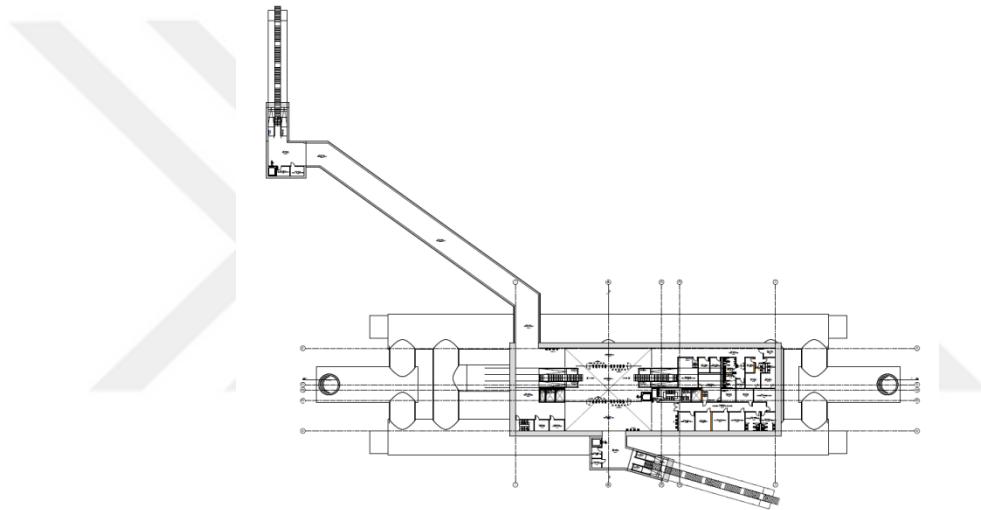


Figure 7.19 Akkent Station Ticket Hall

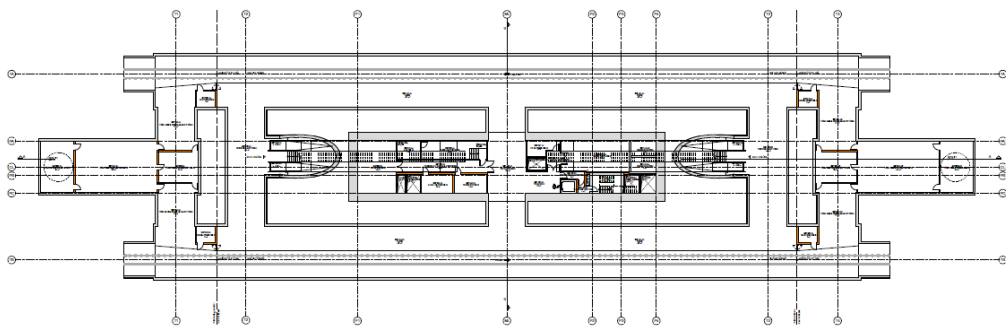


