THE BUILDING PERFORMANCE OF THE METRO STATION BUILDINGS' ENTRANCES

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
THE MIDDLE EAST TECHNICAL UNIVERSITY

BY

GÖKHAN AKSOY

IN PARTIAL FULLFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE
IN
THE DEPARTMENT OF ARCHITECTURE

DECEMBER 2003

Approval of the Graduate School of Natural and Applied Sciences

Prof. Dr. Canan Özgen
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

Assoc. Prof. Dr. Selahattin Önür
Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

Asst. Prof. Dr. Ercüment Erman
Supervisor

Examining Committee Members

Instr. Dr. Ayşe Tavukçuoğlu

Instr. Dr. Halis Günel

Dr. Filiz Bal Koçyiğit

M. Arch Bülent Sülüner

Asst. Prof. Dr. Ercüment Erman

ABSTRACT

THE BUILDING PERFORMANCE OF THE METRO STATION BUILDINGS' ENTRANCES

AKSOY, Gökhan

M.Sc. in Building Science, Department of Architecture

Supervisor: Asst. Prof. Dr. Ercüment Erman, Ph.D.

December 2003,114 pages

Station buildings are the most significant components of metro systems that combine underground facilities to the outer world, and include public life in itself. Thus, it is the main objective of that research, to put forward an acknowledgement documentation, which identifies the main design and construction problems of existing and under construction metro station buildings' entrances, and which comes up with solutions to these problems.

In the scope of thesis, foremost, basic terminology about station buildings are given and historical development of these buildings in abroad and Turkey are explained briefly. Then, observed problems of metro station entrances are put forward in detail. These problems are mainly categorized as design, construction, material and application related problems. Design part is investigated under following sub-titles: Psychological effects, lighting conditions, space requirements, relationship with city, navigation and disabled accessibility of stations. The affect of recent construction techniques and technological developments on design are also explained. Lastly, material choice and application related problems are investigated through such components of station as wall, floor, ceiling and details. All these problems are assessed by making comparisons with examples both from abroad and from Turkey.

Finally, it is comprehended that, because of having weak connections to outer world, the entrances of the stations have adequate contributions neither to the station nor to the city. Assessment of building performance is made under the light of predefined problems and proposals are made in order to be used in design studies to get station entrances free from those problems.

Keywords: Metro Station, Station Entrance, Building performance.

ÖZ

METRO İSTASYONLARININ GİRİŞ YAPILARININ YAPISAL PERFORMANSLARI

AKSOY, Gökhan
Yüksek Lisans, Yapı Bilgisi Anabilim Dalı, Mimarlık Bölümü
Tez Yöneticisi: Yrd. Doç. Dr. Ercüment Erman, Ph.D.

Aralık 2003,114 sayfa

İstasyon yapıları metro sistemlerinin dış dünya ile ilişkisini sağlayan ve sosyal hayatı içinde barındıran en önemli bileşenleridir. Bu bakımdan mevcut veya inşaa edilmekte olan sistemlerdeki istasyon yapılarının giriş bölümlerinin temel tasarım ve yapım sorunlarını ortaya koyan ve çeşitli çözüm önerileri sunan kapsamlı bir bilgi kaynağı oluşturmak bu araştırmanın asıl amacıdır.

Tez kapsamında, önce İstasyon yapıları ile ilgili genel tanımlar verilmekte ve bu yapıların Türkiye ve dünyadaki tarihsel gelişimleri kısaca anlatılmaktadır. Daha sonra ise istasyon binalarının giriş bölümlerinde gözlemlenen problemler detaylı bir biçimde ortaya konulmaktadır. Bu problemler tasarımla ilgili olanlar, yapısal olanlar ve malzeme ve uygulama ile ilgili olanlar olarak sınıflandırılmaktadır. Tasarım ile ilgili olanlar şu alt başlıklar altında incelenmektedir: Metro istasyonlarının, insanlar üzerindeki psikolojik etkileri, aydınlanma durumları, mekan gereksinimleri, şehir ile ilişkileri, yönlendirme durumları ve engelli erişimleri. Yeni inşaat teknikleri ve teknolojik gelişmelerin tasarım üzerindeki etkileri incelenmektedir. Son olarak malzeme seçimi ve

uygulamayla ilgili sorunlar duvar, zemin, tavan ve detaylar gibi istasyon bileşenleri üzerinden incelenmektedir. Tüm bu sorunlar yurt dışından ve yurt içinden seçilen örneklerle kıyaslamalar yapmak suretiyle değerlendirilmektedir.

Sonuç olarak ise, Türkiye’ deki metro istasyon girişlerinin dış mekan ile olan ilşkisinin zayıf olduğu ve bu sebeple gerek şehire, gerek istasyona olumlu katkılarının bulunmadığı tespit edilmiştir. Belirtilmiş olan problemler ışığında metro istasyon giriş yapılarının performanslarının değerlendirmesi yapılmakta ve yukarıda sözü edilen tasarımsal hatalardan uzak metro istasyonları elde etmeye yönelik çalışmalarda kullanılmak üzere öneriler sunulmaktadır.

Anahtar Kelimeler: Metro İstasyonu, İstasyon Girişi, Bina Performansı.

To My Family;

My Mother Belgu Makbule AKSOY, My Father Ömer AKSOY

and My Sister Aysan AKSOY

ACKNOWLEDGEMENTS

I would like to express my sincere thanks to Ercüment ERMAN for his guidance, supervision, continued interest and encouragement thought this study.

I am very grateful to Mrs. Günnur GÜVEN, Finishing Works and Technical Purchasing Coordinator, Güriş Construction and Engineering CO, INC.

And my friend, Yonca GÜNAY Architect, Güriş Construction and Engineering CO, INC. for their help.

Likewise, I am very thankful to Mrs. Filiz BAL KOÇYİĞİT, for her attention and help throughout the study.

Finally, I would like to express my sincere appreciation and gratitude to all my parents Belgu AKSOY and Ömer AKSOY, my sister Aysan AKSOY and my friends for their encouragement and patience.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Recently in Turkey, where the construction of metro network systems' construction almost newly started, it is important to identify the Metro understanding, correctly at the beginning. The most significant components of those systems are the station buildings because of their function, including the public life. In general public places of the cities are the streets and squares. The station buildings are the enclosed public places of the cities. Therefore providing the continuation of the public space is important. In that continuation the entrances of the stations play an important role of connecting the city and the station.

I.1. Definition of the Problem

The requirements of human being have changed by the development of the technology and the urban life. Today human need fast, safe, comfortable transportation. Underground transportation is the most preferred option as an urban transportation system, especially in the case of transporting large numbers of people through a crowded city. Although many developed countries have been using underground transportation for many decades, these systems and their contribution to city is comparably new task for Turkey. Since Turkey has been using that system for about two decades, almost all big cities are waiting for a new texture constituting of metro networks. When completed all these cities gain a new and different look by the help of networks and stations as a new building type. Today most of these systems are under the construction period. This period of time is a valuable opportunity, to construct systems in the best possible way from the very beginning. The design procedure of these systems should not be a trial and error method, because there are experiences of previously constructed metro systems in the western world which can be learned from.

Especially the station buildings of the system should have to be carefully reviewed in the manner of their contribution to city, and proposed public life inside. By the enhancements of Turkish government and construction companies, all requirements such as technology, capital, work force, adequate equipment, qualified labor, etc. are satisfied and the constructions were made complying with the international standards. But, while the engineering part is qualified enough the architectural design seems to be lacking when compared with the examples from abroad.

Figure I. 1: Entrance of Tandoğan station neither has contemporary appearance nor reflects city character; Ankara.

The station buildings of those systems are the open interfaces of the underground tunnels to the outer world and the entrances of those stations are the buffer zones in between the station and outer world. In that sense, they should be considered carefully. In addition to its functional advantages, it has a very big responsibility by its architectural form in city silhouette.

Station entrances of these systems are one of the most important components of the city. As a result, apart from the underground system, the entrances of station buildings should be not only the product of engineering but also the architecture. As seen in Figure I. 1 and Figure I. 2 many of the existing stations in Turkey do not have such a contemporary appearance and appropriateness to the city character by their entrances or above ground components. They seem to be the products of engineering profession rather than architecture.

Figure I. 2: Kolej station entrance does not have any relationship with the city by its structure or form, Ankara.

Figure I. 3: Air shaft of metro station disturbing the pedestrian flow, Ankara.

The station entrances are not only the components of the stations but also the ones of the city, because of the visibility from outside. The above ground parts of the stations such as entrance structures, skylights, and the technical shafts should have the aesthetical and functional quality enough to satisfy the requirements of both the patrons and the city. If properly designed they can even become the landmarks of the city. In order to provide such quality these components should either reflect the characteristic features of its surrounding, or have a unique architectural style of its own. However, in Turkey most of the stations and entrance structures seem to be distant from being any landmark or even the components of a united system or reflecting a specified character. They are reflecting neither any architectural currencies marks nor any feature of the region they serve to. For instance in Figure I. 3 the form of the mass block of the airshaft disturbs the aesthetical view of the city and the location of it disturbs the pedestrian flow. The standardization of the stations provides the sense of belonging to an entire system.

I. 4. A Demirtepe station I. 4. B Bahçelievler station

Figure I. 4: Non standardized entrances of stations from Ankara.

Today increasing the architectural space quality of these stations is another task which the architects concern with. Designing huge spaces with huge voids and taking light deep into the station is the most common way of improving the space quality. By the help of developed technology in engineering field it is now possible to built large span spaces for stations. By the help of new construction techniques in sheltering it is also possible to take light into the station. The architecture of the station buildings in Turkey, İstanbul, Ankara, İzmir, etc. does not seem to be qualified enough in terms of space quality, lighting, orientation, space use, etc. Inside the stations there is no exploitation of spacious spaces, natural lighting, and architectural attitude to help navigation which could have improve the comfort level of the station and link it to the outer world. Nearly, in none of the big stations the natural light does exist. The natural light in enclosed spaces facilitates the feeling of navigation and time. For instance, as seen in Figure I. 5, even being the biggest station of Ankara Kızılay station does not have such spacious spaces or natural light infiltrating inside the station.

Figure I. 5: Several storey station without any spacious spaces or natural light inside Kızılay Ankaray, metro line connection, Ankara.

Designing stations to be freely accessible to disabled people is one of the main concerns. It is important to not see all the disabled people as wheelchair users, they may also suffer from impairment of hearing, vision and other facts. The design solutions offered for them seem to be attached later on to the stations. But the proposal should have to be a component of the system not an isolated one. Visually segregated solutions become obstacle, not a physical but psychological one. In Turkey many stations have disabled accessibility, with their physical measurements, but with psychological obstacles. As seen in Figure I. 6 the disabled lifts are segregated from the entrance of the station.

Figure I. 6: Isolated handicapped entrances for elevators from Kolej station, Ankara.

There are some extra functions added to the building in many stations. Especially, large commercial areas added to the station halls in order to increase the economic income. But problems can occur with these stations containing large commercial areas, the clarity functions and the sense of direction can be lost because of these busy spaces. Therefore the relationship between the station entrance and those retail areas should be considered carefully.

The main factor for choosing the cladding material, in station building should have to be the durability and safety. The materials appropriateness to the standards affect the comfort and safety levels and the life of the station. In stations the usage of durable but smooth surfaced material, resulted in less maintenance and easy cleaning but more dangerous surfaces. Especially in outdoor stairways at rainy or snowy days, it becomes very difficult to go up or down because of the very slippery floor surface. Likewise incorrectly designed details in finishing materials result in impairment of materials in shorter period of time than the expected life of the material. In Figure I. 7 such incorrectly chosen flooring material can be seen.

Figure I. 7: Examples of wrong material choice in entrance of Kızılay metro station, Ankara.

Lastly, the construction method of the station has many effects on the design of the station entrance. The building should be perceived as a whole by its structure and form. Different construction methods results in different station designs. Such as location of the station in the city affects the decision of structural system, or the cavity and openness of the station is directly related with the structural system. The construction method of the station effect the depth of the station in the ground which effects the natural lightning of the station interior and the transparency of the station entrance. Moreover, the decision on the construction method also effects the construction phase. For example, the termination of the traffic above the station during construction can be minimized by the correct construction method. Thus the structural system and the construction method, affecting the effectiveness of the stations, should be investigated carefully. The recently constructed station buildings, although located short way below ground, do not have any openings to the outside because of the chosen structural system.

I.2. Objective of the Thesis

The objective of this study is to make a critical analysis of metro entrance problems. These problems in current metro stations are; lacking of architectural attitude, in contrast with the engineering, not providing sufficient space enhancements in order to minimize their negative psychological effects on human beings of the subterranean structures. Because of that architectural deficiency the stations are far from being components of the city however they could improve the city silhouette having sculptural or architectural quality. Lighting, HVAC, acoustics, and navigation systems are not providing the requirements of a subterranean structure. Solutions for durability, maintenance, safety, security measurements and structural system and construction methods are not selected considering the conditions of Turkey. Under the light of these problems this study will constitute a systematic and comprehensive document, which will be used in the studies of obtaining Metro stations, distant from the problems mentioned above, providing optimum solutions, holding architectural quality, and being a component of the whole system.

I.3. Method and Scope of the Research

The scope of the research is evaluation of metro station entrances according to performance criteria set by the researcher. At the first phase, the performance criteria of stations are settled considering the problems mentioned above. Secondly, these criteria are investigated by the information given in literature survey. As a result of the literature survey, illustrated examples are analyzed. Finally the suggestions are made to improve the general quality of the stations. These suggestions are made by comparing examples one by one on these specialized topics.

The scope of the study is limited with the concept of subway stations, because remain of the system, except the stations, are under the concern of engineering, not the architecture. Moreover the stations, by their contribution to city and public usage make them directly related with the architecture. The economical factors constitute the most important factors in the designing process. All restrictions about design processes are directly related with monetary factors. But because of being the concern of a totally different profession and the author's profession is apart from that one, this thesis study does not include any financial topic.

I.4. Terms and Definitions

Metro Station

Railroad transit systems are the networks of mass transportation in order to carry crowded people inside the cities. Because of the dense texture of the cities these transportation networks are mostly located under the ground. Therefore those systems are consist of mainly two parts the tunnels and the stations. A station of an underground system is the building where the passengers of the system and the trains meet each other. In addition to this main function, today stations have some additional functions, and requirements.

Platform

Platform is a part of the station, where the passengers are waiting for the train. This platform is elevated in order to make it possible to get in to or out from the train. The information boards, security devices, and places are also located in this place. In some stations there are barriers to prevent passengers to fall in to the track zone. There are mainly two types of platforms; side platform and center platform.

Entrance

The entrances of the underground station buildings are the opened interfaces of the underground tunnels to the outer world; they are the gates that connect the outer, natural world to the dark tunnels of manmade system. So it is a transition part of a system. As a result it has to respond many requirements of both the outer world and the station itself. For example from the view point of city silhouette an entrance building should have a landmark quality, or from an architectural point of view it has to respond the requirements of space quality, or from an engineering point of view it has to respond functional requirements. Entrance is the place which the patrons of the station first contact, so the first impression and knowledge about the station should be given here. In properly designed entrances, the one entering into the station has an idea about the station, direction and destination before entering in. after entering the station the contact with the outer world should be keep as far as possible. However defining the entrance part of a station building can be difficult, because the boundaries are not well defined. A definition can be made as; the entrance of a station is the area that is in between the outer periphery of the station and the turnstiles of metro. However in some situations this definition is not valid because the turnstiles are located in the periphery of the station. Therefore another description can be made as; the entrance of the station is the area that starts with the periphery of the building and ends with the platform. In most cases the platforms are located downstairs in stations thus it can be said that the staircases and escalators are included in the entrance part of the station. Thus staircases and escalators are potentially valid places to combine the entrance of the station and the station itself. Without any visual link between the entrance part and the station the passengers do not have any opinion about the outside world or any about the time. But when they come closer to the gate, you have a visual contact with the outside, you see the light coming into the station, and then you have an opinion about the outside world, the surrounding city or the time. Therefore the function of the entrance is to combine the station with the outer world.

Building Performance of Metro Stations

Metro stations are the spaces that have public use, with very limited pause time. Therefore stations have many requirements to satisfy the public needs and to function properly. For instance the durability is a very important requirement in stations because of the limited maintenance times; or the comfort levels are very significant in order to minimize the negative effects of being underground. Thus the requirements of underground stations are rather different and important than the ordinary buildings. The level of satisfying the requirements of stations can be named as the building performance of the station.

Design Criteria

In order to have adequate building performance any building should be properly designed from the very beginning. Therefore, it is very important to define the needs and problems of the building during the design process. Those requirements, defined as a problem, are the design criteria of the design processes. In this research the observed problems of the existing station entrances are investigated under the defined design criteria headings.

I.5. Historical Background of Subway Stations

The metro systems are started as luxurious transporting vehicles in the cities, and thus they are not very popular. They have lots of problems such as; pollution especially from steam engines. By time with developing technologies, it overcomes the handicaps for example; the invention of electrical engines. Today, the metro systems have indispensable, dense networks under the cities with the most developed technologies like escalators and construction methods. Below is the explanation of this development process in abroad and in Turkey.

I.5.1. Historical Development in Abroad

In second half of the eighteenth century the industrial revolution began in Europe. As a result, the metropolises' populations increased and city centers become relatively small. Most of them were suffering from traffic congestion and looked for some alternative transportation techniques, because working and living zones of the cities become segregated. Especially, industrial mass production required larger areas, and the distances between the workplaces and dwellings increased. It was then required a fast, safe, feasible and new kind of transportation which could freely enter the intensively built up inner-city texture. Only an underground transport system could satisfy all these requirements.

In addition to these requirements, the technical developments were also made it possible to construct such kind of systems in underground. Without the enormous technological advancements of that time, it was impossible to construct railway lines beneath the city. With the invention of shield tunneling technology, it became possible to construct the subway in a financial manner. As a result, in 1863, the first subway line established between Paddington and Farrington in London (Bal, 1995: 8). Another important development in technology is that the utilization of electricity in subway systems. Steam engines could not have a future in those systems due to their undesired effects and danger in the tunnels. It was impossible clear the tunnels from the output of those engines' smoke and gas (Bal, 1995: 9). The first danger was the risk of fire, because of the boilers of the engines. The other was the moisture getting out of the engines caused the timber and brick based construction system decayed which resulted in the dust and undesired smokes. Moreover decayed bricks could even fall down into the station and tunnels. Finally, the first electrically powered metro system opened in London, in 1890. That was accepted as the first real metro system all over the world.

Today London Metro, with its still growing extensions, is one of the most significant systems of all around the world. Those developments were followed by those in Europe and America. Some of these systems steps further by their special features. For example: Moscow metro is remarkable for the scale and luxury of the station interiors. The stations were designed as the examples of socialist design, in the official style of revolutionary romanticism. Sculptors encouraged creating monumental works to inspire the travelers. Today in Moscow metro the tradition maintained in the stations of creating opportunities for contemporary artists. This and the grand scale of the station helps to support the popular demand on mass public transport in the city. (Edwards, 1997: 44) New York metro has significance by its grandeur scale. It has 456 stations, in a totally 371 km length at 23 different lines. London Metro has the longest track lines about 410 km (The Architectural Review, May 1999: 54). The first full automatic Metro is the Bay Area Rapid Transit (BART) System activated in 1976 in San Francisco. Likewise the first driverless activated system is in Lille France. Up until the present day (2003), 85 semi – automatic, 18 automatic, 6 driverless subway systems have been constructed in various techniques and designs which some of them are on an enormous scale (http://www.metropla.net). This information helps to prove that the technical achievements of subways made them widespread over the cities by making more feasible and effective. However, it is not always the engineering skills, make them remarkable. The architectural styles also define the character of the Systems and especially the stations. There were of course, some changes in the architectural manner of the underground structures according to the current style. In some periods, Subway stations were built in utilized manner, in which costs are minimized and constructions are simplified. On the contrary, at some other times, the visual impact stepped further, with ornamentations, and space and light presentations. As seen in Figure I. 8 Moscow metro stations can be valid examples for that kind of stations.

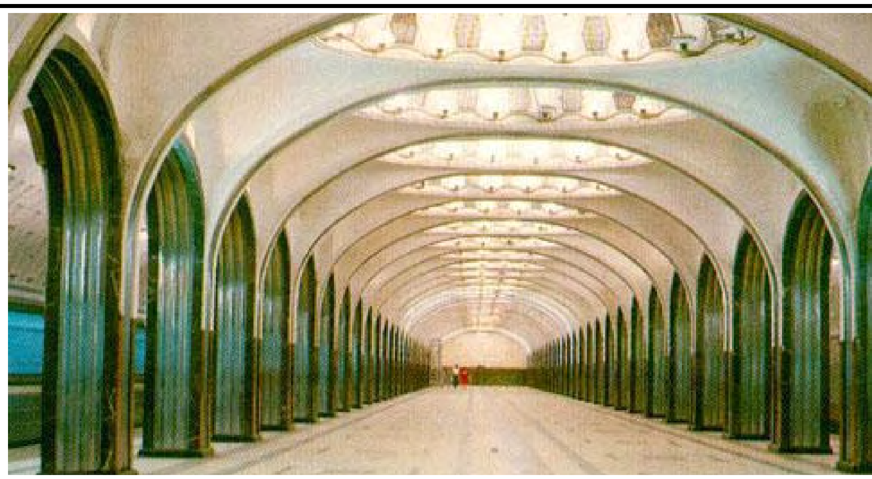


Figure I. 8: Metro stations with ornamentations, Moscow, Russia.
(Downloaded in July 2003 from: http://www. metropla. net)

Figure I. 9: Art Nevau style station entrances in Paris by Hector Guimard
(Downloaded in September 2003 from: http://www.metropla.net)

Some outstanding examples of stations were built in Vienna, Berlin and Hamburg whereas having the fact that authorities avoided the extra costs for the unprofitable design quality if that would be under ground. Because almost all of these systems were established by the private companies, which were only profit oriented. Some developments have led away from the exclusively profit oriented approach to running such public transport systems. The main reason is that these public transport systems were reserved for the upper income people. Paris has also a famous Metro System, with its Art Nevau style decorated station entrances by Hectro Guimard as seen in Figure I. 9. On the contrary, London Metro stations defined by Lawrence as; “Very little architectural character in any of the stations, but a wonderful amount of engineering skill and good workmanship." (1997: 11 – 25)

I.5.2. Historical Development in Turkey

The "Tünel" which was completed in 1875 is the world's second and Turkey's first metro system in Ottoman Period (Engin, 2000: 62). It combines İstanbul's two significant districts, Galata and Beyoglu with a line length of 555m., and with two stations. The trains of the system travel the 63m level difference between these two stations in a parabolic way. The system consists of two trains, travels in their own track, pulled by means of horizontal cables. These two cars provide equivalent balance to each other which minimizes the energy used. The trains were controlled by the machine operator from the control room located at Beyoğlu station. The power supply of the system was a steam engine until 1968 (Engin, 2000: 63 – 65).

