A RESEARCH ON THE DESIGN CRITERIA OF SUBWAY STATIONS

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submitted by **ÖZGÜR ÖZTÜRK** in partial fulfillment of the requirements for the degree of **Doctor of Philosophy in Architecture, Middle East Technical University** by,

Prof. Dr. Halil Kalıpçılar
Dean, Graduate School of **Natural and Applied Sciences** __________________

Prof. Dr. Fatma Cana Bilsel
Head of the Department, **Architecture** __________________

Prof. Dr. Soofia Tahira Elias Ozkan
Supervisor, **Architecture** __________________

Examining Committee Members:

Prof. Dr. Fatma Cana Bilsel
Architecture Dept., METU __________________

Prof. Dr. Soofia Tahira Elias Ozkan
Architecture Dept., METU __________________

Asst. Prof.Dr.Cem Kırlangıçoğlu
Urban & Regional Planning Dep., Sakarya University __________________

Prof. Dr Burak Asiliskender
Architecture Dept., Abdullah Gül University __________________

Prof. Dr. İnci Basa
Architecture Dept., METU __________________

Date: 23.09.2020

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

Name, Last name : Özgür, Öztürk

Signature :

ABSTRACT

A RESEARCH ON THE DESIGN CRITERIA OF SUBWAY STATIONS

Öztürk, Özgür
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Supervisor: Prof. Dr. Soofia Tahira Elias Ozkan

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Subway systems are complex infrastructural elements that require the cooperation of various engineering and architectural disciplines. In addition, by being buried, subway stations lack the visibility to be a part of an architectural design concern. However, with their important features in the urban context combined with their high number of users, subway stations should be evaluated as more than dots showing the station locations on the transportation network. As a result, this study develops an alternative look at this significant part of the infrastructural component. This dissertation is aimed to investigate the subway stations from architectural design concerns perspective and challenged the common understanding that claims them to be engineering structures.

This study investigates the concept of the subway station from two different viewpoints. First, it presents the developed technical approaches to the design of stations by looking at various national and international technical design guidelines and standards to understand alternative design approaches in the world. Afterward, subway stations dating from the first ones to the contemporary examples are presented to trace the story of the subway station design and to understand alternative design approaches.

The findings of the study show us that the current prescriptive method to design a subway station has its problems and pitfalls which keep generating urban underground spaces with solely a technical approach.In other words, the current process for designing subway stations focuses on the related engineering criteria based on standards and technical guidelines.   Hence, this study offers suggestions to designers to enhance their station designs and presents a guideline for designing subway stations with a greater focus on the architectural design process.

During this study, the COVID-19 pandemic broke out, and the common concepts such as personal space, transportation, and closed spaces changed dramatically. Consequently, this study also looks at how the pandemic has affected our understanding of subway stations and how use of inner-city transportation has changed and will evolve in the future.

Keywords: Subway stations, Underground spaces, Design guidelines, Design standards, Epidemics

ÖZ

METRO İSTASYONLARININ TASARIM KRİTERLERİ ÜZERİNE BİR ARAŞTIRMA

Öztürk, Özgür
Doktora, Mimarlık
Tez Yöneticisi: Prof. Dr. Soofia Tahira Elias Ozkan

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Metro sistemleri, çeşitli mühendislik ve mimari disiplinlerin iş birliğini gerektiren karmaşık altyapı unsurlarıdır. Bu yapılar yerin altında görünürlükten yoksun bir durumda oldukları için, mimari tasarım olarak çok irdelenmemiş bir konu olarak karşımıza çıkmaktadır. Ancak metro istasyonları, kentsel bağlamdaki referans olabilme özellikleri ve yüksek kullanıcı sayısı ile ulaşım sağlayan bir nokta olmaktan ötesinde değerlendirilmelidir. Bu durumdan dolay, bu çalışma bir altyapı proje unsuru olarak kabul edilen istasyonlara farklı bir bakış geliştirmektedir. Bu tez, metro istasyonlarını mimari tasarım açısından araştırmayı amaçlamakta ve bunların mühendislik yapıları olduğunu iddia eden ortak anlayışa meydan okumaktadır.

Bu çalışma, metro istasyonu konseptini iki farklı bakış açısıyla incelemektedir. İlk olarak, dünyadaki alternatif tasarım yaklaşımlarını anlamak için çeşitli ulusal ve uluslararası teknik tasarım kılavuzlarına ve standartlarına bakarak istasyonların tasarımına yönelik gelişmiş teknik yaklaşımları sunar. Ardından, metro istasyonu tasarımının öyküsünün izini sürmek ve alternatif tasarım yaklaşımlarını anlamak için ilklerinden çağdaş örneklere uzanan metro istasyonları sunulur.

Çalışmanın bulguları bize, bir metro istasyonunu tasarlamak için mevcut yöntemlerin, tek bir teknik yaklaşımla ve kuralcı olarak devam etmesi dahilinde

yerin altında oluşturdukları kamusal mekanlarda çeşitli problemlerin olduğunu göstermektedir. Başka bir deyişle, metro istasyonlarının tasarlanması için mevcut süreç, standartlara ve teknik yönergelere dayanan ilgili mühendislik kriterlerine odaklanmaktadır. Bu nedenle, bu çalışma tasarımcılara istasyon tasarımlarını geliştirmek için öneriler sunmakta ve mimari tasarım sürecine daha fazla odaklanarak metro istasyonlarının tasarlanması için bir kılavuz sunmaktadır.

Çalışmanın araştırılması sırasında, COVID-19 salgını patlak verdi ve kişisel alan, ulaşım ve kapalı alanlar gibi ortak kavramlar çarpıcı biçimde değişti. Dolayısıyla bu çalışma, aynı zamanda pandeminin metro istasyonları anlayışımızı nasıl etkilediğini ve şehir içi ulaşım kullanımının nasıl değiştiğini ve gelecekte nasıl gelişeceğini de incelemektedir.

Anahtar Kelimeler: Metro İstasyonları, Yeraltı Mekanları, Tasarım Kılavuzları, Tasarım standartları, Pandemi

To my wonderful family for their never-ending support,

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INTRODUCTION

1.1 Problem Definition

Starting from human's first journey out of Africa, their survival, as well as advancement, has depended on communication and transportation. They had to move from one location to another for different reasons like safety, sustenance, or search for new pastures. With time, settlements emerged near water bodies and fertile lands and developed into cities that were connected to other cities through rivers, roads, and rails to establish trade. The Persian royal road from Susa to Sardis, mentioned in Herodotus's History (1998) as the movement of information, armies, and goods across the empire, was a critical link that held the Persian empire together. Two of the seven wonders of the ancient world, the Great Lighthouse of Alexandria and the Colossus of Rhodes, are edifices that reflect the importance of transportation and connection to other cities in human history. The Romans had perfected the concept of being connected with roads, bridges, and maritime structures to other parts of the world and considered their capital as the capital of the world (Caput Mundi). However, until the integration of railways in the cities, cities were in more walkable scales due to fundamental logistic reasons (English, 2019). Cities with ports or harbors along the sea, lakes, or rivers used them for transloading only, while moving inside the city was limited by the capacities of the local means of transportation (Vuchic, 2007).

Commuting for work on a daily basis was a concept developed with the industrial revolution and steam-powered trains. Along with the industrial revolution, with new job opportunities and services, the population shifted from rural areas to cities. This population movement, called urbanization, started in the 18th century still keeps its momentum. At the beginning of the 21st century, more than half of the world population started to live in the cities (United Nations, 2018). As shown in English's (2019) interesting map study, where he compares the expansion of cities of different eras in order to trace the evolution of the cities, one can see that the size of the cities expanded in a dramatic way (Figure 1). At the same time, this expansion could not have been achieved without the power of modern transportation systems.

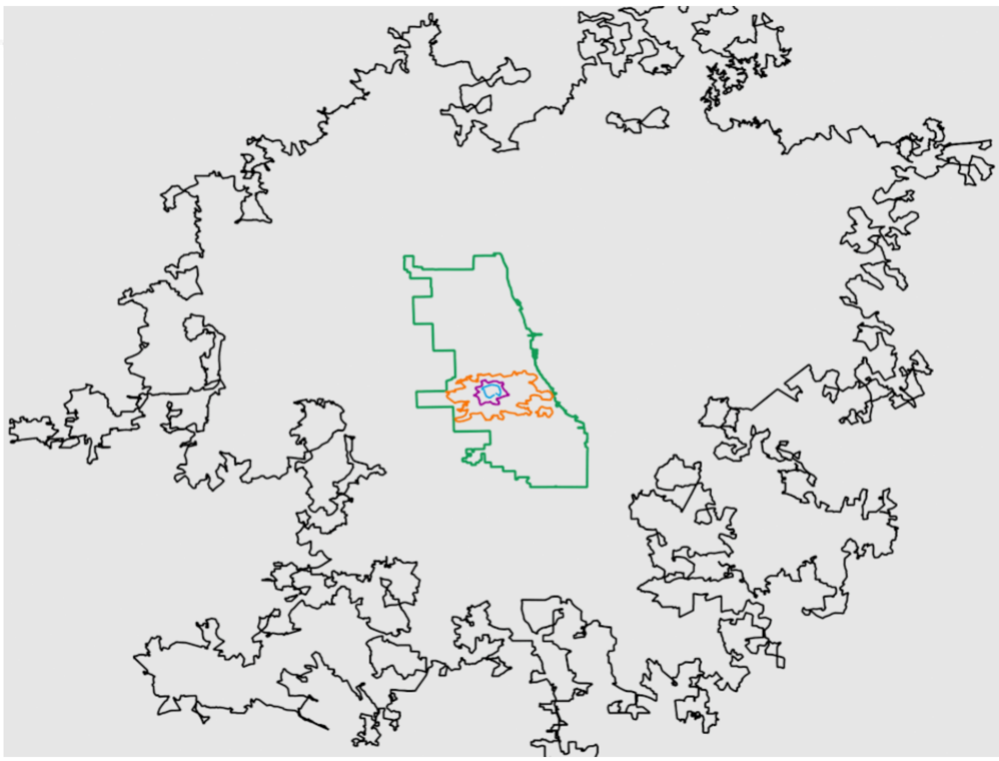


Figure 1- The borders of Ancient Imperial Rome around 275 A.D. in purple, Medieval Paris around 1383 in blue, Victorian London around 1870 in orange, early 20th century Chicago, and modern-day Atlanta. Source: (English, 2019)

In metropolitan cities, railway systems play an essential role in the formation of urban patterns within urban transportation and suburban - city relationship. This ease of movement from the periphery to urban centers has led to congestions in the city at peak hours. Just as traffic jams on roads, station buildings also appear in the news due to pedestrian jams (Şenerdem, 2010; BBC News, 2014; İHA, 2015; Hürriyet Haber, 2016; Wong, 2016). According to a study conducted by the Netherlands Embassy, İstanbul is the most congested city in Europe and the 6th most congested in the world (Nuijens, 2018).

Consequently, it is imperative to develop solutions to the existing situation and provide better mass transportation in the city. On a daily basis, 2 million people use the subway systems in İstanbul. In most congested metropolises, it is possible to see a high volume of passenger transportation with railway systems, while more and more cities are getting interested in constructing light rail or subway/metro systems. For example, the existing subway infrastructure in İstanbul is 156km long (İstanbul Büyükşehir Belediyesi, 2020), excluding Marmaray line, and with the expansions of existing lines and construction of new lines, it is expected that the total length will exceed 500km. Similarly, other Turkish cities are aspiring to develop and expand a rail-based transportation system. However, despite the good intentions and the political will to establish a hi-tech subway transportation system, attention to the architectural design of the subway stations has been neglected so far.

A review of studies conducted on subway stations has shown that due to the interdisciplinary framework of this building type and different design inputs, most of the research is based on the performance analysis of different disciplines, such as the engineering design of the subway stations. These studies mostly focus on fire protection, fire prevention, HVAC systems, acoustics, structures, geotechnical issues, and egress and evacuation problems in subway stations, with hardly any focus on the architectural design concerns of a subway station.

Due to a lack of architectural discourse on this building type, standard or typical architectural designs of subway stations have started to draw the attention of researchers from different aspects; such as:

- The effect of a Subway Station on the urban pattern.
- The effect of the urban pattern on the Subway Station.

- Accessibility of/in Subway station from its peripheral areas.
- The history of the Subway Station or Subway line in the selected time period.

Moreover, when looking at the built stations, it is possible to see a simplistic design approach applied to all stations along the line. The starting point for the design process of this station is mostly technical guidelines and standards. While these guidelines and standards are mostly related to emergency evacuation, scaling building elements for different uses, design for fire protection, and providing accessibility.

Due to its nature, transportation systems require not only planning and organization but also technology and techniques to fabricate. They are applied in urban scales and commissioned by the authorities. In addition, because of their technicality, they require close collaboration among different disciplines of engineering and design. Owing to its vast scale and collaborative nature, urban transportation projects are mostly classified as infrastructural projects and managed by engineers. As a result, in a considerable portion of infrastructural projects, architectural design concerns are overlooked compared to structural and financial design concerns. However, this technical approach creates a design environment where designers also focus on the functionality, and design guidelines generate stations with a lack of contextual approaches. Nevertheless, starting from ancient times, transportation has played a vital role in shaping our lifestyle, both from functionality and contextual perspectives.

In this context, it is difficult to say whether transportation buildings are the superstructure part of the infrastructure only or an entity on their own. Instead of coming up with a definitive approach to fix responsibilities for management purposes, we can accept transportation buildings to be in a grey area where they combine both infrastructure and superstructure. Otherwise, these buildings will be seen as isolated, mono-functioning, and mostly products of engineering where architects are expected to design within the strict boundaries of engineering concerns.

Therefore, this study is organized around six sets of questions:

1. Regarding the infrastructural setting and engineering influences, what is the design process of a subway station at different standards and guidelines?
2. How has the design of subway stations changed and shaped with various design concerns in different periods, both in the international and national contexts, along with their design influences?
3. What are the problems and discrepancies of a sole technical approach if the design standards and guidelines are accepted as the only method to develop spaces and places of subway stations?
4. How can one develop a critical perspective on subway stations' existing design process and underline subway stations' design issues by looking at the guidelines and contemporary examples?
5. How can we improve the existing design approaches based on the addressed issues while avoiding any international design suggestions?
6. Lastly, how has the current pandemic affected subway stations' use alongside the suggested precautions to prevent further disease spread, given that subway stations are shaped and optimized according to various standards and guidelines focusing on safety?

1.2 Conceptual Framework of the Study

This study takes into consideration the common misconception where the subway stations are regarded as engineering buildings. It is possible to trace this idea shaped around its infrastructural setting. Along with the concentrated engineering cooperation in the process, subway stations are deducted into this misconception along with its other project parts such as retaining walls, track alignment design, mining methods for underground tunnels, viaduct systems, signal design of the track. Due to its intense scale, both from the financial and physical perspectives, subway projects are funded by transportation operators or corporations. Thus, the main concern for the majority of the projects had been functionality with optimized forms. Therefore, the main design concerns are documented with design guidelines and technical standards shaping the underground space.

In order to challenge the misconstruction mentioned above, this dissertation will focus on the design guidelines and standards used in the design of the subway stations. (therefore) in order to develop a better understanding of the design of the subway station, the history of the subway station design presented to show how similar standards and guidelines are interpreted in different times and locations. In this respect, the primary purpose of this dissertation is to contribute to the architectural design of the subway stations and develop suggestions for future designs.

1.2.1 Transit Architecture

Railways have shaped our environment and urban patterns in the last two centuries. They have helped to connect and expand the existing cities and towns and generate new settlements. Their speed and capacity on land were revolutionary, combined with their consistent and fast travel possibilities, which is why railways became the most preferred urban transport system. In literature, this emergence of transportation is also considered as the emergence of urbanism in a broader context.

Railways were developed as an alternative transportation method to canal transportation systems between Liverpool and Manchester. The railway line aimed to transport cotton from the Liverpool docks to Manchester mills and the textile products from the mills back to Liverpool. Due to their efficient and fast transportation potential, railways covered long distances in a short time. Concurrently, a new building type, was born to serve the railways as transit stations. The first transit station was the Crown Street Station in Liverpool as the world's first dedicated intercity passenger railway station built in 1830 along with the first steam-powered railway engine. However, as mentioned by Griffin (2004), before the current typical designs were produced, one could hardly notice a station from other buildings. These buildings were not designed as transit stations but ordinary buildings to be used as terminal buildings. Starting with the second half of the 19th century, with increased passenger activity, train stations became not only major transportation nodes for industrialized cities but also became iconic buildings acting as gateways to the cities, and inspiration points for artists like Monet, Manet, Cezanne and more. In their paintings (Figure 2), we see that with new machines and means of transportation, new backgrounds and environments emerged as a part of daily life. Moreover, with its speed and mechanization, they also influenced new ideas and manifestations in the history of architecture (Banham, 1960)

Figure 2- Arrival of the Normandy Train, Gare Saint-Lazare by Claude Monet (1877)

Similar to train stations, especially after the second world war, airplanes have changed the means of intercity travels. This new type of transportation was creating a fast connection to the rest of the world and has decreased the traveling time dramatically (Kazda and Caves, 2010). As cities have started to build their airports, similar to the 19th-century train stations, airports turned into national showplaces besides their functions (Blow, 2005). Even the names of the airports had been items of prestige, and some of them are named after leaders, aviators, artists, cultural leaders, scientists, and even athletes. One can still see similar contemporary airport projects in different countries had more concerns than the functionality of the buildings and become items of prestige of its city such as the Daxing Airport in Beijing or the Istanbul Grand Airport.

However, when looking at the inner-city scale transportation, it is hard to see similar concerns. Especially in the everyday activities of the daily life majority of the subway stations had been designed according to the mechanical design process and repeated at different locations despite their similar passenger numbers.

Currently, transportation buildings are also under scrutiny because of the ongoing COVID-19 pandemic. While at the spreading stages of the pandemic, transportation-related buildings are regarded as hazardous and centers for the spread.

Due to its high number of users, transportation systems had to challenge various concerns every day, such as; contactless travel experiences, reduced number of users, use of masks in vehicles and stations, and integration of natural ventilation systems to bring in the fresh air. Adapting to the current situation brought forth new concerns to the existing design knowns based on personal space and underground space.

1.2.2 Station Design for Subways

Nowadays, stations for every kind of vehicle (tram, train, bus), airports, and supporting structures like the bridges are defined as transit architecture. While looking at these buildings and their relation to infrastructure, Allen (1991) highlights the crucial relationship between instrumentality and function. Still, airports and train stations are perceived beyond their functionality and instrumentality. They are perceived as prestigious landmarks and access points to the city, almost as the monumental gateways of the antiquity. However, we can hardly see similar approaches when we look at the subway stations.

In addition to connecting cities and towns together, rail-based systems started to respond to mass transportation needs due to their potential for high volumes of transportation and speed. There were attempts at mass transportation with horse-powered cable cars, omnibuses, and various other solutions, but using railway systems as a mean of inner-city transportation was first started in London, in 1863, with steam-powered locomotives.

Together with industrialization, cities started to develop and construct their mass transportation systems, which were based on road and rail networks. Turkey's subway adventure started in 1895 with the "Tunnel" connecting Karaköy to Beyoğlu. However, after the Tunnel, Turkey gave a century-long break to the design and construction of underground railway lines as a city transportation system. Until 1989 there were proposals to build subway lines mostly for İstanbul, and the first project which was constructed was the Aksaray-Kocatepe Line which is a part of the current M1 line connecting Yenikapı to Atatürk Airport followed by the Ankaray (Dikimevi-Kızılay-AŞTİ line) project in Ankara.

Currently, active railway system types are; Tram, Light Rail Transport Systems (LRTs), Subways, Commuter Rail, Intercity Rails, Maglev, and Monorails. They all have different passenger capacity, range, cost, track design, and speed. Tram, LRS, Subway, and Commuter rail systems can be counted as alternative public transportation systems with their service speed and capacities. Tramlines are integrated into the city traffic lines and merged with the vehicular traffic; however, the most generic form of the rapid railway system that is referred to as the underground, subway, U-Bahn or Tube does not interfere with vehicular traffic (Ström, 1994). These systems can be defined as urban railway transportation with high capacity and frequency of service, which is completely isolated with tunnels, viaducts, or on a surface level but with a grade separation from other sorts of traffic, such as street vehicles or pedestrians.

Until five years ago, starting with London, 388 cities had LRTs (UITP, 2015a), and 148 cities had subway systems in 540 different lines (UITP, 2014); the numbers may have increased since then. The busiest system in the world is Tokyo, with 3.6 billion passenger trips per year; and is followed by Moscow, Shanghai, Beijing, and Seoul (Table 1). Subway lines in Asia carry, in total, over 80 million passengers per day, in addition to the most crowded subways systems of Paris (Île-de-France Mobilités, 2017), New York (MTA, 2015) and Mexico City (UITP, 2015b).

Table 1- Top 10 busiest subways in the world with their annual ridership numbers *(UITP, 2018)*

City	annual ridership in millions
Tokyo	3463
Moscow	2369
Shanghai	2044
Beijing	1988
Seoul	1885
New York City	1806
New Delhi	1789
Guangzhou	1730
Mexico City	1678
Hong Kong	1600

From the local perspective, 2.25 million people use the railway systems in İstanbul for transportation needs on a daily basis (İETT, 2017). In 2016, a total of 576,709,343 people traveled in the city, including tramlines, subways, commuter rail, and light rail systems in İstanbul, which was 17.6 percent of the entire transportation load (Metro İstanbul, 2017). In the same year, 99 million people used the Ankara Rail Systems, which includes Subways, Ankaray, and commuter lines(Ankara EGO, 2017). At the moment, besides İstanbul and Ankara, İzmir, Adana, Konya, Samsun, Kocaeli, Kayseri, Eskişehir, Bursa, and Antalya also have their railway transport systems. Given the population of these cities and projected passenger numbers and volumes, one can safely say that there is already a high demand for railway transport services, and the existing infrastructure will have to expand in time.

According to the Oxford Dictionary (2018b), "a station is a place on a railway line where trains regularly stop so that passengers can get on or off." Merriam-Webster(2018a) defines the station as; "A stopping place: such as(1): a regular stopping place in a transportation route; a bus station (2): the building connected with such a stopping place."

Even though there are numerous attempts to integrate the railway infrastructure into the ideal city (Banham, 1960), it is hard to find a definitive depiction of a station. A subway station is organized with a platform area to serve as a stopping point for the running vehicles and enable pedestrians to board and alight from these vehicles. Since these platforms are below the ground level, vertical circulation elements are needed to provide a safe passageway to its users from the platform level to the ground above. There are turnstiles, ticket offices, information desks, security systems, shops, sanitary services, and other passenger related service spaces in the underground stations. Besides, although it is not apparent even to the regular users, there are also technical rooms to provide heating ventilation air-conditioning (HVAC), fire suppression systems, power supply, emergency generators, telecommunication systems, signaling equipment, security systems, wastewater management and drainage systems that require as much space as the concourses and platforms. The provision of these spaces and the "maintenance of decent environmental conditions" (Banham, 1984) within the station are the responsibilities of various A&E design teams who influence the architecture of the station.

Table 2- Underground Space usage categorized according to usage and orientation according to Carmody and Sterling (1993)

Underground Space Usage by Function

	People-Oriented	Product Oriented
Residential	Single-Family Multi-Family	
Non-residential	Religious Recreational Institutional Commercial	Industrial Parking Storage Agriculture
Infrastructure	Transportation of Passengers	Transportation of Goods Utilities Energy Disposal Mines
Military	Civil Defense	Military Facilities

Similarly, due to track construction and security concerns, stations could be located at different levels: above, at or under the ground. Both the technical design and the track design could also affect the architectural vocabulary of the building and the system. Besides, as mentioned by Carmody and Sterling (1993), one can trace a variety of underground space uses such as storage, religious, institutional, military facilities, and even residential uses in addition to transportation systems (Table 2). Metro is the accepted term in Turkish for these systems, yet its definition also implies that the system is mostly located underground. The origin for the metro is from the French *métro,* which is short for *métropolitain,* and most of the non-English speaking countries prefer using the term metro for their underground railway system. However, these systems are identified by the characteristics of the rail lines on which the vehicles are operated; i.e., the famous elevated Loop Train of Chicago is designated as the "L," which is different from the underground railway networks. In Germany, the underground trains are called the Untergrundbahn (U-Bahn), and in Britain, they are referred to as the Tube. It is important to note that although these definitions apply to the whole transportation system, the stations may have different characteristics at various locations of the line. In order to emphasize the position of "being underground," the terms subway and subway station will be used in this dissertation. However, while mentioning specific subway lines and operators, such as Metro İstanbul, the term metro in them will not be changed.

1.3 Theoretical Framework

It might be interesting to start the theoretical framework with the provocative question: Are underground stations merely dots on the line where the transition from under to above-ground transportation networks occurs (Figure 3), or are they more than that in the urban fabric?

Figure 3- Map of İstanbul Subway lines *(İstanbul Büyükşehir Belediyesi, 2020)*

Cities are complicated phenomena; they are not simply organisms, and yet they are more than machines. By shaping our surroundings, we create a reflection of ourselves into the landscape. Cities behave as warehouses, defense posts, trade colonies, faith centers, or administrative centers. When looked at the current urban patterns and transportation activity, it is possible to trace three structures. First is the "collective transportation system" that provides access to specified regions of the city, whereas personal transportation depends on personal preference. The second type of urban structure is the "adaptive transit" cities, which are no longer on linear paths to the central business district or central node/station in mind. Even though it is possible to trace some districts and areas, destinations have spread out over the urban areas dramatically. In addition, transportation networks not only move people in large volumes but also helps to build communities and our way of life (Allen, 1991). Finally, the last type of urban structure is in a hybrid form that sets up a balance between the transit systems and private automobile ownership. Mixed-use areas, activities, and ease of access combined with the dense urban fabric have helped to establish a relationship between different parts of the built environment (Belanger, 2009).

1.3.1 Station from Urban Design Perspective

Lynch (1984) starts his book "Good City Form," with a very challenging question. "What makes a good city?" At first, he compares the normative theories about the ideal cities and provokes the readers with the possibility of a general normative theory. Then, after examining the past and present uses of the earth and spaces in the cities, villages, parks, and built and natural environments, he proposes his five *" dimensions of settlement quality"* as Vitality, Sense, Fit, Access, and Control. In 1977, during one of his studies along with a set of students from planning and architecture Lynch came up with a cornucopia of values such as "accessibility, choice and opportunity, identity, strong social networks, safety, good services, pollution-free environment, strong natural features and sense of place." Accordingly, he proposed a systematic approach to improving cities, based on his newly defined social elements for urban planning. However, as mentioned before, cities are complicated phenomena, and with different people and cultures, people might get a different result from the same design methodology.

Following Lynch's train of thought, one can come up with a similar question: What is a "station" and what makes a Good Station? According to Carmody and Sterling (1993), despite the fact that subway systems enable the transportation of vast volumes of people efficiently, these underground solutions tend to create numerous effects on their users just because they are under the ground level. The authors have listed them to be:

- The sense of being excluded from the rest of the surroundings
- The sense of confinement that artificial lighting creates
- The lack of orientation and positioning of one's self within the city in order to define route planning
- The fear of not being able to escape in case of an emergency event

Lang(1994) points out some basic concerns regarding the integration of infrastructure and its surroundings. He identifies them as:

- Ease of movement
- Shortening pedestrian routes
- Protection from the climate
- Reworking the city to improve the infrastructure

With a similar approach, Allen (1991) proposes two assessments for urban infrastructure to develop his seven propositions on Infrastructural Urbanism. He suggests points and lines create complex systems, and expression could be achieved by combining technique and material.

Later, when discussing the urban design and connecting the different parts of the city with various infrastructure elements like roads, paths, and train lines the majority of the concerns come from the lines, and we observe different lines intersecting, leading to different paths to various places on/above/under the ground. Accordingly, Allen (1991) suggests seven propositions on infrastructure and urbanism and concludes with Smithson's (1963, p. 73) claim that "… the time has come to approach architecture urbanistically and urbanism architecturally."

Since there is a high demand for LRT and subway systems in Turkish cities, one needs to ask: is the design process of the subway, station an engineering, or an architectural concern? Nevertheless, with the track design and other engineering concerns, a majority of the stations are designed under the ground level. It is not only because of traction and route design but because Turkish cities have grown in an uncontrollable fashion that forced the infrastructure to follow the city's shape rather than shaping the city, and this pushed the track design underground. Similarly, route and supporting structures also followed every possible gap in the urban fabric. As a result, the existing infrastructure is shaped by the existing urban pattern.

On the other hand, the station design process was influenced by engineering concerns while the architectural design was neglected and regarded as a discipline that should fit in the framework defined by the engineers. This approach brings out a monotonous design approach for the stations. As a result, this study aims to connect the station to the city and break the monotonous approach from different aspects.

1.3.2 Station as a Place

It is possible to claim that subways stations are also considered as non-places due to its function and urban context, as Augé (2006) claims, non-places separate people from their identity creating mass groups such as commuters, passengers, shoppers, and consumers. Moreover, the notion of travel generates a relationship between gaze and landscape on a fictional scale; therefore, travelers' space could be regarded as the archetype of non-place. Besides, he also claims that it is easy to pinpoint these places because they have "instructions for use" where signage and warnings shape how the people should move around and behave. Additionally, these spaces do not contain any inhabitants, and their users remain anonymous. Interestingly, the term space from the traveler's perspective may be the epitome of non-place. As a result, it is possible to claim subway stations as non-place from Augé's point of view.