Figure 7.20 Akkent Station Platform Floor

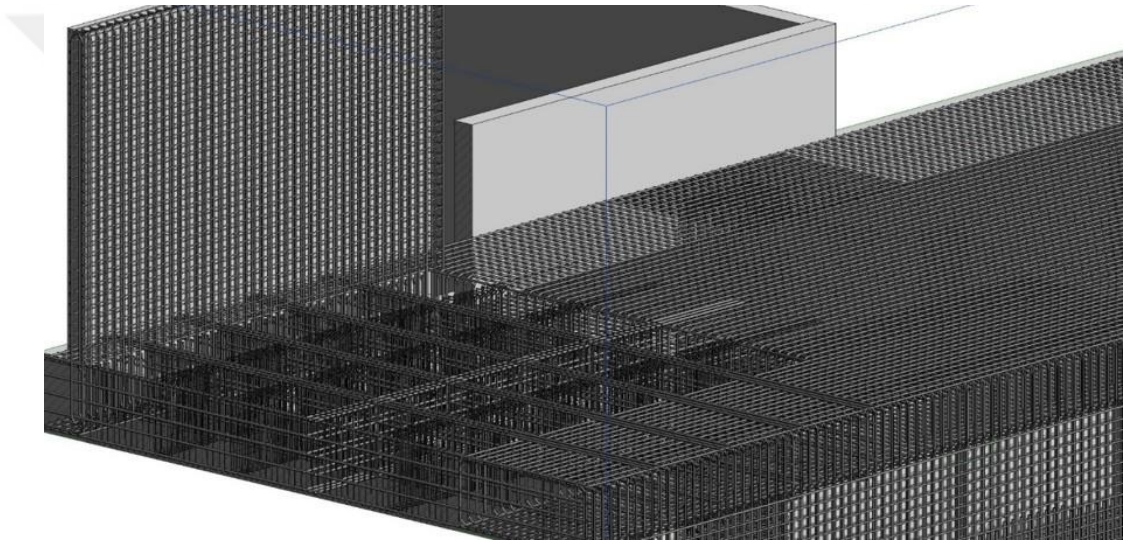
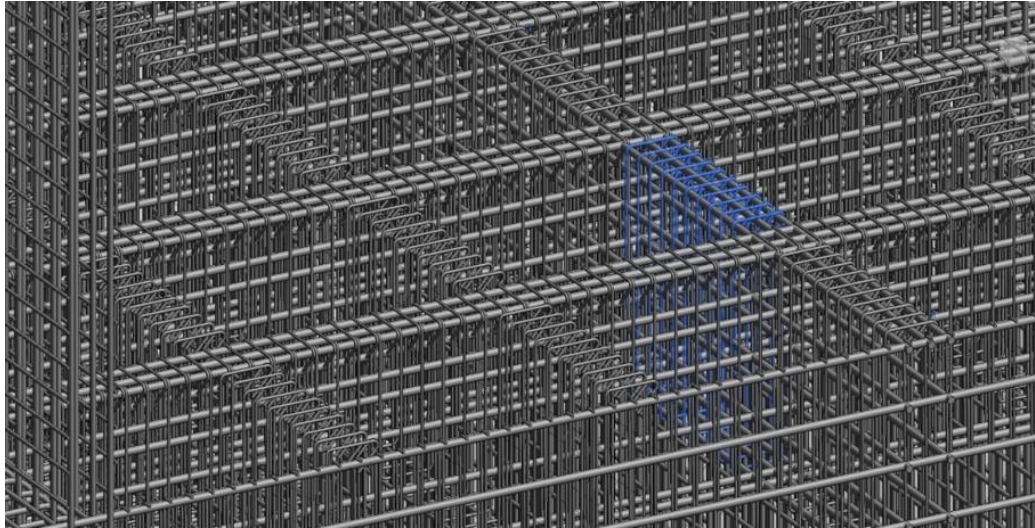