I. 10. A I. 10. B I. 10. C

Figure I. 10: "Tünel" metro system, İstanbul
(Downloaded in July 2003 from: http://www.metropla.net)

In 1968 there was a renovation study on the system in order to comply with the requirements of modern technology. After that study the system has some new features as follows: the "Tünel" has two trains traveling on one single track at opposite directions, the track segregates into two distinct tracks in the middle of the tunnel in order to avoid the crash of the two trains, and trains have rubber wheel in order to prevent the excessive noise and undesired shocks. (Figure I. 10)

It is a well known fact that the “Tünel” has many positive effects on İstanbul’s and citizens’ social life. People no more suffering from the upward sloped sidewalks, especially in cold or hot weather conditions. Moreover the system shortened the travel time. It had also many positive effects on the city life, Beyoglu, famous with its entertainment and commercial life, had gained an enormous liveliness so that the square in front of the Beyoglu had named as “Tünel meydanı” and some surrounding stores take their names from the “Tünel”.

The metro system is significant by being one of the first underground systems in the world. The other few examples[1] from abroad are also small scaled projects. This means that, having seen the encouraging effects, this project could be a very successful first step for Ottoman Empire in the urban transportation systems. This first small step should be followed by next ones. It was essential to have Turkey, establish an advanced network of metro systems. However, unfortunately until 1990s there were not any, even small, metro projects established or completed. This does not mean that any trials were not exist, they were not come into reality only. The contractor of the “Tünel” project, Gavand, had developed a project, including the line along the Bosporus coast, from Kumkapı to Kilyos, at the Europe side of İstanbul. The following proposals, continued during 1887, 1909 and 1912, were all denied by the government because of the bureaucratic and financial reasons. They all could not become reality, even could not exceed the project phase.

In 1936, the need for a new metro system became more definite. Thus, in Turkish Republic period, some new studies and proposals were made. French city planner, Prost, invited to Turkey and he proposed a new Taksim – Bayezid Metro project. But again, due to the same reasons, having a high financial portrait and because of the bureaucracy impeded the construction of those systems. Finally, in 1989 a light metro line was built from Aksaray

[1] The first metro system was built in 1863 in London and in 1867 New York which was unsuccessful trial. (Engin, 2000)

towards the western suburbs and it was extended to Yenibosna until 1995. After being extended to the airport in 2002, it has a total length of 20 km with 18 stations (www.ankara-bel.gov.tr) Construction of the first full metro line started in 1991 and the first phase between Taksim and 4th Levent opened after some delays in September 2000 (Figure I. 11). The line has a capacity of carrying 70.000 people per hour per direction. The metro was built by the cut-and-cover method to withstand earthquakes of up to 9 Richter magnitude. Stations look similar, although a different cladding colour was chosen for each of them. Platform length is 180m. Total length of the metro line is 7.9 km with 6 stations.

I. 11. A Taksim Station I. 11. B 4th Levent station

Figure I. 11: Metro station examples from İstanbul
(Downloaded in September 2003 from: http://www.metropla.net)

The second phase of the Metro from Taksim to Yenikapı, across the Golden Horn on a bridge and underground through the old city, is under construction. It will be 5.4 km long and have 4 stations. At Yenikapı it will intersect with the extended light rail and with suburban trains. Later it will be extended northwards from 4th Levent to Ayazağa. The suburban rail lines are planned to be upgraded to full metro standard in the future. A tunnel under the Bosporus has been planned for some time.

Ankara metro is another remarkable project of Turkey. It consist of four phases, one light rail named Ankaray, from ASTI to Kızılay, one existing Metro from Batıkent to Kızılay, and two further, still constructing, lines. The studies of the project reach back to 1960's. Paused project studies, restarted in 1982, and finalized in 1993. At first the built operate transfer model is thought to be appropriate for the existing Metro line, but later, the consortium, consist of two local and one foreign firm, took the responsibility of the construction job by Turnkey Job method. As a result the first phase of the Ankara Metro construction started in 1993 and resulted in 1997. This system consist of 14.6 km line combining 12 stations which of six have side platform and five have central platforms. The Kızılay station has both side and central stations. There are also metro systems in Bursa and İzmir which are of the other big cities of Turkey. Bursa Metro was completed in 2002 and the one of İzmir in 2000.

I.5.3. The Responsibility of Architect and Engineer in Metro Design

In order to achieve an underground system, carrying features mentioned in Chapter 2, very first step should be to decide on who is going to take the main concern, the architects or the engineers? In underground systems the engineers have a vital responsibility and tend to be the province of civil engineers rather than structural engineers and architects because of the fact that underground railways as a whole are so complicated implement in earthmoving, and tunneling underground. Constructed building should resist not only the gravity of soil but also lateral loads of the earthquakes or the pressure of the underground water and many more. The designs of tunnels of the system are the concern of the civil engineers without any argument. But the stations' position can not be so clear due to its functions. The stations, unlikely the tunnels, are the places where the passengers perceive as a public space. As Hackelsberger mentioned the stations designs not only bent on the functionality of structures for handling passenger flow but rather focused on a contemporary appearance and the architecture of public spaces (1997: 09). Different opinions occur throughout the history, whether the architects or the engineers are the main concerned parties. Civil engineering is a precise science with rules determined by the physics of structures and the condition of soils. On the other hand structural engineering and architecture is a question of construction and how it is perceived by the users of buildings.

One point of view mentioned by Edwards argues that in underground systems, station design is directly related to the engineering of tunnels, because the stations are perceived as supplementary buildings of lines and tunnels, but not worthy structures by their own (1997: 105 – 106). Another point of view suggests that civil engineers resolve the problems below ground and the architects solve the ones of above ground. As underground stations are necessarily positioned below ground they have tended to be seen as a tunneling issue, not one of architecture. Hence in many countries underground stations are designed by civil engineers, often with an assistant architect mostly on the ornamentation and above ground works. In spite of having that balance there is still a problem with the roles of the professions. An underground station as a whole has some above and below ground parts altogether, thus it can not be separated into parts which will design by the engineers, or the ones by architects. It should be an unbroken process of design. Architecture and structure have to become an integrated part of the metro project from the very start. This means that they should be included in the project as early as the feasibility studies and preparation of tender material.

Contemporary underground lines, however, have broken this model. It is claimed by Edwards that in recent underground railway projects there is a better balance between the civil, structural engineering and architectural professions (1997: 106). The result is a new generation of stations, where the space and structural design is more important than the ornamentation. Edwards claimed that if the fundamentals are right, then less effort is needed in the design process such as colors, graphics or decorative finishes. In recent projects civil engineers are used as tunnelers, and the independent architects selected for the stations and above-ground development. This situation provides better integration of the station and the above ground development of the station land. Figure I. 12 proves the continuity of station design above and below ground.

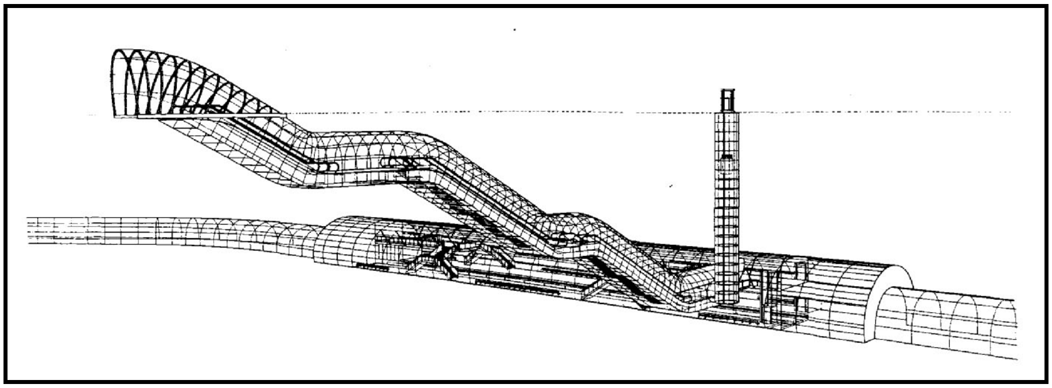


Figure I. 12: Continuity of station design above and below ground, Bilbao metro. (L'arca 110, 14)

Underground railways were traditionally the preserve of civil engineers, but today architects are often the lead designers, by the help of improved tunneling and construction methods as in the case of Bilbao Metro by Sir Norman Foster and Partners (shown in Figure I. 12). The New Austrian Tunneling Method (NATM) has opened up fresh opportunities for underground architecture (L'arca 110, 1996: 10 – 14). Different tunnel profiles are now available, and the costs of large bores have been reduced.

Working together in a well organized schedule and division of partnership can be the best choice, however, there is still a problem, the members of the each professions have negative prejudices against each other. The engineers believe that the architects will propose unrealistic, extreme projects; and the architects believe that the engineers come up with ordinary, traditional solutions. In fact, generally, none of them provide optimum solution. The optimum can only be made by working together in order to improve each others work. As mentioned in the Copenhagen Metro Inauguration Seminar the final solution, shared by both architects and the engineers, is even more attractive, exciting, non-traditional than the first proposal made by architects and even more realistic, financially viable than the engineers' at first. The result is, therefore, a success, an attractive and architecturally unique facility, for the Copenhagen and the citizens. (BOY, MOLGAARD, 2002: 58) (Figure I. 13)

Figure I. 13: Section showing the spacious space, Copenhagen.
(Sorensen and Larsen, 2002: 15)

Another task about the architectural and industrial success relies on how early that partnership is begun, very often architects have been used after the engineering of stations and track has been decided. If not the position of the architect becomes responsible only decoration of the surface. Transport engineering and urban design should be harmonized from the very beginning of the project with strong a design process. Without such design presence the system will not be an aesthetically unified task but gathering of uncoordinated elements.

Thus it can easily be understood that planning an underground station is a complicated task involving a wide range of professional disciplines, some of which sometimes conflict with each other. Interior design is one of these conflicting professions with architecture in underground Metro station designs. Subterranean structures, are in fact the cavity spaces located below ground, therefore can only be perceived from inside. Impression from inside make them thought to be the task of interior designers.

According to Hackelsberger, the term ‘Interior Architecture’ is sometimes understood as a depreciating term that implies additional ornamentations, decoration rather than overall design (1997: 15 – 16). In fact interior architecture rely its roots on ancient Egypt and China architecture, which have very few signs about what they have inside. Moreover human being has a strict dependence on hollow words such as natural, subterranean spaces and protective caves, that can only be experienced from inside. Because these places were not only their protective shelter but also their means of ancient art. That description proves the Hackelsberger’s definition; ‘Interior Architecture’ is adding ornaments to an existing interior space, not designing a whole brand new space.

I. 14. A I. 14. B

Figure I. 14: Ornament examples from stations in Nurnberg, Germany. (Downloaded in October 2003 from: http://www.metropla.net)

On the contrary, constructing an underground station requires an overall designing process. Edwards mentioned that, Charles Holden[2], concerned to

[2] C. Holden was the chief architect of the London metro.

ensure that the enduring elements of station had priority over the surface decoration (1997: 44 – 50). The existing station examples from Turkey are likely to have additional ornaments rather than an overall design. Their interior spaces, seems to be shaped according to the requirements of the engineering issues. The role of architecture is limited with surface cladding decisions, small scale tiling layouts, rather than having a total design style. A resembling example can be seen in Figure I. 14 from Nurnberg, Germany.

CHAPTER II

PERFORMANCE CRITERIA OF SUBWAY ENTRANCE

Although having one of the higher construction costs, the metro can said to be the most appropriate solution for mass transport due to its functional capacity to transport large numbers of passengers through the city without causing problems for traffic, in a fast and frequent way. Accident statistics are very low because of its adaptability to fully or semi automated (even driverless) systems. Moreover it has many architectural advantages, especially in between the built city center. These advantages can only be valid if they are designed according to some standards, otherwise these systems can remain as lifeless, left caves of the city. Especially the stations of these systems should satisfy the basic requirements of city and citizens. Ease of use, timelessness, contribution to city, adaptability to new systems, safety, security, lightning, air conditioning, correct acoustics, etc. can be count as some of these requirements. In that chapter of the thesis, the criteria which should have significant consideration during design process are described under three basic titles. Three basic criteria; define the efficiency of the station; can be counted as; architectural design, structural design and construction and material. The architectural design criteria; such as the lighting, navigation, and space design, define the appropriateness of the overall design to the requirements. Structural criteria such as the situation of the ground and the structural system, define the appropriateness of the structure or construction method to the design of the station, and finally construction and material performance such as durability, clean ability, non slipperiness and proper detailing defines the finishing works' appropriateness to the functional requirements and overall design.

II.1. Architectural Design Criteria

Likely on all design efforts, underground design efforts focus point is people as passengers. The main aim is not only to reach the passengers to his destination quickly, comfortably and safely but also feel them in positive moods. In order to provide that aim there are some points which should be considered in the design of the station entrances. It is necessary to define some design criteria at the very beginning of the design processes. Attitude of the station to the city, being a public space, the language of the station, being timeless or reflecting the age, being a component of a united system, or standing alone as separate building, provided comfort levels, providing positive feelings, simplicity and clarity can be counted as some of these criteria. By the help of those criteria, the objective of the design process can be exposed even before the building erected. In Chapter II, the design criteria are categorized under the light of observed problems of metro station entrances.

At the first days of Metro the stations are perceived and designed merely as waiting areas, the places of interchanging of passengers from train to platform or vice versa. The necessities of people are improved by the technological development and the progress in the city life. The stations are not any more boring enclosed cavities but the most important public spaces of the city. They embraced a character as a system in relation with the one of city. In relation the entrances of the stations are also changed in accommodation with the city. The entrances of the stations are the most related components of the system to the city. The relation between the station entrances themselves should be a point of consideration. The question of whether the station entrances of a system become fully standardized, even replicated examples of each other, or unique buildings which are linked to each other by some defined properties. By the increase of the passenger capacity the scale of the stations are improved. Increased scales resulted in the bigger limitations during the construction and design progress. Thus in the planning phase of those complex stations it become important to provide the clarity and simplicity. Most of the additional spaces which take the station away from clarity usually located in the entrance part. Beyond this simplicity it become important to affect people in a psychological manner, such as; claustrophobic feelings in crowded places surmounted by volumetric spaces and by taking natural light deep into the station.

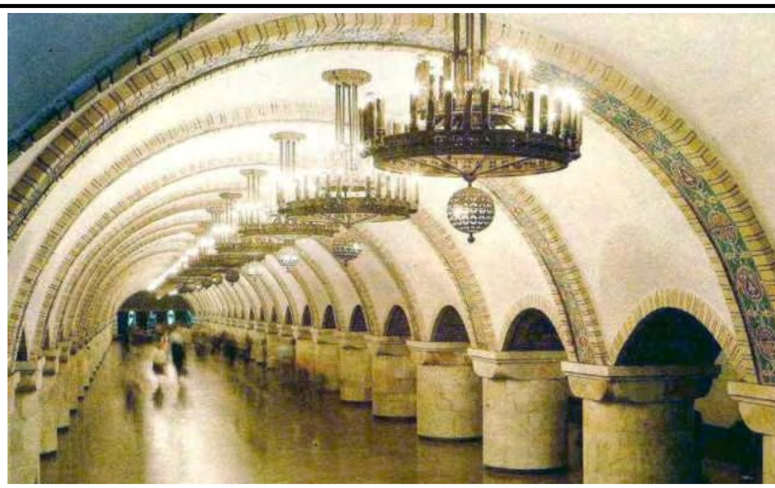


Figure II. 15: A view from the interior of metro station, Moscow.
(Downloaded in July 2003 from: http://www. metropla. net)

Today new underground systems built under great national projects, they were not short of money and technological innovations. The main aim is to build the most advanced system of all from both operating and design points of view. Thus it can be said that a new international style seems to occur. However, yet, every metropolitan underground system has its own character. Ant the entrances of the stations are the most significant components of the system which put forward those characters. According to Soderstorm, it can only be achieved by the assimilation of local culture and atmosphere by the architect (1998: 47 – 49). For example, in 1929 Charles Holden, the chief architect, of London Metro, had reported that he sought station designs that were: “As pure and as true as a Bach fugue; an architecture as telling of joy in plan, structure and material; joy, too, in all the human and mechanical activities which make up architecture today" (Soderstorm, 1998: 78). It can be understood that, in that time London Metro has a minimalist character, on the contrary Moscow Metro has a style of revolutionary romanticism. Sculptors encouraged creating monumental works to inspire the travelers, as seen in Figure II. 15. The entrance structures of those stations are opened interfaces of those characters and styles to the city.

According to Edwards, underground railways are traditionally the most aesthetically consistent system of any railway type (1997: 44 – 50). therefore there have been two different attitudes; according to first one, the underground stations reflect their age, technical knowledge and ideas of life. The other one suggests that they are timeless spaces, connecting the past and the future, not concerning the present.

Large and complex railway systems cannot readily be accepted by a single design practice. Constructing the whole system as a whole becomes difficult and a pluralist type of design attitude occur. Each station is designed within itself, as a separate building not as a system of all stations. But it is important to not understand that 'separate' as 'alienated'. For example on London's Jubilee Line Extension, the 11 stations have each been designed by different architects and a coordinator (chief architect Roland Paoletti) a head, in order to achieve a system constituting unique elements differently interpreted. The aim is to form a design language by using three main elements; the expression of the constructional and structural elements; the manipulation of natural light, to give spiritual uplift to public spaces; and the use of types and sizes of interior volumes to give clarity and legibility to the stations. The language is not defined in construction details. Under the control of chief architect, the architects develop their own interpretation to creating space, light and structure. There is not a corporate style. The finishes and details impose a standard order. The design of many finishes at booking halls platform surfaces and around escalators, signage and seats will bring a familiar range of recognizable parts to unify the 11 new stations. However the structures are the first to be expressed rather than the details. (Figure II. 16) As a result the entrance of the stations both from inside and from outside reflect its own character to the city and to the patrons. And the harmony within the station provided with the construction details.

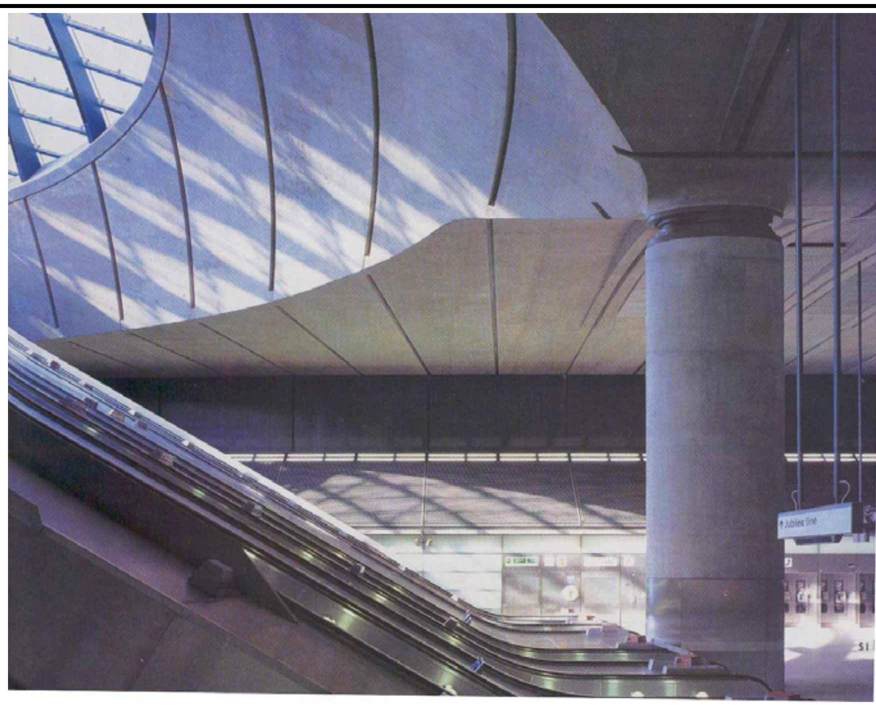


Figure II. 16: Canary Warf station entrance by Foster and Partners, London, England. (The Architectural Review, June 2000: 51)

Being a high-quality example it is worth to list the design considerations of those stations of Jubilee Line Extension. According to Edwards, the design of stations and their finishes subscribe the following rules (1997: 48).

- Maximize prefabrication (speed in construction).
- Keep it simple.
- Design for replaceability.
- Use light, particularly daylight, to guide passengers.
- Use structure to uplift the spirit and define routes.
- Exploit varieties of space.
- Define zones with materials (platform, ticket office, routes).

- Provide variety and richness at each station, rather than uniformity.
- Employ a language of design from concept to materials.
- Integrate space, light and structure as unifying elements.
- Use materials that are easily cleaned and durable.
- Use light-colored finishes for lighting energy conservation and appearance.

By the guidance of these rules the stations and their entrances are perceived as a coordinated system of architecture below ground, rather than isolated buildings. It is consistency of principals rather than boring repetition of single style from station to station.

The architects and engineers are subject to large number of conditions which can limit the design scope. Natural, technical engineering problems, building restrictions, traffic laws, legal and financial limitations and those inherent in democratic processes force them to find what is feasible. This is the main aim from the very beginning of the project by architects and engineers. Although having all these limitations, developing technology, and design attitude provides a freedom and make contemporary metro stations into a feast for eyes. These new stations' entrance spaces become significant by their creative use of forms and colors. Entrances become more transparent and that transparency provides a strong link between inside and outside.

Traditionally the created spaces of the stations can not go beyond to be fully enclosed, artificially lighted structures based upon the subterranean tubes of space. However the contemporary station entrances bring daylight into the public concourse areas and use few storey height spaces to give volumetric effect to spaces. With modern forms of tunneling a variety of profiles and sizes of tunnel can be constructed economically (Edwards, 1997: 48). Station entrances are designed in order to carry dense crowded passenger loads, and large halls connected with escalators and lifts. London's new Metro line, Jubilee Line Extension, is a valuable example; being one of the eleven stations Canary Warf station entrance, with its shell type roof has architectural quality of space from inside and a landmark effect from outside (Figure II. 17). Structural elements are not hidden by covering elements like, suspended ceilings, covering walls or advertising boards, in order to provide directional legibility for the users of the stations. According to Edwards, contemporary underground stations getting more unlikely to be a rectangular box, due to their move towards more natural methods of lighting, heating and ventilating (1997: 101). Working with nature as a source of energy and visual delight is beginning to shape a new generation of railway station entrance. As a result their architectural form is more distinctive and as an outcome, the station serves better as a landmark. Legibility from outside also improves the legibility from inside, so better landmarks provide more legible spaces, when combined with the natural use of light guiding passengers. This resulted in a more satisfactory mixture of architecture and the building services than an earlier generation of station entrances.

II. 17. A

II. 17. B

Figure II. 17: Canary Warf Station entrance by Foster and Partners, London, England (The Architectural Review, June 2000: 55)

The ideal station is the one where travelers can grasp the logic or the overall scheme of the station's design and comprehend its various spaces even before enter inside the space. In complex stations, it gets more difficult to inform the station without using any signs or boards. Structure, light, and details are necessary to guide passengers through the various levels and directions. Especially the repeated details and variations on a specific theme reinforced the impression of traveling on a coherent network. A valid example of such exploited structural elements which series can be seen in BART system, San Francisco. As Edwards mentioned (1997: 98):

> "Details in particular, if near to eye level, provide legibility to interior spaces. The rhythms of structure too are important; a line of columns or a framework of beams overhead can guide passengers to preferred routes and give clear direction to organizational or spatial hierarchies. Light, especially natural light has the benefit of focusing attention upon important spaces, such as booking halls, or of leading passengers towards platforms and entrances."