However, train stations of inter-city scales, constitute the memory of places to their users with their different properties. These buildings are not only structures where people board and alight specific types of vehicles but also places of identity, relations, and history. Moreover, they create an exterior image where they are landmarks and even monumental gateways to their cities. Even in the earliest examples of the train stations, we can see that they had been an inspiration for architects, engineers, and, more importantly, artists of the era to capture its dynamism, power, and speed. Artistic renderings of railways and train stations by Manet, Monet, Pinchon, and even Italian futurists presented their understanding of the new building type.

Starting with the first examples of railway stations, one of the essential features they provide was combining different functions into a single entity. The first specifically designed train station, which is Lime Street station in Liverpool, accommodated additional services for their users, such as; restaurants, offices, hotels, commercial areas, shops, and even housing. Due to their high passenger capacity and their accessibility to the rest of the world, train stations turned into monumental gateways of their cities as objects of prestige.

Subway stations are thought-provoking buildings in a very complex context and respond to every feature of Lynch's elements, i.e., path, landmark, edge, node, district, and landmark. They act as paths with the movement they have inside and on the surface. They work as edges with their existence and connecting railway tunnels. They create their own districts with their existence and act as nodes with the modal shifts and transportation opportunities. They are also nodes with the connectivity possibilities with other stations along the line. Most importantly, they are landmarks in our cities and daily life, even though they are buried meters below the ground level. Even though they are not visible above ground, a simple signpost creates the awareness of their existence and the possibilities that they provide.

Currently, with the COVID-19 epidemic, subway systems and stations are considered hazardous spaces because of the suggested distancing in public spaces with ongoing travel demands. Along with different safety measures such as mandatory use of facemasks, distancing rules, and decreased passenger capacities, there is a considerable drop in the number of traveling people by subway systems (Harris, 2020; Park, 2020). Typically, one can trace that subway stations were prepared and used as air-raid shelters (London, 1940; Sorokina, 2019), but none of the stations were designed or shaped by a security standard or a design guideline, which includes pathogen contamination. Given the fact that personal spaces are a significant design indicator for subway stations, now designers face new challenges to overcome the situation because of the emergency situation we are facing in the world. As a result, designing a subway station is a proactive design process due to its technical and contextual complexity, and without comparative research on both of the aspects with supporting data, design considerations of a subway station would always be addressed as an engineering problem. This research will develop a new critical approach to the buried landmarks along with the city, which currently operates as big concrete pumps pushing people along the route.

1.4 Methodological Approach

This research approaches the concept of the “station" from two different perspectives; technical and theoretical. Firstly, this research will try to review the existing technical publications/ documents related to subway station design. The main intention of inspecting the technical design guidelines in the first place is to emphasize the technical aspects of the design schematics of the subway stations. This technical review is necessary due to the interdisciplinary nature of the subway station design. In other words, a subway station design has to meet the professional dictates of the selected design standards and guidelines. Otherwise, without this functionality, the building can lose its meaning and be refurbished into other functions for new purposes. To this end, starting from Australia to Canada, cities and their subway operators were contacted to obtain information about their design guidelines. Related documents for Istanbul, London, Paris, Stockholm, Cairo, New York, Los Angeles, Porto, and Toronto subway lines were obtained from administrative offices, system operators, and design firms. However, the Tokyo Metro stated that they had applied different standard guidelines for different projects, and Seoul Metro’s guidelines could not be obtained due to the bureaucratic procedures.

As a second step, different subway stations from various subway lines were studied from different periods of the 20th and 21st centuries. Even though the first subway stations were built in the 19th century, until the first electric-powered streetcars designed by Siemens & Halske exhibited at the Berlin Trade Fair in 1879, subway stations had other significant concerns, such as the steam, heat and, toxic fumes coming from the vehicles (Vuchic, 2007). Therefore, the selected timespan starts from the 20th-century examples. This approach presents us with a historiography of the subway station design from different regions and shows us how the design of a subway station is questioned methodologically in different timelines. A detailed station selection process has been conducted to select the stations for the station review part. Even if the details of the process are explained in the following chapters, the station selection method's main intention was to cover influential designs where its alterations can be applied in different settings. Therefore, instead of unique solutions at different geographies, regular solutions with innovative design approaches are mentioned in the study. This approach has also helped to develop the needed critical perspective on design concerns of the station design from the design guidelines perspective and emphasized the possible pitfalls and problems of the existing parametrical approach. It has enabled the identification of the missing architectural approach in station design and started the discussion on the question mentioned earlier, i.e., what is a “station” and what makes a Good Station? During the research several architectural offices had been contacted to acquire detailed information regarding their station design approach along with technical drawings. Especially, Silvio d'Ascia and Eduardo Souto de Moura offices provided necessary information for this research.

Thirdly, in accordance with the literature review, problems and discrepancies in technical documents and design guidelines will be documented. In view of the fact that the current design approach and space definitions of the stations are shaped by a combination of national and international standards and design guidelines, conflicting situations will be underlined and then discussed. Because the common design method rests on the idea that the subway station as an engineering building shapes the stations based on the sole technical approach and does not develop beyond that point unless the design team challenges the situation. In short, this chapter will show that even though they are a part of an infrastructure project, subway stations are not engineering buildings, by documenting the flaws and contradictions on the quantitative design guidelines. Because, unless a critical view on the current system is developed, contradicting guidelines will shape the underground spaces based on the assumptions of an unvalidated design method.

After this comparative study, this dissertation will present design suggestions while preventing any international design intention. These design suggestions will suggest an alternative understanding of the underground space both from the architectural and urban scales. In addition, the design suggestions are shaped around how to interpret the crowd, urban context, and alternative transportation methods for future design cases based on contemporary designs and events.

Given the fact that subway stations require multidisciplinary design approaches at different scales, the design process is not only limited to architects but also includes interior designers, graphic designers, landscape architects, lighting designers, crowd management experts, and even industrial designers. Thus, to emphasize the contributions of the design team, this research focuses on the role of all the designers in the design process. As a result, recommendations will be made to the designers instead of just the architects, interior designers, or landscape designers.

In addition, with the ongoing pandemic, people stayed away from using subway systems, and the ridership had dropped dramatically. Cities had to shut down their mass transportation systems to prevent the further spread of the disease. Along with the decreased number of cases, some of the countries started to operate their subway systems with various protective methods. These protective methods have been applied to prevent the further spread of the disease, and the most common ones were physical distancing, mandatory use of facemasks, contactless payment systems, and reduced capacities. Thus, with these new protective methods, this research will try to present how the stations will be (re)shaped for the upcoming years.

Subsequently, by inspecting the theoretical frameworks of building underground and infrastructural approach, combined with the built examples and studies, this research has developed a comprehensive approach to the complex interdisciplinary design process of the selected building type. In this process, due to the complexity of the subway stations, architectural design, and infrastructural urbanism, arguments are discussed to develop a design methodology.

In other words, this research, which was shaped as a result of the authors' professional experience and academic studies made during the last six years, presents a critical analysis of the existing practice of subway station design and outlines a design guideline for the theoretical and practical approach for the design of future subway stations.

CHAPTER 2

LITERATURE REVIEW

This chapter presents a literature review regarding the subway station design by examining architectural design standards, design guidelines, technical documents, and design briefs. Even though there are different standards and design guidelines for every country, the main challenge was to obtain them. During the research period, Turkish, American, Canadian, British, Japanese, Korean, French, and Chinese authorities were contacted, in view of their high passenger capacities; however, due to different technical difficulties, Korean, French, and Chinese standards and design guidelines could not be obtained. Besides the related Turkish standards, TS 12127 and TS 12186 related standards were reviewed and evaluated among different design guidelines developed by the same standard. As a result, first, this chapter will review the entire design process of the subway station design showing the alternative approaches to a design project. Then, the design criteria for subway stations will be presented. The primary purpose of this step is to familiarize the readers with the technical aspects of the subway stations so that the readers could comprehend the terminology of the technical standards and design guidelines. Lastly, national and international standards, along with design guidelines from different projects throughout the world, are reviewed to understand the nature of the current subway station design process.

2.1 Designing a Station

It is important to define the participants in a subway station to have a more straightforward layout of the design process. It can be divided into three groups based on their impact on the overall design. The first group is the major participants in the design, and the second group can be named as a consultant/advisory group. In addition, the last group is the users of the area where the station is designed according to their numbers. Major participants are; Track Alignment Designers, Architects, Urban Planners, Infrastructure planners, Geotechnical, Structural, Electrical, Mechanical Engineering teams (Transport for New South Wales Asset Standards Authority, 2010b). Consultant groups can be defined as the groups that assess specific design problems that might improve the user experience of the design. Sustainability advisors, acoustical, landscape, interior, façade designers could be in a consultant group as well as artists participating with their art (JICA, 2010a; Transport for London, 2013).

2.1.1 Design Phases of a Subway Station

Firstly, it is important to define the phases of architectural design so that we can have a clearer picture of the design phases of subway stations. Two major project delivery phase models have been studied for this project to understand and assess the timeline of project delivery. Unfortunately, the only Turkish legal document addressing major project delivery phase models is the Turkish chamber of architects' specifications regarding architectural services and minimum fee, i.e., *TMMOB Mimarlar Odasi Mimarlik Hizmetleri Şartnamesi ve En Az Bedel Tarifesi* (2011) which gives us concise information about the station design specifications and fee structure.

The model of the American Institute of Architects (AIA) suggests a linear workflow for projects regardless of its delivery method (Bernstein, 2013). Even though there are different forms of project delivery types such as traditional, project management, and design-build, one can determine certain project delivery phases. These are Predesign, Schematic Design, Design Development, Bidding or Negotiation, Contract/Construction Documents, and Construction Contract Administration (Brix and Hayes, 2013). A closer look at the Basic and Additional Services Document

(AIA document b101tm–2007 Owner-Architect agreement) reveals that the project activities are sequential, and one activity has to be approaching an end before starting the next phase. The sequence of these activities can be followed in the figure below (Figure 4).

Figure 4 - Project Phases According to AIA from pre-design to construction administration phases (Brix and Hayes, 2013).

On the other hand, the Royal Institute of British Architects (RIBA) suggests a different workflow compared to AIA's linear system. RIBA recommends a system called the Plan of Work (Figure 5), which was first developed in 1963 (2013):

- Stage 0: Strategic Definition
- Stage 1: Preparation and Brief
- Stage 2: Concept Design,
- Stage 3: Developed Design,
- Stage 4: Technical Design,
- Stage 5: Construction,
- Stage 6: Handover and Close Out
- Stage 7 In Use

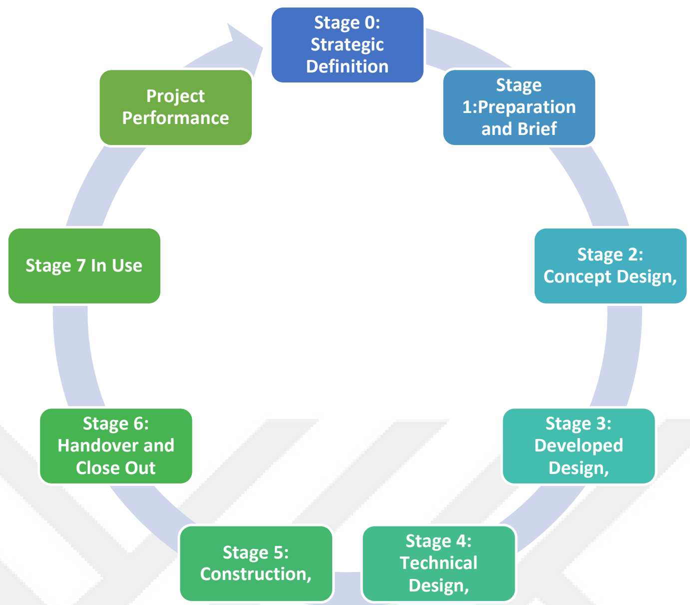


Figure 5 – Cyclic RIBA Plan of work(Bernstein, 2013)

The most important difference between them is the fact that RIBA suggests a cyclic lifecycle and emphasizes feedback for future projects. AIA's project cycles are selected due to its similarities to the existing project delivery method in Turkey in addition to the linear workflow for projects regardless of its project delivery method, whether it is traditional, construction management or design-build (Bernstein, 2013), compared to the *Royal Institute of British Architects* (RIBA) *Plan of Work* (Sinclair, 2013).

Due to the high technical input of different engineering disciplines, while designing for vehicles and pedestrians, some of the design considerations have to be resolved to prevent any significant conflicts and revisions in further steps of the design and by establishing the design phases. By doing so, we can have a more precise layout of the responsibilities and expected design arrangements from architects within their design context. As a result, schematic design, design development, and construction document phases are inspected and emphasize where the architects are expected to plan a design or a solution for the station.

During the design process, various national and international standards and design guidelines are used to determine the architectural design of the station. An extensive review of the standards is presented in the following sections, while TS 12127 (TSE, 1997a), TS 12186 (TSE, 1997b), NFPA 101 (National Fire Protection Association., 2017a) and NFPA 130 (National Fire Protection Association., 2017b) are the major standards related to the subject. Accordingly, the three design phases, namely: Schematic Design, Design Development, and Construction Documents, are explained in the following paragraphs in more detail.

2.1.1.1 Schematic Design

At the schematic design stage, a basic layout showing the suggested workflow of the station is expected to be settled. Therefore, the basic outline of the station is developed where one can see the platform, concourses, connection corridors combined with the ancillary service areas to inform project participants. Starting with the schematic design phase integration among the major participants is strongly recommended to prevent any significant conflict at the following stages. As suggested by AIA, plans, elevations, and sections should be submitted, which give information about the essential mechanisms of the project and their interrelationships.

The schematic design phase is also a significant opportunity to test the design with the pedestrian movement. If possible, simulations must be made to validate the first designs so that architectural teams can revise circulation elements (stairs, escalators, corridors, elevator) by affecting the other teams' designs' as little as possible.

2.1.1.2 Design Development

At the design development stage, teams are expected to develop their designs well integrated with each other as much as possible so that major changes can be avoided in the final stage by the other project partners. Nevertheless, changes can be made due to advisor groups' demands or suggestions.

2.1.1.3 Construction Documents

At the construction documents stage, every major and consultant teams are responsible for developing their project documents as detailed as possible so that the project could be constructed at the site. High levels of integration and collaboration among every team are vital. At this stage, concerns regarding the pedestrian movement inside the station are expected to be resolved. However, if a significant revision is needed due to unforeseen consequences, different simulation is also suggested to test the proposed solutions. At the end of this phase, detailed drawings and manuals are produced by design teams to construct and operate a functioning subway station.

2.1.2 Design Criteria for Subways

In view of the fact that the design of a subway station is a multidisciplinary process, this research will only focus on the architectural design concerns of the subway stations and will not mention engineering design concerns unless it has a direct effect on the design. Therefore, from the architectural design perspective, the design of a station takes shape according to criteria under consideration, e.g., the typology of the station as well as the types of platforms. These criteria are given in detail as follows:

2.1.2.1 Types of Stations

Due to the track alignment design, there are three main alternatives for the location of the station. The defining criterion of these alternative types is the location of the platform, which defines the classification of the stations, i.e., it can be an aerial/elevated station, at-grade, or underground (K W Griffin, 2004).

When the platform level of the station is above the ground level with the help of viaduct structures, they are called elevated stations (Figure 6). They are heavily dependent on vertical circulation elements such as stairs, escalators, and elevators, for pedestrian access. Pedestrians and vehicles may be exposed to all weather conditions, yet canopies and the structural design can help the designers to create a strong visual and physical impact. At aerial stations, pedestrian guidance can be achieved not only with direction signs but also with a visual connection to the exterior.

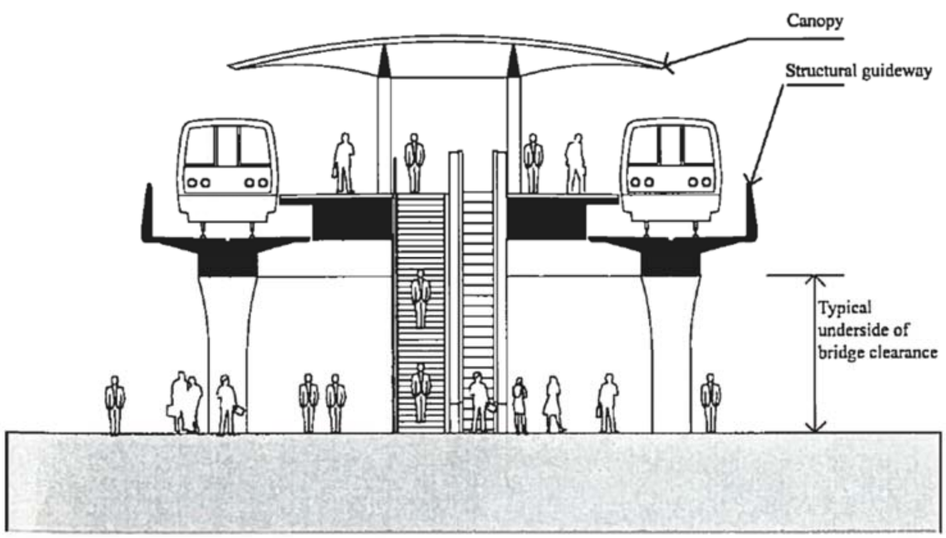


Figure 6 – Schematic section of an elevated station (Griffin, 2004).

When the track level of the station is at the street level, or close, at-grade station type designs are implemented. These types of stations are not dependent on vertical circulation elements compared to the other two alternatives as long as they provide safe track-crossing conditions for pedestrians. However, with the high volumes of pedestrians, track crossings require an overpass or underpass that also requires vertical circulation elements (Figure 7). Similar to aerial stations, these stations would require canopies and sound barriers to protect pedestrians. Due to grade levels and construction techniques, it is possible to find different variations of the space organizations in this type of station due to the shape of the landscape like retained fill, open cuts or retained walled. At the retained fill stations, platform area is located on top of an embarkment and pedestrian access is provided with underground connections (Figure 8). Open cut stations are designed where the grade does not require any reinforcement to support the platform level and this type is considered the most economic approach (Figure 9). Yet, in urban context they also act as barriers because of the land they occupy. Lastly, retained cut stations are built at places where a retaining wall holds the earth to create a space for the platform (Figure 10).

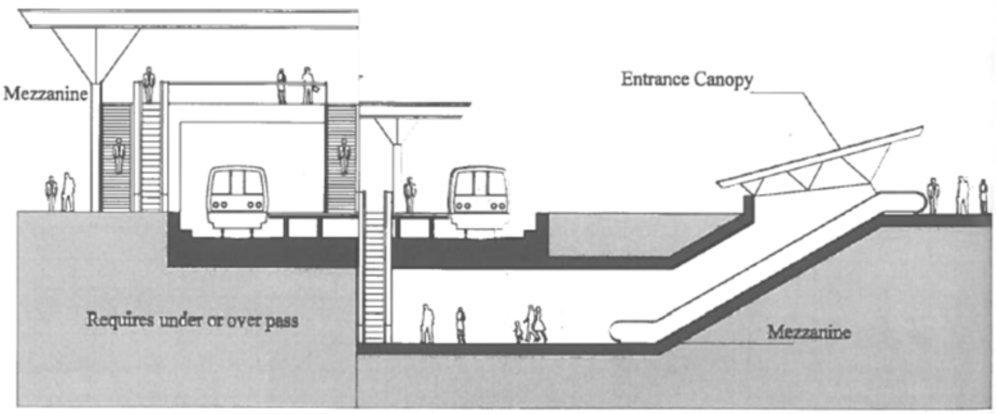


Figure 7 – Schematic section of an at-grade station type showing the platform with alternative under and overpass alternatives to the platform (Griffin, 2004).

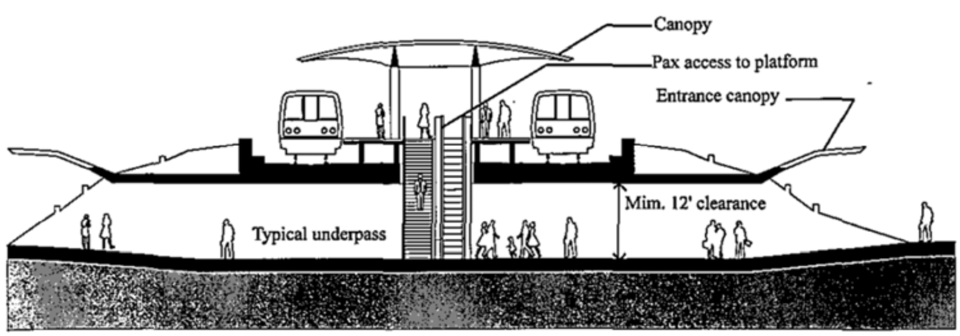


Figure 8 – Schematic section of a retained fill station type showing the underpass connection and the platform (Griffin, 2004).

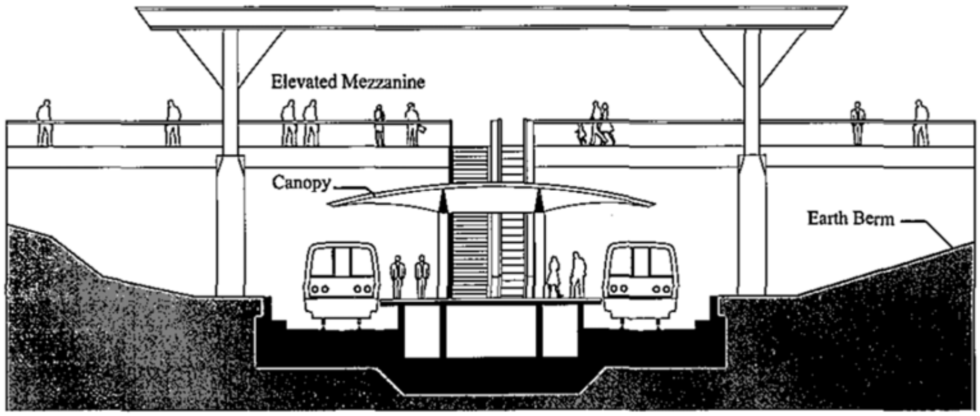


Figure 9 - Schematic section of an open cut station type showing the location of the elevated mezzanine and the platform (Griffin, 2004).

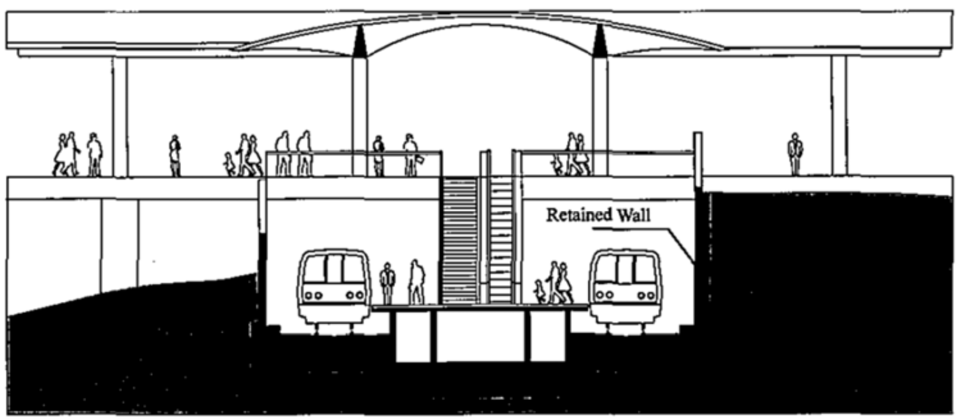


Figure 10 - Schematic section of a retained cut station type showing the elevated mezzanine, platform and the retaining wall (Griffin, 2004).

Lastly, stations could be constructed in the underground. Similarly, to aerial stations, these stations are also heavily dependent on vertical circulation elements. However, these stations also require massive mechanical and electrical systems to provide lighting and ventilation for its users. Due to its context, these stations have the least visual and physical aids to its users when orientation is required. As a result, pedestrian signs and guidance are very critical not only for its daily use but also for emergencies. Depending on the construction method and the track alignment, underground stations could be constructed in three different methods; cut-and-cover, mined, and binocular. As one can understand from its name, the cut-and-cover method excavates the ground and prepare the space for underground construction and then covers the area for future uses (Figure 11). Depending on the tunnel construction method two different types can be seen mined and binocular stations. Both of the structures are used either when there is not sufficient space for construction activities on the surface level or when the track alignment is deeper for cut-and-cover construction methods. Mined type is selected when the station is in a suitable geology to support vault like structures underground that helps to create large spaces (Figure 12). Binocular stations are designed as multiple tunnels combined into each other where each tube provides a platform for a single track (Figure 13). It is important to note that station types are determined according to the urban pattern and can be combined due to construction possibilities on the surface and underground.

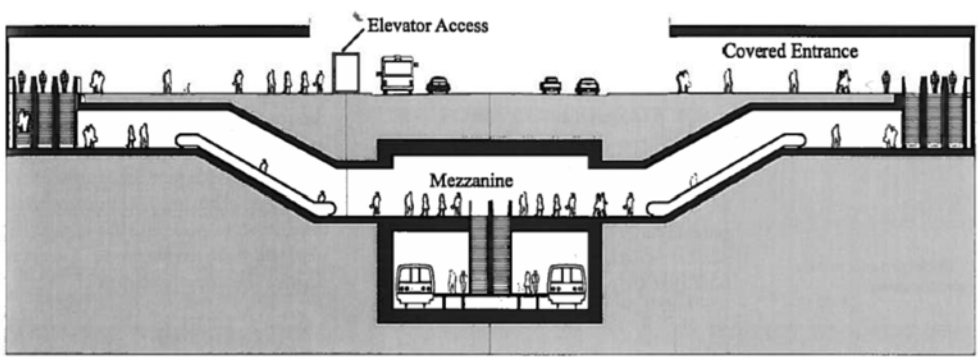


Figure 11 – Schematic section of an underground cut and cover station with two entrance structures (Griffin, 2004).

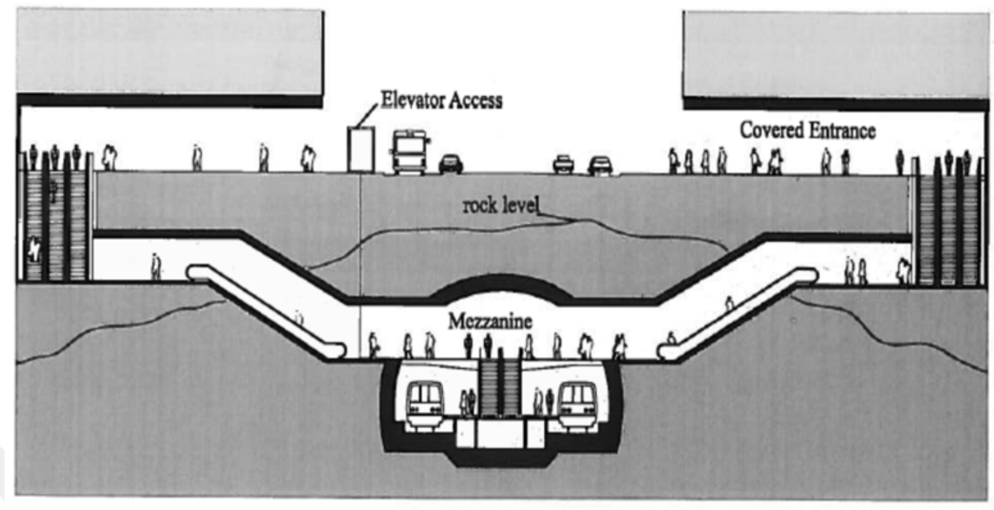


Figure 12 - Schematic section of a mined station at the rock level with two entrances (Griffin, 2004).

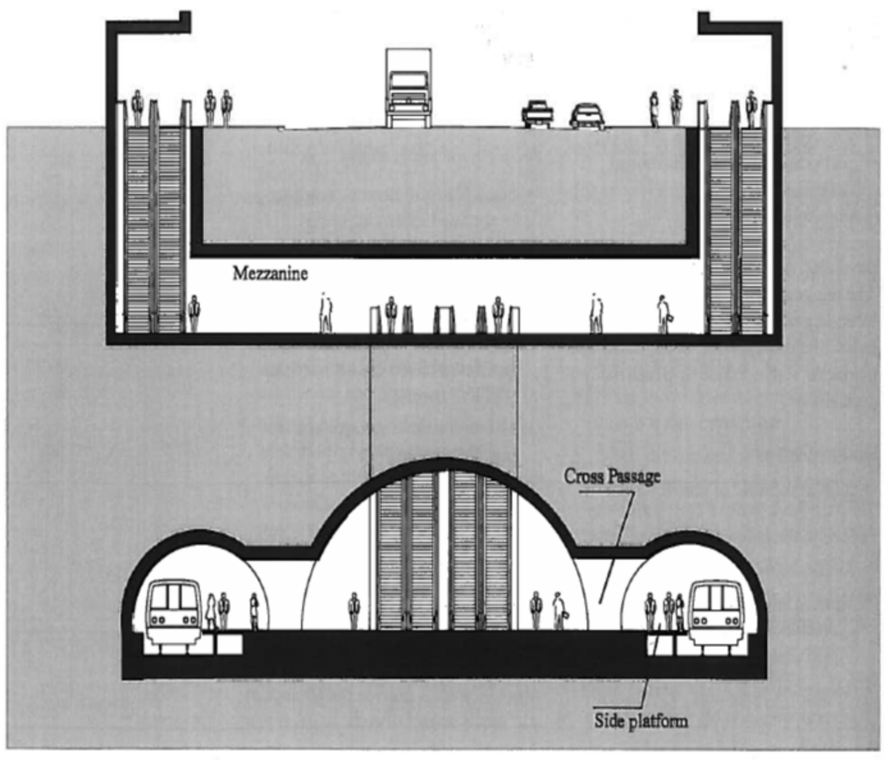


Figure 13 - Schematic section of a binocular station where parallel tunnels are connected to each other with cross passages along with an underground mezzanine with multiple entrances (Griffin, 2004).