Figure 7.21 Station Reinforcement Plan 3D Revit Images

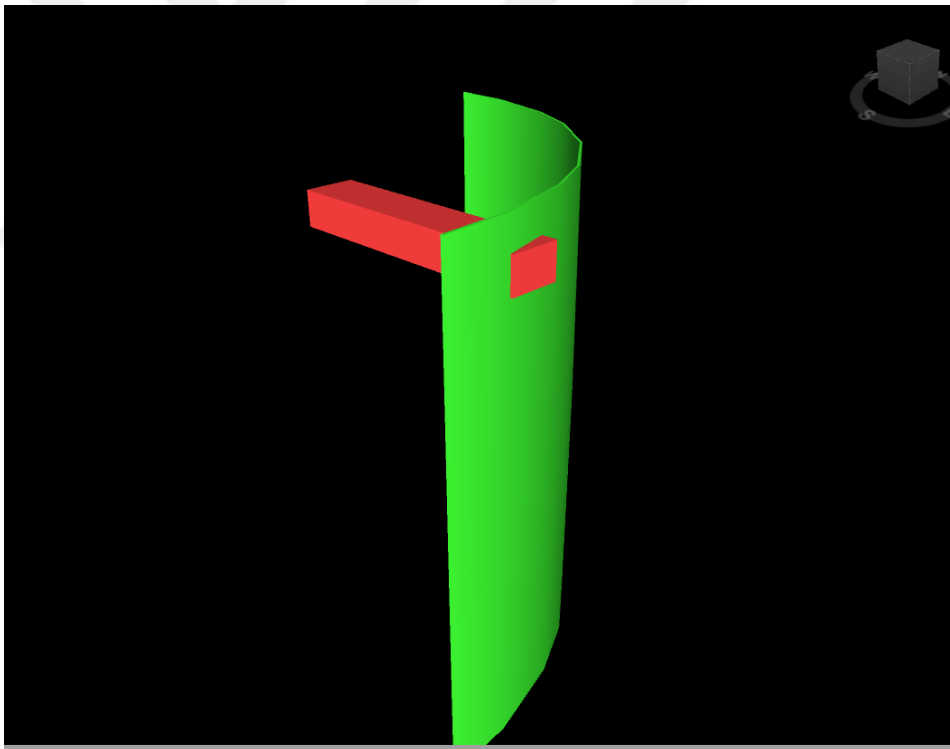
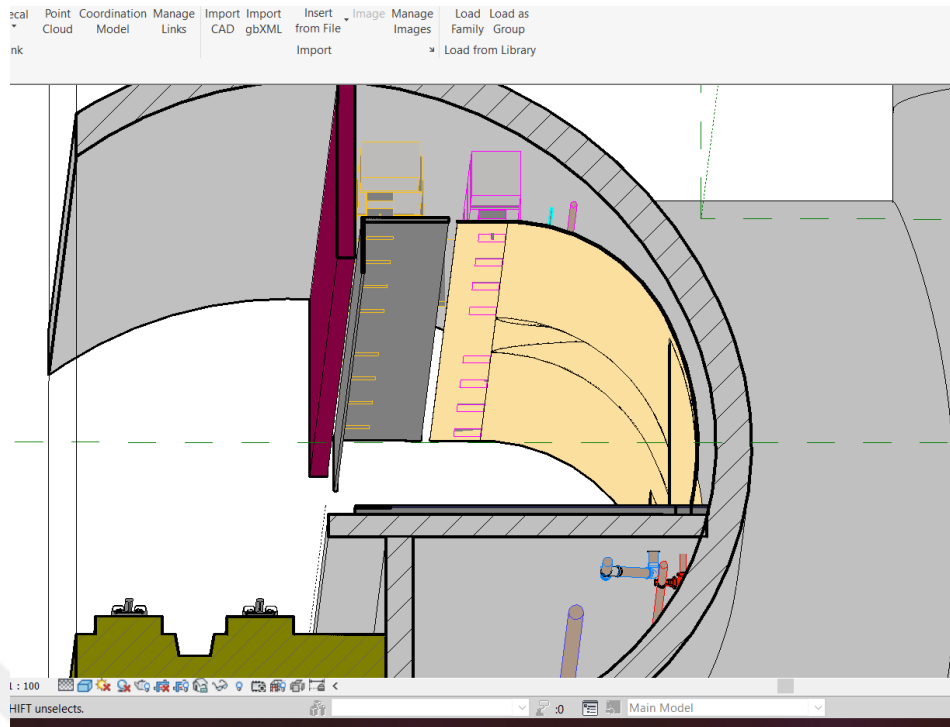