The following headings are examining the main features of the stations' entrances which affect the comfort and safety level and aesthetic of the entrance, such as; contribution to city, space requirements, psychological effects, lighting, heating, ventilating, air conditioning, navigation, acoustics, safety and security, durability and maintenance, disabled accessibility and additional functions

II.1.1. Station Entrances' Contribution to City

The underground stations, especially the above ground parts of the stations are the parts that integrate the system with the city. Therefore should be considered as components of the city as well as of the underground system. The above ground parts which can be specified as entrance shelters, skylights and the technical shafts, should have the visual quality of having 'landscape furniture' of the city, even sometimes the landmarks. When glancing at the recent stations in Turkey one can realize that such a design attitude does not exist in those station entrances, whether if they have an entrance canopy (Figure II. 19) or not (Figure II. 18). They are reflecting neither the architectural style characteristics of the city nor the characteristic style of the time. Transportation engineering, station architecture and urban design should be harmonized from the earlier stage of the project in order to get desired mixture of the underground system with the city.

Figure II. 18: Station entrance without an entrance structure above ground level, Kızılay metro station, Ankara.

Figure II. 19: Station entrance with an entrance structure, Tandoğan metro station, Ankara.

It could be argued that the station architecture should reflect the characteristics of its neighborhood, so that the architecture below ground mirrors that above. In the past, the underground stations characterize the suburban landscape. Today, underground railways in western world adopt a different attitude, for example in Jubilee Line Extension different architects are charged to design each station. So that different station design attitudes for different locations can be achieved. This has provided a richness and diversity rather than boring uniformity (Edwards, 1997: 45 – 46). In Turkey However, the situation is dissimilar. The stations' entrance structures are seem to be neither any component of system, nor a unique element reflecting its own character, as seen in figure II. 20.

II. 20. A Dikimevi station II. 20. B Kurtuluş Station

Figure II. 20: Examples of metro station entrances in a single system, not having a common architectural language, Ankara.

Edwards claimed that there are two different effects of stations to the city, at macro scale and at micro scale. At macro scale the system totally changes the cities scenes transport routes and transformed the fabric of the city. At micro scale, however, there are small, significant changes occur, altering the character of neighborhoods, shopping patterns and social life (Edwards, 1997: 87). The main task is the settlement of the station building into the cities' existent textures, being dependent upon the cultural background as well as concrete structure of the city. To do this without damaging the city texture, or provide the acceptance of the underground system by the citizens, it is necessary to pay attention to some topics, mentioned below, during design.

Station entrance building should be designed as a public building, linking internal volume to external one. External public space, often outside the boundaries of the station entrance, is an important consideration. Public squares adjacent to station entrances should allow the transition in scale and movement patterns. For instance, some stations allow the transition in the transportation vehicle by the auto parks, stops, or bicycle parks nearby the entrance surrounding. Aşti station in Ankara has such a function of contribution to the cities transportation system by the auto park, bicycle park and bus terminal nearby the station as seen in Figure II. 21.

Figure II. 21: Aşti station, an important gathering point of city transportation system by its relation with surrounding.

Underground stations, with their scale and function directly related human life and city, become essential urban buildings. Therefore the entrance gate of the station, are also the consideration points of city planner's. They are the components of the city as city furniture which express the character of its own or the one of surrounding. The technology is the main means of expression whereby function, program and the architectural forms can be communicated. The technological meaning can be expressed by structure, construction and materials. The result is a question of space from inside, and structurally expressed architectural forms from outside; likewise landmarks. The subway station entrance architecture should be therefore at least as significant for our vital consciousness as many a surface building. This visual display should be reinforced by adding community spaces into stations, which can lead to the generation of local shops and businesses along their path. The creation of a square at the station entrance could encourage the location of offices and community services (Figure II. 22). Taking on such a responsibility can allow the station to assume a civilizing role upon the city (Edwards, 1997: 90).

II. 22. A II. 22. B II. 22. C

Figure II. 22: Canary Warf Station, significant by its sculptural entrance structures, London, England (The Architectural Review, June 2000: 51).

Munich subway system is more than being the main structure of the public transport system. Hackelsberger mentions that they are true public spaces, even more important than the uninhabited public squares. It is one of the major constituents of the city, with their design task and spectacular attractions below ground. Moreover, the architecture below ground in some way matches or at least relates to the buildings above, enabling easy orientation in the city. Stations located by the parks or open spaces, have the chance of having more open or more direct access structures, providing direct visual links between surface level and station concourse (1997: 28). Edward shows the London underground stations as examples of how a station becomes the heart of its neighborhood. Hammersmith Broadway Station, whose plan is to reinforce the station as a point of connection, is located upon a complicated pedestrian field with gardens, shops and cafes where the routes across the site connect with the transport facilities. Life below and above ground is harmonized with new squares, malls, paths and concourses (Edwards, 1997: 91).

There should be a natural, legible sequence of spaces for the traveler from the urban street to the dark underground tunnels. Stations should not have to be considered as single functioned buildings, modern social life makes them multi – purpose. Today every kind of retail shops, banks, exhibitions even the offices are the inevitable constituents of large underground stations. This should not be resisted, but should be turned into advantage by the designer. Through the station entrance these spaces are united with the rest of the city. Although all these extra spaces damage the clarity of the plan scheme of the station, by a painstaking study can easily be turned into richness. In order to achieve the relation between the public and private, and between the program and urban context, three main questions should be considered; order, integration, relationship. All of them are based on compromise between sides; for example, order, means distilling clarity from complex demands and programs; integration, means balancing human needs with technology; and relationship, means a compromise between the needs of the human and that of the city which the station serves (Edwards, 1997: 92 – 93).

II. 23. A

II. 23. B

Figure II. 23: Aerial view of station site before and after the construction of metro, Copenhagen (Sorensen and Larsen, 2002: 11 – 18).

Copenhagen metro, likewise, is not seen as better and faster connection between the parts of the city but also a city space itself, which impact, not only the passengers but also all those who merely pass the metro's squares, everyday, this was the aim besides providing improvements in traffic of the designer's right from the very beginning. According to the designers of the Copenhagen metro, the stations are brand new elements of the city and must be adapted to its surroundings. They aimed to improve the quality of the site, where impossible, wished to left the site untouched. This relationship between the site and station gets more significance when considering the historic squares, constitutes a base point for the project's design process. Figure II. 23 proves the improvement of an empty space by the existence of the station. The open car park in between the historic buildings, improved into a public square which is favorable by the pedestrians. The metro will manifest its existence without drowning out its urban connection. The relationship between the outer world and the tunnels are provided with the elements such as entrance canopies, skylights, and air ducts. Such system's apertures, in other words the above ground elements, with their various functions, represent sculptural symbols in the square, each with their own form for intake of light, air and passengers. These above ground elements developed from purely functional point of view are also remarkable city elements which serve as a symbol for the metro stations. During the day they appear as transparent link from outside to inside and at night as an illuminated creative element for an effect of illumination and as a symbol. (Figure II. 24) However, limiting these elements in to a minimized scale, allow the station to be located in cluttered city textures without demolishing any property and with very little interference in the city's road network.
(Sorensen and Larsen, 2002: 35 - 53)

II. 24. A II. 24. B

Figure II. 24: Night view from skylights and entrances of metro Station, Copenhagen (Sorensen and Larsen, 2002: 40 – 53)

II.1.2. Space Requirements of Station Entrances

When traveling, or just passing through an underground station, one is inevitably enclosed by the walls and roofs; and the only thing perceived is that enclosed space without conscious of the outer natural or manmade world. The visual and physical links between the space and the outer world are generally limited and insufficient through entrances. In most cases the form of the enclosed space can not go beyond to be a relatively larger tunnel or a rectangular box. It can easily be understood from Figure II. 25, that the station entrance has an ordinary rectangular shape without any gallery voids or skylight openings which can enhance positive feelings to the passengers. Below; the ways of designing such positive spaces are explained and exampled. According to the researchers opinion the ways of enhancing the space quality of the spaces can be categorized in such main topics; the first one is bringing daylight deep into the stations, second one is providing larger station volumes, another one is exposing the structural elements, and the last one is providing gallery voids in between the floors of the station. By the help of those design attitudes it is possible to obtain clarity, and flexibility in stations, the openness provides feeling of direction and time, and relationship to the outer world.

Figure II. 25: Metro station entrance without any gallery voids, Taksim, İstanbul.

Designers have developed ways of bringing daylight down into the dark caverns of underground stations. This has obvious benefits for the welfare and amenity of travelers. Stations formed as deep underground cuts rather than enclosed tunnels providing the opportunity of bringing natural light to underground concourses and platforms. Individuals, then, have the sense of direction and time. Changes in the methods of construction and technology allowed stations dimensioned as larger diameter tunnels, and formed various shapes rather than circular bores, such as elliptical ones. Finally by the introduction of new tunneling techniques, huge volumes of spaces with several story heights and gallery voids are now possible. These gallery spaces provide spacious spaces with the feeling of openness and freedom. In Figure II. 26, stations in Athens Greek, show those spacious spaces although having crossing beams which disturb the openness of the station. Figure II. 27 shows a more open space free from crossing beams in Dusseldorf Germany. These two examples shows how the entrance of the station and the station itself combined to each other by the exploitation of the spacious spaces.


II. 26. A II. 26. B

Figure II. 26: Station examples showing spacious spaces, Athens, Greek.
(Downloaded in October 2003 from: http://www.metropla.net)


II. 27. A II. 27. B

Figure II. 27: Spacious spaces in stations, Düsseldorf, Germany.
(Downloaded in October 2003 from: http://www.metropla.net)

Stations' main function is the transition and movement of the people. Moving from indoor to outdoor or from train to the platform are the most critical subjects in a station. Thus the function schemes get more significance. More than many other building types as they mediate between public and private realms, the stations are face to question of promenade and ease of passage in public places; therefore main idea should be clarity of spaces. In most cases the form of the station plans are determined by the existing buildings' foundations, tunnel tracks and infrastructure routes, even if they are located underneath a street or partly below buildings. Placement and form of the access structures are also subject to existing traffic areas and surrounding buildings. The result is unsystematically shaped spaces, with no or little daylight. But still there are contemporary examples of orderly planned, clear spaces with appropriate structures.

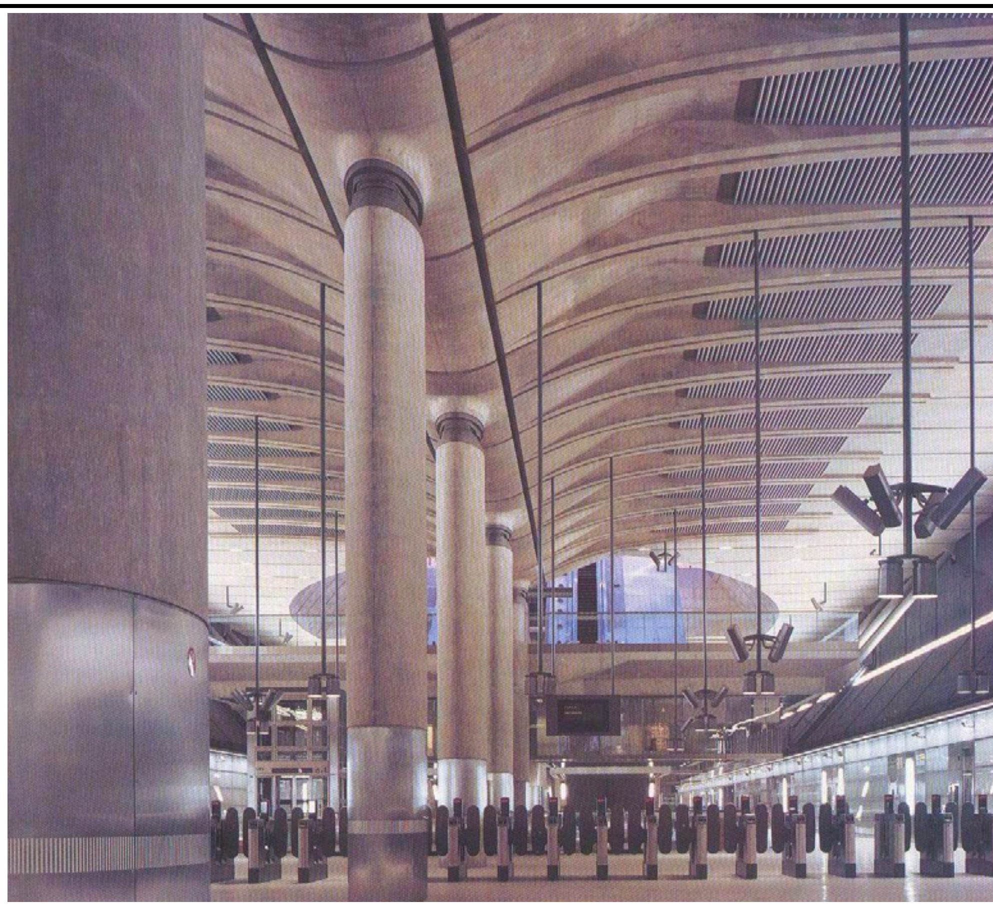


Figure II. 28: Canary Warf Station by Foster and Partners, London, England (The Architectural Review, June 2000: 53).

Canary Warf Station in London (Figure II. 28) can be a valid example to those clear underground spaces, there are comprehensible public space clearly defined passenger routes and abundant escalators. But still the problem of circulation was of importance in design of the station, and Fosters have dealt with it brilliantly. Dramatic, functional, elegantly resolved, building has been planned with a clear logic so that passage at all times is straight forward and there is hardly need for directions. A futuristic excitement is attached to this station. Great banks of escalators, bathed in light, carry passengers to the ticket hall. This cathedral like volume is articulated by a central row of colossal elliptical columns that rise, from the platform level below, to the roof, to meet the rhythmic pattern of arching ribs. Naturally lit and lined down its sides by ticket machines, offices and shops, the concourse is open through its length and breadth (The Architectural Review, June 2000: 51 – 55).

The Metro station must communicate a large amount of information to travelers and that is done via the design of the physical space, not by some information boards. Right from the outside square, to the waiting platform a sense of direction should be exist, between the sequential spaces. Of course some information systems are exist but they are secondary importance.

Modern city life, unlikely those in past, affects the space requirements of the stations. In ninetieth century, stations due to the requirements of social life, there are separated lounges for first class passengers and for the others; stations were deliberately class conscious. Today, however, stations designs' carry signs of the ideas about openness, flexibility and freedom. The barriers between platforms and waiting room class distinction have withdrawn from the station, leaving the station as more obviously a building of the city.

Additional facilities such as: kiosks, shops, automats, telephones and advertising showcases, provide the possibility of enhancing the attractiveness of subway stations. However, contemporary stations' main facility is still the transportation and waiting circulation spaces and platforms should therefore be designed in such a way that passengers reach their destination in the shortest possible way or allow them to wait in appropriate spaces which are neither overcrowded nor uninhabited.

In order to achieve those right amounts of density in spaces the movement of people should be reduced to a simpler state, to a natural process. As the passenger move in the station, the patrons pass through consequence of spaces, the surrounding changes unnoticeably from the outdoor to the underground. All those spaces are united with each other both with visually and aurally with no separating doors, from the entrance to the cavernous platform level. The space requirements changes not only by differentiation of space but also by differentiation of time in a day. After the morning rush hour a station can appear quite deserted. An optimum dimension should be found out; because the problem is not merely one of maximizing the space, but of providing its efficient use. Over scaled spaces can result in uninhabited places especially in less used times of the day, which can result in the feeling of loneliness and insecure (Edwards, 1997: 98). As a general rule, designers need to allow for 3 m^2 per passenger in station concourses, 2 m^2 per passenger in core areas and 1 m^2 per passenger on platforms. Greater density of occupation at platforms is accepted, as passengers here do not wait for great lengths of time and are not usually moving in various directions. In concourse areas passengers may be buying tickets, newspapers, checking on timetables or using telephones and moving in different directions (Edwards, 1997: 98).

Figure II. 29: Botanic station, although having the structural probabilities there is no spacious spaces, Ankara.

Recently constructing stations in Ankara, although having the technical, structural and geographical possibilities and the experiences from older stations, still have not such spacious spaces which can enhance the quality of the interior and exterior of the station entrance. For instance, in Figure II 29 and Figure II. 30 the Botanic station constructed with a totally enclose mass block, however it is possible to design the station in a more transparent block because it is located short way below the ground surface level which makes it easy to relate the outer and the inner of the station.

Figure II. 30: Botanic station, do not have any relation with the outside world although constructed short way below ground, Ankara.

II.1.3. Psychological Effects of Station Entrances

The concept of traveling underground is something that needed to be prepared for mentally as well as physically even in today’s modern societies. Moving from airy outside, to dark underground spaces, does not provide a feeling of pleasure (Figure II. 31). The paragraphs below describe the possible measurements in stations against that negative effect on human being. The designer’s task is not only to minimize that unpleasant feeling but also awaken some other senses. Huge scaled spaces imply a feeling of admiration; openness and glimpses of the sky and city through skylights provide travelers a feeling of the world out side and a clear impression of how far underground they actually are; uncluttered spaces provide a feeling of safety and security (Sorensen and Larsen, 2002: 55). Metro passengers while going down to the platform are probably thinking primarily about destination, but a well organized station they will also perceive the space quality, the light from the skylight and the details.

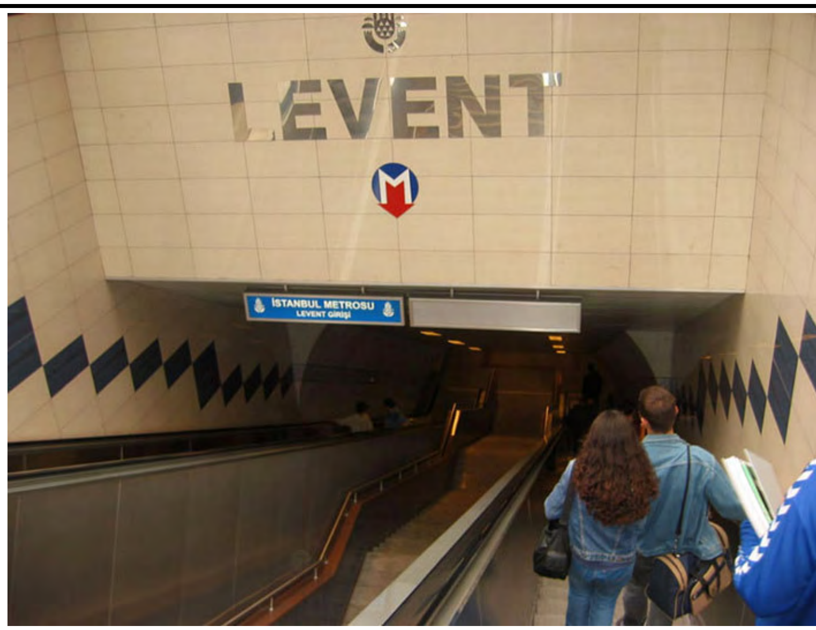


Figure II. 31: There is a feeling of entering a dark cave when there is no exploitation of natural light inside, Levent, İstanbul.

The utilization of insensitive modern styles and materials in station cavities make people feel more lonely and desperate. Fully automated metro systems improve the feeling of loneliness and desperate. Thus, many recent fully automated underground systems employ employees to work underground with passengers, although there is no need for them at all. These employees main function is to accompany and guide the passengers.

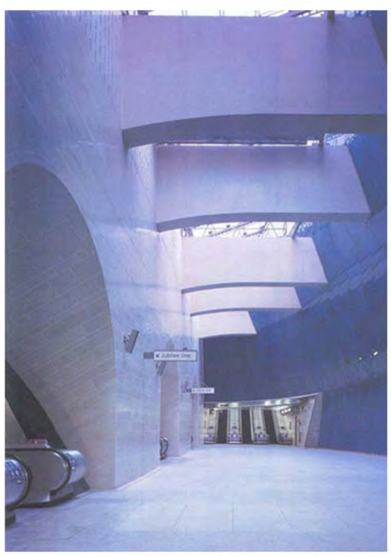
The architecture can also help the passengers of metro to make them ready for their underground travel, and guide them through station. The open, airy spaces of the station with their uncomplicated, regular construction exude the air of being safe place for every passenger. Orientation and navigation are easy and sources of light and air are clearly identifiable. In cathedral like metro stations of Moscow, shown in Figure II. 32, it is aimed to influence people by exaggerated ornamented spaces and feel them as if they are in building constructed to show off the government's political power of socialist regime. However in western world, designs influence people in a different manner, such as utilization of technology, material, and simple forms of spaces. The examples from Turkey have tendency to have a minimalist type of attitude instead of ornamented ones. However this minimalism rests only in the space forms, not in the decoration and details of the stations. Patterning on wall surfaces constitutes a contradiction.

II. 32. A　　　　II. 32. B

Figure II. 32: Cathedral like Moscow metro station entrances awaken the feeling of admiration (Downloaded in July 2003 from: http://www.metropla.net)

II.1.4. Lighting in Station Entrances

Recent metro stations of Turkey, seems to be the products of contemporary engineering, however the needs of contemporary architecture is mostly underestimated. Architectural inner spaces should not be considered as merely enclosed boxes but spaces which imply some feelings and thoughts to the passengers, most of all, feeling of direction and safety should be caused passengers to perceive. Light, especially the natural light is a valuable means to provide such feelings. In some metro station buildings such a valuable means seems not to be utilized, such as in Kizilay metro station, Ankara. The lighting systems generally designed merely for illumination only, but not to indicate something. Thus the stations become artificially and equally lighted spaces, where the attention does not focus on some particular points, such as booking halls, platforms and entrances. Any particular feelings do not provided by the foreground and background or light and shadow utilization. As a result the space itself does not lead the passengers throughout the stations. The light inside the underground stations is not only a means of aesthetics but also of safety. Entering suddenly from outside, with high illumination levels, to the inside, with comparatively less illuminated space, provides problems of vision or vice versa is also true (Bal, 1995: 73 – 80). In that part of the thesis, important points and measurements of a correct lighting design are investigated under the light of some examples.



II. 33. A

II. 33. B

Figure II. 33: Station entrances with skylights provide a positive atmosphere, Canary Wharf Station, London. (The Architectural Review, June 2000: 51)

The building itself and light should not be considered as separate concerns but elements in a unity. According to Edwards (1997), form, space and structure are the three main elements of modern stations. Moreover they are perceived, enjoyed and understood through the medium of both natural and artificial light (1997: 92). As seen in Figure II. 33 the natural light from the skylight and the structural elements seem in an accommodation as a unity in Canary Wharf Station. The essential role of the architecture in stations is to guide passengers to avoid the use of signs and direction boards. An ideal station is one where ordinary travelers grasp the logic of a station's design and comprehend its various functional spaces. For example, Munich's subway illumination is designed to provide, both the citizens and the visitors of the city, find their ways around the city by subway and minimizing the carelessness or widespread vandalism in stations (Hackelsberger, 1997: 92). Light strikes a surface and highlights a detail or an important part, and diffuse light leave the structure as background element thus the differentiation between the important and less important elements is provided. Hackelsberger mentions that light makes the underground spaces, visible and safe; it illuminates colors and engenders emotions (1997: 42).