Meanwhile, according to the Japan International Cooperation Agency's (JICA, 2010b) preparatory survey report for the Greater Cairo Metro line, it is possible to identify three different types of stations from a design perspective. These are; Signature Station, Modal Interchange Station, and Typical stations.

Signature stations are mostly distinguishing stations along the line where the design of the station is considered as a showcase of the whole project. Stations that enable connections to touristic areas, important urban locations, airports, and train stations have more potential to be a signature station. The most iconic station design examples are considered as signature stations of their lines, such as; Foster's Canary Warf, Calatrava's Satolas TGV Station, or Grimshaw's Waterloo stations.

Typical stations focus on the parallel of properties of different station locations and aim to develop similar design solutions to develop a cost-effective design. These stations have very similar architectural layouts, both in technical and passenger area design. Compared to the other types of stations, typical stations are showcases of the most neglected part of the project, i.e., its architectural design (Figure 14).

Figure 14 – Central tunnel of Yenisahra Station in Istanbul showing the lack of architectural features (author)

The Modal Interchange Stations are the third type of station, where a connection to other modes of intercity travel is provided, such as different subway lines, trams, bus stations, taxis, and sea transport. It is also possible to see additional car parking options in station designs where they provide a chance to change transportation modes from private to public.

In this regard, Transport for London (TfL) authorities categories their stations in four types according to passenger activity, namely, gateway, destination, metro, and local (2019b). Similar to JICA's Signature Station Approach, Gateway stations are the main transportation hubs where high volumes visitors enter the transportation system, such as King's Cross St. Pancras or Heathrow airport stations. The other three station types, destination, metro, and local, can be evaluated in an ordered fashion due to the passenger volume. Destination type stations highlight famous tourist and commercial destinations. Metro type stations serve inner London communities, whereas local stations serve communities in the outskirts of London city.

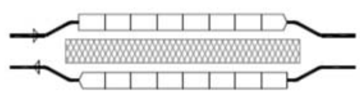
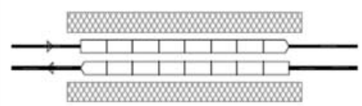
2.1.2.2 Types of Platforms

Depending on the location of the station, it is possible to find four different platform designs. These are; island, separated, split, and flow-through platforms (JICA, 2010a; Swedish Transport Administration, 2018; Garavito-Bruhn, Napoli and Towell, 2019), mostly determined by the complexity of the track system and the alignment design (Figure 15).

Island platforms are the most basic platform type where all passengers use the same platform to board trains or alight from them. Passenger load is directed to a single platform and is considered a more comfortable choice for the passengers. However, due to the fact that the rail lines from both sides limit the platform, future expansion is limited and requires a change on the tracks.

Compared to the island platforms, separated platforms are situated along the route, where two platforms provide access to the different trains for boarding and alighting purposes. This approach will provide space for future development and have less passenger congestion compared to the island platform types; however, it will require more vertical circulation elements, such as escalators, stairs, and elevators. On Table 3, a comparison of the Island and Separate types of platforms can be seen made by the Japan International Cooperation Agency (JICA, 2010a)

Table 3 - Types of Platform according to the Japan International Cooperation Agency (JICA, 2010a)

	Island Type	Separate Type
		
Advantage	Generally, total platform width will be minimized with same furnishings because passengers bound for both directions will share a single escalator. Also, it will be easier for passengers to select the platform	It will involve simple straight track arrangement. It will involve less passenger congestion, even if trains in both directions arrive at the same time.
Disadvantage	It will require expansion of the distance between the mainlines.	Twice the number of escalators and/or elevators will be required compared to the island type.

A split platform is where tracks are split into two or more levels and stacked on each other. This approach allows designers to have a narrower station footprint by creating a deeper station on vertical sections and requires vertical circulation elements similar to side platforms(Pulido *et al.*, 2018; Aksman, Grigson and Giffen, 2019).

Lastly, flow-through platforms enable passengers to board or alight trains from their dedicated platforms. This approach will enable higher capacity passenger movements compared to island and side platforms at the same dwell time. However, it will require more platform area and vertical circulation elements in order to connect different platforms to each other.

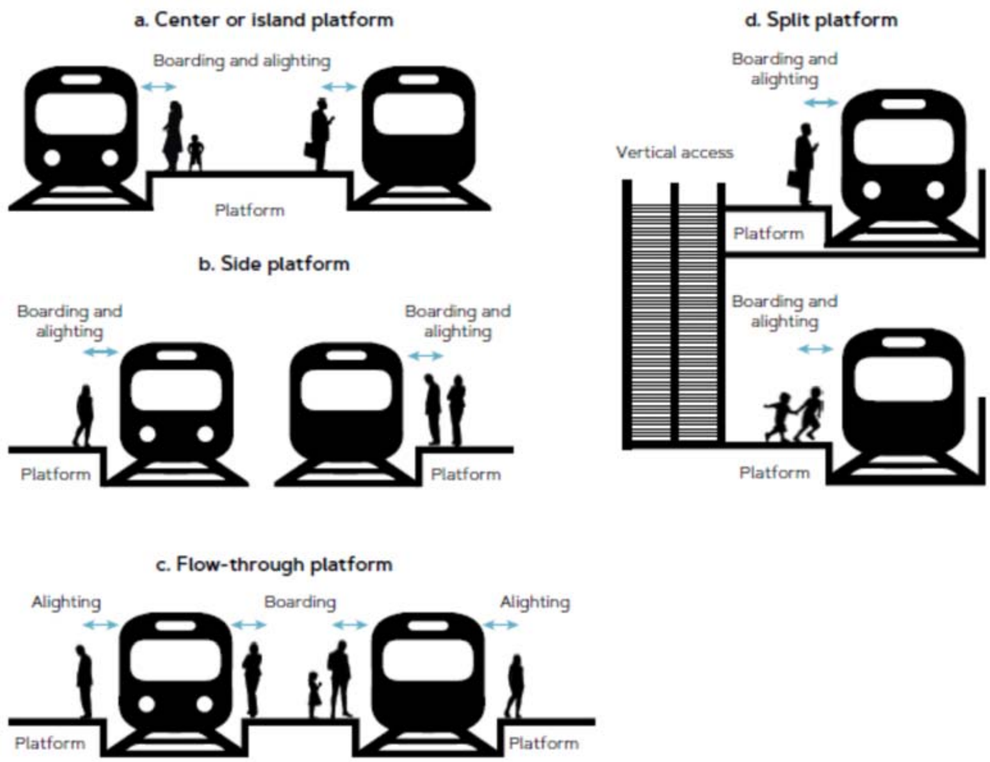


Figure 15 - Platform Types with its boarding and alighting properties according to Pulido et al., (2018)

It is also essential to keep in mind that factors such as geophysical state of the station location and the urban context of the area also affects the station design. Determining top of the rail elevation has a direct effect not only on the station design or the construction method but also on the city, which is built upon. In the station design case, it is expected that by determining the top of the rail elevation, designers will have a clearer idea about the type of the station and possible pedestrian circulation solutions. When looking at the location of the station, it is possible to see that standard approaches are developed in regular neighborhoods of the city. On the other hand, when possible additional functions are applicable, different methods and design approaches are developed to improve the passenger experience, such as multi-modal transportation possibilities, cultural centers, or other services.

It is also important to keep in mind that geotechnical attributes of the selected route also have a direct effect on the station design. According to the different geophysical formations, different tunnel methods and compositions are developed to reinforce the station so that designers can have the desired space to fit in their station layout. The existence of rock or soil formation determines the section of the tunnel and the related design. One of the most striking examples of this situation is the iconic Stockholm subway station design approach, where the subway stations are also considered as an underground art exhibition (Swedish Transport Administration, 2016; Stockholm läns Landsting, 2017). However, the remarkable station designs are a product of the rock formation beneath the city. Formations of gneiss, granite, granodiorite, sandstone, and marble rocks beneath the city enabled engineers and architects to develop a unique approach where they can carve out their station layout into the rocks rather than building reinforcements to support tunnel structures (Vähäaho, 2014; *Geology of Sweden*, 2019).

In addition, by looking at the feasibility reports and similar reports containing the suggested vehicle information (dimension, capacity, and the headway) and passenger numbers (alighting and departing), the architect is expected to define some of the basic parameters of the station including the width of the platform, the number of turnstiles, stairs, elevators and emergency exits based on local and international standards. Depending on this information, architects will develop a fixed-width approach or calculate the width of the platform based on passenger load and allocated personal space per person.

2.2 Standards and Design Guidelines

During the design and construction process of a subway station, it is possible to see different standards and design guidelines. First, this research will present the related national standard, which focuses on the design of subway stations. Afterward, it will review the similar international standards and design guidelines related to the subway station design. Besides, it will also discuss the design guidelines of subway lines to present how different projects interpreted the international standard within their context.

2.2.1 National Standards

Major national standards regarding the subway station design and their approach to the subject will give us an understanding of how it is perceived and executed in Turkey. It is crucial to keep in mind that both of the Turkish standards related to the station design were issued in 1997 while covering a wide range of design topics as general design suggestions, station segments, material recommendations, acoustical design recommendations, lighting design recommendations, signage and accessibility for people with reduced mobility.

There are three relevant Turkish Standards (TS) that can be used for the design of Rapid Transit Systems in urban areas: Design Criteria of Underground Station Facilities, Design Criteria of Ground Station Facilities, and Requirements of accessibility in buildings for people with disabilities and mobility constraints. These are discussed in the following sections:

2.2.1.1 TS 12127: Design Criteria for Underground Station Facilities

While general design suggestions cover the basics of the station design, one of the most important detail is about the use of escalators and stairs. This Standard suggests an escalator must be taken into consideration if the ascending distance 3,5 meters or the descending height is greater than 7 meters.

Station Segments presents the most critical segment of the standard by establishing a general layout of the station with its dimensions (Table 4). However, TS12127 states that it is for station buildings which have a passenger load of 5000 to 60000 passengers per hour. Generally, calculations to evaluate the size of the building elements are based on the passenger load in selected periods as passengers per hour (PPH), Passenger per Minute (PPM), or passenger per square meters (PSM).

Table 4- Capacities of different station segments with their minimum widths according to TS12127

Segment	Width	Capacity (passenger per minute)
Corridors and walkways	1 meter	80
Staircases	1 meter	65
Escalator (speed 5m/s)	1.20 meter	80
Escalator (speed 6m/s)	1.20 meter	100

After that, TS 12127 starts to define a station building starting from the street level. Design minimums such as how many entrances, WCs, and emergency exits should be placed in a station. Taking into consideration every possible architectural element of the station design, TS 12127 outlines their capacities and design considerations following a passenger activity from the surface to the train, followed by the technical rooms and their configurations.

Next, the standard defines capacity for the turnstiles and vertical circulation elements of a station, including stairs, escalators, moving sidewalks, ramps, and elevators (Table 5). According to the standards, turnstiles perform differently in the event of entering and exiting the station. Besides, different staircases provide dissimilar capacities depending on the direction of the and the use of the staircase, such as; one-way or two-way passenger staircase, emergency staircase, and personnel staircase. Naturally, both for the moving sidewalks and escalators, the standard suggests a constant capacity.

Table 5- Capacities of different elements with their minimum widths according to TS 12127

Element	Width	Capacity people per minute
Turnstiles Entering	50 cm	35 ppm
Turnstiles Exiting	50 cm	40 ppm
Passenger staircase	One way 1.20m	50-65 ppm for a 1m wide
Passenger staircase	Two way 2.00m	50-65 ppm for a 1m wide
Emergency Staircase	1.20m	NA
Personnel Staircase	1.20m	NA
Moving Sidewalks	1.00m	8000 ppm with 0.5m/s walking speed
Escalators	1.00m	120 ppm
Ramps (maximum length of 10m with the slope %8(1/12)	1.70m	65ppm

In addition to the dimension suggestions, accepted passenger velocity on a staircase is also defined, assuming its width to be 60cm, as 15m/min with 35ppm for the ascending passengers, and 18.30m/min with 40 ppm for the descending passengers. In addition, elevators are expected to be designed according to TS EN 81-1-20 (TSE, 2014) with the required minimum of $3m^2$ area for the passenger cabin.

For the platform design, the standards define all of the three dimensions of the platform area. The minimum clearance height for the platform area is given as 2.50m with 3.50m minimum platform level height and 50cm clearance from the vehicle lanes. The minimum unobstructed width must be 2.50m and 6.00m (5+2x 0.5 safety line) for the island and 3.00m for the side platform designs. However, this standard shape the width of the platform according to the peak-period passenger capacity calculation methods. The required platform area is calculated based on the number of trains per minute multiplied by the number of passengers combined with the required minimum area per passenger with the safety factors. The most important part here is the fact that the standard accepts personal space as $0.5m^2$ per person and assumes that pedestrians disperse to the platform area homogenously. Lastly, the required evacuation time to the area of safety for the station design must be 4 minutes. An example of the existing calculation method is added to the Appendices A

2.2.1.2 TS 12186: Design Criteria for Ground Station Facilities

As a follow up to the TS 12127, TS 12816 Rail rapid transit system in urban areas part 2 (TSE, 1997b)was issued in April 1997, and as TS 12127, this standard is also in effect. Similarly, this standard started with basic definitions about the ground station types and followed by the basic rules about the ground station design. Expectedly, the standard also depicts various architectural elements related to elevated and at the grade station types such as canopies (Figure 16). Similar to TS 12127 standard suggest that personal space should be 0.35 to 0.50 square meter per person. This standard also focuses on the dimensions of building elements, their relation to each other, minimum material requirements in terms of durability, security and maintenance, and physical environmental control elements design guidelines. Likewise, the most questionable part of the standard is the fact that it has never been revised since its release in 1997.

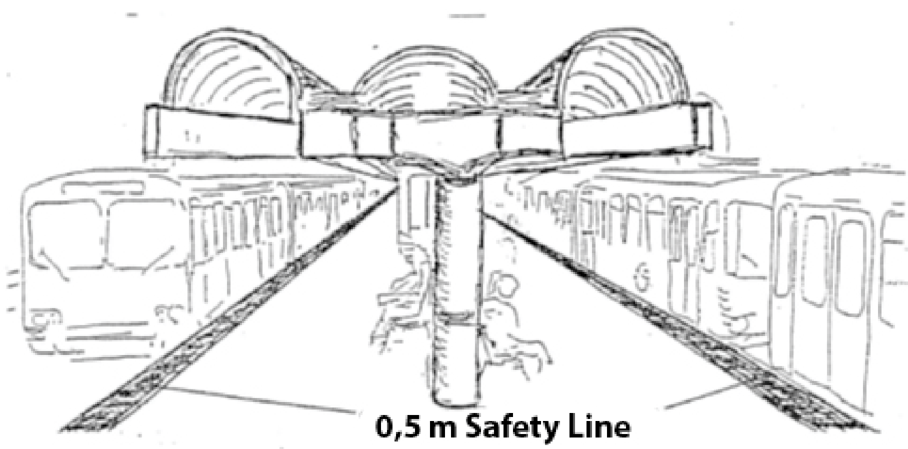


Figure 16 - Canopy and seating recommendation with 50cm security line (also known as Yellow Line) according to TS 12186 *(1997b)*

2.2.1.3 TS 9111: Accessibility for people with disabilities and mobility constraints

TS 9111 The requirements of accessibility in buildings for people with disabilities and mobility constraints (TSE, 2011) standard is relatively new compared to the other two. The last edition was issued in 2011 and is still in effect. Alike other standard documents, this document also starts with basic definitions about the notion of accessibility and how it should be achieved with different disabilities. However, one can also see that there are also case-specific examples and drawings related to the station buildings such as ticketing systems, as seen in Figure 17. This standard focuses on the accessibility principles that must be considered in every type of building. As a result, it covers every building type, including station buildings. However, as the standard's name indicates, it recommends accessibility solutions similar to the American Disabilities Act (ADA) Design guidelines (2012) and International Union of Railways' Standard Code 140 Accessibility To Stations In Europe (UIC, 2008).

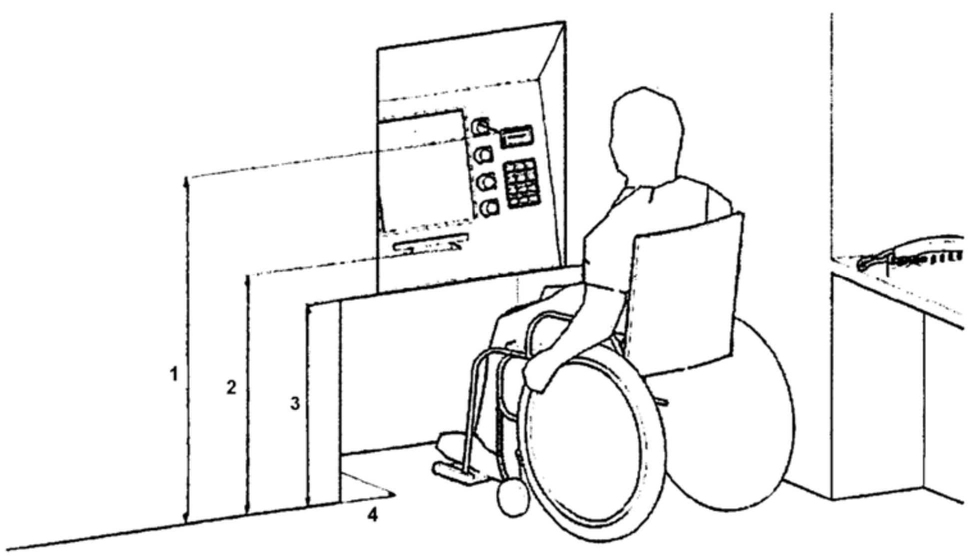


Figure 17 - Ticket system according to TS9111 Maximum lengths in order 110-80-75-60cm *(TSE, 2011)*

2.2.2 International Standards

International standards and guidelines contain a lot of pertinent information on various parameters that can be used for the design of subway stations. Some noteworthy standards from USA, UK, Australia, Germany, and China are listed as follows:

- American Public Transportation Association (APTA) standards;
- American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual "Chapter 6 Buildings and Support Facilities";
- German Federal Regulations on the construction and operation of light rail transit systems(2008);
- National Fire Protection Association (NFPA) standards code 101(National Fire Protection Association., 2017a) and 130 (National Fire Protection Association., 2017b);
- British Standards Institute's PD 7974-6:2004 the application of fire safety engineering principles to fire safety design of buildings - Part 6: Human factors: Life safety strategies — Occupant evacuation, behavior and condition (Sub-system 6) (British Standards Institute, 2004);
- GB 50157-2013 Code for Design of Metro issued by the Government of China (2013).
- International Union of Railways' Standard Code 140 regarding "Accessibility To Stations In Europe" (UIC, 2008);,
- American Disabilities Act (ADA) Design guidelines (2012);
- Russian Subway Design Standards,
- South Australian Government's Technical Standard Part 129003 (2013);
- Transport for New South Wales Asset Standards Authority's RailCorp Engineering Standards (2010a, 2010b, 2010c, 2016a, 2016b);

In these standards, three different design concerns are addressed. These are; design for daily users, accessibility for people with reduced mobility, and evacuation for emergencies. Three major standards from each subject will be inspected in detail and will be compared with other standards. During the research process, different countries and their respective subway operation management were contacted to acquire their related standards. Tokyo, Paris, Beijing, Seoul, and Milano subways and their relevant technical designers were reached to obtain information related to the subject.

Moreover, among the standards, the most common document related to the subway station design is the NFPA standard called the Standard for fixed guideway transit and passenger rail systems (National Fire Protection Association., 2017b). NFPA130 is also consulted in Turkish subway station designs as the existing Turkish standards respond to a problem. In addition to NFPA 130, NFPA 101(National Fire Protection Association., 2017a), UIC code 140(UIC, 2008), and LUL guide are also relevant documents that will be addressed in detail in this chapter.

2.2.2.1 APTA Guidelines and Principles for the Design of Rapid Transit Facilities

American Public Transportation Association (APTA) Guidelines and Principles for the Design of Rapid Transit Facilities (1981) also has a series of design guidelines and suggestions for designers to shape their architectural elements according to passenger load (Neff, Dickens and Public Transportation Association, 2015) similar to Transport for London's Design guideline (2012). However, APTA suggests a constant load of passengers at every station instead of peak hour passenger loads. This standard is similar to Turkish standards TS 12127(TSE, 1997b) and TS 12186 (TSE, 1997b) APTA suggests constant flow rates at fixed widths such as each 1100 mm width of stairway provides an exit capacity of 65 persons per minute and each 1220 mm wide escalator provides an exit capacity of 100 persons per minute. In addition, this document also suggests that stair widths should be multiples of 550mm unit of exit width and escalators should be within the dimensions of 600mm to 1220mm. One of the interesting factors about this document is that Canada also accepts this document as a design guideline for their station design, for instance, in the city of Edmonton Light Rail System (LRT) technical design documents of different lines (The City of Edmonton, 2012, 2014, 2017).

Similar to TS 12127 (TSE, 1997b), APTA suggests that if the vertical distance of two stories exceeds 3.7m, one escalator servicing ascending, and if the distance is greater than 7,3m, two escalators should be placed in the design. The most crucial difference in APTA standard is the occupancy of 0.743 square meters per person in contrast to Turkish equivalent 0.35 to 0.50 square meter per person (TSE, 1997a) or Transport for London's 0.93m2 per passenger (2012). Lastly, the suggested egress capacity is 3 minutes, regardless of the depth of the station. A detailed calculation of the APTA standards can be seen in Table 6.

Table 6- APTA design calculations showing the calculations for platforms, widths for staircases and escalators *(American Public Transit Association. Rail Transit Committee.; Transit Development Corporation., 1981)*

	Definition	Value	Notes
Platform width (center)	Platform length	123 meters	
	Passengers alight from trains	1000 people (500 each train)	
	Occupancy allowance	0,743	APTA standard
	Required area	743m2	1000x0,743
	Platform Width	743/123 = 6,04 meters	Required area / platform length
Excluding the allowance for the vertical circulation elements.			
To exit 1000 persons from the platform within 3 minutes			
	Exit rate	1000/3 min = 333 person/min	
	1 Unit stair width capacity	32 people (96 people in 3min)	2-unit stair width is required minimum (65 people per min)
	exit width are required	1000/96 = 11	Rounded up
Calculation 1	Provide 2 1220 mm escalators	600	2 x 100 p/min. x 3 min
	Provide 2 1100 mm stairs	390	2 x 65 p/min. x 3 min.
		990	total
	As above, but assume one escalator is down for maintenance		
Calculation 2	Provide 1 1220 mm escalators	300	1 x 100 p/min. x 3 min
	Provide 2 1650 mm stairs	576	2 x 96 p/min. x 3 min.
		876	p exiting in 3 min

Table 6 (continued) - APTA design calculations showing the calculations for platforms, widths for staircases and escalators *(American Public Transit Association. Rail Transit Committee.; Transit Development Corporation., 1981)*

	Increase stair width in case one escalator is down for maintenance		
Calculation 3	2 - 1220 mm escalators	300	1 x 100 p/min. x 3 min
	2 - 2100 mm stairs	780	2 x 130(35*4) p/min. x 3 min.
		1080	people exiting in 3 min
One Up escalator if the vertical distance exceeds 3.7 m			
One Down escalator (in addition to the Up escalator) if the vertical distance exceeds 7.3 m (in addition to the Up escalator)			
Platform width	Safety zone requirements	800mm	400 per boarding side
	Width from # of escalators	1220mm	1220m per esc
	Width from the stairs	2100mm	
	Platform Width (accessible)	6040 mm	
		10.16 meters	

2.2.2.2 AREMA Manual: Guidelines for Buildings and Support Facilities

As one can see from the name of the association, American Railway Engineering and Maintenance-of-Way Association (AREMA), the focus of the manuals is mostly around the railway infrastructure instead of the subway line or station design. However, Chapter 6 on Buildings and Support Facilities (2018) outlines specifics to designers not only for railway station design but also supporting structures such as railway office buildings, car repair shops, train depots, locomotive sanding facilities, locomotive washing facilities and observation tower in the US. The document suggests that architectural design and uniform graphics can be a convenient marketing tool, and standardized elements can be a practical approach to reduce project and maintenance costs.

The AREMA Guide divides passenger service characteristics into two types; inter-city and commuter passengers. Inter-city users are regarded as mostly stranger to the buildings with possible baggage or have some accessibility issues such as being with an infant or elderly. As a result, inter-city type passengers occupy more space at the station and demands service rooms (like waiting rooms, ticket issuing windows, toilets, vending machines) On the other hand, commuter user profiles are more used to the station layout due to the fact that they use the building on a regular basis and this familiarity enables them to be more active, less luggage and mostly linear flow from train to exit. The document suggests designing for two passenger types as much as possible to have an efficient station design.

Afterward, the document defines station types according to its approach. These types are Inter-city stations, commuter stations, intermodal passenger stations, combination freight, and passenger stations, and historic buildings. The basic layout of the station types is based on the room types and how they are changed according to the room type. Similar to pedestrian properties mentioned in the document, the requirements of the station types differ according to the user type and other transportation opportunities other than the train connection itself. In addition, only in this document, we also see an attempt to evaluate historical station buildings from a technical design guideline perspective.

From the technical approach, the document suggests fixed values to designers for a uniform design approach along the line. Island platforms should have a minimum 17feet (5,18 meters) width, and for small and medium-sized platforms, the suggested width is between 10 to 20 feet (3 to 6 meters) depending on the passenger load. When looked at the stair width data, the minimum recommended width is 48 inches (1.2 meters), and they also must comply with the American Disabilities Act (ADA) design guidelines(2012). Moreover, at the non-terminal stations, it strongly suggests multiple stairs to separate pedestrian movement. When a canopy design is needed, the document suggests architecturally integrated design approaches by structural design, color, form, and material choices.

2.2.2.3 German Regulations: Construction and Operation of LRT Systems

The German Federal Regulations for the construction and operation of "Straßenbahnen" include regulations for LRT, tramway, and subway systems of the German cities(Hafter, 2008). From this document, readers can access the definition of the station, and essential design criteria, such as proper signage. According to the standard, the width of platforms must accommodate passenger load, yet it is not possible to trace any suggested calculation method. On the other hand, the platform width standard dictates a clearance of 2m width unless the platforms are located in traffic areas or highways.

2.2.2.4 NFPA 130: Fixed Guideway Transit and Passenger Rail Systems

National Fire Protection Agency (NFPA) addresses various disasters and emergencies, from basic preemptive methods to campus safety in school shootings. Likewise, NFPA code 130 focuses on the standards for fixed guideway transit and passenger rail systems, as one can see from the name of the standard. However, it is vital to keep in mind that NFPA 130 is evaluated as a standard or a guideline in different North American states and Canada. Therefore, NFPA 130 is considered as an international standard in different countries where an applicable standard is partially or entirely missing.

It is vital to keep in mind that one of the most critical aspects of NFPA 130 is the standard was revised fourteen times until its issue in 1975 to its current form in 2020. Besides, the standard focuses not only on the station design but also on the rail system, so it is possible to find information and design concerns regarding the line components and cross passage designs.

Like every standard, NFPA 130 starts with definitions and general design concerns. The standard stands out with some crucial definitions as Engineering Analysis and Computational Fluid Dynamics, where other standards do not cover such definitions or approaches, yet, by the nature of the document, it focuses mostly on fire safety.

The standard uses a similar approach to the Turkish Standards, where the distribution of peak or critical passenger/occupant load is used to calculate the different aspects of the station. However, it is imperative to keep in mind that NFPA 130 is focused on the egress calculations of the railway facilities rather than providing a design guideline for the design of subway stations.

Compared to the Turkish standards, NFPA suggests the minimum clear width for platforms, corridors, and ramps is 1120mm (44inches); however, at these building elements, 300mm from sidewall and 450mm from platform edges will be subtracted. The minimum staircase with egress intention should be 1120mm, where their capacity 55.5 p/m-min with the 14.6m/min speed on the vertical components. Maximum suggested egress capacity for the platforms, ramps, and corridors is 81.9 p/m-min (person per meter in meter) where the maximum travel speed is 37.7m/min (124ft/min). On the other hand, suggested travel speed for concourses and other areas is 61m/min (200ft/min). For the escalators, the suggested nominal width 1m with the travel speed of 30m/min, providing the capacity of 75p/min. Gate type fare barriers or turnstiles provide 50 p/min as an egress capacity with the clear width 455mm up to the 1m height or 530mm at 1m or higher situations.

On the other hand, turnstile-type fare gates provide 25p/min for egress calculations. Though, we do not have any information regarding the capacity of the turnstiles for daily use situations. In addition, according to NFPA 130, platform evacuation time is 4 minutes, and evacuation time to the point of safety is 6 minutes in contrast to the Turkish standard, which only dictates evacuation time for the station.

2.2.2.5 PD 7974-6: Fire safety design of buildings

The British Standards Institute in 2004 issued PD 7974-6 "The application of fire safety engineering principles to fire safety design of buildings. Human factors. Life safety strategies. Occupant evacuation, behavior, and condition". This standard aimed to develop fire safety engineering codes to provide fire safety, starting from the design of buildings. Even though the standard is mostly focused on fire safety, as one can understand from its name, provided data gives an insight into the station design in the United Kingdom except studies conducted by Transport for London. This Standard evaluates the subway station as a transportation building type, and it includes subway stations, railway stations, and airports. Standards suggest that the behavioral pattern of the pedestrians should be considered as wary, yet they must be regarded as unfamiliar with the building plan, which requires assistance from its personnel.