Figure 7.22 Navisworks & Revit Conflict Checks Images

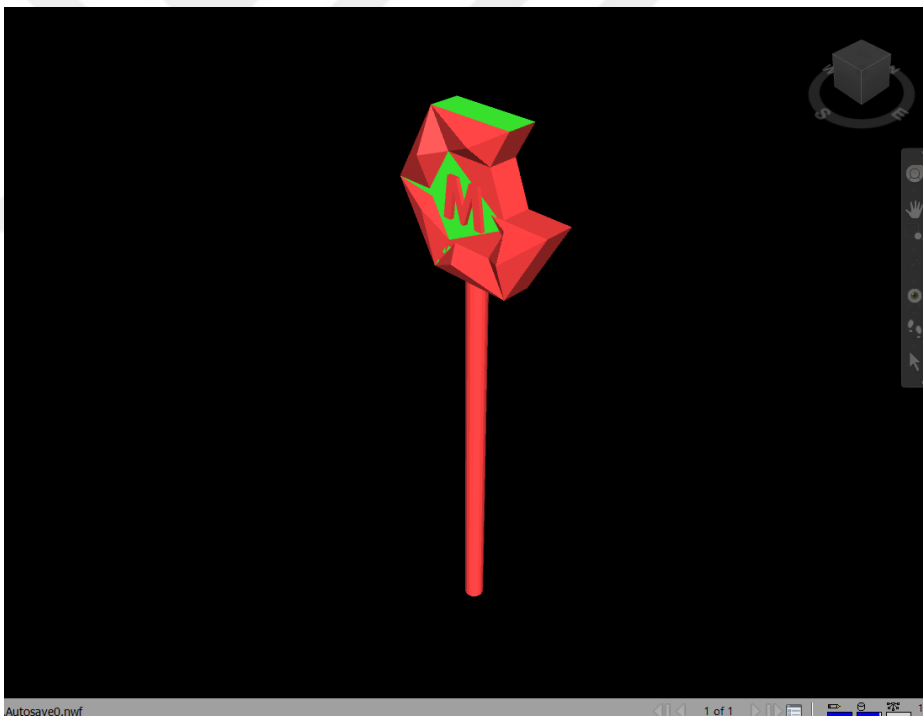
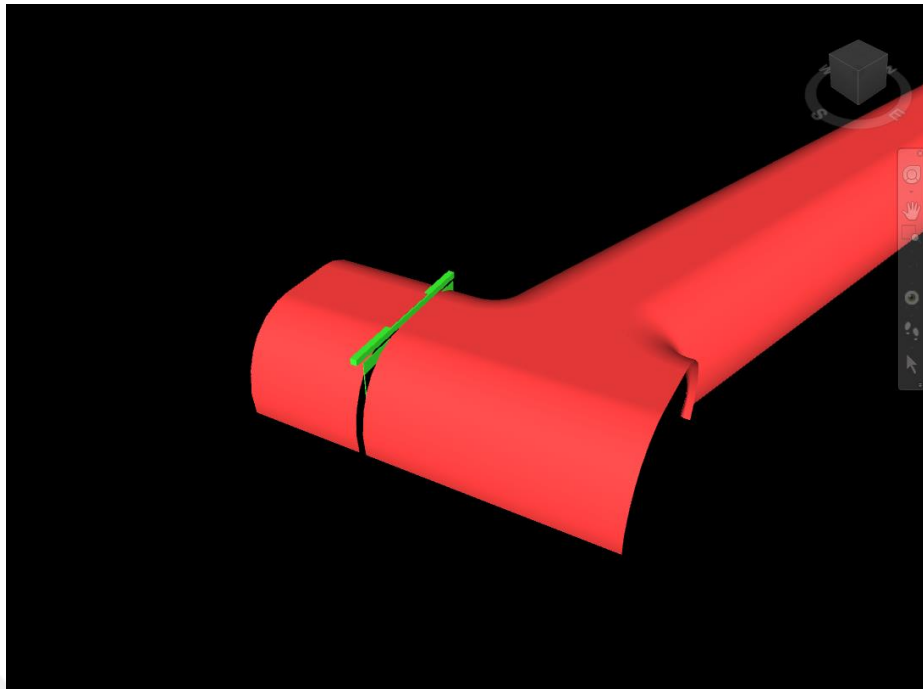


Figure 7.23 Navisworks & Revit Conflict Checks Images

Table 7.1 Main BIM Goals

PRIORITY	TARGET DESCRIPTION	POTENTIAL BIM USE
High	3D Coordination	Conflict Control
Medium	Model Based Cost Estimation	BIM BOQ (MTO & QTO)
Low	Phase Planning (4D)	Business Program Model Integration
Low	Site Information Sheet	RDS

Table 7.2 BIM Usages

PLAN		DESIGN	PRODUCTION	OPERATION
CURRENT SITUATION MODELING	x	CURRENT SITUATION MODELING	CURRENT SITUATION MODELING	CURRENT SITUATION MODELING
COST ESTIMATION	x	COST ESTIMATION	COST ESTIMATION	COST ESTIMATION
	x	3-DIMENSIONAL COORDINATION		
	x	LOCAL INFORMATION SHEETS (RDS)		
		PHASE PLANNING (4D)		
		DESIGN CONTROL		