The way of diffusing the light is as more important as the light source itself (Bal, 1995: 74). The diffuse of the light is depending on the texture, color, brightness and quality of the surface material. In addition, the coming angle of the light ray to the surface has secondary importance. Human being perceives almost 80% of his information about the surroundings with the eyes. Thus, light, reflected by the surroundings is the most important medium in perception. Therefore light has a special function in underground spaces, where a strong feeling of security, orientation and guidance is required. There are some general points should be considered during the design of the lighting, such as monotonous, or diffuse lighting should be avoided as well as dark niches. The "tunnel effect" should be counteracted especially in the entrance regions. External brightness prevents view in a dark hole when there are not enough adaptation zones, the entrances of the stations are designed in order to satisfy that requirement of providing adaptation zones. An information system should be built up with dark and light zones should be provided. According to the researchers opinion, there are mainly three kinds of lighting methods used in underground spaces to maintain such as; natural Lighting, artificial lighting and imitated Natural Lighting.

Natural Lighting

Daylight in underground stations, make the components of the station visible and make it easier to grasp the station at once. The result is more open spaces with more readability. Thus some architectural inventions are employed, such as, skylights, reflective shafts in order to take natural daylight into the underground station. Entrances have significance in taking light into the station because they are the main components which the station connect to outside. In some cases natural daylight taken into the station directly by skylights if the depth of the station and the existing situation of the above ground permits, if not, daylight is deflected down into the station by using glass walls or reflective shafts of translucent material. Deflected natural light is generally easier to manipulate than artificial lighting, and gives more wholesome quality to subterranean spaces (Edwards, 1997: 91).

Figure II. 34: The staircase void in the slab taking natural light from station entrance, Ankara.

In Turkey most of the stations can not take natural light inside. Figure II. 34 proves that the possibility of taking light in. In that example the staircase void provides natural light and in most cases the only source of natural light is such stairs. However it is not impossible to open such voids as skylights. In Figure II. 34 it is also seen that because of there is no daylight inside the station when leaving the station, the patrons are facing with the problem of glare effect.

II. 35. A II. 35. B

Figure II. 35: Natural light resembling lighting fixtures, St Petersburg, Russia. (Downloaded in October 2003 from: http://www.metropla.net)

It is very difficult to imitate the daylight effect with artificial light. It is the problem of not only illuminating the space intensity about 10,000 lux but also imitating the color of light and changing light conditions changing according to the dynamic behavior of daylight. (Sorensen and Larsen, 2002: 15) All day lighting dynamics can be experienced with cooler light in the morning and warmer in the evening (Edwards, 1997: 95). All day light simulations based purely on artificial lighting involve an enormous expenditure of control effort to produce the effect of daylight, which will nevertheless appear artificial. However there are still some examples of imitated natural light with lighting fixtures resembling skylights by their shape and by their diffuse lights as seen in Figure II. 35.

These skylights and light shafts do not only serve for only one function; they create special cohesion between above and below ground, a link is created between the outside world and the deep-lying underground station; specially designed skylights add a sculptural element to the outdoor squares; they project daylight down into the station which is manipulated as an architectural feature, facilitates passenger orientation, and gives the passenger a sense of navigating in familiar surroundings. The skylights are the landmarks of the above ground squares which indicate the axis of the metro station's layout. Thereby they convey general visually recognizable information about the station scheme even before the passengers enter down into the station. Also during the night these skylights are legible landmarks for navigation, with the help of the light coming up from the station. In Figure II. 36 a proposal, which is not applied later, for Ankaray Kızılay station with skylights, can be seen.

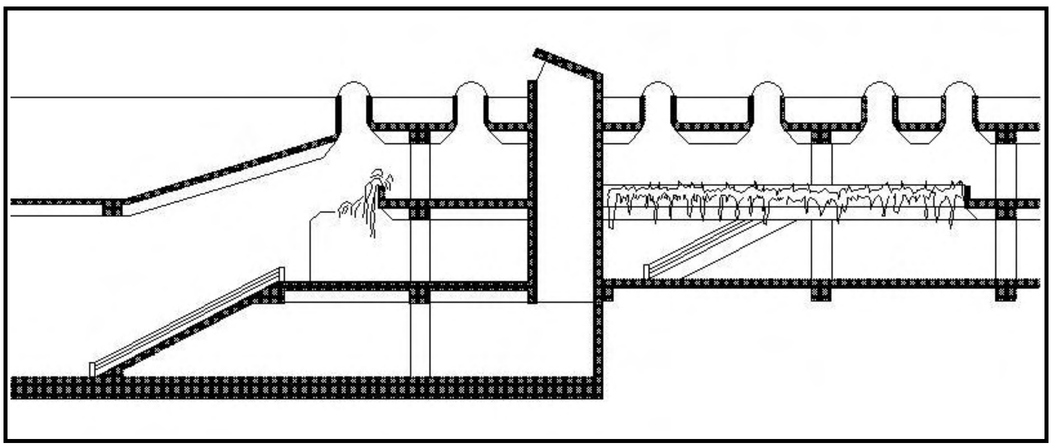
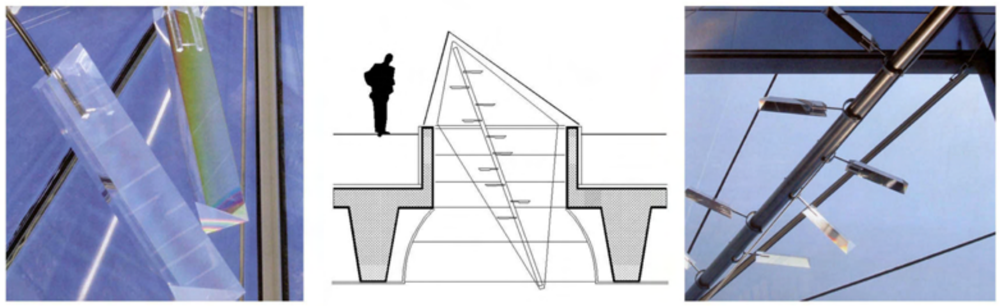


Figure II. 36: A proposal for Ankaray Kızılay station with skylights, Ankara. (Ankara Municipality, 1990)

Extreme glaring and sharp passing from dark to highly lit spaces should be avoided; a smooth passing between differently lit spaces should be preferred (Sorensen and Larsen, 2002: 15). Especially at 10 – 14 hours when the sunrays are coming perpendicularly, the high illumination levels could be dangerous (Bal, 1995: 73). On the contrary to the Bal's explanations mentioning the difficulty and objections of using natural light, today it is possible to control the natural light with light diffraction elements and semi permeable glasses (Sorensen and Larsen, 2002: 16). In Copenhagen metro glass prisms are used to diffract the light and provide a positive atmosphere inside, as shown in Figure II. 37 and Figure II. 38.



II. 37. A II. 37. B II. 37. C

Figure II. 37: Light diffraction elements the skylights, Copenhagen
(Sorensen and Larsen, 2002: 14 – 15)

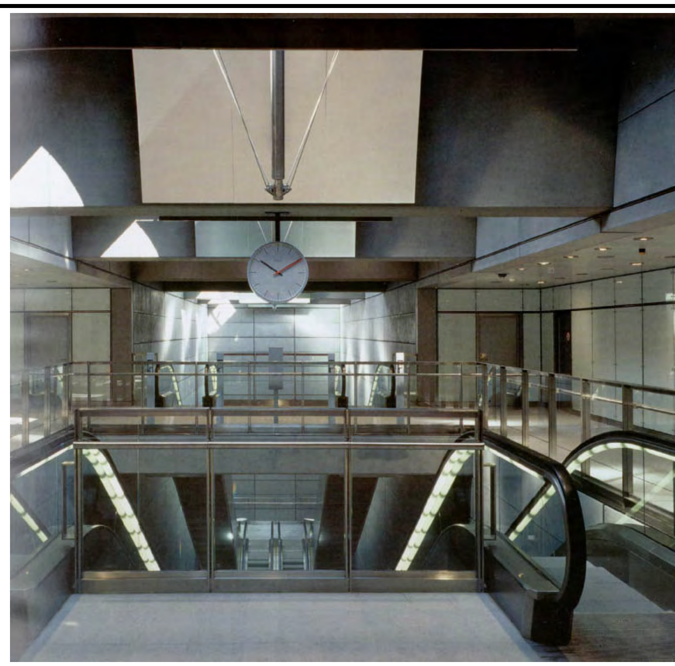


Figure II. 38: Metro station with natural light from skylights, Copenhagen.
(Sorensen and Larsen, 2002: 14 – 15)

Natural lighting has some physical enhancements other than its psychological and aesthetical effects. It is important especially for the employee of the station due to their long hours spend in enclosed stations. Sunlight has certain physiological effects on human activities. Hughes mentioned the necessity of sunlight by its effects on some hormones and vitamins in the human body (1987: 73 – 78). An underground space provides an appropriate environment for many harmful species, such as bacteria, yeast, mold and viruses due to humid condition and darkness. Sunlight is also capable of killing these species and enhance the health facilities of the underground space.

Artificial Lighting

Natural lighting is a preferred option with no doubt but it is not always possible especially when speaking about an underground space, mostly because of the depth of the platform halls of the station. The solution is then artificial lighting. Certainly, the preparation of the artificial lighting projects is more complicated when compared with the natural lighting system. There are some more technical issues to solve in addition to the every significant points of the natural lighting process. The critical points of lighting are mentioned in following paragraphs.

Figure II. 39: Artificial lighting having a guidance feature, Check Republic.
(Downloaded in October 2003 from: http://www.metropla.net)

Figure II. 40: Equally illuminated entrance without any focus point, Ankara.

Achieving the optimum illumination level is the main concern for the reasons of the energy saving and passenger comfort. Moreover zoning, guidance and focusing points should be investigated with the help of lighting. There are many ways and means of achieving the required illumination inside the station. In Figure II. 39 the guidance effect of the lighting fixtures can be seen. Turkish standards mention that lighting should be designed to provide safety, comfort and easy circulation; there should be smooth transitions from less illumination to more (TS 12460). Escalators must be free of shadowy areas; the platform edges must be clearly visible. Illumination level should be balanced in all spaces inside the station, excluding platforms, staircases and other attention required fields should be illuminated more in order to focus the attention. The lighting fixtures must be of same kind at the whole stations of a system, in order to provide, ease of maintenance, cleaning and spare storage. In Turkey the most commonly used one is the luminescent tubes because of cost reasons. The improper design of such illumination fixtures results in equally illuminated spaces without any focus points (Figure II. 40). The location and direction of the lighting fixtures should be designed in order to prevent the glowing effect on human eye (Bal, 1995: 80). Indirect lighting then comes as a solution. Light reflecting from surfaces provides more diffuse light in spaces (Figure II. 41).

Figure II. 41: Indirect lighting in station, St Petersburg, Russia.
(Downloaded in October 2003 from: http://www.metropla.net)

Apart from fulfilling technical – operational requirements, it is an important design task to create well balanced lighting. Lighting fixtures are not the only elements to provide such balanced lighting. All surfaces such as, walls, ceilings and floors should be considered as a constituent element of the system. The vertical wall surfaces should be illuminated; moreover, the coating materials of the surfaces are also important; due to their characteristics of deflecting light. The deflection amount of light should neither glare and discomfort the eye nor decrease the illumination level. In order to enhance the efficiency of the available daylight, the side wall surfaces and the ceiling surfaces can be clad with semi reflective glossy materials. In this manner all the daylight is deflected into the depths of the underground region with virtually no loss. Lighting system is not only a task of getting the adequate light in spaces but to maintain the durability of the system. Maintenance and cleaning of the system should not disturb the operation of the station (Edwards, 1997: 105). For example, if lamps are fitted with special casings, lamp shades or reflectors, these have to be designed in such a way that changing a lamp does not take more than 30 seconds (Edwards, 1997: 105).

Figure II. 42: Artificial lighting on escalator field of metro station, Copenhagen (Sorensen and Larsen, 2002: 16).

Copenhagen metro can be valid example to show the effective lighting system in underground stations. The zones of concourse level which are not day lit are supplemented with wall washers. The vertical wall surfaces are almost exclusively illuminated. The access zones to the escalators are zoned using artificial sunlight which provides guidance with vertical light and security with horizontal lighting. The large region of air space is illuminated with special projectors in the parapet region and free-form surface mirrors on the ceiling to produce the greatest possible freedom from glare and ease of maintenance. Brilliant light, equivalent to the sun is thus produced. Such a system provides information, comfort, security and greater attentiveness when boarding the train. (Sorensen and Larsen, 2002: 15) (Figure II. 42)

II.1.5. Heating, Ventilating, Air Conditioning in Station Entrances

Metro systems success depends on the harmonious work of engineering systems. Heating, ventilating and air conditioning are the main systems which are designed to satisfy the physical needs and to obtain a certain level of comfort. (Bal, 1995: 91) When the issue is an underground space the requirements these systems becomes different from the ones of ordinary buildings. In fact the priorities of the problematic issues become different in underground spaces. The following paragraphs explain the needs and comfort levels of underground stations.

Being independent from the outside temperature, subterranean spaces, generally does not require any heating systems. The heat generated from the sources within the station usually provides sufficient temperature. Main heat sources are trains, human bodies, lighting fixtures, escalators, lifts and various mechanical equipments. However heat inside the station is still an important problem. Especially at the crowded hours heat and humidity emitted from the human bodies also cause a considerable decrease in the comfort level of the station. Relative humidity in the interior should be under 60% level (Bal, 1995: 103). Thus many kinds of ventilation schemes are developed in order to get the appropriate moisture and heating level (Bal, 1995: 100 - 103). The calculations of HVAC systems are done considering 3˚ degrees of difference between outside and station (Bal, 1995: 103). When designing ventilation systems the locations of the shafts should be determined considering the flow direction and speed of the air in order not to damage the equipments and disturb the passengers. Ventilating systems providing high and direct air currency, results in unwanted blowing effects in stations. Especially at the entrances of the stations there is a problem about the velocity of the air. At windy days this blowing effect occurs from outside to inside and also from inside to outside if the platform is near to station entrance because of the piston effect of the moving trains. (Bal, 1995: 91 – 94) Waterproofing material covering outside the station not only prevents the water to infiltrate inside but also prevents the moisture to be absorbed by soil. However, insufficient ventilation results in high moisture levels in stations. Likewise, the mass soil outside the station prevent the over heated air to escape. In addition to heat and moisture there are more dangerous gases to be exhausted such as high carbon dioxide, toxic brake dust and fumes from trains (Edwards, 1997: 98). In some situations the level of toxic dust and fumes are so high that a physical or airy separation is needed between trains, platforms and concourses (Edwards, 1997: 98). The higher carbon dioxide levels can result in less healthy environment following with higher bacteria population. Unventilated underground spaces provide not only uncomfortable for passengers but also shorten the life of the mechanical equipments inside. The main system currently being used by many of the underground systems is “piston effect” which means to use the movement of the trains to push the dirty air out through the ventilation shafts. This is the most common and effective way of ventilating spaces, but in some cases it may not be adequate. More specialized systems may be required; especially in the emergency situations. In an emergency situation the poisonous smokes and hot gases should be exhausted in the shortest possible way while fresh air is pumped into the station. (Bal, 1995: 80). The shafts nearer to fire, work for sucking and the ones far from fire are for blowing fresh air by that way the smoke and fire are blocked to pasture. By the developing technology today there are many fully automatic emergency systems which determine and block the danger by itself.

The mechanical equipments in stations can provide some other problems such as aesthetics and noise from equipments. Suspended ceiling is a very useful means to hide these equipments inside. In addition by its sound absorbent feature minimizing the noise is also possible. However of course it is the designer’s choice to hide or expose such equipments. In Figure II. 43

the exposed ventilation ducts can be seen in Zurich, Switzerland. Moreover the technical spaces of underground metro stations, takes large areas, and where it is not possible to locate these spaces underground, it important to properly design the above ground technical buildings. These exposed buildings disturb the entrance of the station and city silhouette.

II. 43. A II. 43. B

Figure II. 43: Ventilation ducts in stations, Zurich, Switzerland.
(Downloaded in October 2003 from: http://www.metropla.net)

II.1.6. Navigation Through Stations

As the environments get crowded and enlarged in scale, it gets more difficult to comprehend for the user because they become more complicated. The need to help people reaching their destinations, become more vital as the scale and complexity of the stations get larger. As Altay mentioned in his thesis, having way finding problems in an enclosed space people can have some psychological problems too, such as, a feeling of alienation and lost (1997: 15). There are also the problems of functional inefficiency and loss of time. Navigation is a general problem in many public buildings, but in underground spaces it becomes more important. There are more limitations in an underground space; there are no visual links between the outside and the inside of the space, this means that the user cannot take outside as a reference point. Moreover the general layout, scheme of the building is undetermined; by seeing the outer form of above ground building people usually have any idea about it even before they enter inside. In the case of underground spaces the passenger have no cue what is exist in the inside of the space they are about to enter. For instance in Taksim station, İstanbul, one can easily lost his/her direction, because of the similar corridors, and not having the ability of seeing the station as a whole. Passengers can not see the other side of the corners at the end of those long corridors. Thus they cannot comprehend the station as a whole. (Figure II. 44) The ways of providing navigation for passengers inside an enclosed space by architectural manners are described in following paragraphs.

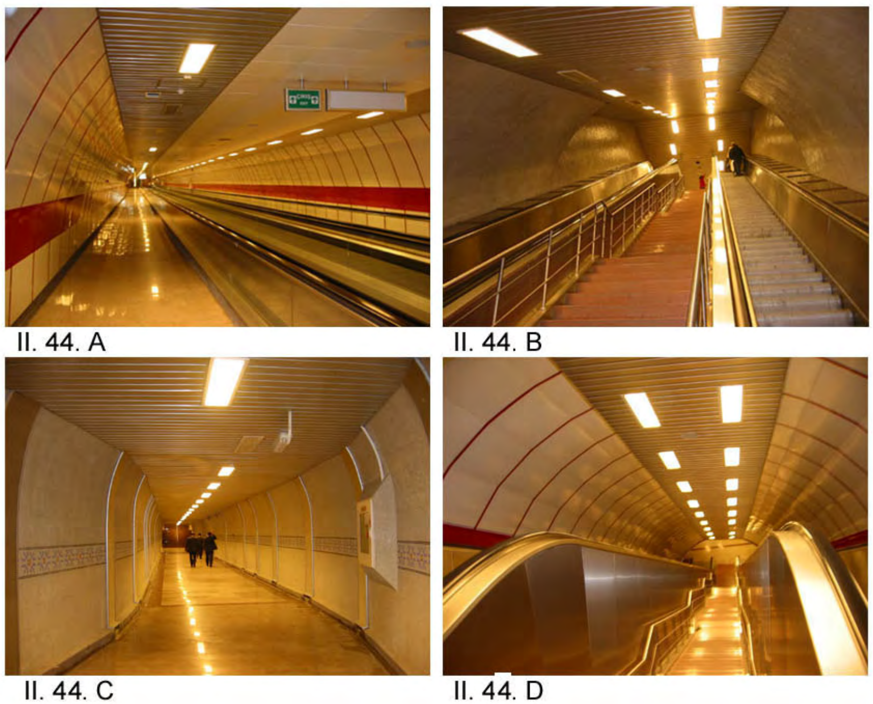


Figure II. 44: Corridors and corners prevent vision, Taksim station, İstanbul

Recent architectural approaches in underground design require a massaging system about orientation of the passenger; but not merely with using graphical signalization. The role of the architectural design is to help passengers to define the routes in the spaces and to provide psychological encouragement. There are numbers of ways to manage perceptual markers, which passengers can use to orientate themselves (Edwards, 1997: 94). First one is to provide various spaces instead of monotonous ones. By using variety of colors, materials or light at identical but resembling fields of station; it can be achieved to differentiate them from each other. Second one is to utilizing significant elements, landmarks in the interior, such as sculptures, artworks or even the structural elements themselves. As seen in Figure II. 45 the row of structural elements provide a feeling of direction in Canary Wharf Station. Another way of providing easy orientation is to provide visibility inside the space. Certain rotes, entrances platforms, vertical circulation shafts should be easily perceived and architecturally expressed. As Altay mentioned, the choice of the structure gains importance in that manner, because structural elements, walls, columns should not represent any obstacle against visibility (1997: 18).

Figure II. 45: Row of structural elements provides a feeling of navigation BART system San Francisco. (Downloaded in October 2003 from: http://www.metropla.net)

Briefly the perception of the passenger is essential. The greater the complexity of the station, the more difficult to clarify the movement of the passengers. However it does not matter how much does the circulation schemes are simple unless the passenger does not understand it. Being able to read a key route, to identify the right escalator, to know the direction of train side, to be guided to the right platform, are the main concerns of the architectural design (Edwards, 1997: 94).

II.1.7. Acoustics in Station Entrances

In that part of the thesis, comfort levels related to sound and need for acoustical measurements, are explained, and methods and suggestions are made by the guidance of examples from abroad. Acoustics of an enclosed space is very significant by its ability to characterize the space and to provide overall space quality and comfort. The spaces in the entrance part of the station expose to the sounds from both exterior and from interior, for instance the noise of the traffic outside and the vibration of the trains inside. As mentioned in the Introduction, the entrances are not only the area of turnstiles but the term entrance also includes the waiting areas, booking halls, etc. Hence while examining the sound conditions in entrance parts it should be considered as enclosed spaces. Uncontrolled noise and vibrations in enclosed spaces, makes them not only distracting but also dangerous. A noisy station is not a safe place, as cries for help and important announcements can not be heard. Controlling noise and vibrations requires more effort than an ordinary building because of being fully enclosed and the character of the materials used inside. There are various types of sources of sound inside the station; the passengers, the mechanical equipments, the trains and the vibrations from outside (Bal, 1995: 54). Bal mentions that high frequency noise are more dangerous than low frequency band noise, here the vibration close to noise. According to Bal, in order to achieve a pleasant and functional environment, the first step in designing process should be to determine whether the sound is desired or not inside the space such as audibility of announcements has vital importance while the noises from air ducts are disturbing (1995: 68). If the sound has an importance to be heard, then the placements and directions of the sources, such as announcement speakers, are done with critical calculations. While the noise is undesired, then reducing the undesired noise and managing the reverberations can be achieved by certain methods. Turkish Standards Institute collected all these measures under four main topics: Minimize the noise of the vehicles, provide the understandability of the announcements, and minimize the mumbling of the crowd and controlling the noise from mechanical equipment (TS 12127, 1997: 21). According to these standards, in general, the resultant design should satisfy below quantities; in empty stations, the reverberation time should be in the range of 1,2s – 1,4s; the maximum sound level should be 55db in an empty station and 80 – 85db in station with train; minimum 50% of public spaces should applied with acoustic measures (TS 12127, 1997: 21).