The most important part of the document is its definitions of the pedestrian speed in different building spaces and occasions. According to the standard, the unimpeded walking speed of a pedestrian is around 1,2m/s based on works of Pauls (2003), Nelson and Mowrer(2002), Fruin (1971) and Predtechenskii and Milinskii (1978). When we look at the vertical speed, we can see that depending on the dimensional properties of the stair; we can see values between 0,6m/s to 1,05m/s. However, it is essential to keep in mind that the primary purpose of the standard is providing sufficient egress to its users.

2.2.2.6 GB 50157-2013: Code for Design of Metro

When looking at the Chinese standard GB 50157-2013 Code for Design of Metro (2013), we can see that one of the most important points of the standard is focused on egress of the subway station rather than design for daily use. In contrast to NFPA 130 (2017b), where the platform of the subway station should be evacuated in four minutes, and the whole station should be evacuated in six minutes, GB 50157-2013 requires that the entire station must be evacuated in six minutes including the one minute reaction time. It is possible to see that extensive studies (Jiang *et al.*, 2009; Wang, Chen and Li, 2012; Jia and Fang, 2016; Chen *et al.*, 2017) aim to compare or layout the mathematics of the approach to the standard.

2.2.2.7 UIC 140 PRM TSI: Accessibility Standards

The International Union of Railways (UIC) aims to provide the same level of accessibility to all of its users. In order to achieve accessible stations all over Europe, UIC code 140 (2008) was developed. Similar to Turkish Standard 9111 (TSE, 2011), it also presents case study drawings and recommendations for designers for more accessible station design (Figure 18). However, compared to Turkish Standard 9111 (TSE, 2011), UIC 140 has a different definition of people with reduced mobility (PRM). According to the standard, not only people with disabilities but also people with children, people with luggage, elderly people, pregnant women, people with small stature are regarded as PRM. Standard layouts have various accessibility solutions from the entrance of the station to the boarding platforms.

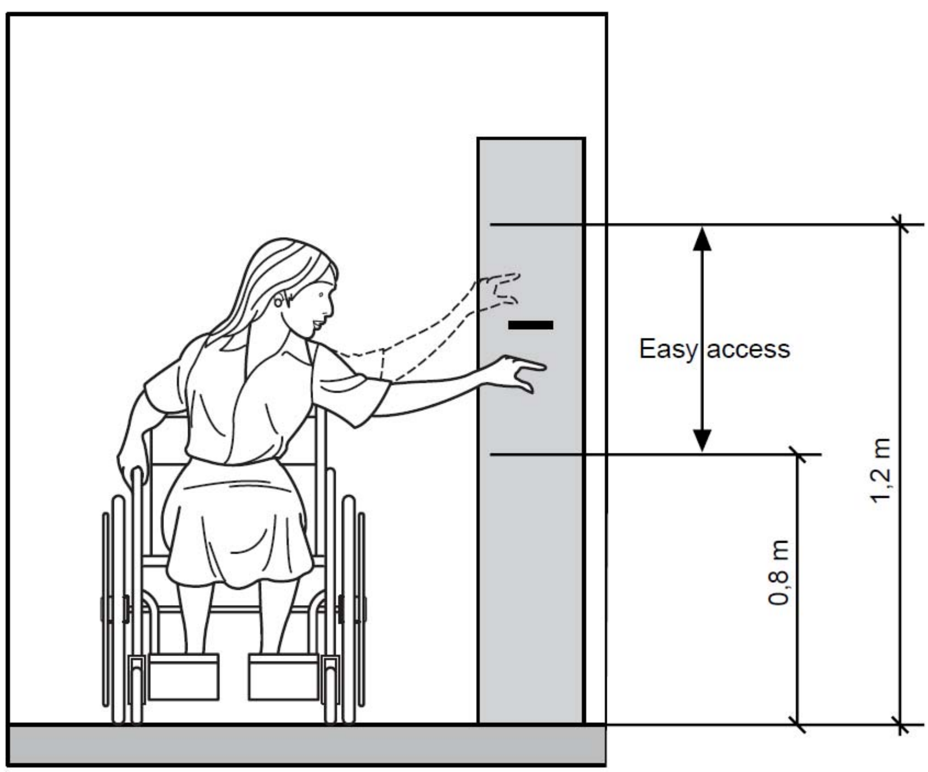


Figure 18 – A schematic drawing of the suggested accessibility to ticket machines according to UIC 140 *(UIC, 2008)*

2.2.2.8 ADA: Guidelines for Accessibility

Similar to the UIC 140 American Disabilities Act (ADA) Design Guidelines (United States Department of Justice, 2012) aims to provide accessibility to station users. According to the guidelines, at least one accessible route should connect each story in a multi-story building (Figure 19). In contrast to UIC 140 code ADA design guideline covers an extensive range of design suggestions. However, ADA design guidelines include all types of buildings, from office buildings to substations. Technical design guidelines that follow American design guidelines as a basis for their stations apply ADA Guidelines compared to the UIC 140 unless they are connected to the European interoperability railway network.

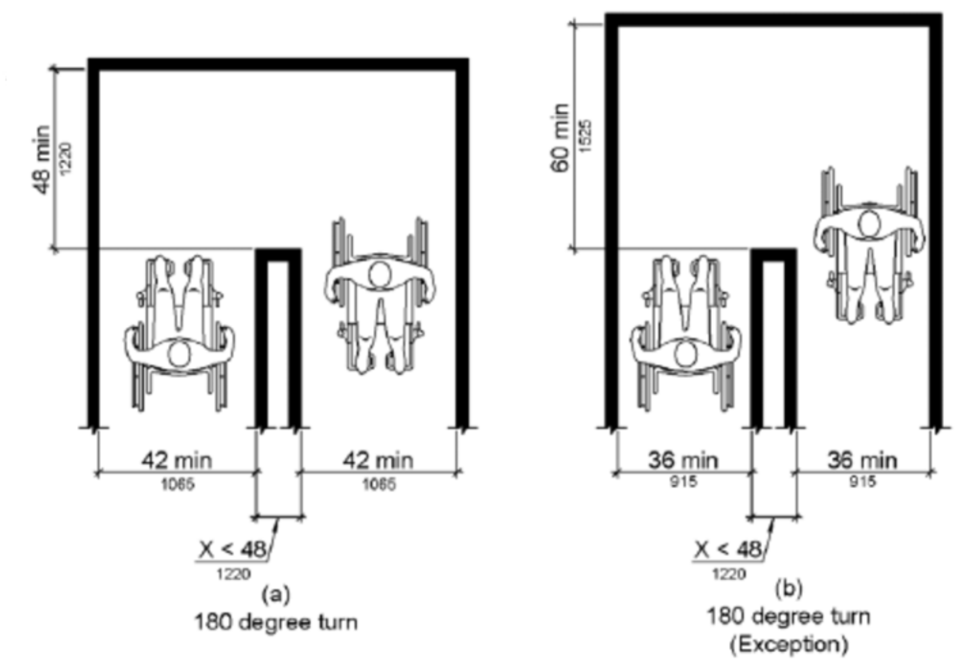


Figure 19 - Ramp dimensions for a 180-degree turn to provide wheelchair access according to ADA *(2000)*

2.2.2.9 Russia: Subway Design Standards

As we know from the UITP data, the Moscow subway is among one of the most crowded subway lines in the world (Nadler, 2001; UITP, 2015a). However, when looking at the design guidelines and related standards for subway station design, we see a critical approach in developing the existing situation (Kholshevnikov *et al.*, 2008; Gravit, Vaititckii and Shpakova, 2016). Whereas, from the popular perspective, we see admiration for the station designs of the Moscow subway.

On the other hand, it is evident that existing station designs have problems with the current passenger volumes (Korotaev, 2016), and there are remarkable efforts to enhance the station design (Maslak and Boytsov, 2016). However, instead of the current designs and guidelines in Russia, subway station designs of Moscow and St. Petersburg stand out as notable examples from their time. Throughout their construction of the two lines, the focus was on designing each of the forty-seven stations on these lines as a "showpiece of the socialist achievement of the First Five-Year Plan" (Figure 20) (Adams, 2008). Details on these showpieces are discussed further in the following chapter.

Figure 20 - Proposed design perspective for the Teatralnaia Subway Station Line 2 Moscow Metro at the Screen of the Worker's Newspaper (Kettering, 2000a)

2.2.2.10 Australia: Standards and Design Guidelines

It is possible to access two-state standards and design guidelines for railway and LRT construction. Transport for New South Wales Asset Standards Authority's ESB standard series Standards (2010a, 2010b, 2010c, 2016a, 2016b) and Technical Standard Part 129003 (2013) published by the South Australian Government

According to ESB 000 (2010a), there are 368 stations in RailCorp's rail network, and the primary intention of these documents is to create a coherent design approach among all stations so that they can also optimize construction and maintenance through its design life. The ESB 001 standard (2010b) lays out an extensive project process for the future line, and it is supported by ESB 002 standard (2010c) by explaining design principles. These principles are safety, security, buildability, maintenance and life cycle, accessibility, environment, and heritage. This approach enables designers to have a holistic approach to station design in order to create a welcoming space not only to passengers but also to its staff. However, when looked at, ESB 003 standard (2016a) suggests the application of NFPA 130 (2017b) on egress design. As a result, on station design, they use the peak-hour passenger load approach to determine suggested widths for architectural elements. However, the standard lays out a very informative circulation plan for station design and defines three activities for passengers; queuing, milling (at passenger info), and waiting. Moreover, suggested area occupancy is between 0,65 to 0,93 m2, with the inter-person spacing 914mm. When looked at, the following standard ESB 004 (2016b) presents the accessibility standards and solutions in a very particular way similar to UIC Code 140 (UIC, 2008).

Another interesting document is the Technical Standard Part 129003 (2013)published by the South Australian Government. In view of the fact that the Adelaide Metropolitan Passenger Rail Network (AMPRN) operates 85 stations, it is essential to review its approach to station design. The document identifies station types and platform types similar to the rest of the standards, yet one of the most important notions is the fact that it suggests minimum platform widths according to the platform type (Figure 21). According to the document, marginal platforms require a minimum of 4,5 meters, island platforms with single side loading 4,5 meters, island platforms with dual loading requires a minimum of 7,8 meters, and at integrated interchange stations require 8,0-meter-wide platforms.

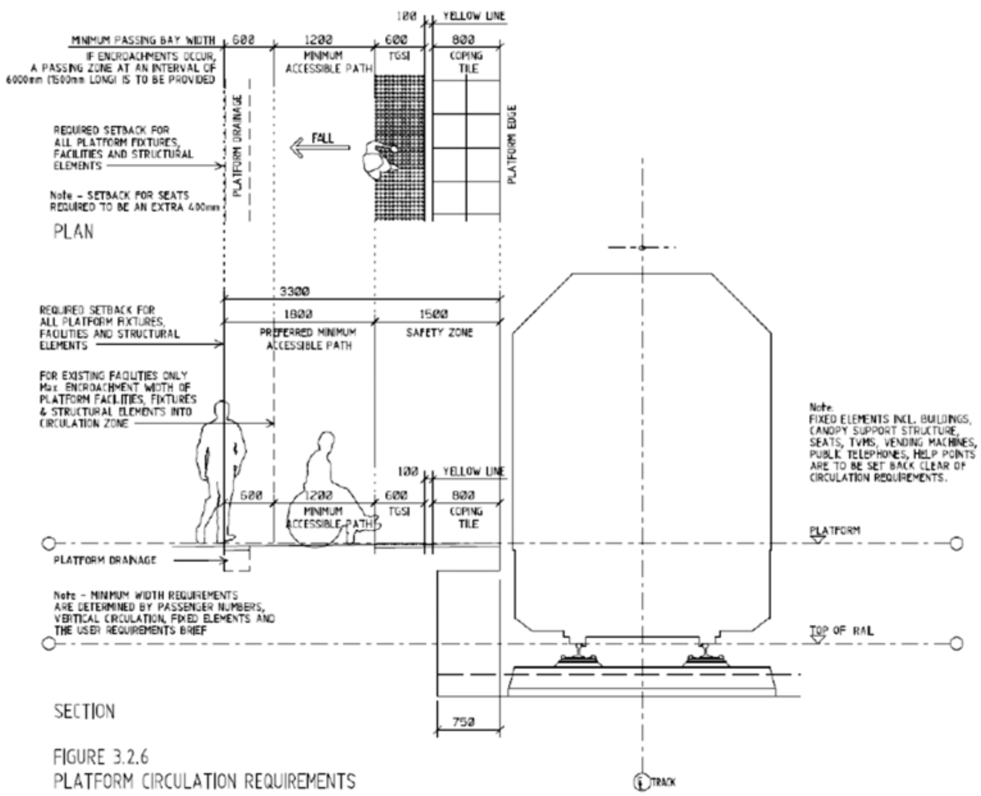


Figure 21 – Section and plan views for the platform circulation requirements *(Transport for New South Wales Asset Standards Authority, 2016b)*

Design Guidelines

Besides the standards related to subway station design, it is also essential to review design guidelines and technical specifications of different projects. This approach will give us an insight into how these national standards are evaluated and applied n different geographies. The notable design guidelines being used by different countries can be listed as follows:

- Transit Capacity and Quality of Service Manual (National Academies of Sciences Engineering and Medicine, 2013c) by National Academies of Sciences Engineering and Medicine
- London Underground's LuL G371a:2012 Station Planning Standards and Guidelines (Transport for London, 2012), and the London Underground Station Design Idiom (2019a),
- Design Guidelines for North American Cities: New York City Transit Authority's Graphic Standard Manual (Vignelli and Noorda, 1970),
- Swedish Transport Administration Reports (ARUP, 2016; Swedish Transport Administration, 2016, 2018; Stockholm läns Landsting, 2017),
- The Urban Rail Development Handbook was published by the World Bank Group (Pulido *et al.*, 2018).
- JICA Preparatory Survey on Greater Cairo Metro Line No.4 in the Arab Republic of Egypt Final Report
- Metro Design Criteria and General Principles (2019) by İstanbul Büyükşehir Belediyesi (IBB, i.e., Istanbul Metropolitan Municipality) Directorate of Rail System Projects.

In addition to country-based guides, a vast collection of design guidelines in different states and cities, such as those belonging to the States of New York, Florida, and California in the USA, the cities of Austin (Texas), Washington D.C., Honolulu, and Edmonton (Canada) are also inspected to gain an insight regarding the station design. These five guidelines are explained in more details in the following sections:

2.2.2.11 Transit Capacity and Quality of Service Manual

One of the essential guidelines in this respect is the Transit Capacity and Quality of Service Manual (2013c) published by the National Academies of Sciences Engineering and Medicine. Manual covers an extensive range of subjects such as; Quality of Service Methods, Bus Transit Capacity, Demand-Responsive Transit, Rail transit capacity, and Station capacity. Two chapters, Chapter 5 Quality of

Service Methods (2013a) and Chapter 10 Station Capacity (2013b), layout extensive detail about the station design and its components.

The Quality of Service Methods (2013a) provides service measures and other performance measures for designers and operators. One of the most important evaluations in this chapter is its approach to passenger load and its assessment both from the passenger and the operator perspective so that the designer can create an equilibrium. In addition, the chapter also compares different approaches to the body ellipse and the possible number of people per square meter. According to the section, studies made in the seventies show that body ellipse of the human body occupies $0.22m^{2.}$ However, when looked at the current suggested model, one can see that the proposed area has been increased to $0.24m^2$. Besides, for passengers with bags or backpacks, the same area goes up to 0.4-0.5 m^2 (Table 7).

Table 7- Pedestrian projected areas in different situations and conditions *(National Academies of Sciences Engineering and Medicine, 2013b)*

Situation	Projected Area (ft^2)	Projected Area (m^2)
Standing	2.2-2.6	0.20-0.24
... with briefcase, computer bag	3.4-4.1	0.32-0.38
... with daypack	3.8-4.2	0.35-0.39
... with suitcases	4.4-6.3	0.41-0.59
... with stroller	7.3-12.5	0.95-1.15
... with bicycle (horizontal) 1	1.8-16.6	1.10-1.54
Holding on to stanchion	3.5-4.0	0.33-0.37
Tight double seat	3.8 per person	0.35 per person
Comfortable seating	5.9 per person	0.55 per person
Personal transporter	3.8-5.5	0.35-0.51
Wheelchair/scooter space (ADA)	10.0 (30 in. x 48 in.)	0.93 (0.76 m x 1.22 m)

Chapter 10 on Station Capacity (2013b) is outstanding documentation that provides insights about the key components and the dynamics of a station. However, this document recommends using the fire safety and evacuation standards dictated by NFPA 130 (2017b) for safety requirements and the American Disabilities Act (ADA) Design Guidelines (2012) for accessibility requirements. One of the positive aspects is that the document establishes pedestrian circulation patterns based on Fruin's (1971) guidelines. However, when we looked at the horizontal and vertical metrics of pedestrians, we see a different approach. According to literature sources, horizontal circulation is affected by pedestrian speed, pedestrian density, pedestrian characteristics (such as; reduced mobility, luggage, strollers, and bicycle), and the sufficient width of the walkway. Pedestrian speed is not a constant factor in this study. It suggests that impendent walking speed varies from 45m/min to 145m/min, and 75m/min is the recommended value for designs. While the suggested density of 2.3m2 is recommended for walkways, but when the density drops below 0.5m2 per person, pedestrian flow is expected to stop, which shows us that we might need to develop a critical approach to the TS 12127 (TSE, 1997a).

On the other hand, for vertical circulation capacities, segmentation is taken as 75cm, and the minimum suggested stair width is 1.5meter, whereas the Turkish standards recommend a width of 1.2 meters. In addition, research shows that for vertical circulation, the ascending speed ranges between 12 and 21 m/min (in vertical length), and descending speed varies between 17 to 31m/min. However, it is important to keep in mind that the total length of the stairs affects the speed of the pedestrians also. Accordingly, escalator capacity is also another aspect that should be taken into consideration. Entry width and the operating speed has a direct effect on the capacity of the escalator. Higher speeds than the suggested 36.6m/min would decrease the elevator capacity because they require longer boarding times.

The manual also has design recommendations for platform design. The most critical information is the fact that passengers do not cover platform area evenly like gas molecules similar to Transport for London's (2012) approach. Even if the platform is designed according to standards, passengers might experience congestion in specific areas due to queuing. Therefore, research strongly suggests using microscopic pedestrian simulations to analyze these patterns at stations.

Another useful information in this manual is the suggested capacities and dimensions for faregates/turnstiles. When technical documents indicate particular types of turnstiles with constant capacities, the TRB manual shows how different faregates provide different passenger flows (Table 8).

In contrast to technical documents where a constant occupancy value per person determines the suggested area, TRB prescribes a very detailed step by step approach to designers. Critical stages of this approach which make the difference from rest of the documents are; determining the desired Level of Service (LoS), determining the passenger characteristics (such as reduced mobility, backpacks, bicycles), calculating the desired personal space and buffer zones, queue storage space and safety factors.

Table 8 - Faregate types and capacities *(National Academies of Sciences Engineering and Medicine, 2013b)*

Type of Entrance	Observed Average Headway (s)	Equivalent Pedestrian Volume (p/min)
Free admission (barrier only)	1.0-1.5	40-60
Ticket collection by staff	1.7-2.4	25-35
Single-slot coin- or token-operated	1.2-2.4	25-50
Double-slot coin-operated	2.5-4.0	15-25
BART (transported magstripe ticket, low bi-leaf gate)	2.3-2.9	21-26
London (transported magstripe ticket, high bi-leaf gate)	2.40	25.00
New York (swiped magstripe ticket, turnstile)	2.6-2.9	21-23
London (smart card, high bi-leaf gate)	2.40	25.00
Exit gate, 3.0 ft (0 .9 m) wide	0.80	75.00
Exit gate, 4.0 ft (1.2 m) wide	0.60	100.00
Exit gate, 5.0 ft (1.5 m) wide	0.50	125.00

2.2.2.12 London Underground Station Planning Standards and Guidelines

London underground and its publication related to the subway station and pedestrian simulation is extensive. Transport for London (TfL) has published a series of standards and good practice documents to enhance the design of subway stations. Among them, two reports emphasize the architectural design of the station from two aspects, LUL G371a:2012 Station Planning Standards and Guidelines (Transport for London, 2012) for technical design and London Underground Station Design Idiom (2019a) as a design style guidebook.

Station Planning Standards and Guidelines focus on the technical layout of the station design. Starting from the basics document focuses on laying out an outline for the station. The main contents are passenger space planning and calculating the components of a station according to the passenger load. First, the document layouts passenger related areas based on the passenger load then shape out the technical areas and ancillary facilities according to the same data. Also, the paper suggests design approaches for a secondary income, other free-standing items, and various public facilities. The most important property of this document is the recommended workflow for the width of the platform and staircases, required number of escalators, automated walkways, turnstiles, ticket issuing windows and machines based on peak-hour passenger load calculations. One of the most important aspects in this document is the accepted minimum for the platform design is 0.93m2 per passenger at the busiest part of the platform. In addition, one of the most distinctive properties of the document is the fact that it suggests heterogeneous distributed passenger loads on platforms rather than homogeneous, evenly distributed pedestrian space (Figure 22). An example of the existing calculation method is added to the Appendices B.

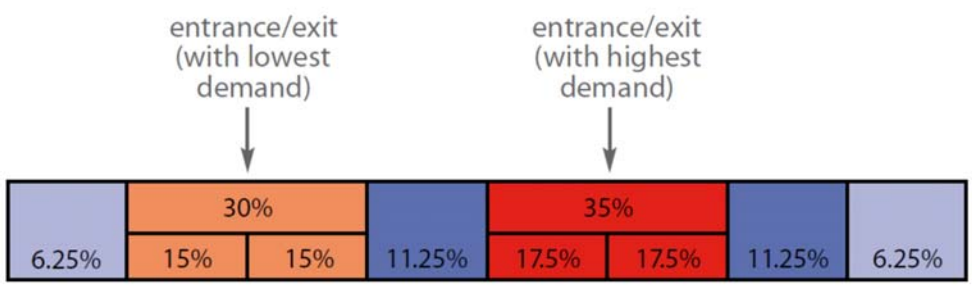


Figure 22 - Passenger load distribution on a side platform with two cross passages according to London Underground Station Planning Standards and Guidelines (Transport for London, 2012)

Station Design Idiom focuses on the design and the decision-making process for the design of a station with the intention of bringing design as the driver of the process. The document is an extensive study extending from necessary modifications as painting an existing station to refurbishments and newly built stations. However, design idiom evaluates the station based on decision making for design in contrast to the Station Planning Standards and Guidelines' quantitative method. Design idiom intends to guide designers for future designs based on its historical design approaches while depicting an "ideal station" with various attributes wholeness, accessibility, and lighting in station related spaces such as platforms, concourses, routeways, corridors and, ticket halls (Figure 23). The most important aspect of the guide is focused on the user experience of the space to achieve wholeness and provide comfort for staff and passengers rather than using the human body as a space calculation factor.

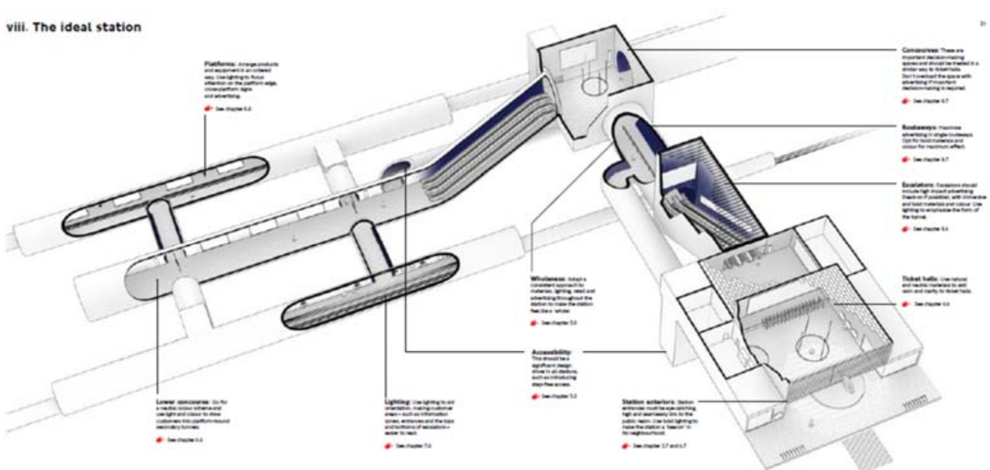


Figure 23 - Schematic Design layout of an ideal station according to Transport for London (2019a)

In addition to both of the documents, Transport for London (TfL) published a series of documents to design transport facilities in London. These additional documents help designers to layout their different types of design such as capacity guidance information on railway station (Network Rail – Station Capacity Guidance, 2014) pedestrian comfort guidance for station design (Transport for London, 2010a), traffic modeling guides (Transport for London, 2010b), guidelines to design bus stops for operational and construction (London Bus Services Limited and London Buses, 2002) and a striking study modeling methods for pedestrian simulation software (Clear, 2016).

2.2.2.13 Design Guidelines for North American Cities

One of the most interesting design guidelines belongs to New York City Transit Authority's Graphic Standard Manual (Vignelli and Noorda, 1970), which is similar to Noorda's work at Milano Subway (Kutkan, 2010). It is considered as a modernist masterwork and extensive descriptions for the iconic New York City subway signs, which are still in use (Figure 24). Designers have the chance to observe a primary sign distribution in a station and acquire every information about the signage system letter by letter with detailed explanations.

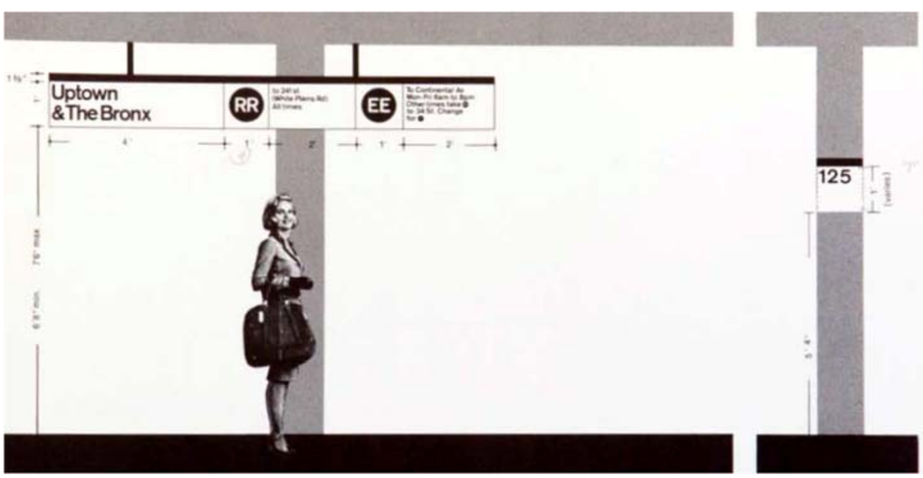


Figure 24 - Directional Signs on platforms according to New York City Transit Authority's Graphic Standard Manual (Vignelli and Noorda, 1970)ne

New York City is modernizing its subway infrastructure (New York City Transit, 2017) and additions to the new signaling system, renovations of the existing stations, new subway cars, and a new fare payment system. One of the interesting additions to the current subway lines is the Second Avenue Subway, which will be constructed in four phases. Moreover, the project also executes different underground station types due to the dense urban context of the surface where construction operations are highly challenging for any cut-and-cover type of construction activity (Figure 25). Extensive documentation regarding the extension can be found in the literature regarding the subjects such as; refurbishment of an existing underground station (Garavito-Bruhn, Napoli and Towell, 2019), deep excavation support (Grigson, Ho and LeMus, 2019), design of new underground stations (Aksman, Grigson and Giffen, 2019), reconstructing existing buildings for new station entrances (Giffen, Ezzeldin and Towell, 2019) and design of a new elevator only entrance (Voorwinde and Giffen, 2019).

One of the interesting articles regarding the subway expansion was the design of an elevator only entrance for a subway station due to the tight footprints. However, in order to apply NFPA 130 and ADA Design codes to their stations, a tunnel was designed, which leads pedestrians to neighboring buildings. It is also interesting to see the approaches to station design and their design concerns. However, according to the research typical design approach was developed for economical optimization.

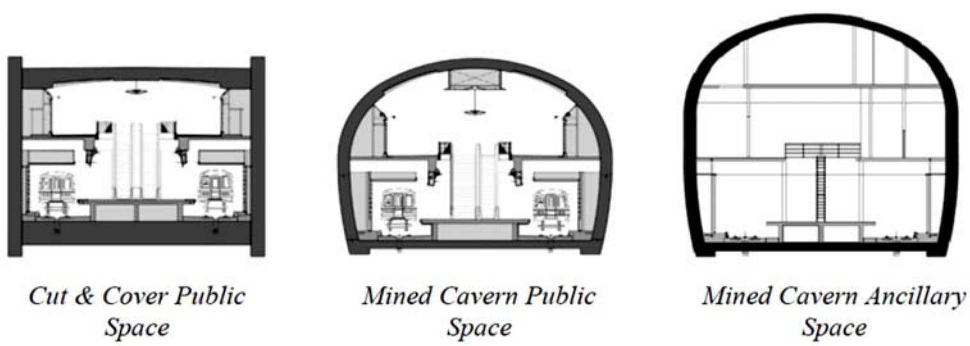


Figure 25 – Suggested station types at 2nd Avenue subway line project *(Aksman, Grigson and Giffen, 2019)*

In addition to the New York Subway documentation, it is also possible to find a similar document from different states in the United States. These documents will give us an insight into how the same standards shape different design approaches. For this research, several materials are inspected to evaluate how designers generate different station designs based on the same criteria. These documents are:

- South Florida East Coast Corridor (SFECC) Transit Analysis: Station Design Guidelines for SFECC (EDSA Inc., 2006),
- The Caltrain Corridor Vision Plan (Amin, 2017) and California High-Speed Train Project Technical Memorandum (Way, 2010),
- Transit Design Guide: Standards & Best Practices of Austin Texas (2017),
- Guidelines for Station Site and Access Planning Washington (2005),
- Honolulu Rail Transit (Boeing, 2016),
- Station and Support Facility Design Guidelines User Guide (Metropolitan Council, 2012)
- City of Edmonton's Design Guidelines (2012, 2014, 2017).