Table 7.3 Stakeholder Requirements

BIM TARGETS	TARGET DEFINITIONS
Design Management	The modeling process and the design process will continue together.
Integrated Project Management	Thanks to the coordination in all interdisciplinary studies, it will be ensured that the project processes are carried out fully and completely, and the project is managed in a holistic manner.
Code Compliance	The Building Model will be defined in accordance with the CSI code listing.
3D Control & Planning	Area planning and requirement program will be checked for compliance.
2D and 3D document management	Dynamic documents such as plan, section, facade, perspective will be created.
Conflict control	Conflict control analysis is used to check for collisions between one or more models / objects. In order to reduce the number of change requests during construction works, collision control should be done early and this control should continue throughout the design process.
3D Coordination	Interdisciplinary coordination will be controlled by combining models.
4D Conformity	Time parameters will be added during the manufacturing phase. Modeling will be done in the additive method of time information..
5D Conformity	Modeling will be done in the method that can be added to cost and time information.

Table 7.4 Project scope

	Symbolic	Amount	Size	Shape	Place	Management	Information	
LOD 100	X							Schematic Design
LOD 200		X	X	X	X			Preliminary
LOD 300		X	X	X	X	X	X	Exact

Table 7.5 Project BIM Lod Levels

Model Objectives	Predicted LOD Levels
Conflict report	LOD 200-300-400
Quantity	LOD 200-300-400
2D Visualization	LOD 300-400-500
Principle conflict coordination	LOD 300-400-500
Conflict coordination	LOD 400-500
3D Visualization and animation	LOD 300-400-500
System analysis	LOD 400-500
4D Visualization *	LOD 400-500
4D Business and Field planning *	LOD 300-400-500
5D building cost estimates *	LOD 400-500
Virtual reality simulation *	LOD 300-400-500
Consultancy	LOD 200-300-400-500

Table 7.6 Elements to be Modeled According to Disciplines

Analysis	Analysis Device	Model	Project Steps	File Format
Visualization	Revit-3dsmax	Revit	LOD 100,200,300	rvt
Structural	Sta4Cad, Robot	Revit	LOD 100,200,300	rvt
Conflict Detection	Navisworks	Revit	LOD 100,200,300	rvt, nwc, xlsx
BOQ	Excel	Revit	LOD 100,200,300	xlsx
Lighting	Dialux	Revit	LOD 300	
Pedestrian Simulation	Massmotion	Revit	LOD 200	.avi

Table 7.7 Architectural Model Lod Table

Model Level Delivery Table	LOD 300 (Final Project)		LOD 400 (Application Project)		LOD 500 (As Built)	
	2D CAD	3D MODEL	2D CAD	3D MODEL	2D CAD	3D MODEL
ARCHITECTURAL						
Walls	E	E	E	E	E	E
Dividing Walls	E	E	E	E	E	E
Floors	E	E	E	E	E	E
Raised Floors	E	E	E	E	E	E
Roofs	E	E	E	E	E	E
Doors	E	E	E	E	E	E
Windows	E	E	E	E	E	E
Suspended Ceiling	E	E	E	E	E	E
Coatings	E	E	E	E	E	E
Facade Elements	E	E	E	E	E	E
Sanitaryware	E	E	E	E	E	E
Furniture	E	E	E	E	E	E

Table 7.8 Structural Model Lod Table

Model Level Delivery Table	LOD 300 (Final Project)		LOD 400 (Application Project)		LOD 500 (As Built)	
	2D CAD	3D MODEL	2D CAD	3D MODEL	2D CAD	3D MODEL
STATIC						
Raft foundation	E	E	E	E	E	E
Column Formwork	E	E	E	E	E	E
Curtain Formwork	E	E	E	E	E	E
Flooring Formwork	E	E	E	E	E	E
Beam Formwork	E	E	E	E	E	E
Column Reinforcement	E		E		E	
Curtain Reinforcement	E		E		E	
Flooring Reinforcement	E		E		E	
Beam Reinforcement	E		E		E	
Tunnel Reinforcement	E		E		E	
Tunnel Formwork	E		E		E	
Excavation Retaining Mold	E	E	E	E	E	E
Excavation Retaining Reinforcement	E		E		E	