II. 46. A

II. 46. B

Figure II. 46: Sound reflective panels, Nurnberg, Germany.
(Downloaded in October 2003 from: http://www.metropla.net)

The major noise source inside a station is the trains. As Edwards mentioned, by the introduction of new generation trains, greater attention has to be paid to the noise problem; as the trains become faster the problem of noise becomes more complex to deal with both for the station and for the neighboring buildings also (1997: 101). That sort of noise can be reduced by sound absorbing materials placed inside the tunnels and stations. Resonators can also be placed beneath the platform edges to reduce the high pitched noise caused by the contact between wheel and rail, and plywood boxes can be placed above the suspended ceilings of stations to minimize low-pitched noise. Free standing screens for noise deflection can also be utilized in stations. In Figure II. 46, sound reflective surfaces placed inside the station for both acoustical and aesthetical reasons, in Nurnberg, Germany. Moreover the side walls of the station have some rectangular ornaments, which have the ability to disperse the sound.

Another important source of noise is the human itself. Especially at the peak hours, the mumble coming from the crowd becomes very disturbing. The audibility of the sound inside the space is directly related with the plentitude of people in the station. In crowded hours because of the human bodies there is a highly absorbing environment which results in the lack of sound; On the contrary at the empty hours there can be undesired reverberation which results in the confusion of the sounds. Changing environment, if not prevented, can lead to not hearing the announcements or misunderstanding them.

Mechanical equipment is another source of noise which should keep under control. As a first measure these equipments should be placed as far as possible from the general use spaces. If it is not possible it should be covered with sound absorbing material and hung above the suspended ceiling. The placement and quality of the speakers are also important for the audibility and understandability of the announcements in order to prevent lack of hearing and misunderstanding.

Human can hear a noise in two different ways; directly and reflected from a surface. If the reflected and noises arrival time to the ear is different than reverberations and mumblings occur (Bal, 1995: 59). Inside the station almost all of the floor and wall surface materials are usually very sound reflective. Thus, sound absorbing elements or covering materials can be used to minimize the reflection. The reflection of the sound inside the station is directly related with the shape of the station. Since in circular formed stations the sound reflects in a dispersed way, the reverberations and mumblings are minimized. Thin and narrow spaces becomes more problematic due to reverberation times becomes higher. In order to utilize reflection in a positive manner; angled; curved walls relief type ornamentations reflectors or even rough surfaces can be used to deflect noise away from sensitive areas and diffuse it equally (Figure II. 47 and 48). Those sensitive areas can be counted as; ticket areas, waiting rooms, and platforms, because of the long waiting times in those spaces. The need for rigid materials in those spaces causes hard materials which result in more reflection (Bal, 1995: 59 – 68). Thus ceilings become more important because of freedom to use sound absorbent materials. Bal claims that the time spent in a space is directly related with the noise level of that space. Thus the acoustical design of the stations is important especially for the workers of the station. The most disturbing source of sound for the workers because of the high sound levels are the trains, thus they should be taken into special consideration. Upper corners of the platforms should be cleared from perpendicular angles and filleted in order to diffuse the sound. Rough texture should be used on the surfaces below the platform and sides of the track. Calculations of noises from passenger are rather more difficult because of not based on any standards. The calculations should be done regarding the peak hours of the station. At the empty hours reverberation times should also be calculated (Bal, 1995: 69).

II. 47. A II. 47. B

Figure II. 47: Curved walls relief type ornamentations, Praha, Check Rep.
(Downloaded in October 2003 from: http://www.metropla.net)

II. 48. A II. 48. B

Figure II. 48: Rough rock surfaces with shotcrete, Stockholm, Sweden.
(Downloaded in October 2003 from: http://www.metropla.net)

II.1.8. Safety and Security in Station Entrances

Underground stations are generally considered as unsafe places, because of the fact that they are more open to terrorist attacks, disasters, vandalism and accidents. Moreover being an underground structure there is no way out except than the specified exits. In fact in many of the stations from Turkey dot not have any emergency exits. This means that entrances gain a significant importance in that manner. Thus, the injury and death rates are higher than the ordinary buildings during natural or man made disaster (Altay, 1997: 50). In addition to these risks there are also psychological needs for safety and security. Edwards claimed that safety in enclosed spaces is a matter of direct risk and perceived risk. Fear of crime at stations is often greater than the real crime (1997: 95). Thus it is significant to minimize this fear and unpleasant feelings by utilizing architectural elements, such as light, color, acoustics, and safety conscious design. These measurements were explained in the "Psychological Effects of Station Entrances" in Section II.1.3 of the thesis. In the following paragraphs safety measurements in stations and in entrances are categorized in order to explain the measurements can be taken against accidents, disasters and vandalism.

Safety Against Accidents

Minimizing real and fear risks require to satisfy many aspects altogether such as; station layout, lighting, orientation, details, maintenance, signalization, inspection and also training of staff are all effective on the safety level of the station. Most of the accidents occur due to dissatisfaction of these general design criteria. Some areas of the stations have greater risk than the other ones and thus require various risk abatement methods. For example, platforms have one of the most dangerous risk in stations; falling onto the tracks. The contemporary stations have retractable glass barriers between the track and the platform as a precaution. This segregation process started as an experiment and follows a trend world wide. This new component of stations not only prevents the passengers falling on the track but also provide a segregation of air as a part of air conditioning measurement. Moreover, it has some aesthetic advantages; the usage of glass provides high graffiti resistance and ease of cleaning. At night when lit it provides a welcoming glow to the station (Edwards, 1997: 47) (Figure II. 49). In order to focus people's attention on important and critical points lighting, colors and textures should be used. Especially at the edges of platforms, escalators and staircases contrasting colors and textures are beneficial for even disabled passengers (Figure II. 50)

Figure II. 49: Jubilee line extension, Westminster station, glass barrier example, London, England. (Downloaded in October 2003 from: http://www.metropla.net)

Figure II. 50: Contrasting colors of platform boarding lines, Bart system San Francisco (Downloaded in October 2003 from: http://www.metropla.net).

Safety Against Disasters

Natural and man made disasters are the most dangerous situations for the underground stations. Being in underground and enclosed spaces makes the situation more critical. In case of fire, flood, earthquake, and attacks of explosion or poisonous gas, passengers inside have very limited exit ways. Moreover, passengers generally have no idea about their navigation because of the panic; if the signalization lacks, than many people don't know where to escape. It should be considered that the escape process takes more time than an ordinary building, because of the fact that the passengers are running towards upstairs which requires more energy than an ordinary escape. This signalization should be designed with not only lighted sign boards but also architectural elements because there is a risk of energy shortage, nevertheless there should be utilization of emergency lighting, fully automated fire suppression and smoke ventilation systems. The smoke coming from the fire or poisonous gases should be exhausted and fresh air should be in taken as fast as possible. Signalization board's material should be photo luminescent which have the ability of storing light and keeps shining in darkness for long hours (Carmody and Sterling, 1984: 303). Audio and video alarm systems should inform people in order to decrease the escape time. In an emergency condition it is very difficult to find and rescue people under danger, thus the plan scheme of the stations must be clear. Altay suggested that according to human psychology people have tendency to use the route they entered, while the emergency exits remain untouched (1997: 55). Thus at the entrance part of the stations the open type of plan and gallery voids help the people to see the exit and direct them selves. However there is a risk of the spreading of smoke in such open spaces. Hence at the escalators smoke curtains, fire resistant barriers falling down from the ceiling, can be placed in order to delay the spreading time of the smoke (Altay, 1997: 55).

Safety Against Vandalism

Although vandalism and attack against people are mainly the problem of human behavior and psychology, by utilizing correct design of stations it can be minimized. Such as, the overall layout of the station is an important factor to provide a safe place. Visibility in all directions is an important feature of a space to decrease the crime rates. Thus simplicity of the plan is vital, likewise eliminating sharp edges and extra columns or visual obstacles, ease the visibility both with eye and with closed circuit cameras. Vandalism and people attack are directly related with the density of the spaces. Due to the arrivals and departures of the trains the density is not stable; there are peak hours and dead hours of station. The spaces scaled according to the crowd of peak hours seem empty and lifeless during the rest hours. During these long quite hours it is likely to open some attacks upon people or vandalism upon station. Edwards claimed that, the lower the station occupation the greater the risk from crime and vandalism and the greater the feeling of insecurity among passengers (1997: 95). Thus unused parts or dark niches of the stations should be closed or unauthorized entrance should be restricted. In conclusion providing safety is a task of finding the optimum values. In example contemporary entrance structures of stations consist of totally glazed roofs. These highly glazed roofs can improve the space quality of the station but over scaled glazed surfaces can result in accidents during maintenance. Another precaution against vandalism is the durability of materials used in the spaces which is included in Section II. 1.9.

II.1.9. Durability and Maintenance of Station Entrances

Generally the underground systems are long time investments for cities. Hence they are expected to be functional for many decades. However while the structural systems of the buildings can be designed to have long life span, many of the constructional components can not have such a long life. Principally the life span of building services is shorter than that of the station by a factor of as much as 3 to 1 (Edwards, 1997: 124). This means that because of the different life spans of individual parts, station lighting, ventilation, electrical systems need to be totally renewed several times, in addition upgrading for new technical approaches and maintenances of the system are also possible. Accidents and vandalism are the other effective factors on the maintenance needs. In conclusion accessibility and renewability for the parts of the system are key considerations in the design process. Station design is therefore based upon the concept of permanent and less permanent parts. Furthermore social and technical changes constitute new demands for renovation, for instance, the growth of terrorism led to the introduction of new lighting and camera systems in many stations; and the current concerns over air quality at the trackside are leading to changes in ventilation policy with enclosed platforms (Edwards, 1997: 100).

Figure II. 51: Unprotected escalators and entrances from environmental factors, Ankara

Durability and maintenance are closely related factors; some components of the system require periodical maintenance in order to keep its durability. On the contrary durable materials require less maintenance. For instance, hard covering surfaces are more resist against vandal behaviors and require less maintenance, or steel structures require repainting against corrosion. In any way designs of those public spaces should also include those maintenance processes. Likewise the protection of the equipments against environmental factors is as important as their periodical maintenance. For instance in many stations from Ankara and İstanbul there are no covering structures at the entrances of the stations. The result is the exposition of the stairs and escalators to the environmental factors such as rain snow and freeze. Infiltrating water, results in crack for finishing materials when freeze. Since the escalators have mechanical equipment they are more affected by such environmental factors, and requires frequent maintenance. (Figure II. 51)

Figure II. 52: Brin subway station and cleaning apparatus by Renzo Piano, Genoa (Transport stations 8. Atrium: 30).

As a contemporary attitude glass station entrance roofs raises a new question; how they are going to be cleaned, maintained and repaired? Health and safety regulations place restrictions upon cleaning methods, and lay down standards at the design phase. Designers should determine how maintenance is to be carried out both for replacement and cleaning. There is an example of integration of design and maintenance Figure II. 52, the curved glazed roof and cleaning apparatus were considered as related problems of design at the beginning of design. Cleaning the inside surfaces of the glass is equally important. The dust and fumes from trains quickly discolor glass, especially the areas directly above railway tracks. Brake dust is toxic, discoloring and sticks to glass. Regular cleaning is essential if the station is to keep its bright image.

In Waterloo International Station, the steel structured glass roof positioned above the track the steel work consisted of four separate coatings, and within the life of a typical station the protective coatings on steel structures will need to be renewed perhaps a dozen times (Edwards, 1997: 104). Thus it is a design question of how it is to be undertaken without disrupting the operation of the station, not merely a maintenance one. As an answer Edwards proposes to use aluminum instead of steel, which does not require repainting (1997: 104).

Accessibility of the building services is another design measure to come. According to a current approach exposed services, such as, brightly painted air ducts, are not merely for ease of maintenance, but also for decorative qualities. Replaceable surface cladding materials, such as mechanically fitted stone coverings, or reserved service spaces, provide the accessibility of the services. Setting standards in the design of metro in response to the requirements and adaptations to various designs also provide easier maintenance and repleaceability. Standardization provides mass production, lower costs, less replacement and maintenance times. (Sorensen and Larsen, 2002: 20)

II.1.10. Convenience for Disabled People in Station Entrances

The requirements of disabled people and measurements in a station to make it suitable for them are the concern of the following paragraphs. In this respect stations in Turkey are criticized by comparing them with the ones in western world. To be accessible for disabled people in all manners is a concern at all stages of the design process of a new station. Required accessibility is not only a physical but also a psychological one. The requirements for disabled should influence the whole station concept and the measurements should be appropriate for the use of all passengers. A common misunderstanding about the disabled people is that, they are considered as only wheel chaired; in fact they can have many more kinds of disabilities. Thus the disabled conscious design should include measurements not only for ones having problems in movement but also for the ones suffering from impairment of hearing or vision (Edwards, 1997: 96).

Figure II. 53: Subway station, entrance and elevator for disabled, Vienna, Austria.

Most of the stations have disabled lifts and ramps for wheel chaired people; however their locations and standards seems to be lacking, disabled travelers do not want to feel segregated but part of the life of the station. The provision of separate access for those with limited movement increases the sense of discrimination, and this results a psychological handicap for them. Entrances of Vienna metro stations have separated disabled lifts yet they have the same transparent façade character which is minimizing the isolation. (Figure II. 53) Taksim metro station is a valid example regarding this psychological effect on disabled people with orienting the lifts near by the vertical circulation core (Figure II. 54). However having such disabled lifts most of the stations from Ankara and İstanbul seem to be lacking in that psychological manner, the cores of handicapped people are segregated from the general passenger ones (Figure II. 55). Furthermore these vertical cores are potentially valid elements for underground, especially for linking upstairs to downstairs. However even in recently constructed stations it can be seen that this potential are not used. As seen in Figure II. 56 after the lift is placed, there is no link between two floors.

Figure II. 54: Elevators for disabled people, Taksim, Istanbul.

Figure II. 55: Segregated elevators for disabled from the main entrance of the station, Ankara.

Figure II. 56: Elevator for disabled do not connect the upper floor and the lower one, OSB station, Ankara.

Many consideration points for an applicable disabled conscious design can be categorized as follows: The entrances, navigation, signs, surfaces, platforms, vertical circulation, and toilets. The entrance of the stations should be clearly visible, by the illumination of the entrance canopy and signs. According to Turkish Standards (TS 12460, 1998: 29), doors should be at least 120 cm wide and have kick plates for wheel chair user. In addition to escalators and stairs, lifts and ramps should be provided for different levels of impairment. Routes and level changes designed for disabled access should be available for all passengers. Details such as the width and provision of handrails make travel easier for all. At station entrances, ramps and lifts for wheelchair users should be designed so that everybody is encouraged to use them. General layout and signalization of the station should provide navigation for the users having impairment of vision. Thus interior illumination and contrasting colors need to focus on the critical points. The use of lighting both natural and artificial should guide those with impairment to the key station areas such as circulation routes and platforms. People with impaired vision tend to move towards the light, and this tendency should be reflected in the sequential passage through stations from entrance to platform. Similarly the use of floor finishes and patterning needs to distinguish major from minor routes, and safe from unsafe zones. The requirements for the location of the signs, their height and type are differentiating when considering disabled travelers. For wheel chair users for instance the appropriate sign height becomes 130 cm instead of general 160 cm because of their eye level (TS 12460, 1998: 31). Illuminated signs should be lit about 50 lux more than the ambient light level (Hackelsberger, 1997: 134). Raised lettering and tactile maps can help travelers in station. Surfaces should provide ease of movement and define variations in zones. Textures of finishing materials help disabled travelers to distinguish the safe zones from unsafe ones, such as, platform and staircase edges. However, some textures of the finishing beneficial for some may be hazardous for the others. For instance, carpet type finishing on floors helps the ones with limited hearings by reducing general noise levels and improving the audibility of the announcements, nevertheless they constitute some problems for movements of the wheel chairs.

II.1.11. Additional Functions in Stations

According to Söderstorm the answer for the question “what is underground railway?” is that the stations of underground system is sometimes a house for the houseless people, it is sometimes a concert hall for the street musicians, and sometimes it is only a means of transport (Söderstorm, 1988: 11). Söderstorm’s suggestions and observations belong to the metro spaces of western world. According to the researcher, especially in Turkey, metro is recently established system therefore a culture including musicians or space for homeless is unfamiliar in this notion. However it is still true that stations today are not serving only for transportation facilities. The following paragraphs are explaining these additional functions and their relationship between each other.

Being the most common, and great public enclosed spaces in the city the stations and even the entrances of the stations may take on many various functions, such as, transportation facility centers, commercial centers, museums, religious places etc. There are commercial and cultural advantages in combining the underground stations to some other functions. This situation is not only beneficial for the public but also for the railway developers. For example due to the heavy pedestrian flow, the commercial centers are very attractive for the investors, and the passengers are pleased with saving their time. Combining public transportation and other developments is a crucial aspect of planning urban railways (Edwards, 1997: 49).

II. 57. A Taksim station İstanbul

II. 57. B Kızılay station Ankara

Figure II. 57: Retail shops in stations from Ankara and Istanbul.

Nevertheless in addition to advantages of extra functions on social and economical life there are some problems focusing on the loss of clarity and contradiction. There is a tendency to increase income from concourse areas, and this means attracting more people to the outlets and make them spend more time there. The slower they go the more likely they are to wander into shops and cafes. Efficiency and shortcuts of passenger routes can run counter to the objectives for maximizing the retail profit from the public areas of stations. Unfortunately light, structure and detail, the main elements of the designer to guide passengers through complex railway functions, can be exploited to deflect the passengers into retail areas and cafes, which produce the loss of clarity in the station, in stations housing large commercial areas.

In Figure II. 57 there is two type of examples, one has the retail shops separated from the station functions, and the other one confuse the commercial functions and the transportation ones. The play of light and procession seems to guide passengers rather more towards the local shopping malls than to the booking hall or platform (Edwards, 1997: 99). Furthermore, misadministration of those spaces can result in the loss of the main point. Considering the retail shops as primary importance areas and insertion of extra measurements for beneficial to retail areas such as advertisements, and information boards, can be count, as misadministration. The first aim should always be mass transportation; all additional functions should remain as secondary.

Direct connections of stations to above ground buildings broaden the functionality of the stations. The Louvre Museum Metro station, in Paris, for example, constructed in 1994, now serves almost exclusively the new system underground shopping malls at the Louvre Museum (Edwards, 1997: 49). commercial centers are not the only type of functions which the stations took on. Underground stations can be in contact with almost all kinds of public buildings such as museums, art galleries and other types of transportation facilities; airports bus terminals, etc. Temporary or permanent exhibitions are the other general used extra functions of the stations (Hackelsberger, 1997: 12). This variety in functions of the stations provide free design ideas, for instance a void derived from technical requirements can be turned into an art exhibition space.

II.2. Structural Criteria in Station Entrances

In Section II.2 it is described that how the structure and construction method of the underground station affect the architectural shape and quality of the station and station entrance. In order to achieve this explanation, the construction methods, structural systems and their features are categorized. Constructing underground metro stations is definitely a concern of engineering as much as of architecture. As discussed in Chapter I.5.3 architecture and engineering are very closely related and intricate concepts. Thus, the designs of engineering choices are directly affecting the designs of the stations and vice versa are also true. Local geological and topographic conditions are decisive factors for the choice of construction methods. Because of constructing these buildings inside the cities, under the streets, the environmental factors become significant, such as; interruption of the traffic above or the noise pollution in neighborhood should be considered. For instance, tunneling method force the stations to be located comparatively long way below the street level, while having the advantages of; not disturbing the street level in construction period, providing civil defense spaces, and greater spaces (Söderstorm, 1988: 21). Edwards claimed that the role of architectural structure is often dominant in the design of the station; expressive structural solutions can provide exterior and interior land – marking (1998: 98). The early examples are often short way below the surface, they built in a classical way of construction which was to excavate open shafts in streets and to make load bearing constructions in steel or concrete (Söderstorm, 1988: 101). These early examples of underground systems were built in a spirit of technology in their time. These stations are admired as technological innovations of their age; they are the symbols which still work of that architectural period (Söderstorm, 1998: 35). It is the usage of structure in that way, what makes the underground caverns, public spaces and buildings of the social life.

Deciding on the applicable method in the construction requires deeply investigation of the advantages and disadvantages of the system. For instance, in Copenhagen metro it is very hard to decide between the superficial layout just below the surface in a “Cut and Cover tunnel” and the one located deeper in a bored tunnel under Copenhagen. The first solution restricts the line to uninhabited areas and the second provides a freer, horizontal layout (Boy and Molgaard, 2002: 13 – 14). it is then understood that the “cut and cover” system would not be financially attractive, so it is decided to construct bored tunnels which lies 20 – 30 meters down below the street level. In case of an emergency situation, termination of traffic in one track, the central platform type station is decided. This platform is achieved by expanding the tunnels so that they can accommodate. The escalators are located in between the tunnels. This type of construction has been used in the London Under ground. However this solution is far from providing a feeling of safety and satisfying the desire for clarity. A large space is needed to fulfill these requirements, however this space is obligated to be located 40 – 45 meters deep, in order to get the enough depth under the limestone to get safe construction. This deep station means long escalators and no daylight. Neither of the two solutions was able to fulfill the architectural requirement for day light in the station area. Reconciling the architectures' demands for clear space to the engineers' demands for safe and economic structures caused great difficulties. None of the numerous proposals put forward could meet all of the many contradictory demands.

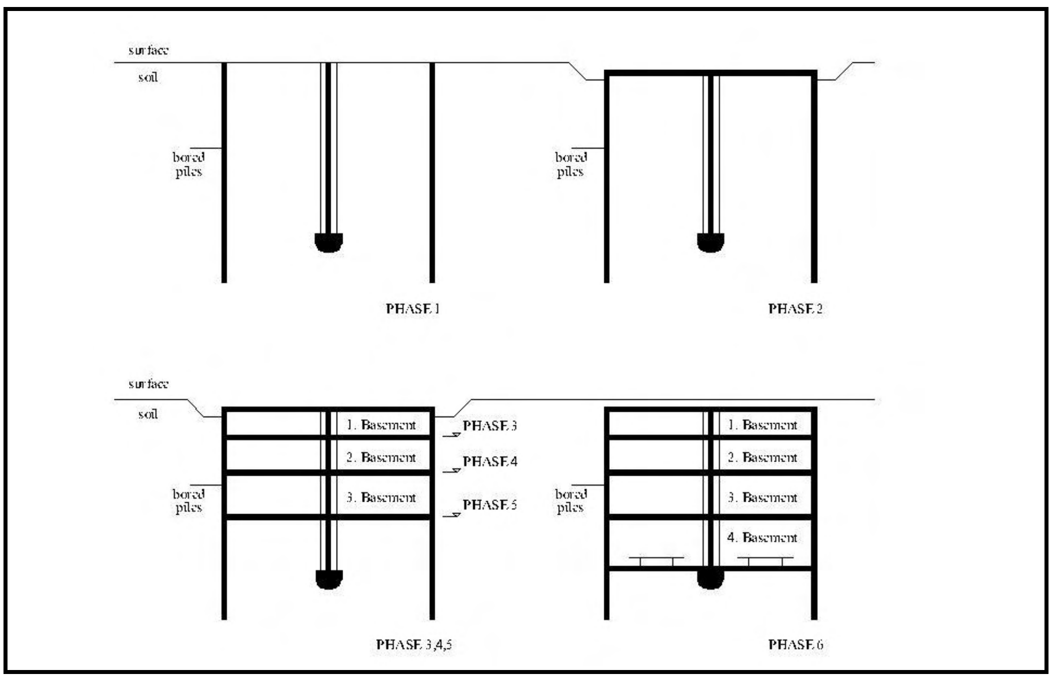


Figure II. 58: Upside down building method. Using bored piles or diaphragm walls (Modified from Hackelsberger, 1997: 37)

Finally one proposal, "constructing from top down" satisfies both the architectural and constructive demands. The final station concept is rectangular box, 22 meters deep, achieved by digging from street level within the casings of secant posts bored down into the limestone. The phases of the construction period can be seen in Figure II. 58. At the level of central station box, it is understood from the design analysis that, it is possible to get the station box, floors and half landings to function structurally as buttressing. Having the advantage of possibility to be constructed at the same time as the buttressing walls are completed, these type stations, can avoid establishing temporary bracing structures. (Sorensen and Larsen, 2002: 45)

Figure II. 59: Heavy concrete structure without any openings, Botanic station, Ankara

Advancing construction technology provides many advantages for stations and their relation with the city. Bal specify these advantages as, opportunity of long span structures, thus providing column free spaces, achieving the desired height spaces and providing resistant spaces against the environmental effects (1995: 43). By the help of contemporary light structures it is now possible relate the station and the outer world more effectively. However there are still some improper attitudes occur in Turkey. For instance the recently constructed stations although being short way under ground and have the opportunity of light steel structures, are constructed with concrete heavy structures without any openings to the outer world (Figure II. 59). In order to get the right decision one should identify all the systems possible for the underground. Classification of those methods or systems will help to identify and understand them. However, all these classifications are so complicated and most of them have not an architectural point of view.