Common themes among these guidelines are that all of them use NFPA 130 and ADA Design Guidelines as their basis for safety and accessibility issues in design, despite their different vehicle capacities. On the other hand, we can hardly see any reference to the Transport Research Board's documentation. Every document suggests similar design concerns and approaches, such as integration into the urban context, accessibility, functional simplicity, security, maintenance, and community identity. For example, a very typical station design can be seen Transit Design Guide: Standards & Best Practices of Austin Texas (2017) (Figure 26).

However, the South Florida East Coast Corridor (SFECC) develops different classification for their stations based on their location: Anchor stations in dense urban areas with substantial passenger volumes, Key Stations in town centers, and intermediate stations in neighborhoods, local parks, special events venues. In addition, this document is against typical station design; instead, it suggests different approaches to stations based on their urban context and user demands aiming at sustainability with detailed explanations for future developments.

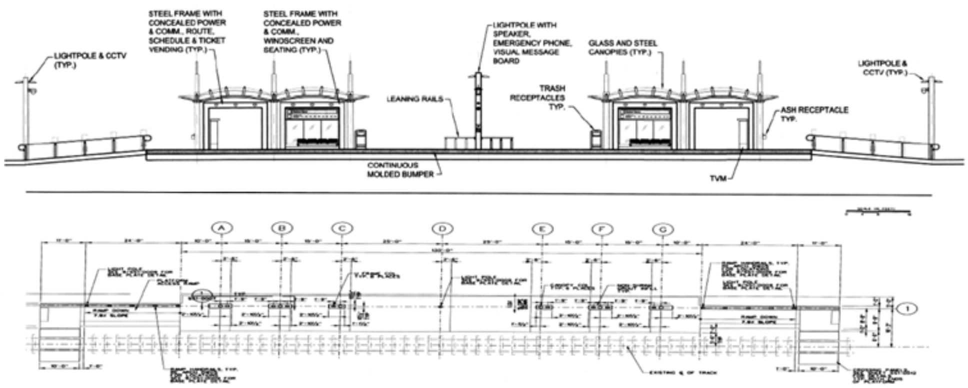


Figure 26 - Railway Station Elevation from Transit Design Guide: Standards & Best Practices of Austin Texas (2017)

2.2.2.14 Swedish Transport Administration Reports

It is possible to access documentation regarding the station design in Sweden, thanks to various reports of Swedish Transport Administration, Stockholm Metro, and studies available on-line. Interesting approaches in these studies show us that station design guidelines suggest constant platform widths, as seen in Figure 27 (ARUP, 2016; Swedish Transport Administration, 2016, 2018; Stockholm läns Landsting, 2017). Moreover, one of the interesting approaches in these studies is the adaptation to the Nordic climate, where designers must prepare for snow removal machines to work on the platforms. (Andersson and Lindvert, 2013). Besides, as in the underground city networks of Canadian cities, it is possible to see similar approaches in similar climates (Vähäaho, 2014).

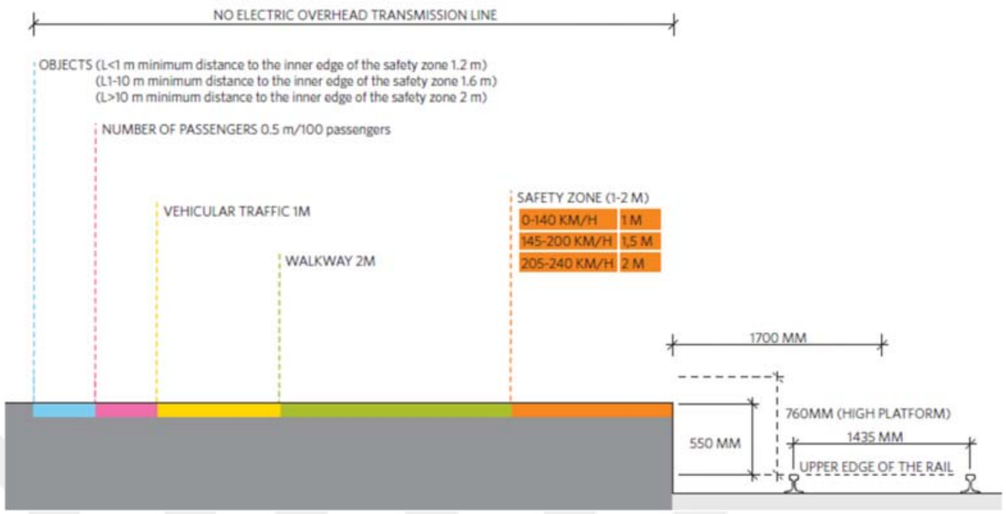


Figure 27 – Suggested dimensions for a platform design by the Swedish Transport Administration *(2018)*

2.2.2.15 World Bank Group Urban Rail Development Handbook

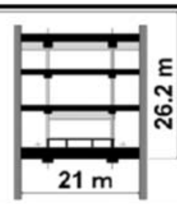
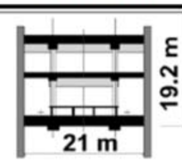
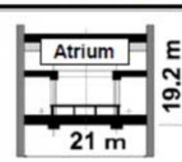
Another informative document that may give us information about the subway station design is The Urban Rail Development Handbook published by the World Bank Group (Pulido *et al.*, 2018). The guide provides its readers with extensive information about subway investments financed by the World Bank Group. The handbook collects intriguing design concerns not only about station design but the whole line. One of the most dramatic information in the report is; in 2012, at Mumbai's rail system, more than 3600 accidental deaths were documented due to lack of platform space, poor safety on overhead bridges, insufficient signage, and inadequate safety measurements between the tracks. This tragic information shows us the importance of the security measures and standards in subway station design.

2.2.2.16 JICAs Approach to Subway Station Design

Another interesting approach to subway station design belongs to the Japan International Cooperation Agency (JICA, 2010a) that was presented in their

Preparatory Survey on Greater Cairo Metro Line. Due to the fact that Cairo, with a population of over 18 million, its design approach might be interesting to trace the similarities and differences between İstanbul, which has a similar population. JICA has a different approach to the station types from a design perspective and develops a critical perspective on standards such as NFPA 130 by comparing different alignment and egress design approaches all over the world. According to this document, an optimized approach should be developed to decrease the station construction costs, unless NFPA 130 is applied for egress calculations. Based on Japanese standards and other countries' experiences, JICA recommends that all material that is used in the station architecture should be non-combustible, and different evacuation passages should be provided without any overlaps (two directions minimum) from the platform to the ground level. Additionally, it recommends using pedestrian simulations and capacity calculations based on unimpeded walking speeds of pedestrians that should be taken as 1.0m/s for flat areas and 0.5m/s for staircases. However, JICA also prescribes fixed platform widths and typical station layouts with 14m width for island platforms, and 9m width for separate platforms, disregarding any Level of Service or comfort approach (Table 9).

Table 9- Comparison of Structures for the Standard Station(JICA, 2010a)

	Three-storey type	Two-storey type	
		Without atrium	With atrium
Outline (cross section)			
Inner width of Station	21.0 m	21.0 m	21.0 m
Station length	190.0 m	280.0 m	320.0 m
Accessibility from concourse to platform	Vertical distance: 13 m use of stairway: 2 times	Vertical distance: 6.0 m use of stairway: 1 time	Vertical distance: 6.0 m use of stairway: 1 time
Volume of Excavation	About 104,500 m^3	About 113,000 m^3	About 129,000 m^3
Concourse (B1 level)	Area: 2,730 m^2 Entrance square: 2 places	Area: 2,310 m^2 Entrance square: 1 place	Area: 3,570 m^2 Entrance square: 2 places
Construction costs ratio	1.0	1.08	1.23
Construction Period ratio	1.0	1.2	1.4
Characteristic	Most economical for construction cost, and similar to Metro Line 3 under construction	Most convenient for passengers, but expensive for construction	Most Convenient and comfortable for passengers, but most expensive for Construction
Recommendation	For typical standard Station of Metro Line 4	For long length station required by another reason like turn-back track	For only special station of Metro Line 4
Applicable station	No.6, 7,8,10,11,14	No.5, 9	inapplicable

Source: JICA Study Team

2.2.2.17 İstanbul Metropolitan Municipality Metro Design Guidelines

In 2019, İstanbul Büyükşehir Belediyesi (IBB, i.e., Istanbul Metropolitan Municipality) Directorate of Rail System Projects issued the Metro Design Criteria and General Principles (2019) to cover all concerns regarding the design of a subway, tramway, or light rail system. The guideline separates the whole line construction into seven chapters and approaches each one methodologically. These chapters are classified on a discipline-based approach involved in the design and construction of the whole line. Relevant chapters cover; subway line design and general design concerns, subway station design and principles, subway route and alignment design concerns from the civil engineering perspective, design of power supply and management, signal and communication system design, design guideline for heating, ventilation and air conditioning (HVAC) systems and fire, safety, and fire prevention systems.

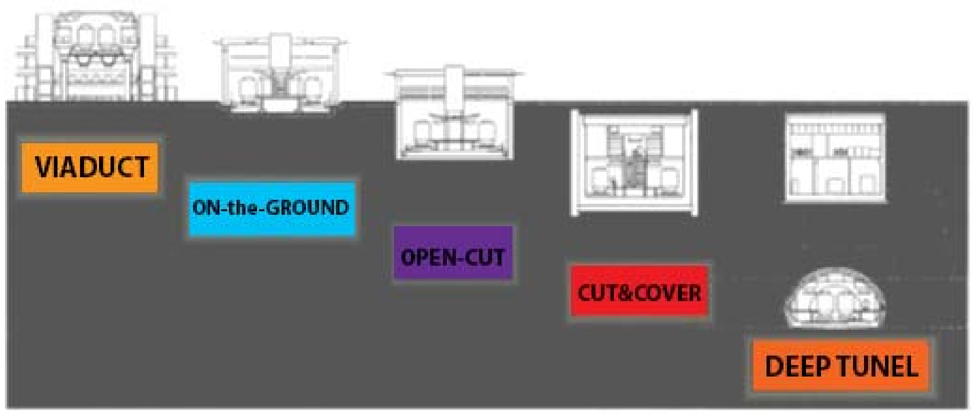


Figure 28 - Station types according to Design Criteria and General Principles(IBB Raylı Sistem Daire Başkanlığı Raylı Sistem Projeler Müdürlüğü, 2019).

Interestingly, the document suggests recommendations for design methodologies and proposes a balanced approach to engineering and architectural designs. While the first chapter covers a general approach to the notion of the station, it also suggests that its design should cover all aspects from passenger experience, ease of access, urban design approaches, ancillary facilities design, operation and management procedures, economic sustainability, and energy efficiency. In addition, one can also see a station classification in Turkish terminology (Figure 28).

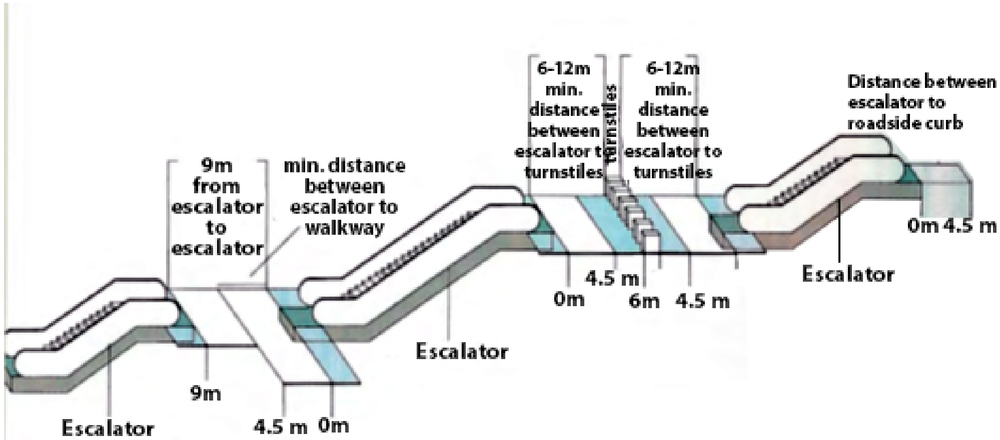


Figure 29- Runoff areas from Design Criteria and General Principles (IBB Raylı Sistem Daire Başkanlığı Raylı Sistem Projeler Müdürlüğü, 2019)

The second chapter lays out the technical approaches and guiding principles of the subway station from the IBB perspective (Figure 29). Unsurprisingly, while the document covers subway stations on a building element and space organization basis, the suggested calculation methods are based on the National standards, such as TS 12127, TS 12186, and TS 9111, international standards, and other design guidelines mentioned in this chapter. Despite its repetition, the guideline stands out as important and pioneering documentation because it is the only design guideline published by a Turkish authority that gives an insight into their ideas and observations regarding the subway station design, except for the design briefs published explicitly for projects.

The rest of the document focuses on the engineering design concerns of the whole line and fire safety recommendations starting from the design process. Along with the recommendations, one can always see that there is a combination of national standards with international guidelines and documentation where necessary. As a result, readers can reach a wide range of information regarding the design and construction of subway lines not only from the architectural design perspective but also from different disciplines of engineering related to the process such as; geotechnical, structural, alignment design, tunnel, electrical, communication, and HVAC. For instance, one can see both the staircase runoff suggestions for architects

(Figure 29) and suggested mining sections and steps in İstanbul for a New Austrian tunneling method (NATM) at the same document. Nevertheless, binding all design recommendations into on single design guideline also show us the intense interdisciplinary environment of the subway lines and stations.

2.3 Non-places and Placemaking

In order to understand the current situation and develop alternative approaches to the underground stations, two concepts, non-places, and placemaking will be inspected. By doing so, we will have a clearer understanding of the possibilities of different approaches.

2.3.1 Non-places

Non-place is a concept developed by French anthropologist Marc Auge to explain anthropological spaces of transience. The main statement is formed around the human behavior of "the passive joys of identity-loss, and the more active pleasure of role-playing" (Augé, 2006, p. 94). These places could be transit related buildings, motorways, hotel rooms, and even shopping malls from different perspectives. Nevertheless, it is equally important that the difference between the place and non-place is based on the difference between "space" and "place" (Von Meiss, 2014). As Auge highlights, his approach is based on analyzing the notions of place and space suggested by Certeau's (2011). According to him, space and place are not opposing definitions. On the contrary, a 'frequented place,' 'an intersection of moving bodies' is space (Augé, 2006, p. 79). In this sense, non-place should be evaluated as a notion opposing the place's idea while creating conditions for the memory attached character.

As one trace for the non-space has two important aspects; their balancing realities connected with spaces formed to create a service and their relation with users. These services include transportation, transit, commerce and leisure, and the activities and relations provided in these spaces. However, it is important to keep in mind that a non-place is not a formulated space definition, but a subjective perception, and any person could define any place as a non-place. For example, a subway station could be defined as a non-place for its daily users. However, it is hard to claim the same for the station staff because they work at that location. Along with social interaction possibilities like meeting with other people or share different activities, it is also important to note that non-places do not provide any accommodation services, and every user remains anonymous.

2.3.2 Placemaking

Another important aspect of enhancing the station design approach is placemaking. Placemaking is an approach to plan, design, and organize public spaces to support and increase people's wellbeing and health. Thus, placemaking enables the development of underused places and reaches their potentials while providing connections between the places and their users (Project for Public Spaces, 2000).

As a concept, placemaking is originated in the 1960s from the planning and design communities focusing on the fact that the design of an urban entity should not be limited to design teams of the projects, but also they should include community participants (Arroyo, 2017). As Jacobs (2011) highlights, with their complex natures, cities have the potential to create different activities for their inhabitants because they are created and shaped its populaces. Therefore, it is equally important to include conventional design teams focusing on the physical construction of the project but also their users so that they can create a life inside and around the project. We also see different authors such as Kretzmann (1993), Schneekloth and Shibley (1995), and Speck (2018) contributing to the subject from different perspectives to develop alternative viewpoints and suggestions to the issue.

As mentioned before, the process of placemaking is complex systems focusing on the building's lifespan rather than the construction process. In the process, As Arroyo

(2017) underlines, different people with varying worldviews and social positions are expected to interact with each other for the common good. Accordingly, with these participations, when applied properly, placemaking will improve both the built and natural environment, reinforce the social structure, and improve the conditions of the societies.

Through the first concept of placemaking, as a design idea to design for people instead of cars and shopping centers, one can see different principles set to help designers. For instance, Project for Public Spaces (2000) suggests eleven elements to overcome any complexity of the design process.

- The Community is the Expert
- Create a Place, Not a Design
- Look for Partners
- You Can See a Lot Just by Observing
- Have a Vision
- Start with the Petunias: Lighter, Quicker, Cheaper
- Triangulate
- They Always Say "It Can't Be Done"
- Form Supports Function
- Money Is Not the Issue
- You Are Never Finished

Even though the suggestions seem ambiguous because of their names, the main intention is based on the fact that placemaking is beyond the design and construction of a structure. These eleven elements trace out a working plan to designers from the conceptual design phase to the diverse uses of the place in different timelines such as; determining the local assets and participants, creating a place for collective activities, and developing a vision for the public space.

On the other hand, Lanzl (2020) suggests six principles for similar design cases. These cases are;

- Quality of life
- A sense of place
- Caring about the community,
- Collaboration and communication

- Active participation
- Tradition and innovation

Thus, as one can see from the names of the principles, Lanzl's (2020) suggestions are also similar, focusing on enhancing the design process and public spaces. However, by comparing both of the suggestions, one can clearly see that the placemaking process is not limited to architects, engineers, and urban planners. These design processes also include participants from the involved communities, artists, and ordinary citizens. They also include methods such as grassroots efforts, community meetings, and projection meetings. By doing so, placemaking has the chance to create the much-needed activation and the local will to improve the design of public spaces.

Additionally, Von Meiss (Von Meiss, 2014) suggests three different strategies to develop their design and establish an identity for its users. The first suggestion is based on the "observation and deep understanding of the values and behavior of the people and groups concerned, as well as the places and the architectural elements crucial to their identity" (Von Meiss, 2014, p. 162). The second suggestion is based on the participation of the buildings' future users in the design process. The last strategy suggests searching for architecture with an orderings structure, followed by the occupants' creation of the place.

It is possible to find different theories and practices regarding placemaking. However, the most important part of the process is to include users in the places' design process. Thus, in the subway station context, one of the challenging aspects is its users' participation in the design process. In order to gather information and enable the user participation Griffiths (2016) suggests the integration of digital infrastructure and so that one can create a technology-enabled responsive environment with a broader set of participants. Especially with concepts such as Internet-of-Things (IoT) and smart systems, municipal departments, and planning departments have the chance to gather information and develop a democratic platform for active participation. Moreover, these places can have the flexibility and ability to respond with ample information regarding the design.

2.4 Pandemic Precautions as a Design Issue in Subway Stations

At the beginning of 2020, a global pandemic shook the world. Lockdown and curfews were imposed across many countries, thereby requiring travelers to keep a distance from each other in public transport (UITP, 2020). Physical distancing became imperative in order to prevent further spread of the infection, and a new concept was integrated into our lives, i.e., social distancing. According to the World Health Organization (WHO), in order to decrease infection spread rates, the suggested distance between two passengers should be increased to one meter from each direction (World Health Organization, 2020a). Along with the pandemic, depending on the urban setting of the station, a significant shift from public transportation to personal transportation options had occurred where subways stations experienced a drop in the passenger numbers by around 35 to 65% (Harris, 2020; Park, 2020). Also, people were advised to stay away from crowded spaces, specifically with limited ventilation, and increase physical distancing in crowded public spaces (O'Sullivan, 2020c; World Health Organization, 2020b). Unfortunately, subway stations contain both conditions, i.e., crowding and ventilation problems. Hence, they are regarded as a high-risk environment because they contain a large number of people in confined spaces, limited information to detect any infected person, and a high number of shared surfaces and machines inside the station such as handrails, ticket machines, and buttons (UITP, 2020).

However, in order to understand the current mindset of the society, it is important to look at a report prepared by the WHO (World Health Organization, 2017). According to this study, every pandemic has four stages; interpandemic, alert, pandemic, and transition phases, as seen in Figure 30**.** In a linear order, the interpandemic phase means the time between the spreads of the diseases. The alert phase means the determination of the pathogen and informs the world regarding any widespread infection. This phase is followed by the pandemic phase, where the global spread of the pathogen is monitored on a worldwide scale. Lastly, at the transition phase, with the decreased spread of the global precautions starts to decrease, and recovery programs start to support the affected communities. The current situation in the world varies in every country, and it is hard to claim that every country has succeeded in the transition phase. However, even in the last twenty years, the world has experienced two severe virus outbreaks, H1N1 (World Health Organization, 2010) and SARS viruses (LeDuc and Barry, 2004; World Health Organization, 2004).

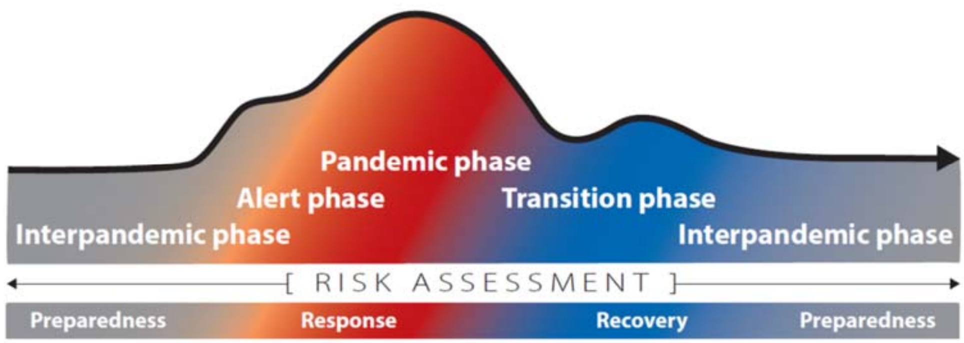


Figure 30 - Global awareness of cases for risk management according to WHO (2017)

In order to reduce the transmission of the virus, the WHO issued set suggestions based on physical distancing (World Health Organization, 2020a). One can find various suggestions for a wide range of activities, starting from greeting each other to distancing suggestions for different activities. In the subway station context, s

At the beginning of the pandemic, WHO issued set suggestions to reduce the transmission of the virus in closed spaces (World Health Organization, 2020a). One can find various suggestions for a wide range of activities, starting from greeting each other to distancing suggestions for different activities. Thus, the subway operators and local governments took precautions based on WHO's suggestions (Centers for Disease Control and Prevention (CDC), 2020; EGO Genel Müdürlüğü Hizmet İyileştirme ve Kurumsal Gelişim Dairesi Başkanlığı, 2020; Metro İstanbul, 2020; Scott, 2020). These precautions can be divided into three parts, passenger safety, staff safety, and vehicle operations. Since the focus of this research is the architectural design concerns for subway stations, safety precautions such as disinfecting the trains after each service at the train depots and ancillary service areas will not be mentioned.

First of all, the mandatory use of masks and physical distancing rules were applied at the stations. As WHO suggests, 1 meter in each direction between the pedestrians turned into the newly accepted pedestrian spacing. Along with this spacing, facemasks turned into a mandatory regulation both for the passengers and the staff. Interestingly, to supply this new demand, some of the manufactures converted their vending machines from where people can buy facemasks (Fuji Electric Global, 2020; Yıldırım, 2020). Cities such as Istanbul, İzmir, London, New York have already adapted these vending machines in their subway stations (Weaver, 2019; Eshot Genel Müdürlüğü, 2020; Morris, 2020). Remarkably, while London Underground Station Planning Standards and Guidelines (Transport for London, 2012) suggest different ticket purchasing quantities and times for subway stations, we have no information either on-demand and purchasing time per person for facemasks in subway stations.

Another safety measure adopted in transit-related buildings during the epidemic is to convert every possible action into a contactless experience both for the staff and passengers. Contactless cards turned into the suggested fare collection method along with smartphone applications as an alternative. Similar precautions are also applied to staff management, where different transportation operators had shifted to contactless cards from biometric fingerprint systems (Meyer and Barone, 2020; Scott, 2020).

In addition, new methods have been adapted to check the body temperature of the pedestrians inside the stations. Depending on the pedestrian load, we can trace subway operators have adapted two different methods; individual control of every pedestrian with a handheld device and mass control of the pedestrian flow with thermal monitoring (EGO Genel Müdürlüğü Hizmet İyileştirme ve Kurumsal Gelişim Dairesi Başkanlığı, 2020; Metro İstanbul, 2020). While the handheld device control method relies on the capacity of the staff operating it, controls with the thermal cameras do not affect the flow of passengers.

WHO and Centers for Disease Control and Prevention (CDC) suggested placing disinfectants around the spaces as a safety precaution (Centers for Disease Control and Prevention (CDC), 2020; World Health Organization, 2020a). As the people move around the stations, they can use these dispensers to disinfect their hands. However, similar to the mask vending machines, no statistical data is showing us the required number of dispensers or the amount of disinfectant in peak-hour-periods.

Additionally, one can also see that with the suggested distancing rules, capacities of elevators and escalators have dropped significantly. Since escalator capacities are based on the assumption that every step is occupied by two pedestrians, with the distancing rules, one can see that one pedestrian would need more than one step. Likewise, similar changes in the capacities of elevators can be seen due to the same rules, as they carry a significantly reduced number of people.

Lastly, since there are alternative design approaches to the platform width of the stations, the stations shaped according to the peak hour passenger load multiplied by area per pedestrian is likely to be problematic because of the physical distancing concerns. It is a high possibility that with the increased area per pedestrian, the existing space requirements will not suffice to the newly needed area. This situation will be inspected in Chapter 4.

CHAPTER 3

A HISTORY OF SUBWAY STATION DESIGN

When we look at the station designs and design guidelines in the literature, we can see that the construction method had shaped the different types of stations. This problem may be related to the functional concerns and complex technical nature of this building typology. However, by looking at the subway station designs from different periods, one can see that this approach is not a contemporary design question. Starting with the first subway stations of the Metropolitan Railway line in London, there were significant design concerns for engineers because of the technology of that period. Steam locomotives operating in underground stations created an unpleasant experience for their users with their steam, burning coal, heat, and fumes. Through the electrification of the locomotives, these factors were eliminated, enabling a more comfortable passenger experience (Vuchic, 2007). After the electrification of vehicles, cities such as Paris, Philadelphia, and Budapest built their subway systems.

This chapter will show the different attempts of redefining the term subway station and its typology, based on different contexts. However, due to the dense urban patterns on the surface or geotechnical properties of the ground, we still see functional approaches mentioned before. As a result, in order to develop a different perspective on the subject, it is essential to review different stations and their design methodology without the technical design guidelines in a timeline; in order to get a clearer picture to understand the meaning of a subway station.

3.1 Criteria for the Selection of Subway Lines and Stations as Case Studies

Even though the first subway system was constructed in London before the electrification of the rolling stock, the dominant architectural concerns in designing the subway stations were focused on the dissipation of fumes and steam from the trains. However, after the electrification of the rolling stock, each city built its subway system according to its own understanding of station design. Influenced by engineering concerns and budgetary limits, we can see that engineers designed the stations, and the architects added the finishing touches to decorate the allocated space. With time, this approach was transformed into the concept of a “typical station,” which has limited transportation possibilities and only complies with the dictionary definition as ”a regular stopping place in a transportation route “(Station, 2018a). Therefore, the most important criterion for selecting the case studies for this research was that the stations should be defined by the framework of a *typical station* instead of an intermodal or a prestige station. By doing so, we could develop a deeper understanding of subway stations focusing on the *typical* understanding of a building type and its importance from various aspects.

In addition to the concept of a typical station, another essential criterion for the selection process was to cover the periods between the 1930s to contemporary times. In view of the fact that that the design and construction of subway line projects require extensive periods such as 10-15 years of design and construction period per line, examples aimed to cover the history of the subway stations until the electrification of the rolling stock. Consequently, while the Moscow subway refers to the post Second World War era, Milano Subway and Washington D.C. subway stand out as inspiring examples that were built between the 1950-1970s. Washington D.C. subway also stands out as a counterpart design approach to the Moscow subway, which increases its importance. In order to cover the timeline between the 1980s and the present time, the same selection method is applied. Three significant examples are followed by prominent examples of subway stations ranging from 1980ies to modern-days are selected to cover the past 90 years subway station design. These examples are; Bilbao Subway, Canary Wharf underground station, Porto subway stations, and New York Second Avenue & 72nd Street Subway. Starting with the Porto Subway Stations, more contemporary station designs that are built or expected to be built in the near future are studied to understand the contemporary design methodologies. Besides, at the Toronto Extension Line (TTC) station designs and Grand Paris line design shows us indications for the possible design ideas in the future.

Along with the chronological order of the stations, the selection process also focused on their contributions for future designs. Therefore, not only the design of the station but also its influence over the subsequent designs are considered during the selection process. By doing so, it is also possible to exclude unique designs where similar design approaches can be applied everywhere in the world. For instance, even though the station designs of the Stockholm subway line is considered exemplary, it is essential to note that due to its geological features, the existing design approach is entirely unique. As a result, unless a city has identical geological features as the city of Stockholm, it is almost impossible to develop similar design approaches because of geotechnical and structural concerns.