Table 7.9 Mechanical Model Lod Table

Model Level Delivery Table	LOD 300 (Final Project)		LOD 400 (Application Project)		LOD 500 (As Built)	
	2D CAD	3D MODEL	2D CAD	3D MODEL	2D CAD	3D MODEL
MECHANICAL						
Building Approach Installations						
Clean Water Connection	E	E	E	E	E	E
Waste Water Connection	E	E	E	E	E	E
Rainwater Connection	E	E	E	E	E	E
Natural Gas Connection	E	E	E	E	E	E
Irrigation	E		E		E	
Hydrant Placement	E	E	E	E	E	E
Waste Water Installation						
Main Lines	E	E	E	E	E	E
Basic Six Lines	E	E	E	E	E	E
Equipment	E	E	E	E	E	E
Clean Water Installation						
Main Lines	E	E	E	E	E	E
Basic Six Lines	E	E	E	E	E	E
Equipment	E	E	E	E	E	E
Fire Installation						
Main Lines	E	E	E	E	E	E
Cross Lines	E	E	E	E	E	E
Sprinkler Heads	E	E	E	E	E	E
Equipment	E	E	E	E	E	E
ENVIRONMENTAL CONTROL SYSTEM						
Piping	E	E	E	E	E	E
Fittings	E	E	E	E	E	E
Cross Lines	E	E	E	E	E	E
Culverts	E	E	E	E	E	E
Equipment (TVF - EXF - VRF etc.)	E	E	E	E	E	E

Table 7.10 Electric-Electronic Model Lod Table

Model Level Delivery Table	LOD 300 (Final Project)		LOD 400 (Application Project)		LOD 500 (As Built)	
	2D CAD	3D MODEL	2D CAD	3D MODEL	2D CAD	3D MODEL
ELECTRIC – ELECTRONIC						
GROUNDING INSTALLATION						
Earthing Conductors	E		E		E	
Ground Electrode	E		E		E	
LIGHTING INSTALLATION						
Luminaires	E	E	E	E	E	E
Keys	E	E	E	E	E	E
Sensors	E	E	E	E	E	E
FORCE DISTRIBUTION AND SOCKET INSTALLATION						
Sockets	E	E	E	E	E	E
Panels (OG-DC-LV Panel cells)	E	E	E	E	E	E
Transformers	E	E	E	E	E	E
UPS	E	E	E	E	E	E
Cables	E		E		E	
Junction Boxes	E	E	E	E	E	E
Parapets	E	E	E	E	E	E
Hand Drying	E	E	E	E	E	E
Turnstiles	E	E	E	E	E	E
Metal detector	E	E	E	E	E	E
FIRE DETECTION AND ALARM INSTALLATION						
Detectors	E	E	E	E	E	E
Flashers	E	E	E	E	E	E
Flasher Horn	E	E	E	E	E	E
Modules	E	E	E	E	E	E
Panels	E	E	E	E	E	E
EMERGENCY ANNOUNCEMENT INSTALLATION						
Speakers	E	E	E	E	E	E
Amplifiers	E	E	E	E	E	E
Cables	E		E		E	
Panels	E	E	E	E	E	E
IP CCTV and SECURITY DELIVERY						

Cameras	E	E	E	E	E	E
Door Control Units	E	E	E	E	E	E
Electric Locks	E	E	E	E	E	E
Cables	E		E		E	
Security Center PCs	E	E	E	E	E	E
IP CCTV and SECURITY DELIVERY						
Sockets	E	E	E	E	E	E
Tile Boxes	E	E	E	E	E	E
Antennas	E		E		E	
Weak Current Distribution Boxes	E	E	E	E	E	E
CABLE CARRYING SYSTEMS						
Cable Trays	E	E	E	E	E	E
Cable Pipes	E	E	E	E	E	E
PARKING GUIDING INSTALLATION						
Loop Detectors	E	E	E	E	E	E
Switches	E		E		E	