II.2.1. Tunneling System

In places where the stations have to be built at deep levels due to pass underneath existing buildings, infrastructures or due to geographical conditions, the appropriate method for construction is the tunneling method. Such tunnel stations are usually consist of two track tunnels with one platform in-between, as shown in Figure II. 60. This platform also holds the vertical circulation elements. The technology used in that method is the same as in mining systems. The tunnel inner surface is clad with sprayed concrete; due to this shotcrete, cracks and leakages are not avoidable (Hackelsberger, 1997: 33 -34). As a result of this permeability and rough surface of sprayed concrete requires cladding and covering elements. The advanced tunneling technologies have changed these methods. Specially designed TBA machines construct the tunnel with its cutting head and places metal plates surrounding the surface of the rounded tunnel by its rear tools. These metal plates are locked to each other in a circular shape and concrete is pumped in – between the surface of the tunnel and plates.

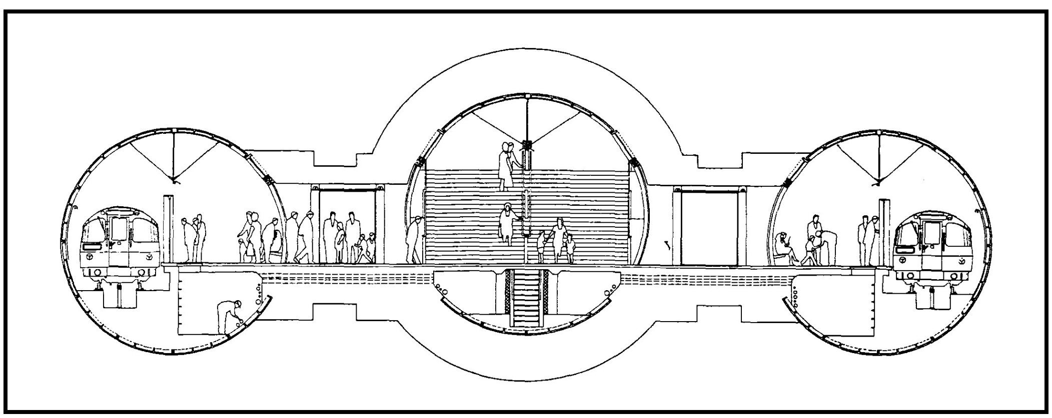


Figure II. 60: Tunnel type of station consists of two track tunnels with one platform in-between (Hackelsberger, 1997: 51).

Stations constructed by tunneling method generally have circular shaped cross section. These types of stations are usually provided free from column spaces. In some situations two circular tunnels intersect each other, which provide a column zone for the station (Figure II. 61) (Bal, 1995: 44). The effect of that type construction to the entrance of the station is generally negative, because of the weak link between the platform level and the entrance level of the station. There is not always visual link between the platform and the entrance because of the limited areas of platforms.

Figure II.61: Station shaped by intersection of tunnels, Germany.
(Downloaded in October 2003 from: http://www.metropla.net)

II.2.2. Cut and Cover System

Cut and cover system is used in places where the station is constructed just below the surface. The building pit is beveled or secured by means of some methods such as; shuttering, injection, groove and bored pile walls. If there is the problem of ground water than secant piling or thin sealing walls are required. In the construction dig the structure is built block by block in the shape of a box. Reinforcements are inserted and concrete is pumped and compacted in the form work as in the above ground buildings. The stations constructed using that method; usually have classical beam and column system. The joints between the blocks are filled with concrete. The station is then covered with excavated soil. Hence water resistance and surface quality is much better than the other sub – grade structures built with other methods. This is the cheapest construction method but having one handicap; requiring large areas. These types of stations offer a variety of design options but because of the weight of the soil above the cross sections of the beams and columns become larger than an ordinary building. Required columns may disturb the openness of the station (Figure II. 62). Moreover the large beam sizes limit the transparency of the station as shown in Figure II. 63, the Botanic station in Ankara does not have any opening to the outdoor even at the entrance floor.

Figure II. 62: Columns disturbing openness of the station, Valencia, Spain. (Downloaded in October 2003 from: http://www.metropla.net)

Figure II. 63: Heavy structure limits the opening to the outdoor, Botanic station, Ankara.

Where there is not enough space for open cast construction, for example in between the buildings under the streets the bored piles and a pile capping slab are used to form a structure. At first a row of large diameter bored piles are driven into the ground on each side of the station. When connected they are secured to each other by a pile cap beam, finally a load bearing floor slabs are cast at the substratum level and pile cap beam level to resist the lateral loads between bored pile walls (Hackelsberger, 1997: 34). This type of construction provides long spanned structures, and surface traffic is only interrupted for a short period of time. Due to the fact that the bored piles have a rough surface and have not water resistance an inner shell is sometimes needed. This inner shell requires additional bracings if it is located deep underground and has high walls, due to the structural problems they present because of the high levels of lateral loads and water pressure. However use of those bracings prevents the clear usage of interior space and impairs the line of vision. Designers therefore must regularly compromise between cutting costs and building a structure of architectural quality. In the case station structures are built in high water levels and with several stories, the construction by means of diaphragm wall with cover slab is the right choice. This method of construction is appropriate for large structures at great depths. Long narrow trenches are cut into the ground and filled with liquid retainers against collapsing. Reinforcements are inserted and then filled with concrete, displacing the liquid by pumping out. The soil in between concretes is excavated and the remaining wall becomes the retaining wall of the pit and the structural wall of the station. Due to the expansion joints water infiltration can not be prevented fully and a sufficiently ventilated, bounded wall cladding is therefore necessary (Hackelsberger, 1997: 35 – 36). By using diaphragm walls in stations great depths and widths can be achieved. In order to stiffen the walls against lateral loads, the concrete floor slabs are cast on the various levels and top level of the diaphragm wall before the subsoil underneath the slab is excavated to the depth of the next lower basement level.

II.3. Construction and Material Performance in Station Entrances

Whatever the structural system of the station is, directly faced parts of the station to the passenger are the surface cladding materials. Concrete, steel or even rough stone surfaces should be covered because of technical and aesthetical reasons. During 1950s and 1960s in the Western World the stations are constructed in concrete pillars, between these pillars there are concrete arches and brick walls. The cladding materials are ceramic tiles and cement mosaic, glazed brick, enameled sheet metals and glass prisms. These type stations' construction period is long. As a result the idea of cave stations are occurred. The suspended ceiling of light metal material is hung in place and the walls are clad with wire mesh. Most of the stations have a pillar of unexcavated rock on the platforms which has the feature of natural sound absorption (Söderstorm, 1988: 23 – 25). Today most of the stations built in "cut and cover" system or advanced tunneling systems. Hence their inside surfaces are not rough as in the past but still there is a requirement of cladding material. In order to provide water resistance, sound absorption, to hide mechanical equipment inside and many more reasons.

Certainly these materials, their construction fittings and details should satisfy some related performance criteria. They must be non-combustible or at least fire-resistant, durable, break resistant, easy to clean, dismountable, replaceable and safe (Hackelsberger, 1997: 12). Since the station is working almost twenty hours a day there is not enough time to maintenance and the maintenance costs are high. This makes it necessary to make all the materials in high level of technical performance (Söderstorm, 1988: 25). Materials also need to be selected so that they do not pose a risk even when they are vandalized. The replacing of materials in a fashion that does not cause potential danger to operatives is part of the criteria for material selection at the outset (Edwards, 1997: 96). It is usually necessary to clad walls, ceilings and floors in order to cope with technical and visual design problems in an appropriate way. The materials should satisfy some requirements changing according to the place they applied thus below there is the specific requirements for various building components.

II.3.1. Floors

Ground surfaces of the entrances are important because they are perceived as the continuation of the public places. Thus they should have at least the same quality as the ground surfaces of the public spaces, they must be robust, non – slip, replaceable, fire resistant and textured so that those with partial sight can feel the edge of platforms or determine the destination route. Textured finishes are normally used to define the risky places in stations such as staircase edges moreover the color contrast should be used in those places. The amount of texturing is important because while textured surface is a useful guide, over textured surface can become an obstacle such as for a heeled woman. The relative texturing of paving surfaces means that some areas are smoother than others: it is these smooth finishes that, when wet, can cause accidents, especially when people are rushing to or from trains (Edwards, 1997: 96). Patterning is also important for the cleaning of the surface; it should not show dirt and easy cleaning. Once worn, the materials should be easily replaceable and of the same quality. Resistance to frost, low liquid absorption, suitability for vacuuming and resistance to strong cleaning agents are all indispensable. Granite has shown the best performance in regard to these requirements. This is why it has been the only flooring material used in recent years (Hackelsberger, 1997: 41). According to Turkish Standards Institute the floors should be as flat as possible; if not, there should be ramps instead of stairs. Stairs should be materialized in such a way that the rises' color is differentiating from the one of steps (TS 12460, 1998: 21). However Figure II. 64 proves the arbitrary attitude in designing the floors of the station entrances. In Figure II. 64. A there are several steps up in order to reach the station, and in Figure II. 64. B on the contrary one step down to reach the station.

II. 64. A Maltepe station

II. 64. B Dikimevi station

Figure II. 64: Arbitrary design of metro entrance floorings, Ankara

II.3.2. Walls

The underground stations are totally enclosed spaces, thus the one inside the station, surrounded mostly by the walls starting from the entrance of the station. Apart from the construction and maintenance costs, there are no restricting factors for wall designs. This turns them into one of the most important and rewarding parts of the design. Important design requirements for wall surfaces can be summarized as; ease of replacement, ease of cleaning, low absorption against graffiti, robustness, fire resistant, water and moisture resistance, resistance against all kinds of solvents and detergents (TS 12127, 1997: 20). The surfaces must be easily cleanable without becoming worn or scratched. Especially the parts above the reachable level (approximately 250 cm) should be easily cleaned because of the difficulty to reach, and the above parts should be resisting to vandalism. Broken or decorative elements should be easily replaceable. All wall surfaces should remain clean for long periods or have measurements against graffiti. For instance exposed concrete is susceptible to graffiti and spraying, and its surface cannot really be cleaned mechanically without being damaged. Compared to the homogenous natural stones, the texture of which remains unchanged through grinding and polishing, this delicacy is a disadvantage that can be reduced in the construction stage by degrading the surface layer through notching or stone granulating. Nothing is more attractive to sprayers than smooth surfaces, and the suitability of large walls for the application of slogans and graffiti. One measurement against graffiti can be grooves or stone granules which make it harder to write on the surface, however the cleaning process can be easier on the smooth surfaces (Hackelsberger, 1997: 41). According to Turkish Standards Institute The wall surfaces should have a light reflection rate of 50% and this is generally achieved by exploiting light colors. Sharp edges of the walls should be rounded or protective panels should be placed at the edges. In needed spaces the wall surface should have the noise absorbing feature or absorbers should be inserted in the wall layers (TS 12127, 1997: 20). In the current examples from Turkey most of the stations walls are clad with the ceramic tiles, which is durable and easy to clean. All ornaments, relieves and textures on the surfaces are done by that material (Figure II. 65). These two dimensioned texture studies remain as additional ornaments only but not the architectural elements as a component of the station.

Figure II. 65: Texture study on wall surface, OSB station, Ankara.

II.3.3. Ceilings

Because of the need for hiding mechanical equipment, lighting fixtures, and acoustical needs almost all stations' ceilings are constructed as suspended ceilings. Suspended ceilings should be as light colored and light weight as possible. (The reflection rate must be above 80 percent and it should not weigh more than 10 kg per square meter) In some cases, light reflecting ceilings often with a semi – matte luster are installed to increase luminosities and make the low shell spaces appear higher. Open – slatted ceilings have now been abandoned, since they largely absorb the light and have sharply angled lower edges which collect dust (Hackelsberger, 1997: 42). Turkish Standards Institute put forward the standards of ceilings of underground stations as follows, the construction of the suspended ceilings must be stable as to resist the pressure based from the movement of the trains. They should contain the lighting fixtures, mechanical equipments, and acoustical absorbent materials. The minimum height of the ceiling is 270 cm, preferably 350 cm, in public places (TS 12127, 1997: 20). Features related with cleaning, durability and replace ability of the wall and floor surface materials are still valid for the suspended ceilings. In Figure II. 66, there is the combination of the suspended ceiling design with the overall station design in Vienna, Austria.

Figure II. 66: Combination of ceiling with the station design, Vienna, Austria. (Downloaded in October 2003 from: http://www.metropla.net)

II.3.4. Finishing Details

The approach to the whole and to the detail should be equally qualified. The performances of the materials are affected by the constructional details. Rigorous detailing provides both architectural and engineering components, to put forward their whole performance. For instance the metal construction behind the wall surface cladding material defines the smooth surface of the wall or the stability of the components. Moreover detailing affects the general look of the station. Due to the fact that the public transport companies do not dispose of large budgets for through cleaning operations, except for the floors, this leads to an avoidance of potential dust traps, for instance horizontal or slightly inclined surfaces. All details should not have visible dust – trap surfaces. Dust cannot settle on them if they are inclined at an angle of more than 80 degrees to the horizontal plane, and this is of particular importance for glass panes in light fixtures, which must not be dimmed by dust (Hackelsberger, 1997: 41). Where this is not achievable due to the opaque materials, attention will be detracted from dust layers by the glittering light reflections from polished surfaces, e.g. of stainless steel. In order to minimize storage and maintenance expenditures standard designs and relevant planning guidelines were devised for equipment and finishing details. The quality of detailing and final designs has been considerably improved due to increased demands for simplicity and clarity (Hackelsberger, 1997: 42). In some examples from western world it can be seen that genuinely designed unique station buildings, united under a single system only by using the common details. Totally different designed stations share a common language by the use of same details. However the situation is not the same in Turkey, resembling station entrances, in the manner of the form of the structure, become alienated to each other by the use of totally different material and details. (Figure II. 67)

II. 67. A 4th Levent station

II. 67. B Taksim station

Figure II. 67: Two stations from Istanbul, having same form but different details alienated to each other.

CHAPTER III

DISCUSSION AND CONCLUSION

When considering the topics pointed out in Chapter II, it is comprehended that underground stations are very significant components of city life as public spaces, thus should not be perceived as merely subterranean engineering structures, not having any architectural style or character. Such stations naturally remain as lifeless underground cavities apart from the city public spaces. It is again understood that entrances are the most important parts of the stations. The designer therefore must create the best relation between indoor and out door. Hence both architecture and structural system have to be integral parts of the metro project from the very beginning. The stations designs not only bent on the functionality of handling passenger transportation but rather focused on a contemporary appearance and the architecture of public spaces. The entrances of the stations should satisfy both function, aesthetic, comfort and security related requirements.

There are many problems observed by the researcher regarding metro station entrances. In order to put forward the appropriate solution, these problems are categorized under the heading of performance criteria of subway entrances (Chapter II). The performance criteria of subway entrances are composed of architectural, structural, construction and material related criteria. All the observed problems are investigated under the light of those performance criteria.

The above ground connections of the station entrances are important not only for the patrons inside them, but also for the whole city, with their above ground connections. These connections can be specified as; entrance structures itself, skylights and the technical shafts. They should have the visual quality of being the components of the city, or even sometimes the landmarks of the city. While considering the station entrances together with the city there are two different attitudes to occur. First one is that to perceive the stations one by one and the other is to gather them as components of a whole system. At the first decision the stations should reflect its own character, or the one of its neighborhood. The disadvantage of this attitude is the alienation of stations from each other. At the second one, on the contrary, all the stations attached to a system reflect the character of the main system. The disadvantage of that attitude is the standardization of the station; each station becomes an imitation of the other. According to the researcher's opinion, at least one of these attitudes should be applied on city metro systems. This means that the entrances of a metro system in a city either share a common architectural language as a component of a system or reflect their own character as a unique element. For instance, the model applied on Jubilee Line Extension project, London (Figures II. 16, II. 17, II. 22, II. 33) can be valid to obtain, underground transportation systems in Turkey. In Jubilee Line Extension project eleven architects are charged to obtain eleven different stations on a single line with the leadership of one chief architect. Architects achieve variety of characters in their own station. However the chief architect provides the common language in all stations with the standardization in material, details, etc. The result is eleven different stations with their own character, sharing a common language. Thus the system as a whole does not alienated from the city. However, the situation in Turkey is completely different that the stations and entrance structures are far from being the components of a united system or reflecting a specified character.

Current approach in underground architecture requires spacious spaces to minimize the negative effects of being underground. With the developed technology huge volumes of spaces with several story heights and gallery voids are now possible. These gallery spaces provide spacious spaces with the feeling of openness and freedom. Although having all technical opportunities, the metro stations in Turkey are seemed to be far from having such spaces. Even the biggest stations, with several lines intersecting each other, like Kizilay station in Ankara, have several storeys without any openings. This situation result in difficulty of comprehending the whole station at once. However in many examples from western world such as those in Athens, London, Copenhagen, etc. having spacious spaces have been successfully created by using gallery voids and skylights.

The existence of skylights provides another advantage of taking down the natural light deep inside the station. Natural light is another significant point in station designs, in order to enhance the psychological effects and feeling of navigation and time on passengers. Because of being located under the dense city texture it is not always possible for designers to provide sufficient skylights, then reflective light shafts are exploited to take the light in. Although having such opportunities, many of the stations in Turkey do not have any of these components. In most of the stations in Turkey, because of not having top lights there is a feeling of entering a dark cave from outside world. Providing openness to outside world can prevent this effect. Hence, with the poor artificial lighting, each space in the interiors of the station become equally illuminated spaces with no focus points. However, artificial lighting is another means of providing well illuminated spaces. The illumination levels should change according to the importance of the space and creating more or less illuminated spaces and can give the sense of direction. Indirect lighting should be preferable in order to avoid glaring on eye. However lighting designs for stations in Turkey involve none of these critical points and exploit ordinary lighting fixtures which result in poorly illuminated spaces.

Accessibility of handicapped people through entrances is another important point to consider in underground station designs. The biggest misunderstood in designing spaces is the suggestion of all handicapped people as having only mobility disabilities, but they can also have audio and visual disabilities. Improving the illumination level of information boards, increasing the audibility of announcements or providing textured surfaces in critical areas can be counted as measurements in order to satisfy the requirements of disabled conscious design. However a real disabled conscious design can only be achieved by designing spaces in accordance to the requirements of psychological needs of disables. For instance providing disabled lifts is not enough to satisfy the needs of disabled passengers, nevertheless, the needed is to provide the disabled lifts in relation with the vertical circulation cores. By that way the psychological isolation between the passengers and disabled people can be prevented. In many stations from Turkey, although providing disabled circulation cores, the psychological effects on handicapped people are ignored, by providing such isolations.

Today stations entrances should not have to be considered as single functioned buildings; modern social life makes them multi – purpose. Today every kind of retail shops, banks, exhibitions even the offices are the inevitable constituents of large underground stations. While combining these extra functions and station, the perceptibility of the station entrance and the priority of transportation function should always be ensured in design. The measurements in order to increase the monetary profit and to obtain a functional station are contradictory to each other, thus an optimum balance should be found.

Construction method and the structural system affect the design of the underground station and dependently to the station entrance, more than ordinary buildings, because of the high environmental engineering problems in underground. The architectural design of the stations and the structural system can not be considered separately, and should be in harmony in order to achieve defined performance criteria such as; feeling of navigation, appropriate illumination, spacious spaces, and positive psychological effects.

The stations having a structural character does not require some additional ornamentations, but works of art by themselves.

Whatever the structural system of the station is; directly faced parts of the station entrance, to the passenger, are the surface cladding materials and the details. Thus the main factors in the performance of the spaces are the applied materials. The appropriateness of the materials to the standards affects the comfort and safety levels, as well as the liveliness of the station. Although each has different material properties, main features considered in the selection of materials can be counted as; their fire resistance, durability, robustness, clean-ability, acoustical performance, non-slipperiness, ease of replacement, ease of maintenance and water and moisture impermeability, depending on their location applied.

Finally it is understood that the design of underground metro stations is an overall architectural design task. Whole of design processes for the stations should be done under the guidance of architects together with the partnership of the engineers, as done similar in the examples of western world. Spacious spaces, natural light inside the station, and visual and psychological relation between the inside and the outside are the fundamentals for providing a satisfactory performance in metro stations entrances. Further studies are also necessary to compile and classify all the design parameters in a list in which all necessary outlines for a proper design of metro station entrances can be found.

REFERENCES

ALTAY, Yunus, (1997) “Planning Considerations for Underground Train Stations. Yeraltı Tren İstasyonları Planlamasında Kullanılabilecek Tasarım Ölçütleri” Masters thesis, Bilkent University, Ankara.

American National Standards Institute, Inc., (1987) “American National Standard Practice for Tunnel Lighting”, Illuminating Engineering Society of North America, New York.

Ankara Municipality, (1990) “Ankaray, Ankara Hafif Raylı Toplu Taşım Sistemi: Avan Proje 3, Teknik Çizimler. Ankaray, Ankara Rail Transit System: Preliminary Design 3, Technical Drawings”, Desen Ofset, Ankara

Ankara Municipality, (2001) [Internet WWW], Adress: http://www.ankara-bel.gov.tr, Accessed: September 2003

Architectural Review (5) (1999) “Underground Jubilation” Emap Construct, London.

Architectural Review (6) (2000) “A Cut Above” Emap Construct, London.

Architectural Review (8) (1999) “Subterranean Drama” Emap Construct, London.

BAL, Filiz, (1995) “Metro İstasyonlarinda İç Mekanın Biçimlenmesi ve TasarImInI Etkileyen Faktörler. The factors That Affect the Shaping and Design of the Interior Spaces in Metro Stations” Masters thesis, Hacettepe University, Ankara.

BINNEY, Marcus, (1995) “Architecture of Rail: the Way Ahead”. Academy editions, London.