On the other hand, while working on the Turkish subway station designs, one of the most dramatic reality was the fact that from 1875, when the Istanbul Karaköy-Galata tunnel project was built, until the construction of the Aksaray-Kartaltepe line in 1989 no major subway line was constructed in any Turkish city. However, after 1989 we see a slow increase in the development of subway lines. Therefore, due to the enormous time gap, we can hardly develop a similar chronological approach. Consequently, documentation of the subway projects and the architectural debate on the station design played a vital role in the selection process of Turkish subway stations in this dissertation. Significant stations and transportation nodes in Ankara, Istanbul, and Izmir were selected to trace how different design teams had developed their designs. Furthermore, due to the "typical station" design approach, it was determined that almost identical stations were placed along the line for design management and feasibility purposes without any significant architectural concerns. As a result, the selection process for the Turkish stations is based on the documentation of their design process and the related impact on the station design methodology.

Another important aspect in the process was the designing and constructing firms of these stations. In the process, we trace a bottleneck where most subway stations are designed by massive engineering firms such as ARUP, Atkins, Stantec, AECOM, WSP Global, and IBI Group. We trace collaborations with local and international architectural offices in different projects where the design is regarded as more important than financial and project management concerns. Except for the contemporary examples, we either see a standardized design applied to every station to achieve management and financial goals or develop a prestigious station with a renowned architect. However, it is important to note that internationally renowned architectural design firms are composed of various design teams, and it will be an erroneous act to credit one person for the design of such a complex design entity.

3.2 Selected Case Studies

The following subsections present selected case studies on noteworthy subway lines and their unique subway stations. All in all, subway lines in Russia, Italy, the USA, Spain, UK, Portugal, Canada, France, and Turkey were studied, and a total of 19 subway stations are summarized as case studies. As can be seen from the station designs, all of the architects mentioned here had the same design questions in their mind during the design process. However, due to their different contexts and approaches, we see how a simple design question has been interpreted and thus evolved differently through time, even by the same architect in different parts of the city or different cities. For example, the designs of Norman Foster in Spain, UK and Canada, and those of Eduardo Souto de Moura in Portugal.

3.2.1 Moscow Subway: New Stations for a New Ideal

When looked at the historiography of the subway station design, Moscow subway stands out as the first subway station design approach which questions the design methods. Especially since the Moscow subway was the most prestigious part of the second five-year plan in the Union of Soviet Socialist Republics (Wolf, 1994; Vujosevic, 2012). Due to this critical political nature of the project, it turned into a political statement of the state instead of a transportation project in a city. As mentioned by Vujosevic (2012), Moscow subway stands out as the prestige symbol of the Soviet world and socialist modernity. Therefore, stations are designed over and above any technical guideline recommendation, resembling a theater foyer or a lobby of a prestigious hotel. Moreover, from the technical dimension perspective, one can clearly see the allocated spaces and heights are clearly beyond any standard in order to emphasize grandeur meaning.

In addition, materials and their applications were also a critical part of the station design in the Moscow context. Marbles and granites brought from different parts of the union such as the Crimea, Karelia, the Urals, and the Soviet Far East and gilt bronze which is considered as a luxurious material for 18th and 19th century, show us a different approach to the building type compared to is conventional examples. According to Kettering (2000b), the architect Aleksei Dushkin intended to create a "classical" interior with Roman and Italian renaissance references with bronze figures of Lenin, Stalin, collective farmers, miners, soldiers, athletes, and students, in a *Michelangelesque* language. The architectural elements in the subway stations are socialized galleries of eighteenth-century palaces that belonged to the elites of the population. The socialist government brought back formerly aristocratic architectural elements into the daily lives of the public at large. In the view of the fact that is designing a subway project in such fashion in the capital of a new regime, the Moscow subway project was a chance to create a showcase of the Soviet power, production, and culture not only for its daily users but also for tourists (Jenks, 2000).

When we look at the architectural layout of the station design, we see that island type platform designs inside vast tunnels supported by columns not only for structural reasons but also for architectural purposes. A similar approach can be seen in the concourses of the stations, which are designed according to the socialist idea with lightness, freedom, and spaciousness (Lemon, 2000). Furthermore, the depth of the stations is increased in order to provide bomb shelters in case of an air bombardment

(Jenks, 2000). However, similar approaches can be seen at not only other socialist cities such as St. Petersburg, Kyiv, Baku but also in their capitalist counterparts such as London.

From the architectural elements and the picturesque view of the station's perspective, two stations, Mayakovski (Figure 31) and Revolution Square (Ploshchad Revoliutsii) (Figure 32), draw attention with their intriguing approach to design concerns. Compared to their contemporaneous capitalist examples, these stations were a chance to publicize and promote the history of the revolution and project the bright future with the new regime.

Figure 31 - Mayakovski Station platform area (Barış Akdemir,2019)

Figure 32 - Revolution Square station platform area (Barış Akdemir,2019)

Both stations created dramatic storytelling for their users, with mosaics and sculptures placed around the stations. Bronze figures as the heroes of the new regime were placed around the Revolution Square station (Figure 34 and Figure 35), and Mayakovski station had domes and picturesque mosaics to its users. As mentioned by Jenks (2000), station designs were similar to Orthodox cathedrals, where messages were placed on domes. For example, at Mayakovski station, 35 mosaics and figures of soldiers, planes, paratroopers, and bright young soviet youth interested in aviation are shown on the domes of the station (Figure 33), but people had to stand at the bottom of the domes to receive the message.

Figure 33 - Mayakovski station mosaics located at the domes of the station (Baruş Akdemir,2019)

The Soviets saw an opportunity for their political agenda in their subway stations, transforming the building type into a political propaganda platform. According to the soviets, in their “capitalist counterparts,” the subway stations were designed with a profit-based approach, which only provides transportation. In contrast, the Soviet subway is meant not only to provide transportation for the public but also to convey the idea of a well-planned bright communist future (Wolf, 1994; Friedman, 2000; Lemon, 2000).

As Kettering (2000b) highlights, subway stations converted into a completely new meaning by providing the same essential functions while boosting the political ideology for the people, with symbols of power, unity, heroism, bright future, and a powerful military. Because of the nature of the building, subway stations are used on a daily basis, and their users have the chance to see a glimpse of a communist future (Vujosevic, 2012). These political messages were also a chance to shape the Soviet society with its technological development (Jenks, 2000). However, it is also vital to keep in mind that these colorful and flamboyant representations are an illusion created by the Stalinist regime, and when millions of people use these stations, one cannot ignore the influence on their daily life.

Figure 34 - Revolution Square bronze sculptures (Baruş Akdemir,2019)

Even though the Moscow subway is profoundly shaped by the political agenda to influence the community, we can claim that these political motives also are among the first to question the design methodology of the subway stations. Subway symbolized both the Soviet Union’s design ideology for a public building and the technical capabilities of building something very challenging. Consequently, these underground palaces for the people, which were shaped profoundly with social engineering and political propaganda, stand out as the first example which questions the design approach to the subway stations.

Figure 35 - Revolution Square platform tunnel with bronze sculptures (Barış Akdemir,2019)

Even today, we can trace various similar attempts in other cities where murals and mosaics of figures, leaders, heroes, and symbols are depicted on the walls of the stations. The most prominent examples of such political publicity can be seen in different countries, yet Pyongyang subway stands out as the most recent example due to its political context where leaders and the people meet and greet each other in an underground space (Gabriel, 2018).

3.2.2 Milano Subway: The Neo-Rationalist Approach

While the Soviets were busy with constructing their subway, combined with their political context, another country was also having similar debates with different political agendas. 20th century Italy was a productive ground for different architectural approaches such as Prampolini's Futurist manifesto, Italian rationalist movement, and fascist influences on design. Starting from the 1920s and 30s, we know that Italian rationalist architecture aimed to develop a different approach to the design cases, and Metropolitan Milano was one of the critical examples to understand Franco Albini and Bob Noorda and their influence on the current design methodology.

Construction and design of the Milano subway started in 1926 with a national competition. However, due to national and international events such as economic crises and wars, initial construction did not begin until 1952 (Kutkan, 2010). Despite the time gap between the competition project and its execution, the principal design methodology remained loyal to the basic concept from an engineering perspective. The station designs for the Linea M1 were commissioned to architect Franco Albini and his partner architect Franca Helg in 1962 (Jones, 2016; Kutkan-Ozturk, 2019).

In Linea M1, we see that every station has an identical layout with different elevations due to topography. These identical stations were two-story buildings where the passengers are collected into a concourse and distributed to the platform level. In addition to service areas where passengers obtain their tickets and get information about the network, a tobacco shop, and a newspaper stand are also added to the concourse area. One of the challenges for the station design was the fact that the stations' structural design and construction were finished, and Albini and Helg were expected to develop their design on the finishing. The suggested design approach was to combine different materials in 21 stations. These materials include vinyl paint for the ceilings, pointed black rubber tiles with noise reduction features for floors, granite tiles with electrical features to prevent frost for the staircases (Figure 37). Exposed concrete was selected for the vertical surfaces combined with the painted steel railings (Figure 36).

Figure 36 - Milan Subway handrail view with the wall cladding *(Jones, 2016)*.

One of the most important design features of the stations was the collaborative work done with Noorda for the station signage design. Along the station walls at two meters, height color-coordinated bands were designed with the station name and the walking directions for the pedestrians. In addition, Noorda also created a font and visual communication language to simplify the information for the passengers. The main intention of the design methodology was to create a system where standing and sitting passengers could read the signs and move accordingly (Dondina, 2015). Moreover, they also created a series of icons and signs for wayfinding in the process. One of the most significant designs was an iconic double-M logo to signify the entrances of the stations similar to Albini's curved railings, which were never used(Byrnes, 2016). Afterward, Noorda implemented similar graphical designs at New York and Sao Paolo subway systems for signage and passenger movement.

Figure 37 - Milan Subway with Noorda's signage design and Albini and Helg's interior design elements *(Piazza, Anceschi and Baule, 2015)*

Even though there are earlier examples of modernist approaches to subway station design, Italian rationalism, combined with Noorda's innovative graphic communication, paved the way for setting the standard for subway station design for a long time. The rationalist approach, where identical stations with embedded and informative signage systems to connect different parts of the city, turned into a mass-produced system due to its practical and economic reasons. It is possible to trace similar approaches in the design guidelines of the various subway and Light Rail Train (LRT) lines, where the rationalist approach is mixed with standardization for economic benefits. However, the design of the Milano subway stands out as an exquisite example with its original and innovative design approach, space organization, and materials.

3.2.3 Washington D.C. Subway: Questioning the Design Leader (?)

After the Milan subway, one of the most notable examples of subway station design is the Washington subway due to its intriguing design process. It should be noted that Washington, D.C., is a political and representative city intentionally designed as the capital of the United States of America, similar to Canberra, Brasilia, Ankara, and Islamabad (Vuchic, 2007).

Starting in 1955, we see attempts to provide mass transportation for the US capital, followed by the station design process (Schrag, 2014). Similar to the Moscow subway, the Washington subway also had problems because of it being in the capital city. One of the most critical parts of the station design was the architectural design methodology of the stations. In view of the fact that subway stations are federal buildings in the capital, they were expected to "… provide visual testimony to the dignity, enterprise, vigor, and stability of the American Government" (Schrag, 2014). While the political argument for creating a public building in the capital was similar to the Moscow case, a modernist approach was developed for federal architecture with respect to President Kennedy's vision. Even though there were early examples of a federal building with modernist languages, such as Dulles Airport in the area, the Washington subway stands out with its signature spacious underground stations shaped (Figure 38) with its pioneering design methodology.

Figure 38 - Washington D.C. subway platform area view *(Miller and Raines, 2000)*

Before starting on the design of the Washington DC, subway Designer Harry Weese documented the existing subway station designs in other parts of the world and noted their advantages and possible problems. Weese and his team had the chance to visit different cities and their subway systems to formulate a design approach in order to develop one of their own. According to their studies, New York, Boston, and Philadelphia stations were described as reminders of mine shafts, crowded and filthy. Toronto subway stations were depicted as the cleaned-up versions of the New York and Philadelphia subways. Additionally, the Milan subway was praised with its identical circulation design without obstructing columns and combined with its unified graphic design. However, they also showed that in order to develop a station design for their capital to be deemed as a symbol for the American society, they had to challenge the existing design methodology where civil engineers design the whole system with its components and architect are brought in to decorate and beautify the interior spaces.

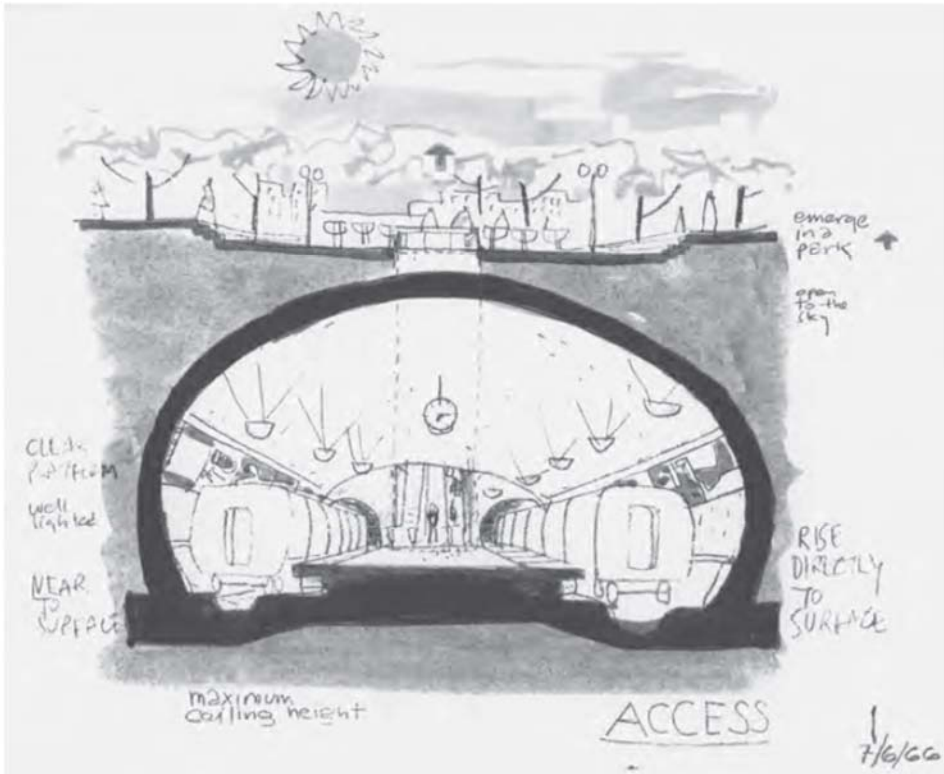


Figure 39- Harry Weese's 1966 sketch of a spacious vaulted station for Washington DC subway *(Schrag, 2014)*

As a result, to prevent the repetition of similar problems they had defined at the beginning, the city commission decided that an architects team should lead the design process instead of engineering teams leading the project (Schrag, 2014). Weese and his team borrowed the concept of cast-iron train sheds from the 19^{th} century and converted the idea into concrete vaults while creating lavish spaces beneath the urbanscape (Figure 39). Moreover, with the reinforced concrete coffer system, they had the chance to develop a unified space without any columns or walls obstructing the experience of the space and applied it to the whole stations (Figure 40). This expansive space enabled architects to provide stations acting as "an underground street" where platforms act as outdoor spaces. By doing so, architect Weese and his team had a chance to create visual connections between the mezzanine and the platform level since they were both located in the same space. Still, the primary intention of the design was to develop a holistic approach to the system, acting as the guiding principle (Miller and Raines, 2000). Even though there were similar attempts to create spacious platform areas and spaces for passengers in different station designs, the Washington subway stands out as an innovative example with its design methodology, where architects started to form the spaces instead of decorating predesigned spaces of engineers.

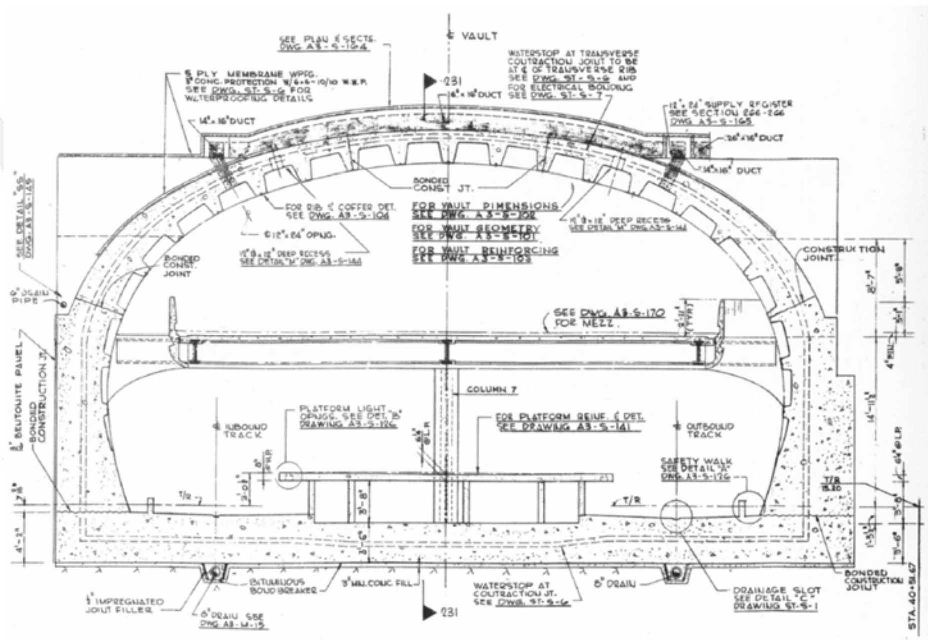


Figure 40 - Section drawing of the vault for Washington subway with construction details *(Miller and Raines, 2000)*

3.2.4 Bilbao Subway: Design by a Star Architect

By looking at the previous examples, we see a constant evolution of the design approaches when architects are allowed to question the methodology of the design process. Bilbao subway also stands out as an exciting milestone to understand contemporary station design examples with its practical approaches. While the initial design of the line started in 1977, construction of the project began in 1988 (Jodidio and Foster, 2001). The Bilbao subway station stands out not only because of its architectural design features, but also because it is regarded as the first stepping stone of Norman Foster's journey into designing subway stations. After his first design in Bilbao, his subsequent designs for the subway stations at Canary Wharf in the UK and York University station in Canada reflect the way his design ideas evolved and took shape as iconic edifices.

Figure 41 - Glass canopy of Bilbao subway stations (Foster+Partners)

In the Bilbao subway station, we can trace attempts to connect the interior space to the urban fabric both on the street and platform levels of the station with natural light, spacious mezzanines, and a distinctive approach to pedestrian movement. With their unique and recognizable shape, the glass canopies (Figure 41) over the entrance stairways lead down to the pedestrian tunnels that take the passengers to the platform level. These canopies are also very successful in marking the entrances of the station on the street level while bringing in natural light as much as possible inside the stations. Additionally, these entrances provide access directly to the platform area instead of any concourses or vestibules, which is a crucial design approach.

Figure 42 - Bilbao Subway interior showing the concourse at the back with platforms at the sides (Foster+Partners)

Instead of the conventional solution, where tunnels connect different parts of the station, we see a holistic approach where the main passenger activity is brought together in one space (Figure 42). By doing so, Foster (2019) could do away with the need for any sophisticated signage that directed passengers where to go; and his direct approach from the street level to the platforms created ease of movement. Combined with its spacious tunnel design, the station's architectural design provided its users with a flexible, spacious, and easy to navigate the space, which is similar to the Washington D.C. Subway (Figure 43). However, in order to hold both of the areas (concourse and platform areas) and create a spacious uninterrupted environment inside, the mezzanine floors had to be suspended from the steel roof structure over the train rails (Quantrill, 1999).

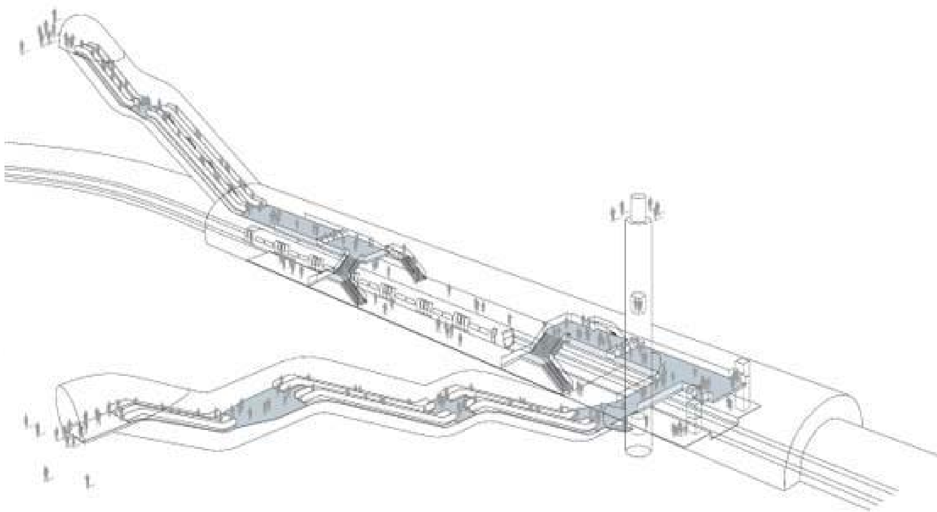


Figure 43- Bilbao Subway diagram showing the passenger movements insides the station (Foster+Partners).

3.2.5 Canary Wharf Station: Daylight under the ground

Canary Wharf Underground Station is a part of the jubilee line in London and designed by Norman Foster. The main dimension of the station is 35 meters wide, 27 meters deep and 313 meters long, and it is built with the cut-and-cover technique. The station is located underground, and the street level of the station is considered as the area's main recreation space. In other words, the station does not extend above the street level except the three entrance structures of the station. However, these three points covered with arching glass canopies play a very critical role in the design. With these three-points, Foster enabled the provision of natural light inside the station, which also acts as a signage system for the pedestrians. Moreover, this approach also enabled him to create an axial pedestrian movement, which helped to place ticket machines, offices, and shops along both sides of the interior space.

Figure 44 - Iconic glass canopy of Canary Wharf Underground Station in London (Foster+Partners)

Canary Wharf Underground Station is expected to be the busiest station along the whole line. Consequently, its design shaped around that fact, and durability and ease of maintenance and accessibility were the main concerns in the station. From the material perspective, one can see robust materials are selected, such as concrete surfaces, stainless steel, and glass, to withstand the passenger load, combined with features such as platform screen doors and service walkways (Figure 44).

Figure 45 - Canary Wharf Underground Station platform area (Foster+Partners)

This station stands out as a unique inspirational example showing us some of the possibilities when the designer questions the existing design methodology. Even though the architectural layout of the station is a typical station, we see how a station makes an impact on its successors by questioning some of the basic notions about the station design. As a result, we see spacious passenger areas connected to the street level not only with vertical circulation elements (stairs, escalators, and elevators) but also with visual connections with the glass canopies. The intent to bring natural light combined with the spacious passenger areas broke the monotonous station idea and created a new design approach where we question the existing design guidelines (Figure 45). This approach inspires even new station designs developed both by the architect himself or any other design team; Canary Wharf Underground Station changed into a tourist attraction where people go to the station to see the space and the lighting design.

3.2.6 Porto Subway Stations: Designs by Star Architects

Porto subway started its operation in 2002 and currently has six lines operating with 82 stations around the city. However, two stations designed by renowned architect

Eduardo Souto de Moura stands out as exciting examples with their design approaches. These stations are Casa da Musica Subway Station and Bolhao Stations.

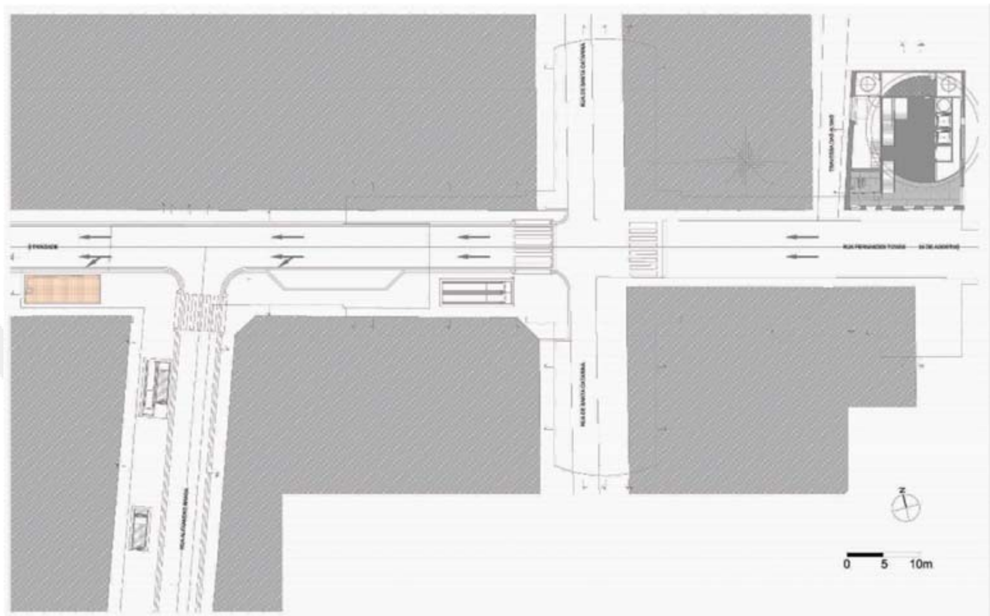


Figure 46 - Bolhao Station Surface level site plan. Station building is located at the top right and two entrances at the left bottom corner of the drawing (Eduardo Souto de Moura)

Bolhao station stands out as an excellent example of station design where a station is designed in a limited space in contrast to the suggested areas in similar design guidelines. Even though two of the three station entrances are designed conventionally (Figure 46), the entrance building at the Fernandes Tomas street, and its design is a unique design approach (Figure 47). The entrance building is located next to an 18th-century chapel Capela das Almas de Santa Catarina famous with its white and blue-tiled façade, thus limiting the allocated space in a challenging fashion. According to Moura himself (Lucan and Bru, 1998), at the beginning of the design, it almost seemed impossible to meet the technical specifications of the system and create something related to the dramatic topography of the historic parts of the city. As a result, at Bolhao Station, while designing a connection between street and platform levels, we see a creative way of providing vertical circulation for all passengers and prevent any disruption to its periphery (Figure 48).

Figure 47 - Bolhao Station entrance building with blue Porto Metro sign (Luis Ferreira Alves)

Moreover, we can also find a gentle touch to some of the station's ancillary spaces, such as the station offices and security rooms where station personnel is located. The staff could access to the sunlight with the provided courtyard. This approach enables the station personally to access direct sunlight, which is a rare design entity in subway stations due to its underground character. The station stands out with its simplistic architecture on the surface yet signifies the station and its location to its users with its own language. The exterior of the station also stands out with parallel approaches to its neighbor Chapel of Souls (Capela das Almas de Santa Catarina), where we see similar material choices and colors without any competition.

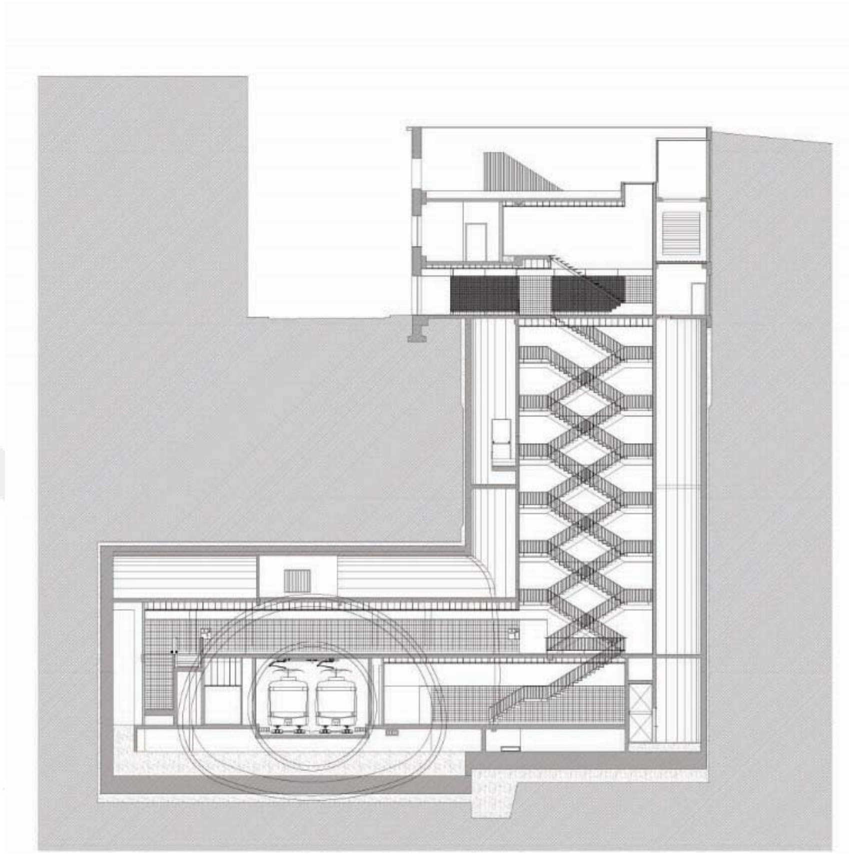


Figure 48 - Bolhao Station section drawing showing the staircase connecting the platform area to the surface (Eduardo Souto de Moura)

Though, it is also essential to keep in mind that Porto uses a different ticketing system called Andante (Transportes Publicos Portugal e Espana, 2013), which does not require the installment of turnstiles like in Turkish Canadian, British or American stations. This installment also reshapes our understanding of the space organization in a station because the concourse is not divided with a barrier into controlled and uncontrolled areas.

However, when looking at the station drawings and sections, it is possible to see some of the textbook layouts of the stations where auxiliary services and technical spaces are placed at the underground part of the station. In addition, passenger entrances are provided from four different points, yet the entrance building at Fernandes Tomás street identifies the station building. Still, the entrance building implies the existence of the station and plays out as an outstanding example where the allocated space for the station is minimal due to the urban pattern.

Casa de Musica station is also located in Porto next to the new Concert Hall by star architect Rem Koolhaas, and it also stands out as an exceptional example of an at-the-grade station type. At-the-grade stations have the challenge for architects where they have to provide a flow of connections for pedestrians at different levels and visibility to the urban context.

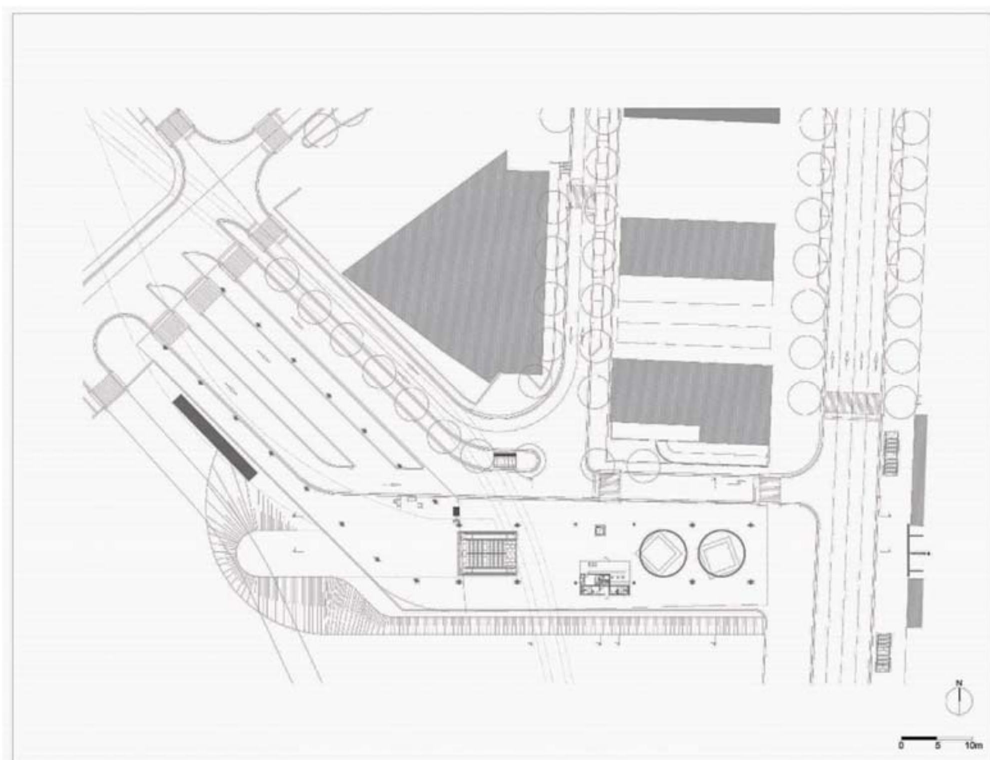


Figure 49 - Casa de Musica station surface level site plan (Eduardo Souto de Moura).

Station provides access to the rail and bus networks of the city. As a result, the station had to provide access to both of the transportation networks in one single building acting as an intermodal station (Figure 49). However, one of the challenges of the design was to create a comprehensive design at different levels of the station.

Figure 50 - Casa de Musica station platform level with their circular skylights (Fernando Guerra | FG+SG)

Consequently, when we look at the station, we see a canopy design uniting the entire area. While the built canopy covers the whole station and bus stops, an elevation difference is added to signify different transportation modes (Figure 51). The station layout shows us that these two transport modes are separated from each other, and a singular pedestrian flow is suggested with the arrangement of vertical circulation elements. Another essential feature of the project is the integration skylights, which provide daylight to the platform level of the station (Figure 50). By doing so, one can integrate natural light into the platform area and break the negative effect of being underground (De Mira Correa, 2011). Notably, natural light illuminating the platform level enabled a dramatic experience for its users. Similar to Bolhao station, thanks to the ticketing system at the city of Porto enabled an orderly flow of pedestrians without turnstiles and reduced area for concourse area design.

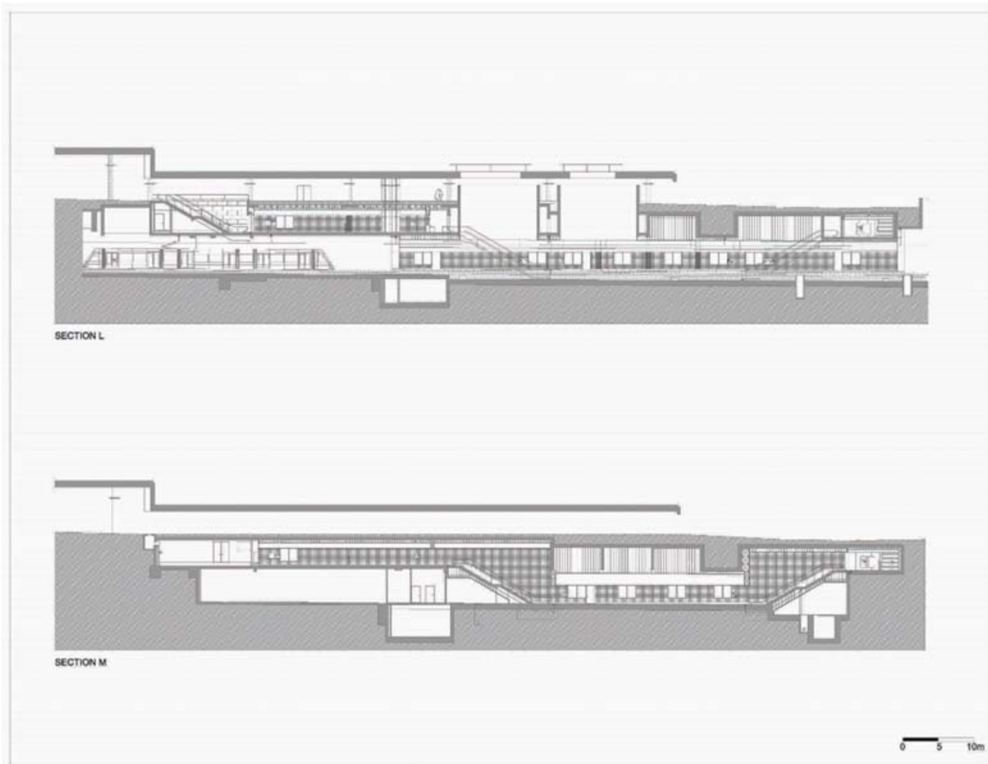


Figure 51 - Casa de Musica longitudinal section drawings (Eduardo Souto de Moura)

3.2.7 New York 2nd Avenue & 72nd Street Subway: Design in a Congested Area

Second Avenue subway project is an expansion of the existing network by adding stations and refurbishments of the existing subway network(Grigson, Ho and LeMus, 2019; Parikh, Phillips and Sykes, 2019). Second Avenue & 72 Street station points out a compelling design case where the allocated construction area for the station is highly limited due to dense urban texture above the ground, which is similar to Bolhao station in Porto (Garavito-Bruhn, Napoli and Towell, 2019; Giffen, Ezzeldin and Towell, 2019; Voorwinde and Giffen, 2019). The station itself has conventional entrances located at different points of the area with escalators and staircases(Aksman, Grigson and Giffen, 2019). However, the entrance located at the SE corner of Second Avenue and 72nd Street has a practical design solution where the vertical circulation is only provided with elevators (Figure 52). A set of five elevators bundled together to provide a connection between the ground floor and mezzanine, which is 72 feet (22 meters approx.) apart. It is vital to keep in mind that the station is expected to comply with both National Fire Protection Agency (NFPA)code 130 and American Disabilities Act (ADA) at the same time while providing this unique vertical access between the street and the station. So, we also see a connection to the existing safety zones to fulfill the fire safety regulations.

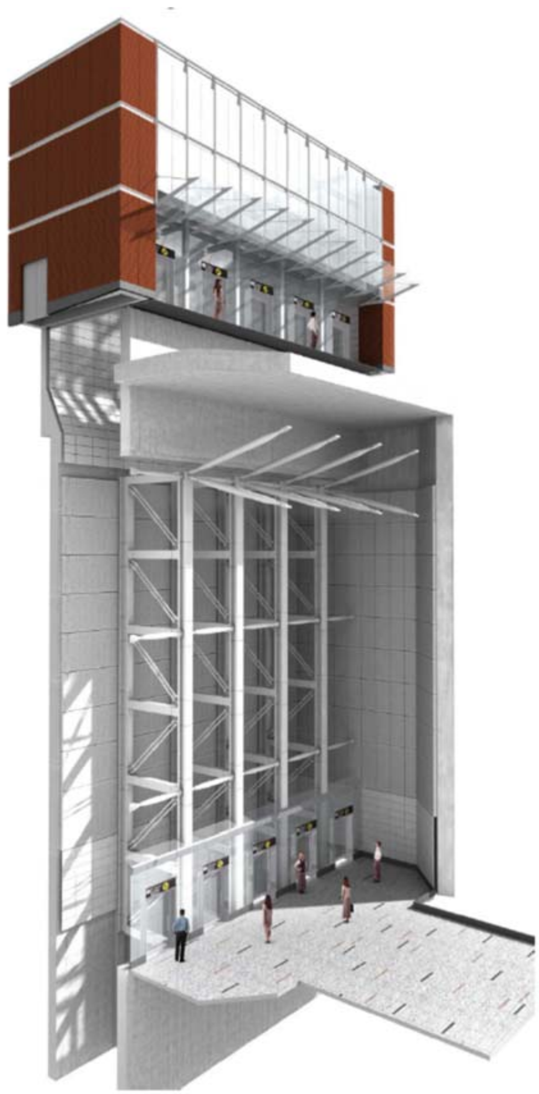


Figure 52 - 3D Cut-away image of the proposed entrance *(Voorwinde and Giffen, 2019)*

Located at a busy corner of the city, visibility to its users was one the primary concern of the design. In addition to providing natural light to the mezzanine level and the exhibition area curated by Metropolitan Transportation Authority (MTA) Arts for Transit program, a skylight is added to the main composition of the entrance structure. Therefore, despite the limited area for construction, we see a composition of cladding and glazing systems that provide daylight to the mezzanine level and provide space for five elevators with 22-person capacity per cabin (Figure 52 and Figure 53).

Figure 53 - Artistic render of the entrance structure on the surface level *(Voorwinde and Giffen, 2019)*

However, due to unforeseen circumstances after the start of the operation of the line, various news and reports are claiming that vertical circulation elements of the station are breaking down (Martinez, 2019). In one of these events, 17 people were trapped when an elevator got stuck (Guse and Tracy, 2019), and combining the fact that they are comparatively brand new, it created a public debate about the design, operation, and maintenance policies (Barone, 2019). The MTA has held an extensive public investigation in order to identify the main reasons behind these outages and problems for future projects (Pokorny, 2019).

3.2.8 Toronto-York Spadina Subway: Integration of Artworks

In 2017 Toronto Transit Commission (TTC) opened the new extension line, which is 8.6 km long and includes six stations in the project. Through the project, TTC's reports and their documentations provided a considerable amount of information about the decision-making process during the design of the stations. Every station is documented from conceptual design to finishes and artwork design decisions to inform the public. An overview of all of the stations shows us that, regardless of their station types, they all provide multimodal transportation services. In order to provide continuous mobility, connections to urban railways, LRT lines, bus networks, car parking areas, and bicycle parks are provided at every station.

Stations are shaped according to fundamental design decisions, and according to these reports, we can clearly see that TTC intends to use its standardized elements for an efficient design from the operation and management point of view. However, when looked at the invited design offices and architects (Norman Foster, Grimshaw, AECOM, & ARUP), the demand was much higher than a standardized station design approach. So, the term "standardized" can be interpreted as shaped by guidelines and regulations and provide a user experience beyond the conventional/standard. As a result, we see that the significant design decision was to create a column-free structure at all different levels of the station. This intention could be interpreted from two different perspectives. From an aesthetics perspective, having a column-free space inside the station will enable designers to create more spacious and luminous areas. From the user experience perspective, it is possible to say that every structural element and service systems such as vending machines, ticket issuing machines, and Automated Teller Machines (ATMs), act as barriers in the passenger movement.

Therefore, a column-free design also provides better movement patterns, which will enhance the user experience. In addition, this structural design approach also provided architects to provide daylight into deep parts of the station when it is possible. Also, one can see that accessibility for people with reduced mobility and sustainability in terms of energy efficiency were major design concepts in the process. Lastly, TCC demanded from their designers to integrate artworks at the stations in the public areas. Every station had its unique artists for their designated spaces integrated with their architecture. Artists and architectural firms such as Panya Clark Espinal, Bruce McLean, Jan Edler, David Pearl, and Paul Raff Studio were commissioned for the artwork areas.

Stations in the project are (TTC, 2017);

- Downsview Park (Toronto Transit Commission (TTC), 2005, 2010d),
- Finch West (Toronto Transit Commission (TTC), 2010a, 2010b),
- York University(Toronto Transit Commission (TTC), 2005, 2010d),
- Pioneer Village (Toronto Transit Commission (TTC), 2009b, 2011),
- Highway 407 (Toronto Transit Commission (TTC), 2009a, 2010c)
- and Vaughan Metropolitan Centre (Toronto Transit Commission (TTC), 2009c, 2010e).

By looking at the station designs, we see that every station is designed independently from each other instead of generating a repetitive approach to maximize project profits. Every station has a unique identity and design approach with respect to their urban context while providing every necessary connection and same materials for wall claddings and floors.

3.2.8.1 Downsview Park Station

The line starts with the Downsview Park Station, also named Sheppard West station, which is integrated into the local railway. With their platform level located underground and railway station at grade, the designers had to locate two above-ground buildings to accommodate the passengers. However, with its green vegetated roof decisions and its form to provide sunlight to the deeper levels, the station emerges as a focal point in its urban context (Figure 54 and Figure 55).

Figure 54 - Downsview Park Station artistic rendering of the design proposal (Toronto Transit Commission (TTC), 2005, 2010d)

Figure 55 - Downsview Park station entrance photograph (Eriksson, 2018)

3.2.8.2 Finch West Station

Sheppard West station is followed by the Finch West station, which is also an underground station. Similarly, it provides multimodal transportation options with its bus terminal and car park options. Moreover, the station entrance buildings are shaped to provide water and energy efficiency, according to the Toronto Green Standards. Even though the platform level is located underground, for various reasons, we see a superstructure signifying both the subway and the bus stop (Figure 56).

Figure 56 – View of Finch West station with its bus station (Transportfan70, 2019)

3.2.8.3 York University Station

The York University station follows Finch West station, and it is the next step of Foster's approach to subway stations. Until this station, Foster first questioned the main components of a typical subway station in Bilbao, and afterward, he integrated daylight and the space configuration in the Canary Wharf Underground Station. In

York University Station, we see the next step, integration to the urban context on the street level, in addition to its predecessors' design concerns.

Figure 57 – Top view of York University Station (Foster+Partners)

Located in the middle of the campus, the station extends to the surface with a V-shaped station building resembling 19th and early 20th-century train station buildings, which act as a monumental gateway of the cities (its striking roof canopy provides a new 'front door' for the university) (Figure 57). Though, we see that the roof only covers the station building without any further function or activity. However, when looked at the station's attempts to connect to its urban context, we see the landscape, which resembles an amphitheater, also creates a height change on the surface of the street level (Figure 58).

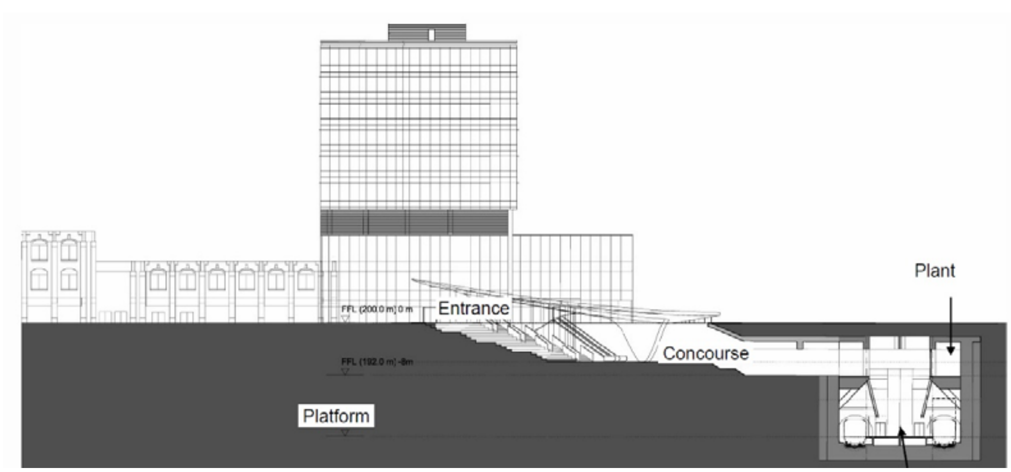


Figure 58 - Section drawing of York University Station *(Toronto Transit Commission (TTC), 2009b)*

The station also has to comply with Toronto building codes and related standards. So, we see a building shaped by these regulations and design guidelines to meet functionality and safety standards (Figure 59). However, the architect also questioned the existing design methodology of subway stations. So instead of a buried concrete box with multiple exits connecting the various parts of its vicinity, we see an attempt to shape the urban context with the subway station and its possibilities within the allocated space on the street level, which has an impact on the daily life of the university community.

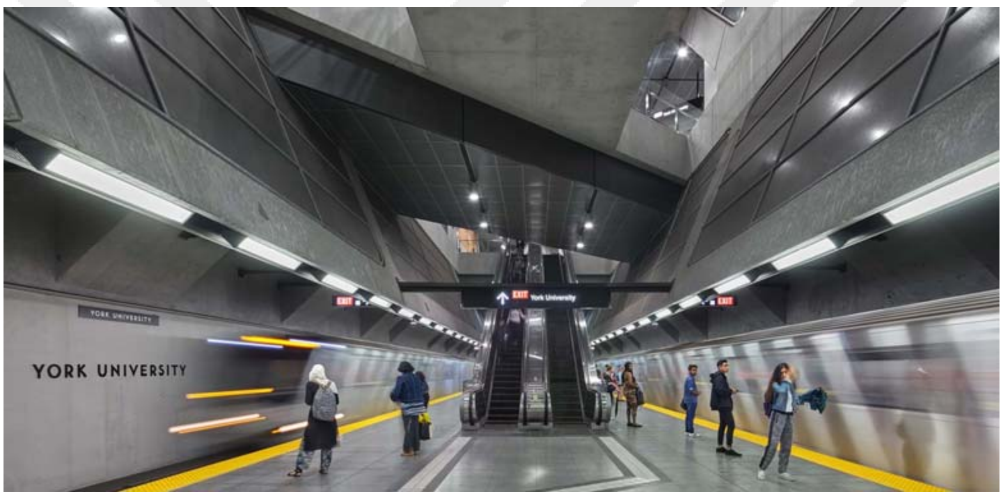


Figure 59 - York University Station platform level (Foster+Partners)

3.2.8.4 Pioneer Village Station

York University station is followed by the Pioneer Village. At the design phase of the project, the name of station was Steeles West Station and afterwards changed to Pioneer Village Station. The station provides bus and car connections in addition to its commuter parking services. The design intends to bring daylight to the platform level and possible future connections despite its depth. However, the design team Richard Stevens Architects and Alsop Architects uniquely reshaped the station structure to provide daylight from its entrances (Figure 60 and Figure 61). With it is curvilinear roof reaching the ground combined with Jan and Tim Edler's super sculpture, LightSPell creates an exceptional space to board or alight trains.

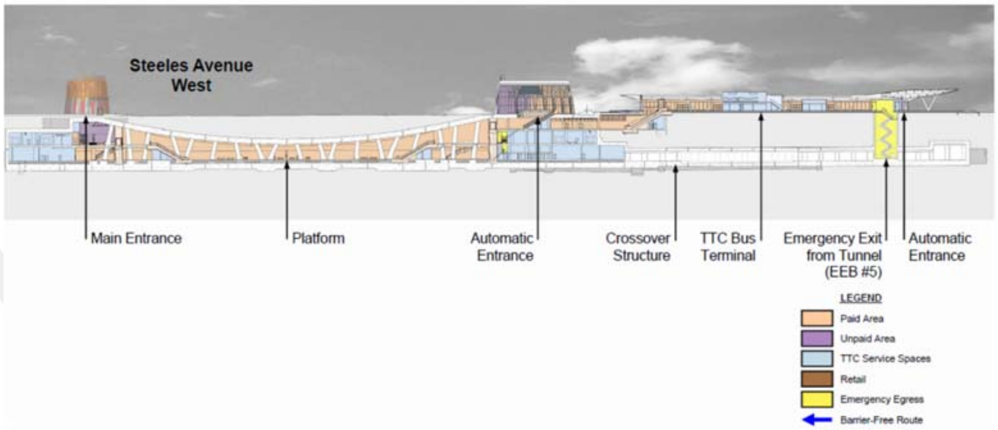


Figure 60 - Pioneer Village Station longitudinal section showing its unique shape under the ground (TTC)

Figure 61 – View of the Pioneer Village Station concourse area showing its curvilinear roof (Leung, 2017)

3.2.8.5 Highway 407 Station

The next station on the line is Highway 407 station, which is designed by AECOM. Similar to the rest of the stations, this station also provides various alternative transportation options. With its sloped windows, both the concourse and the platform levels gain daylight from the east side of the station (Figure 62). Similar glazing can be seen at the bus terminal of the station. In addition, both of the skylights house David Pearl's artwork, where he installed moving projections of color to animate the entire subway station (Figure 63).

Figure 62 - Highway 407 concourse level illuminated with its skylights (Booledozer, 2017)

Figure 63 - Highway 407 station artwork designed by David Pearl (TTC)

3.2.8.6 Vaughan Corporate Centre Station

The last station on the line is Vaughan Corporate Centre Station, which is designed by Grimshaw architects. The station has a very typical layout while providing similar intermodal transportation options. However, the station stands out with its characteristic entrance building with its lustrous metal dome on the surface level (Figure 64). In addition, the design team intended to illuminate the concourse and the platform level by adding lenses and mirrors in the dome. Additionally, with its material choices, the dome also provides a point of reference for the street-level users.

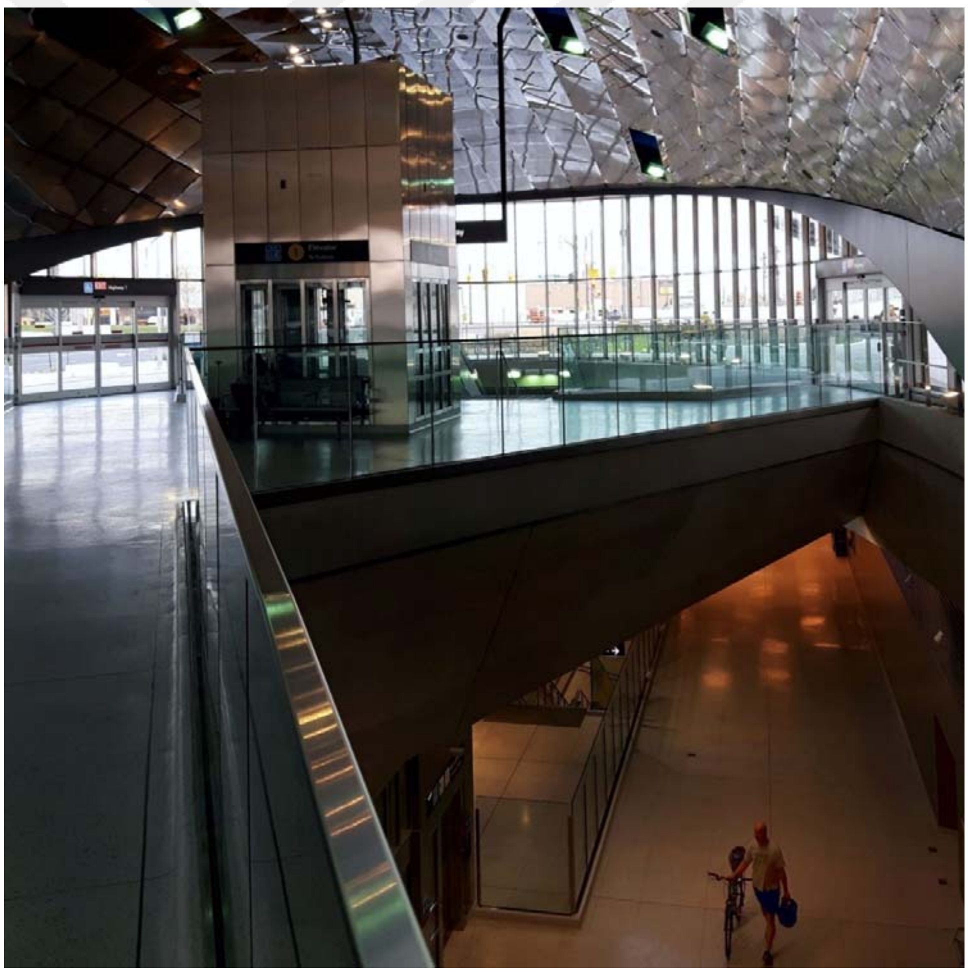


Figure 64 – Interior of Vaughan Corporate Centre Station showing the concourse (Equinox, 2018)

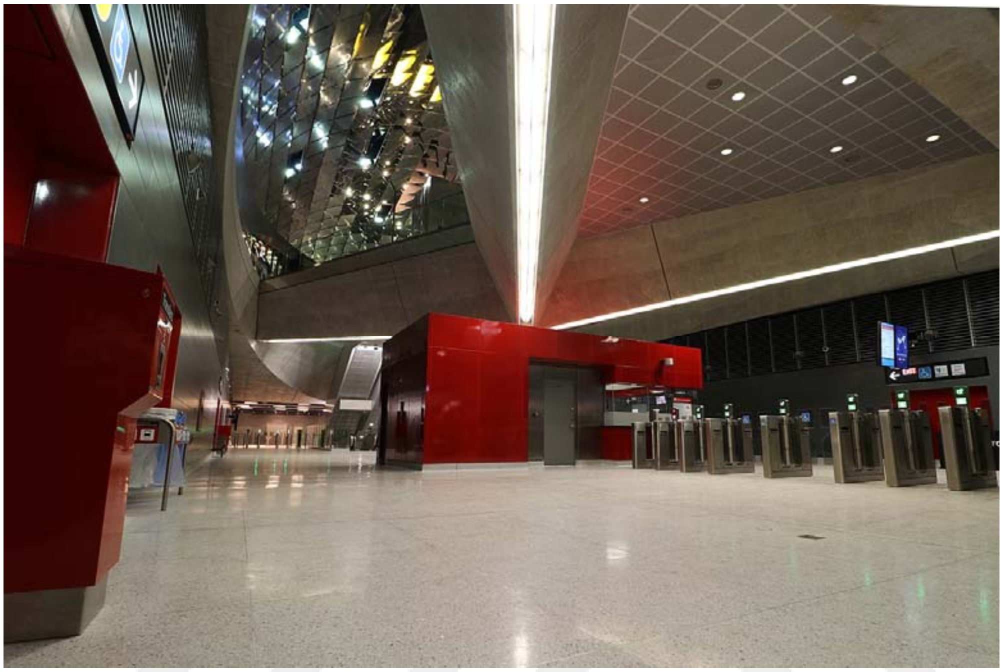


Figure 65 – View of the concourse at Vaughan Corporate Centre Station platform level (Ko, 2017).

3.2.9 Grand Paris Express and Paris Subway Stations

Paris is among the pioneering cities in the world with its subway network. Built for the World fair in1900 Paris Metropolitan underground railway not only became exemplary with its organization and design but also became the eponym of the term “metro” in various languages(‘The Paris Metropolitan Underground Railroad’, 1900).

Started in 2015 (Société du Grand Paris, 2019a), the Grand Paris Express is a breathtaking project both from an urban and architectural point of view. The project aimed to develop four new subway lines (200km), encircling the city to connect its different parts and the subway lines of the city (Figure 66) (Société du Grand Paris, 2016, 2019a). Along the lines, 68 new stations are being built to carry 2 million passengers daily.

With this project, Paris also intended to generate new urban structures by increasing the density and considering the subway stations, with an extensive building program as the driving force behind the intended urban transformation(Société de Calcul Mathématique SA, 2011; Société du Grand Paris, 2014). As mentioned before, numerous architectural design teams participated in the design of the stations, and two stations are selected among them to evaluate and discuss the developed design approach; these are Pont de Bondy (Silvio d'Ascia Architecture – BIG, 2016; Société du Grand Paris, 2019b) and Saint-Denis Pleyel (Kengo Kuma & Associates, 2016; Société du Grand Paris, 2019c) Stations. Both of the stations are a product of an architectural design competition and helped to develop an approach where stations are combined with different features to break the solely technical approach and resulting in monotonous designs.