BINNEY, Marcus, et al. (1984) “Great Railroad Stations of Europe” Thames and Hudson LTD., London.

BOY, Chirstian, MOLGAARD, Torsten, (2002) “Copenhagen Metro Inauguration Seminar” Cowi, Copenhagen.

CARMODY, John, Raymond, Sterling, (1984) “Design Considerations for Underground Buildings” Underground Space 8, Pergamon press, Sydney.

CERVER, Asensio, (1994) “The Architecture of Stations and Terminals” Hearst Books International, New York.

CIB, (1993) “CIB Master List of Headings for the Arrangement and Presentation of Information in Technical Documents for Design and Construction” Publication 18.

EDELSTEIN, Dick, et al. (1992) “New Architecture: Transport Stations” (8) Atrium, Barcelona.

EDWARDS, Brian, (1997) “The Modern Station New Approaches to Railway Architecture”, E & FN SPON, London.

ENGİN, Vahdettin, (2000) “Tünel” Sirmung, İstanbul.

EREN, Melike, (1998) “Light Rail Transportation Systems, Metro Their Construction Methods and Cost Analysis. Metro İnşaat Metodları ve Maliyet Analizleri” Masters thesis, Marmara University, İstanbul.

HACKELSBERGER Christoph, (1997) “U-Bahn-Architectur in Munchen Subway Architecture in Munich” Prestel- Verlag, Munich – New York.

HANE, Tadashi, (1989) “Application of Solar Daylighting Systems to Underground Space” Tunneling and Underground Space Technology 4, Pergamon press, New York.

HOLLON, Steven D. et al., (1980) “Psychological Responses to Earth-Sheltered, Multilevel, and Above Ground Structures with and Without Windows.” Underground Space 5, Pergamon press, Sydney.

HUGHES, Philip C., (1987) “The Use of Simulated Natural Light in the Design of Earth - Sheltered Environment” Tunneling and Underground Space Technology 2, Pergamon press, New York.

HUGHEY, Joseph B., TYE, Robert L., (1984) “Psychological Reactions to Working Underground: A study of Attitudes, Beliefs, and Evaluations.” Underground Space 8, Pergamon press, Sydney.

KARIHANS, Muller, (1981) “The Architecture of Transport in the Federal Republic of Germany” Internationes, Bonn.

L’arca (110) (1996) “Bilbao: crescita Di Una Città, Metro Railway System” L’arca Edizioni, Milano.

L’arca (145) (2000) “Berlin – Spandau Station, Stratford Station” L’arca Edizioni, Milano.

LAWRENCE, David, (1994) “Underground Architecture” Harrow, Middlesex: Capital Transport, London.

LUPIAC, L., (1981) “Underground Mass -Transit Systems: The Optimum Solution in Major Cities” Underground Space 5, Pergamon press, Sydney.

LYNCH, Kevin. (1960) “The Image of the City” Cambridge: Technology Press.

MAHNKE, Frank H., and MAHNKE, Rudolf H., (1987) “Color and Light in Man-Made Environments” Van Nostrand Reinhold, New York.

MCFARLAND, Russell, (1981) “Cutting the High Costs of Subways” Underground Space 5, Pergamon press, Sydney.

MITZI, Sims, (1991) “Sign Design - Graphics, Materials, Techniques” Thames and Hudson, London.

PAUL, Stollard, ABRAHAMS, John, (1991) “Fire from First Principles: A design guide to building fire safety” Chapman and Hall, London.

PEKTAŞ, A. Gülay, (1997) “An Expert System Proposal for the Evaluation of Pedestrian Circulation at Underground Stations. Metro İstasyonlarında Yolcu Sirkülasyonunun Değerlendirilmesi İçin Bir Uzman Sistem Önerisi” Masters thesis, İstanbul Technical University, İstanbul.

SCHWANDL, Robert, (2001) [Internet WWW], Adress: http://www. metropla. net, Accessed: September 2003

SEVDİN, Ayşimin, (1992) “Mimari Tasarimda Bina Total Performansı Kavramı: Metro İstasyonlarında Değerlendirme. The Concept of Total Building Performance İn Architectural Design” Masters thesis, İstanbul Technical University, İstanbul.

SINHA, R.S., (1991) “Underground Structures Design and Construction” Elsevier, Tokyo.

SÖDERSTORM, Goran, (1988) “Art Goes Underground” Trans. Laurie Thompson. Centraltryckeriet AB, Sweden.

SORENSEN, Mille Juul, LARSEN, Lotte Raabo, (2002) “The Architecture: the Deep Stations in Daylight” The Orestad Development Coop., Orestad.

Tekfen Engineering CO., (2002) Application Drawings “Ankara Rail Transit System Stage 3 Works” Ankara.

Turkish Standards (1997) “TS 12127 Part 1: Design Criteria of Underground Station Facilities, Bölüm 1: Yer Altı İstasyon Tesisleri Tasarım Kuralları” Turkish Standards Institute, Ankara.

Turkish Standards (1998) “TS 12460 Part 5: Design Criteria of Facilities for Handicap and Elderly People, Bölüm 5: Özürlü ve Yaşlılar İçin Tesislerde Tasarım Kuralları” Turkish Standards Institute, Ankara.

Turkish Standards (1998) “TS 12461 Part 8: Design and Layout Criteria of Station Symbols, Bölüm 8: İstasyon Tanıtım Sembolleri – Tasarım ve Yerleştirme Kuralları” Turkish Standards Institute, Ankara.

Turkish Standards (1999) “TS 12574 Part 10: Graphs and Signs in Stations, Bölüm 10: İstasyon İçi İşaret ve Grafik Tasarım Kuralları” Turkish Standards Institute, Ankara.

Turkish Standards (2000) “TS 12637 Part 22: Design Rules of the Travel Ticket System, Bölüm 22: Biletlendirme Sistemi Tasarım Kuralları” Turkish Standards Institute, Ankara.

VANCE James E. JR., (1995) “The North American Railroad: Its Origin, Evolution, and Geography” The Johns Hopkins University Press. Baltimore and London.

WADA, Yuji, SAKUGAWA, Hinako, (1990) “Psychological Effects of Working Underground” Tunneling and Underground Space Technology 5, Pergamon press, New York.

XUEYUAN, Hou, YU, Su, (1988) “The Urban Underground Space Environment and Human Performance” Tunneling and Underground Space Technology 3, Pergamon press, New York.

YLINEN, Jaako, (1989) “Spatial Planning in Subsurface Architecture” Tunneling and Underground Space Technology 4, Pergamon press, New York.

NOTE: Photographs and drawings are prepared by the researcher, unless otherwise is mentioned.

APPENDIX A

OSB Station, Third Phase Ankara Metro

In Appendices of the thesis, some drawings of some new stations from Ankara, currently under construction, are illustrated, in order to show the current approach to the metro station entrances. After having experience from old phases of the Ankara underground system, there are some improvements in the designs of the stations entrances. For instance, the skylights seen in Appendix A, in OSB station in third phase of Ankara metro is a valuable development. With the help of those skylights the natural light inside the station provides a positive atmosphere and the feeling of navigation and time. Moreover, the sequential placement of the skylights, help the passengers to grasp the station even before they enter. However there are still some problems related with the topics mentioned in chapter II. As can seen from the Appendix B, although located short way below the surface level and having a green area above the station, Botanic Station, of third phase of Ankara metro, do dot have adequate outdoor relationship. Inside the station there are no spacious spaces which can improve the relationship between the interior and outdoor. Especially the location of the vertical circulation cores seems not to be properly designed. Instead the circulation cores to downstairs could have been placed in a more spacious space, which can combine the entrance of the station and the platform level. In conclusion, it can be understood from the drawings below, the entrances of metro stations still could not integrate the underground system with the city and responds to the users requirements.

Figure A. 1: Site plan of OSB station in third phase metro. (Tekfen Engineering CO., 2002)

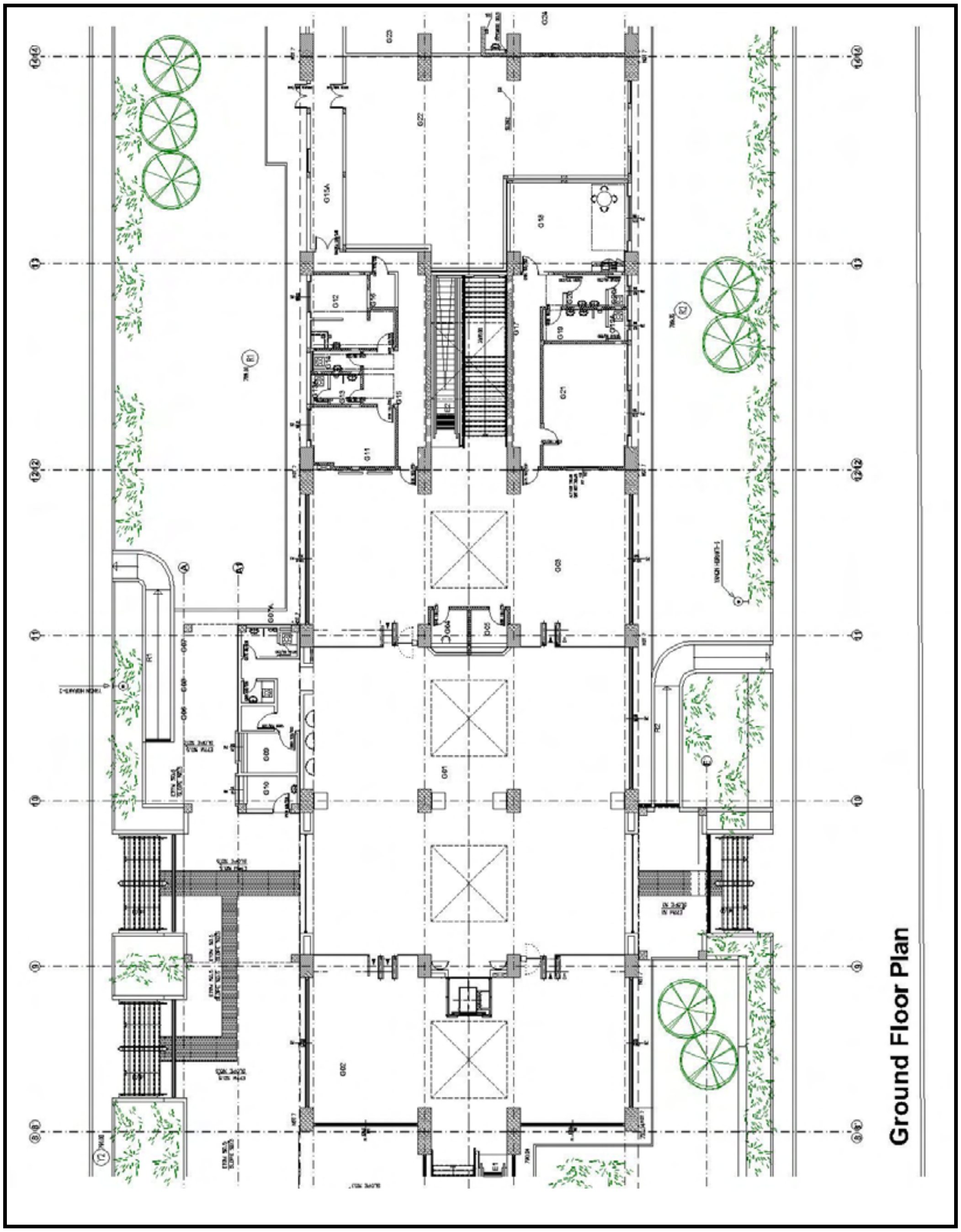


Figure A. 2: Partial entrance floor plan of OSB station in third phase metro. (Tekfen Engineering CO., 2002)

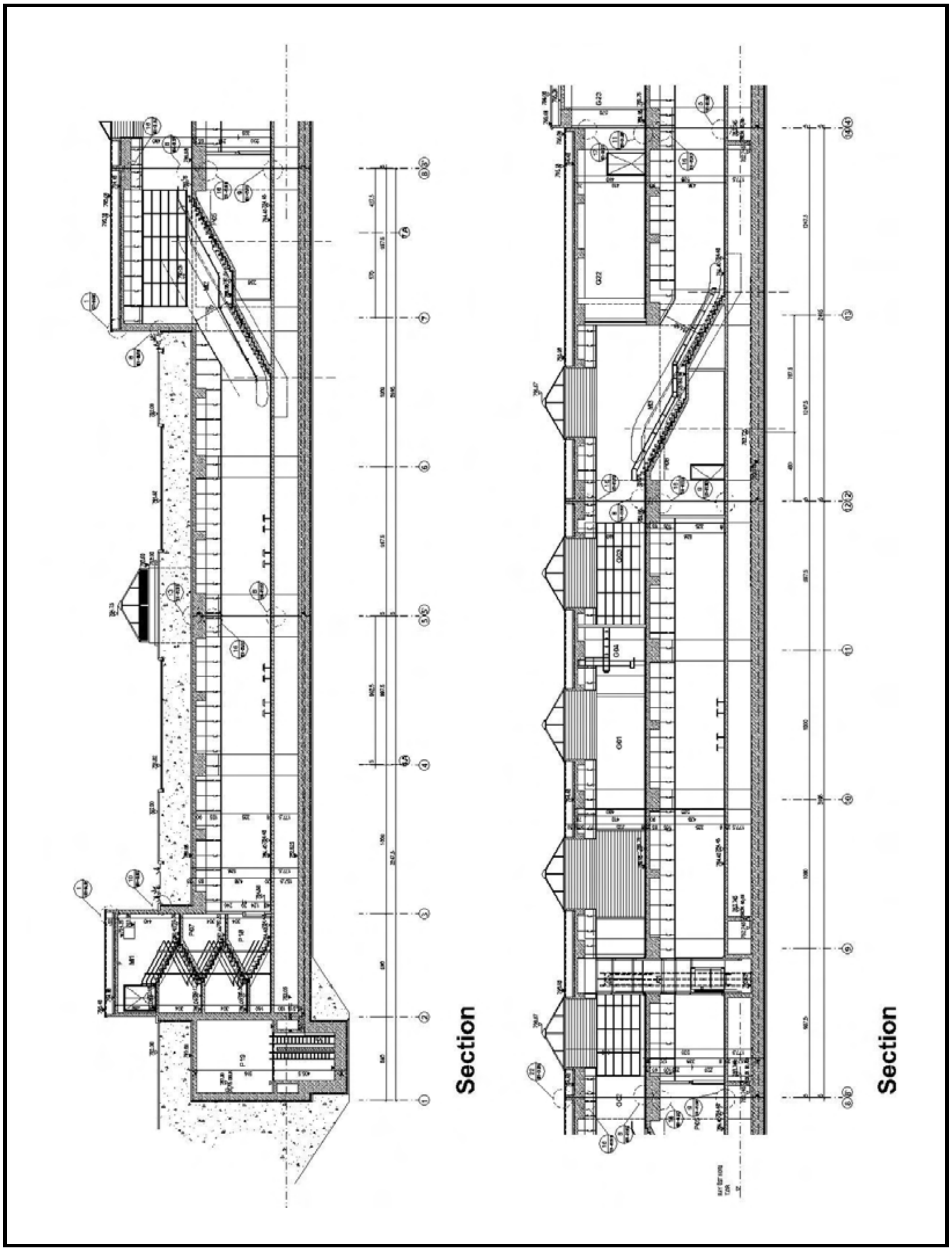


Figure A.3: Longitude section of OSB station in third phase metro. (Tekfen Engineering CO., 2002)

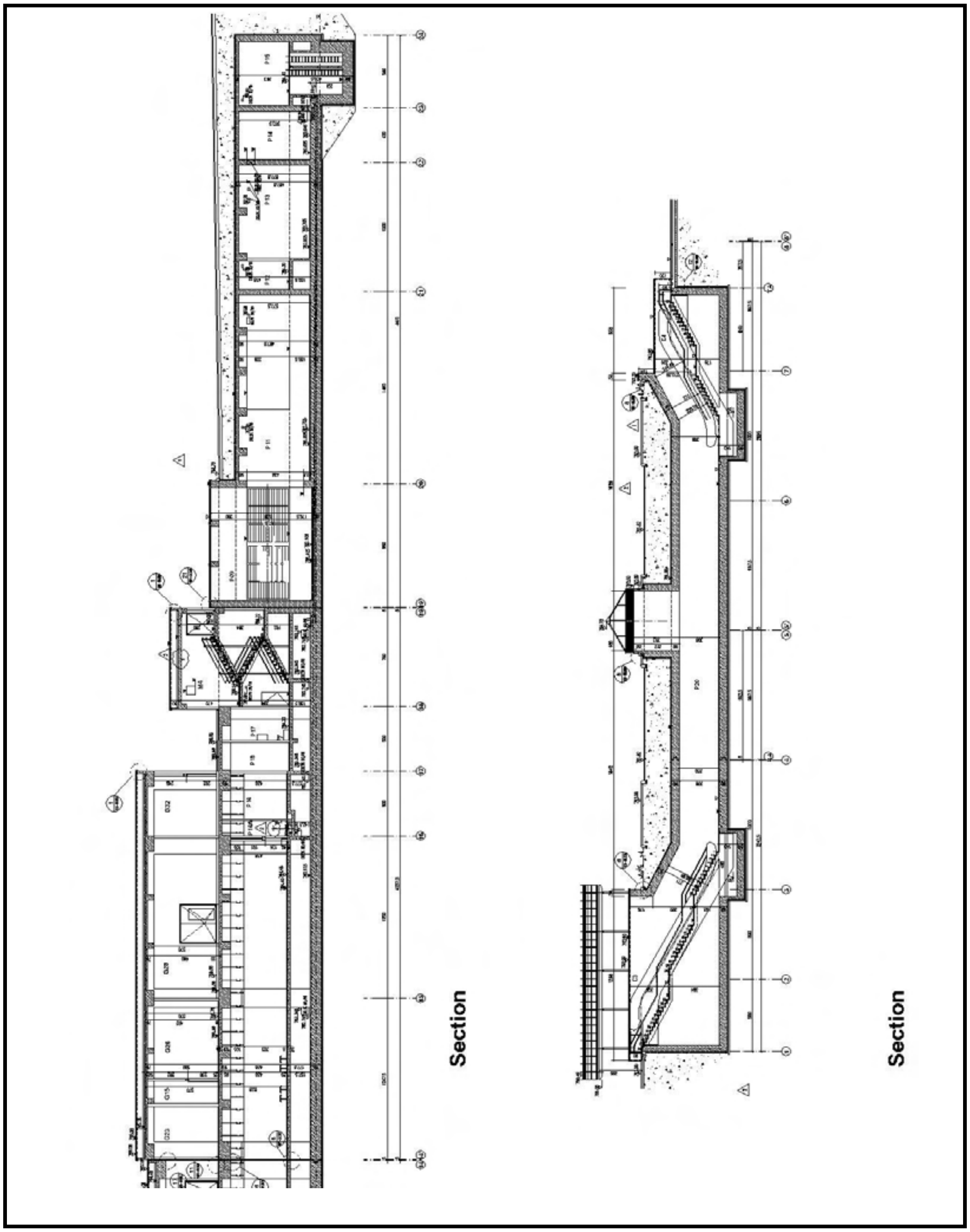


Figure A. 4: Longitude section of OSB station in third phase metro. (Tekfen Engineering CO., 2002)

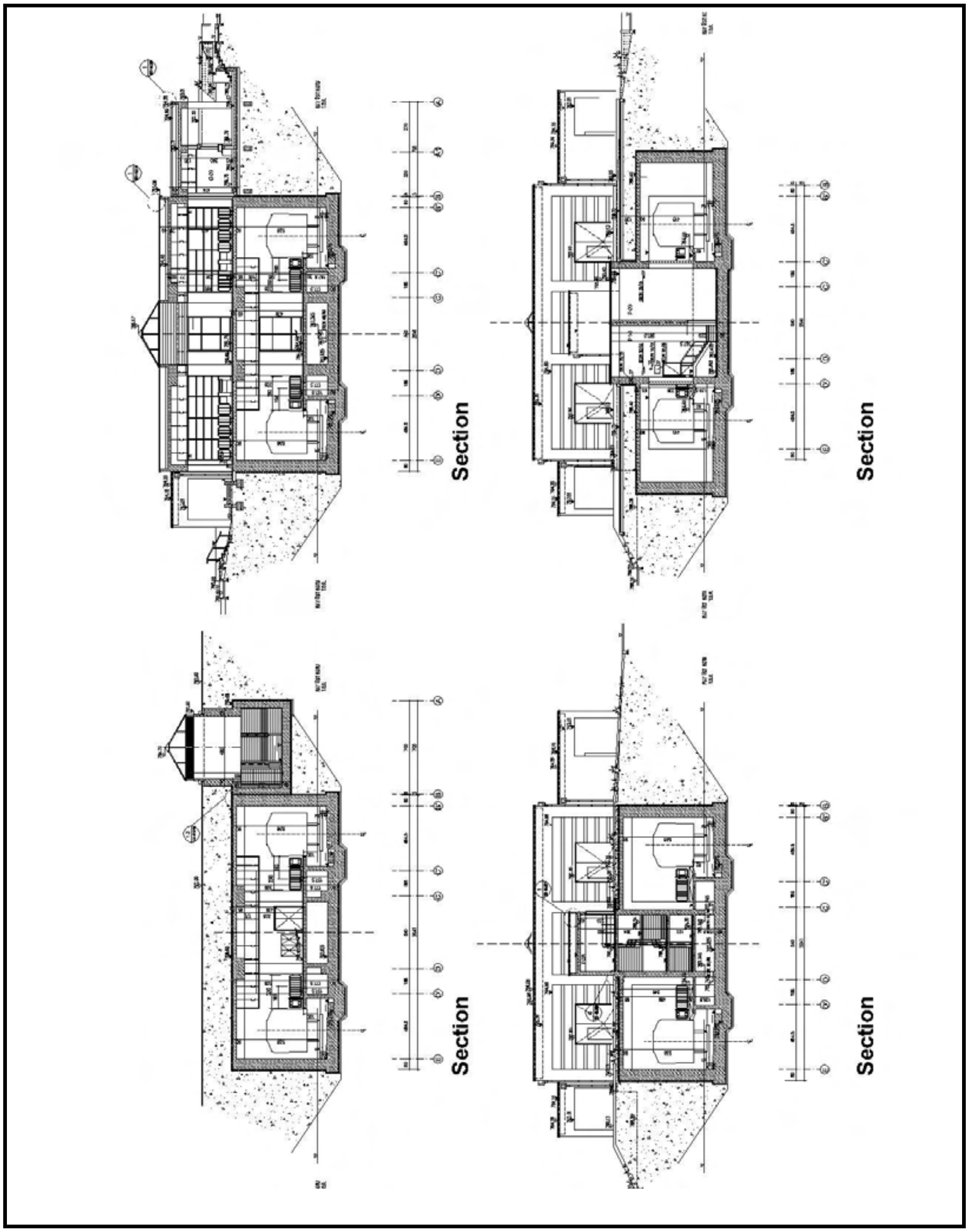


Figure A. 5: Cross section of OSB station in third phase metro. (Tekfen Engineering CO., 2002)

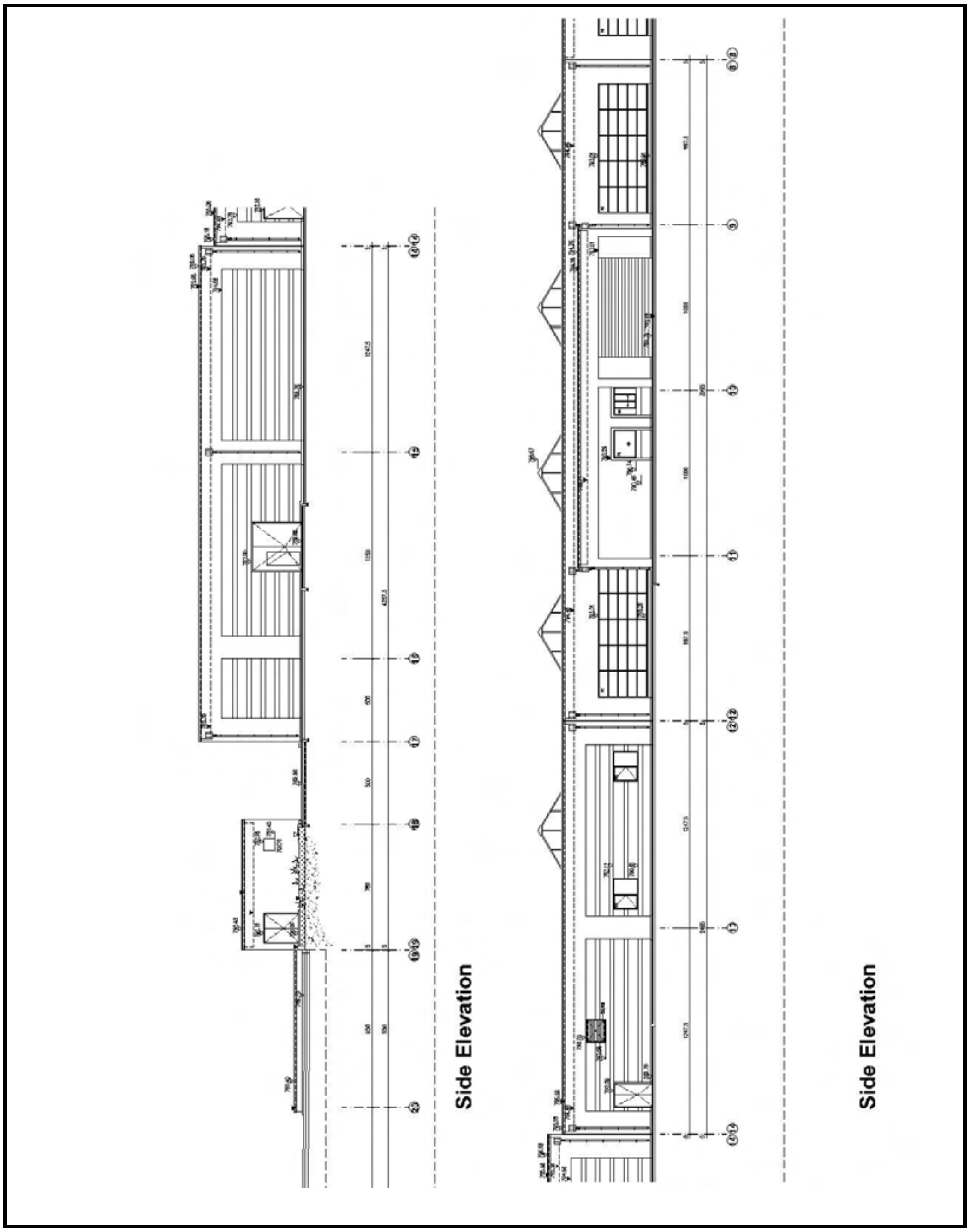


Figure A. 6: Side elevations station of OSB station in third phase metro.
(Tekfen Engineering CO., 2002)

APPENDIX B

Botanic Station, 3. Phase Ankara Metro

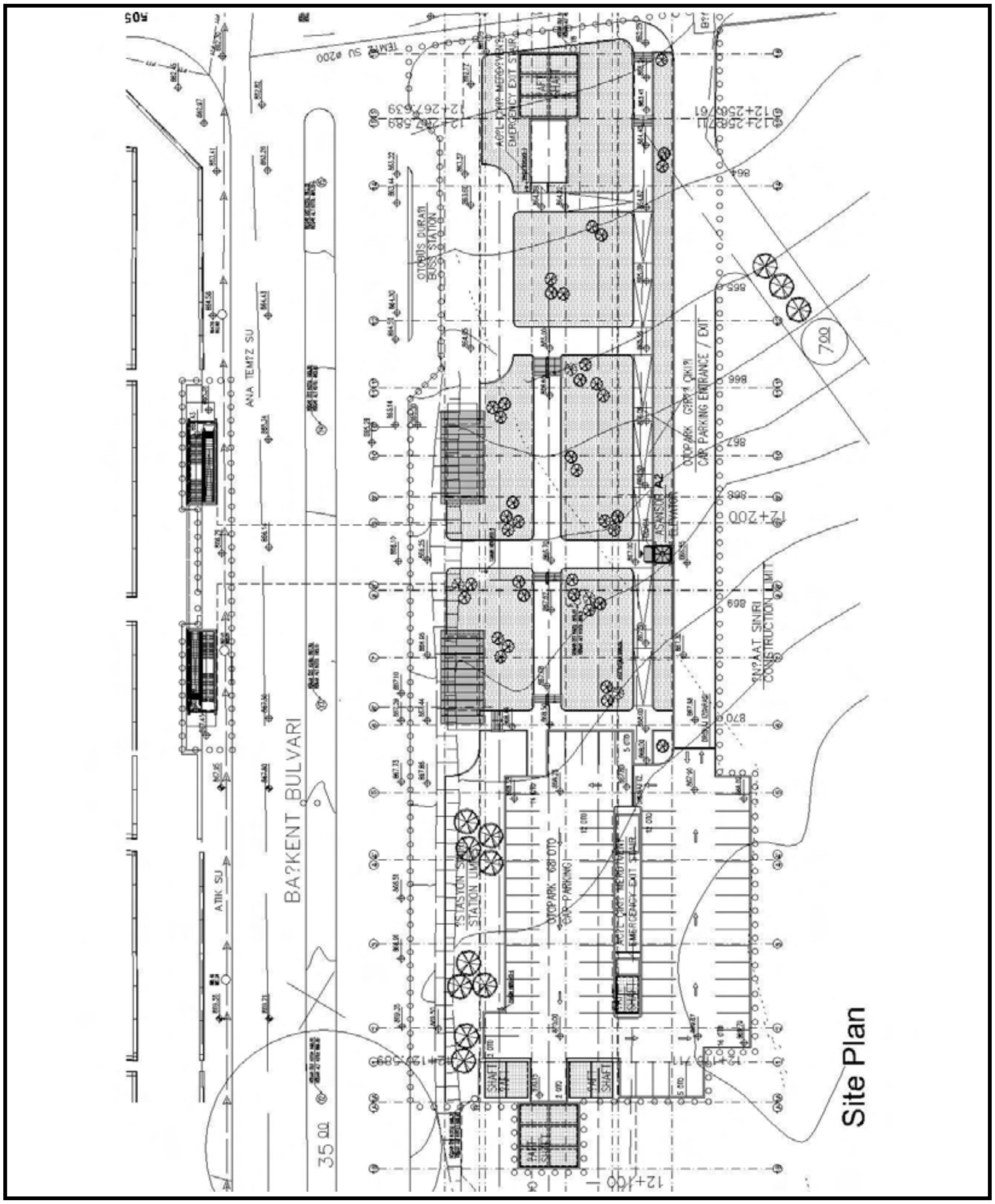


Figure B. 7: Site plan of Botanic station in third phase metro. (Tekfen Engineering CO., 2002)

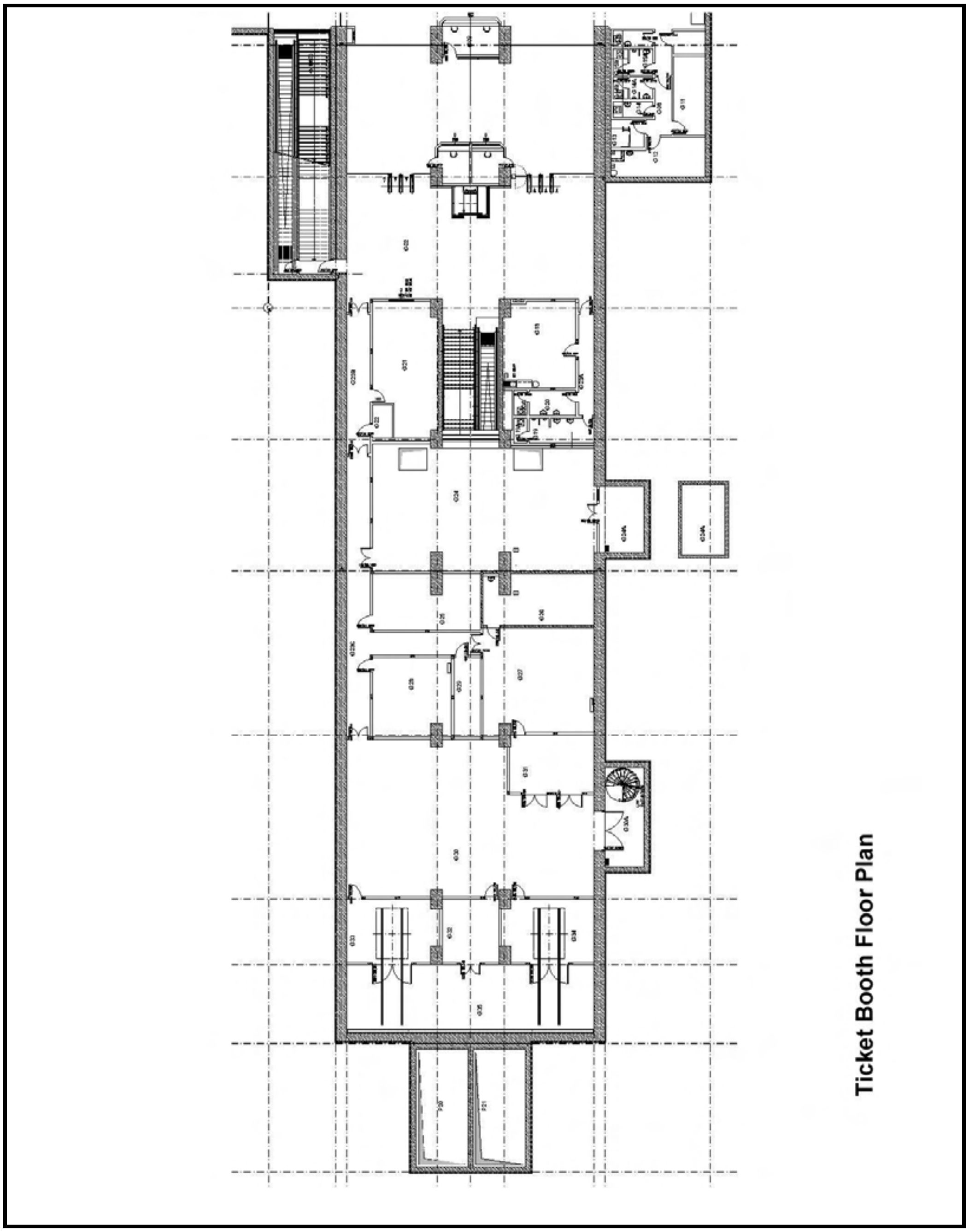


Figure B. 8: Ticket booth floor partial plan of Botanic station in third phase metro. (Tekfen Engineering CO., 2002)

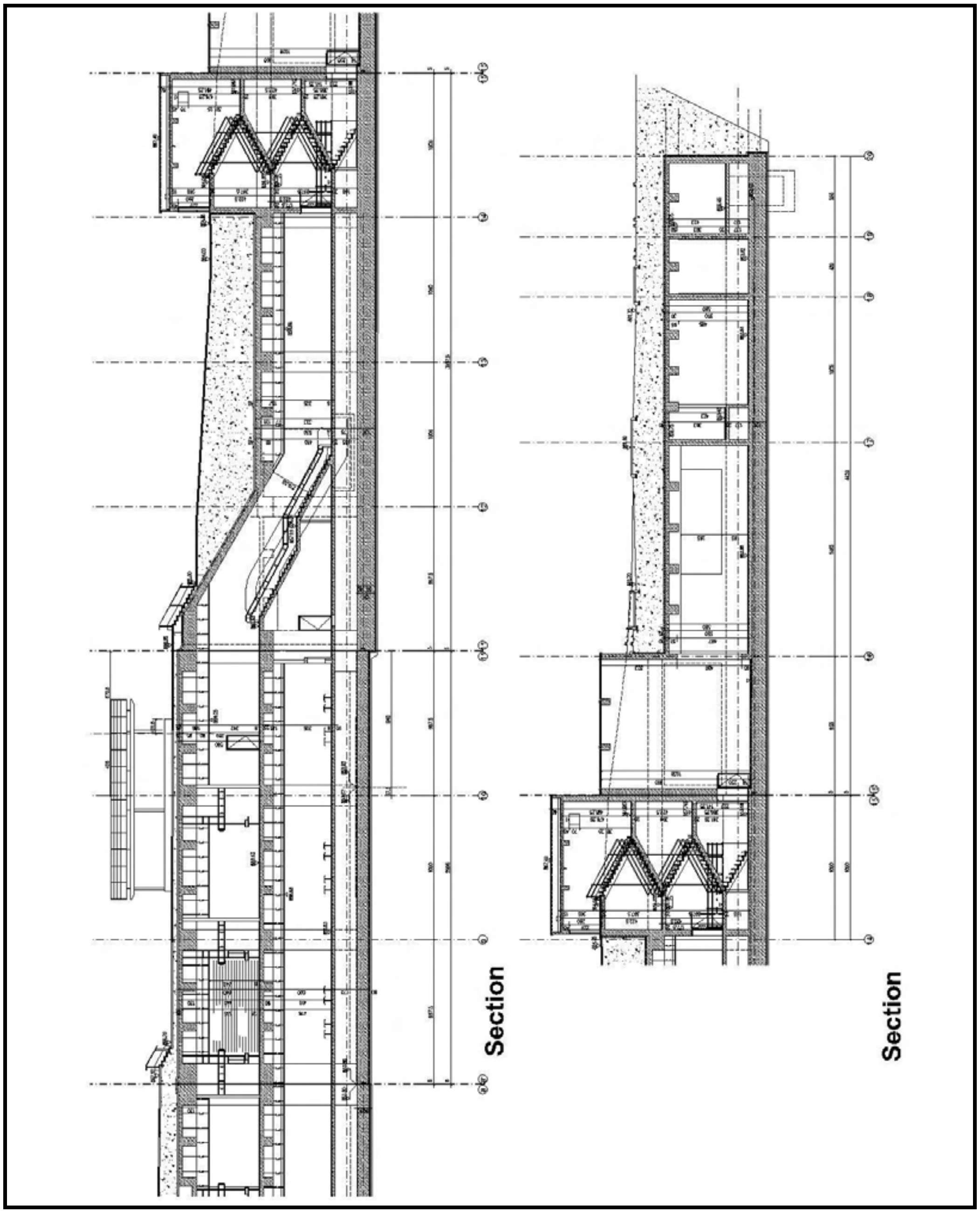


Figure B. 9: Longitude section of Botanic station in third phase metro.
(Tekfen Engineering CO., 2002)

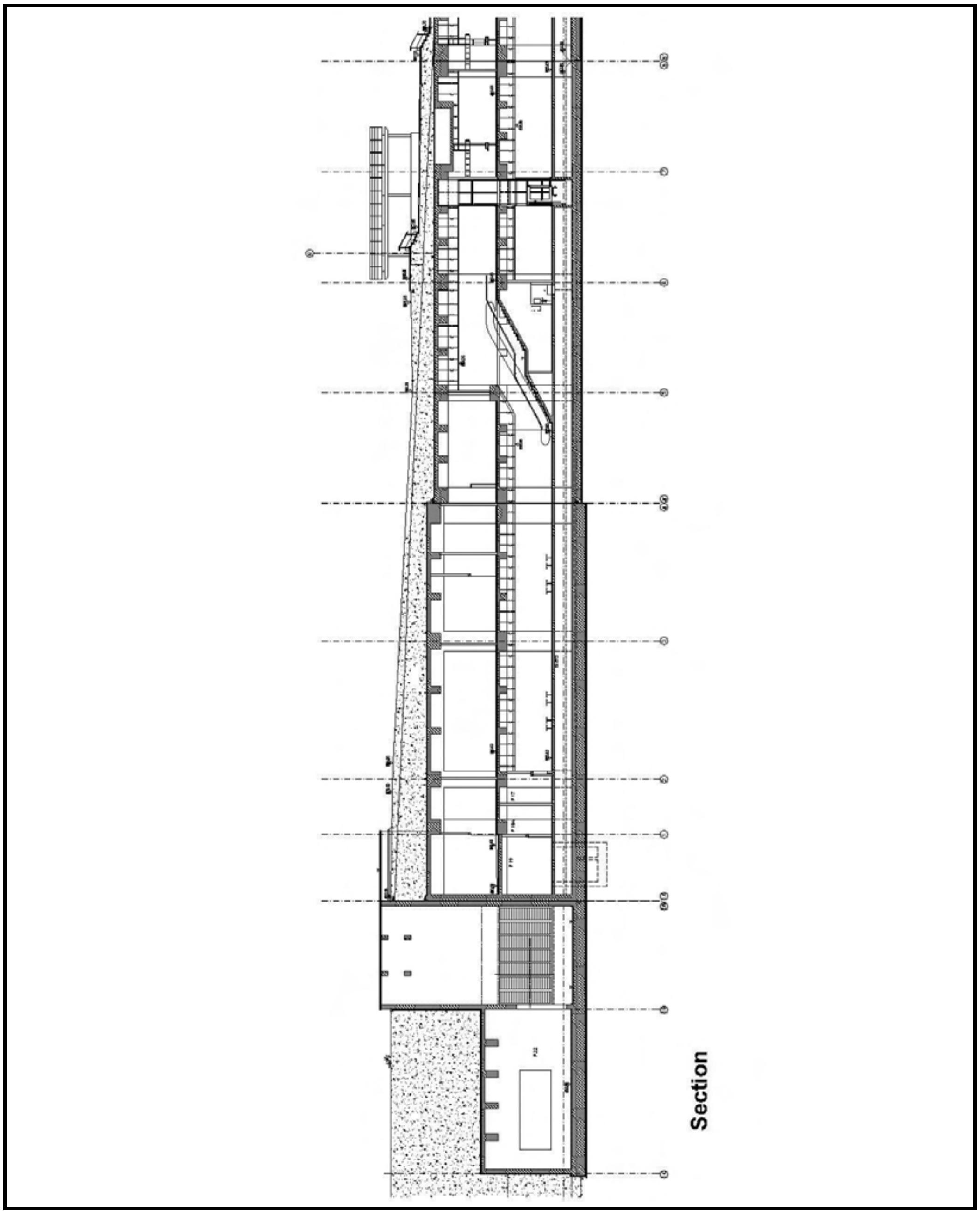


Figure B. 10: Longitude section of Botanic station in third phase metro.
(Tekfen Engineering CO., 2002)

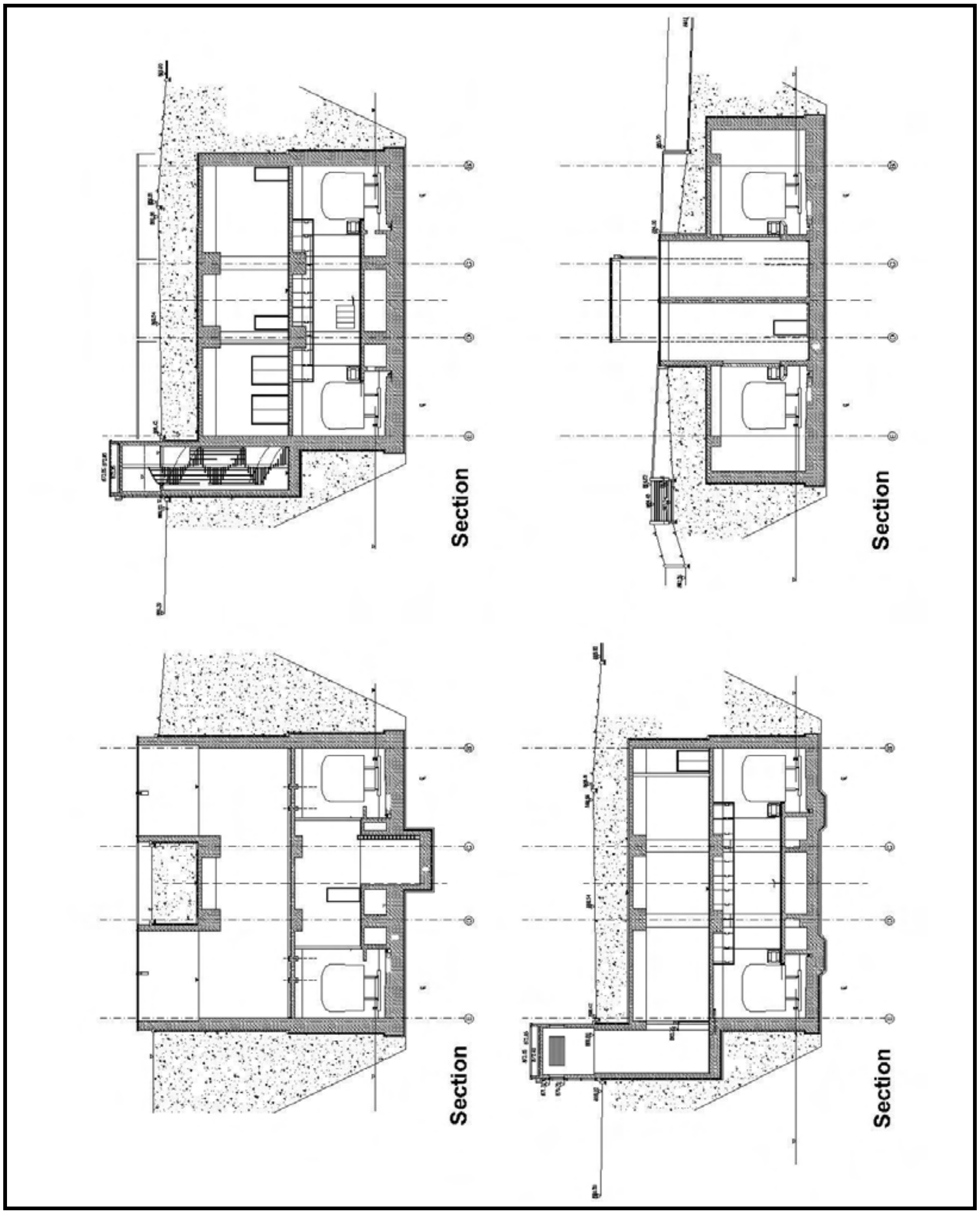


Figure B. 11: Cross sections of Botanic station in third phase metro. (Tekfen Engineering CO., 2002)