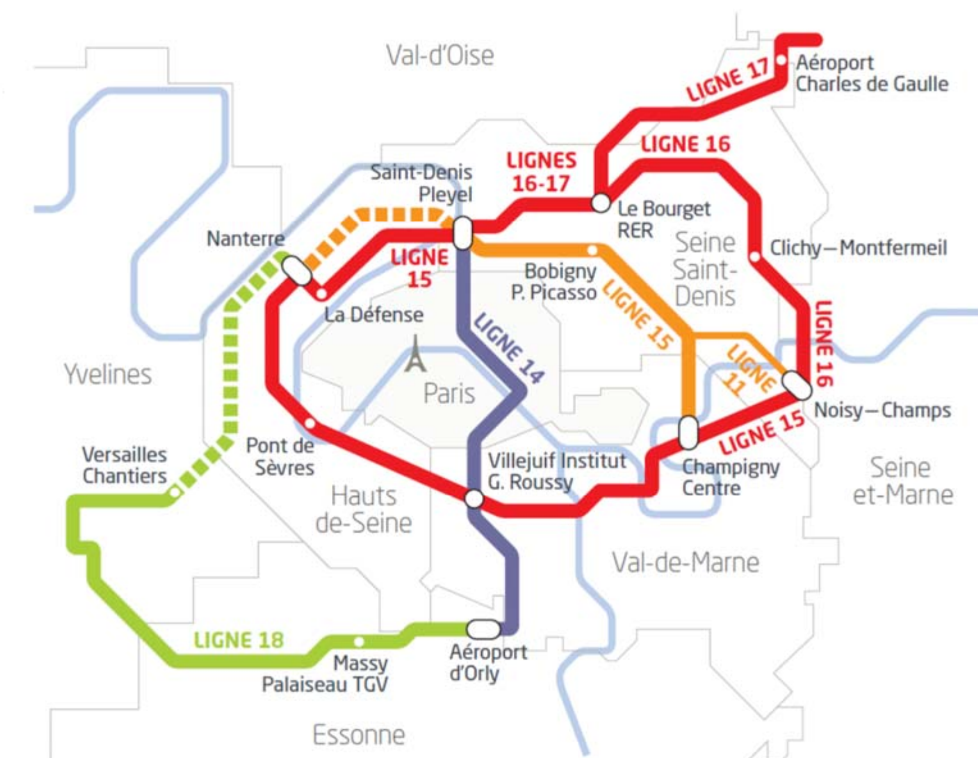


Figure 66 - Map of Grand Paris subway lines *(Société du Grand Paris, 2014)*

3.2.9.1 Pont de Bondy

On the banks of the Canal de l'Ourcq in Paris, Silvio d'Ascia Architecture and Bjarke Ingels Group (BIG) designed a station together to connect three points in the area; Noisy-le-Sec, Bondy, and Bobigny. The aim of the project was to comply with the Parisians' demands for a station design where it becomes more than a simple building to board and alight and inspire a new urban setting along with the station(Silvio d'Ascia Architecture – BIG, 2016).

Figure 67 - Pont de Bondy station artistic rendering *(Silvio d'Ascia Architecture – BIG, 2016)*

The exceptional approach of the station comes from its design approach to connect three different parts of the city with only one single design instead of designing three different entrance structures (Figure 67). The ribbon, as the designers call it, connects these three parts and the existing T1 tramway line by meeting all accessibility demands. Moreover, with the suggested walkway, a skylight is also formed at the center of the path, to illuminate the subway platforms with natural light. In addition, this circular movement on the street level continues inside the station and leads passengers to a very conventional subway station (Figure 68 and Figure 69). However, during their movement through the station, the passengers have a chance to view different exhibits, do shopping, and transfer to other means of transportation.

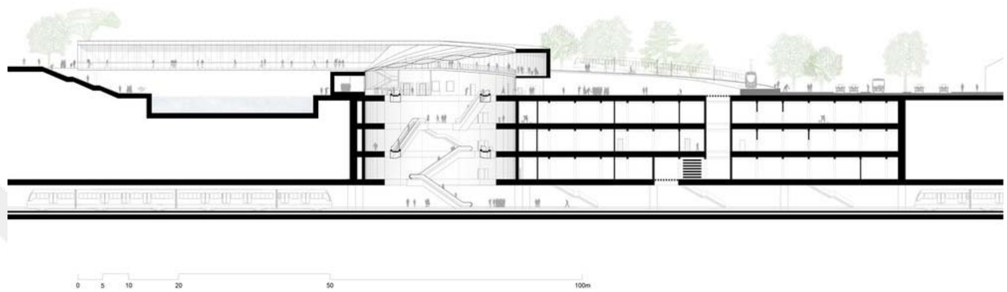


Figure 68 - Pont de Bondy station longitudinal section *(Silvio d'Ascia Architecture – BIG, 2016)*

This station design stands out as a unique approach to the existing methodology of the station design, where architects are obliged to fit in inside the structure created by structural design teams. Even though the basic layout of the station is a standard design, unique approaches developed in the design of the station is critical. Initially, by challenging the existing design approach, instead of creating separate entry buildings for each entrance, by bundling all entrances together turns the station as a unifying element in the urban context. Moreover, the expansion of the station on the street level enables a visual connection to its users even from a distance instead of burying the structure underground and marking it with signposts around the entrances. Furthermore, this expansion on the street level also enables to illuminate of the mezzanine and platform levels of the station with natural daylight.

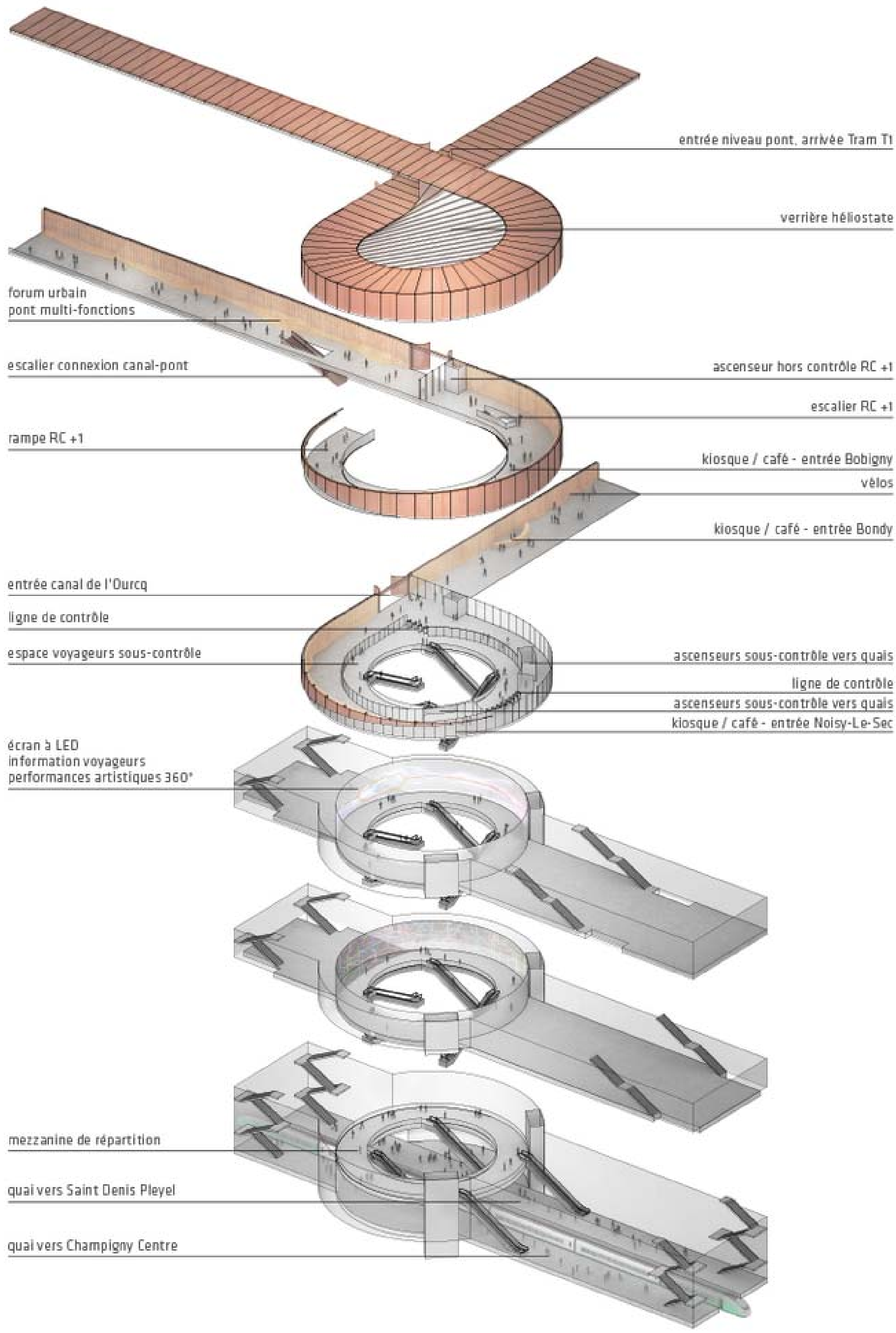


Figure 69 - Exploded 3D view of Pont de Bondy station *(Silvio d'Ascia Architecture – BIG, 2016)*

3.2.9.2 Saint-Denis Pleyel Station

Another impressive subway station design from the Grand Paris project is the Saint-Denis Pleyel Station, designed by Kengo Kuma & Associates. Similar to the previous project, Saint-Denis Pleyel Station also aims to become more than a concrete box buried underground, which only provides a platform to access the vehicle. Therefore, we see that the station aims to extend public spaces at every level of the station with additional features such as a business center, retail space, and multimedia library integrated into the station structure (Figure 70). This approach is also reinforced with the train station on the street level.

Figure 70 - Saint-Denis Pleyel Station artist rendering *(Kengo Kuma & Associates, 2016)*

Moreover, by connecting to the surface, natural ventilation and daylight are provided to every level of the station, including the mezzanine and platform levels (Figure 71). Like the Pont de Bondy station design, we trace a very conventional station design combined with a superstructure on the street level where the pedestrians use the building for other uses than just for their transportation needs. These additional functions not only produce a new user experience on the street level but also shapes a multi-level public space underground as an extension of the street to the platform level.

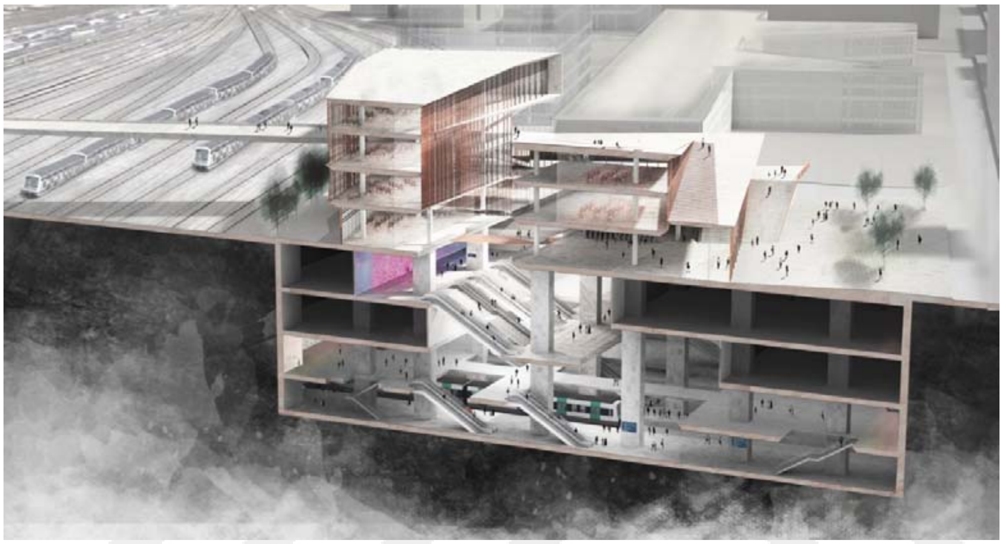


Figure 71 - Section view of Saint-Denis Pleyel Station (Kengo Kuma & Associates, 2016)

3.3 Subway Lines and Stations in Turkey

Turkey's subway endeavor started in 1875 with the Tünel (or the tunnel) project designed and constructed by Eugene Henri Gavand. The Tünel funicular line connects Karaköy and Beyoğlu (formally called Pera) districts to each other (Çelik, 1993; Sahin, 2013). Some claim that the İstanbul Tünel was the second subway attempt of the world after London underground. Along with its historical importance, the İstanbul tunnel stands out as the first underground mass transportation attempt in Turkey. However, the project is an electrified funicular system (Vuchic, 2007). Therefore, it might be erroneous to claim it as a subway project.

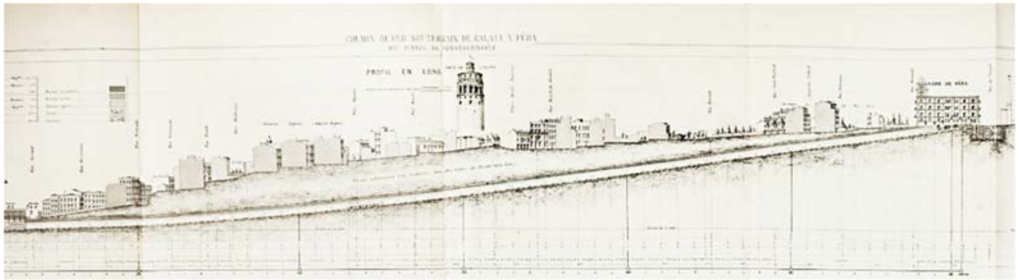


Figure 72 - Section of Tünel Project by Eugene Henri Gavand. Source: (Sahin, 2013)

According to Çelik (1993), with the commercial success of the Tünel project, there were attempts to design a subway and tramway to connect different parts of the city in 1864, 1869, 1881, and 1907. In spite of numerous attempts, the first light rail or subway project in Turkey could not be started until 1989, with the construction of Aksaray – Kartaltepe line, which is a part of the existing M1 Yenikapı – Atatürk Airport line (Metro İstanbul, 2019). This line expanded eight times to essential parts of the city, such as Atatürk Airport, İstanbul Esenler Bus terminal, and Yenikapı transit hub.

İstanbul's first subway line is followed by Ankara's LRT line called Ankaray (Güneş, 2007; Özgür Cevher, 2014; Ankara Büyükşehir Belediyesi, 2019) in 1996, which connected Dikimevi quarters to Ankara Intercity Bus Station (Ankara Şehirlerarası Terminal İşletmesi AŞTİ). Subsequently, in 1997, Ankara subway line M1 started to operate along the Kızılay-Batıkent route(Ankara Büyükşehir Belediyesi, 2019). Ankara subway was followed by İzmir in 2000 (İzmir Metro, 2019), Bursa in 2002 (Burulaş, 2019) and Adana in 2010 (Adana Ulaşım, 2019). Meanwhile, metropolitan cities such as İzmir, Antalya, Konya Eskişehir, and Kayseri also built their tram systems. However, after 2010, we see a considerable expansion of the subway network in Ankara and İstanbul. In İstanbul, 4 lines became operational with their 50 stations, while in Ankara, 33 stations were built on 3 different lines (Table 10).

Table 10 – Operational subway lines in Turkey information adopted from Metro İstanbul, EGO Ankara, İzmir Metro, Burulaş, and Adana Metropolitan Municipality by author.

City	Line Code	Number of Stations	Route	year
İstanbul	M1	23	Yenikapı-Atatürk Airport / Kirazlı	1989
Ankara	Ankaray	11	Dikimevi-AŞTİ	1996
Ankara	M1	12	Kızılay-Batıkent	1997
İstanbul	M2	16	Yenikapı-Hacıosman	2000
İzmir	M1	17	Evka 3-Fahrettin Altan	2000
Bursa	M1	20	Emek-Arabayatağı	2002
Bursa	M2	18	Üniversite-Kestel	2002
Adana	M1	13	Kurttepe-Akıncılar	2010
İstanbul	M4	19	Kadıköy-Tavşantepe	2012
İstanbul	M3	11	Kirazlı-Metrokent–Olimpiyat	2013
Ankara	M2	12	Kızılay-Koru	2014
Ankara	M3	12	Batıkent-Törekent	2014
İstanbul	M6	4	Levent-Boğaziçi Üniversitesi/Hisarüstü	2015
İstanbul	M5	16	Üsküdar-Çekmeköy	2017
Ankara	M4	9	Atatürk Cultural Center-Gazino	2017

By looking at the contemporary stations and their designers, one can also see one national and international engineering design firm responsible for designing Turkey's stations. These engineering firms such as Yapı Merkezi, EMAY Engineering, Yüksel Proje International, Prota Engineering, ARUP, Geodata, Light Rail Transit Consultants GmbH, and Toronto Transit Consultants participated not only with their infrastructural layouts but also with their architectural designs. Thus, interestingly Metro İstanbul also participated in the design processes of different stations in İstanbul and other cities. As a result, as one can see, the subway station in Turkey is profoundly designed by engineering firms or engineering firms leading their designs. Consequently, it is nearly impossible to find an architect or an architectural design team focused on subway station design as a practice.

One of the interesting findings regarding the Turkish subway stations is their typology. A detailed list of the station along with their station typologies are presented at Appendices-C, and it shows us that a considerable part of the stations are built underground. Among the active 213 stations in Turkey, 143 are underground, 50 are at-the-grade, and only 20 are elevated (Figure 73). This situation could be related to various reasons such as the dense urban pattern on the surface, selected construction methods, or to avoid any expropriation along the designed route. However, this approach also developed the current debate regarding the design process of the stations.

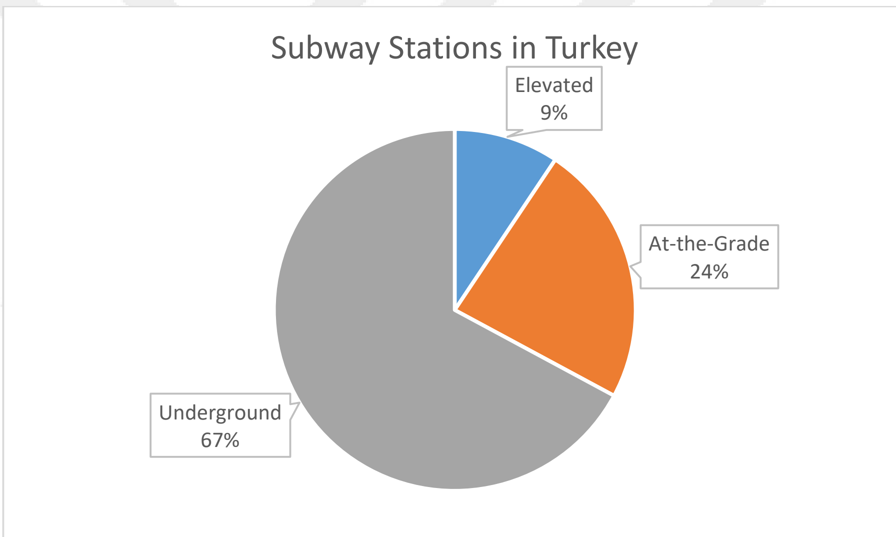


Figure 73 - Subway Station in Turkey and their percentages according to their station typology (author)

3.3.1 İstanbul Subway Stations

Remarkably, amongst the 89 active stations of the İstanbul subway line M1 line stands out with its diverse station types along the route. Among the 23 stations of the line, 11 of them are underground, four elevated, and eight on-the-ground stations, which means that except Haliç station at the M2 Yenikapı-Hacıosman line, while remaining elevated and on-the-ground stations in İstanbul are on this route.

Through the İstanbul subway stations, we see similar design methodologies where engineering shaped the architecture of the station, and architects were given permission to design the allocated spaces. Except for the Haliç Bridge station, every station is designed in a similar fashion to Milan's design methodology. Interestingly, every station had designated areas where murals or mosaics related to the city's history despite the fact that some of the murals and their purpose resembles Moscow subway mosaics. However, the rationalist approach, combined with design standards and guidelines in the İstanbul subway, has created a mixed user experience where stations can only be identified with their station name labels. Given the fact that the İstanbul subway carried over 700 million people annually(Metro İstanbul, 2019), passenger circulation, signage, and circulation elements design had been significant design considerations.

3.3.1.1 Yenikapı Transit Hub

Yenikapı Transit Hub stands out as an interesting project, both with its high volume of passenger use and the history of its urban context. Marmaray project which aims to connect the existing suburban rail network on both European and Asian sides of İstanbul with an immersed tunnel under the Bosporus strait(Lykke and Belkaya, 2005). Along with the renewal of the existing station in the network, two new stations are suggested in Üsküdar and Yenikapı districts.

From the urban perspective, Yenikapı aimed to be a major transit hub both for land and sea transportation alternatives, and from where passengers could access subway and railway lines, bus stations, and sea routes. Currently, passengers can access two subway lines M1 Yenikapı-Atatürk Airport / Kirazlı Line and M2 Yenikapı – Hacıosman line in addition to the railway connection to Marmaray, which is an intercontinental railway line under the Bosphorous sea that crosses İstanbul on the East-West axis. In addition, a nearby ferry terminal is also considered as a part of the transit hub (Figure 74). Interestingly, during Marmaray construction in 2005, archeologists discovered an ancient port dating back to the 4th century A.D. (Rose and Aydingün, 2007). Named as the Theodosius Harbor, archeologists unearthed 35 ship wreckages dating from the 7th to 10th century A.D. with valuable findings. These findings gave information about the rich and colorful history of Ancient Istanbul while providing evidence of the dynamic commercial activities in the port city.

Figure 74 - Satellite view of Yenikapı transportation hub area. Station area is shown with red borders and the ferry terminal at the bottom right part of the image (Google Earth and Maxar Technologies, 2020).

In 2012, a design competition was held for the area by the İstanbul Metropolitan Municipality. The competition aimed to design an archeology park focused on the history of the area, which dates back to 6000 BC. In addition, the area is expected to provide the necessary pedestrian and vehicular connections to the Yenikapı meeting area(Yazman, 2011b, 2011a). Combined with the fact that the designated area is expected to be a vital transportation hub in the city, connections of the area are required to protect passengers from all types of weather conditions. First, in 2011, 12 project teams were selected for the competition. They were expected to design a transit plaza, archeological museum, and exhibition halls, as well as prepare an urban design proposal whereby Yenikapı was to connect the districts in the urban area. In 2012, the selected teams presented their projects, and İstanbul Metropolitan Municipality selected three projects from among them; they were designed by

Eisenman Design - Aytaç Architects collaboration (Figure 75), Francesco Cellini, Insula - Hüseyin Kaptan Atelye 70 collaboration; and Mecanoo architecture - Cafer Bozkurt Architects (Yazman, 2012).

Figure 75 - Artistic rendering of Yenikapı Transit hub showing the site *(Eisenman Architects, 2012)*

Unfortunately, the projects and their building layouts did not include station designs as part of the competition. Instead, design teams were expected to design the urban levels and provide the required connections to the stations located below the competition area (Eisenman Architects, 2012; Kaptan, 2012; Mecanoo, 2012). Currently, Yenikapı transit hub is operational without the suggested exhibition halls and archeology museum even though findings of the Theodosius harbor require a museum (Hürriyet Daily News, 2018).

Still, we see three different lines intersected, thus create a transportation hub for Istanbul. Two subway stations operated by Metro İstanbul (Figure 77 and Figure 78), and Marmaray station operated by the Turkish State Railway (TCCD) combined into each other at this transportation hub. This can be seen at the concourse level yet the connection between the stations are just a physical one (Figure 76). Remarkably, despite all three stations are shaped with the same standards and design guidelines, one cannot see any coherence or reason behind the design decisions except the much-required functionality and interoperability.

Figure 76 - Concourse are of Yenikapı Hub. Left part of the area belongs to Marmaray Line illuminated by a dome opening to surface and its operated by TCDD and right part is operated by Metro İstanbul (Dosseman, 2014).

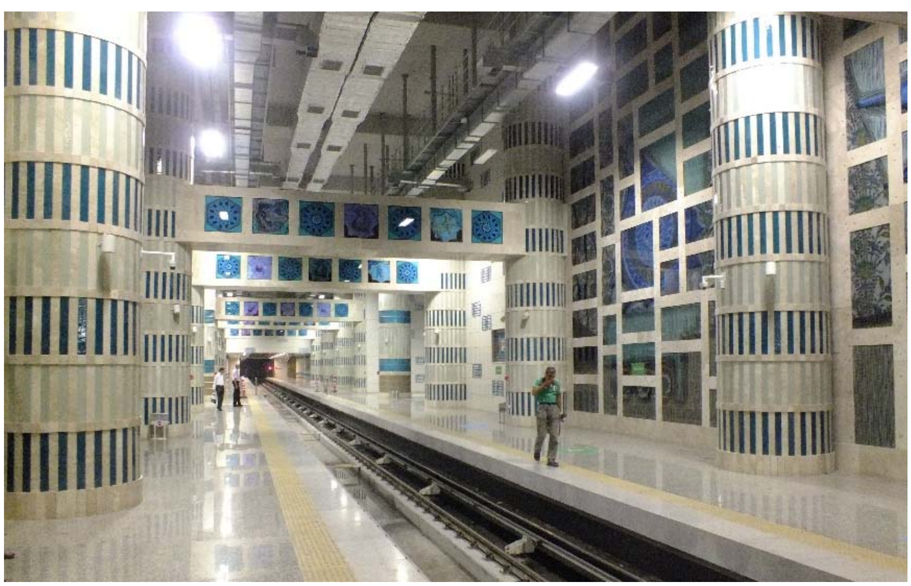


Figure 77 – View of Yenikapı M2 line platform level (Dorsam, 2014b)

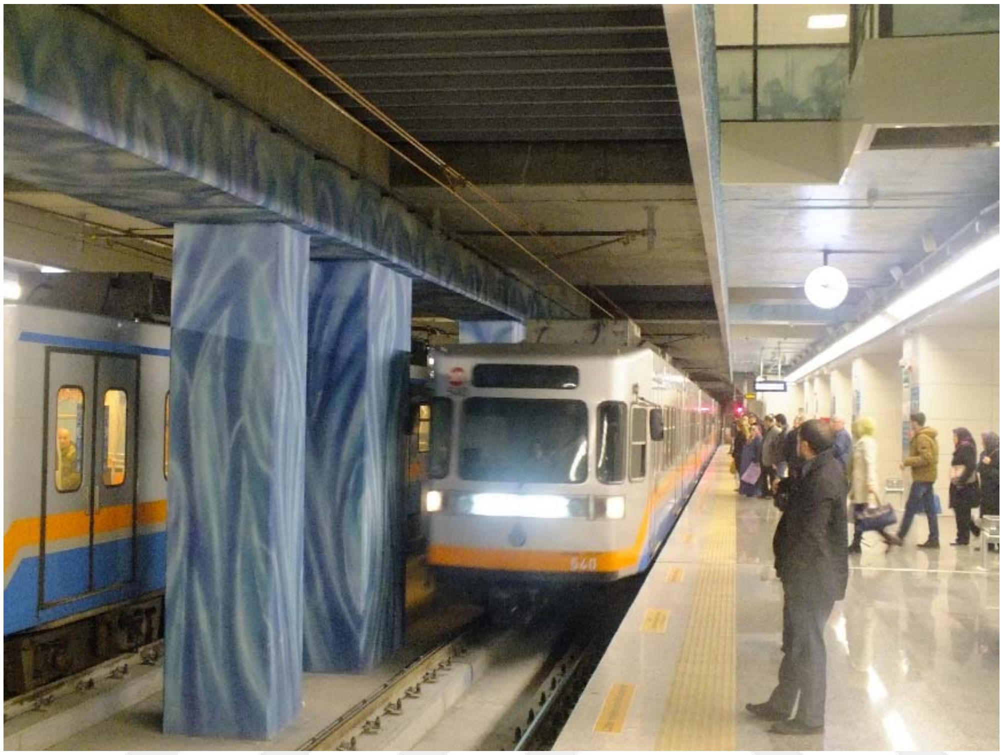


Figure 78 – View of Yenikapı M1 line platform level (Dorsam, 2019)

3.3.1.2 Haliç Bridge Station

Another attractive station in İstanbul is the Haliç Bridge Station located on top of the Gold Horn. In Istanbul, except the M1 line mentioned above, Haliç station stands out as the only station which is not an underground station in the whole İstanbul subway network. However, due to its urban context and design approach, it stands out as a debatable design approach. Designed as a part of the M2 line extension from Taksim to Yenikapı transit hub, the line aims to create a subway corridor on the North-South axis of the city. Along the route, the subway line crosses the historical peninsula of İstanbul, which is a UNESCO World Heritage(UNESCO, 2009). In the middle of the bridge, a subway station is designed to connect both sides of the Golden Horn (Figure 79).

Figure 79 - Artistic rendering of Haliç Bridge Station with the Suleymaniye Mosque at the background (UNESCO, 2009)

Nevertheless, both the station and the bridge created a debate with its design. The bridge is criticized due to its height and its engineering decisions because of its sensitive location (UNESCO, 2009, 2012; Seibert, 2011). When UNESCO evaluated the 11 bridge alternatives submitted by the design teams, it highlighted the fact that some of the suggestions were copied from different projects and the current design was seen to "introduce a new work of art – a new contemporary element in the area" (UNESCO, 2009).

Figure 80 - Haliç Bridge Station at Yenikapı-Hacıosman Line in Istanbul, seen from West (CeeGee, 2014).

While the committee scrutinized the color, pylon caps, ground connections, and the station design in 2012, the majority of the questions were focused on the impacts of the bridge on the Historical Peninsula of İstanbul(UNESCO, 2012). Also, in the 2012 report, questions are asked regarding the station design, approach, and functionally, especially for its daily users. While dimensions of the cable-suspended bridge are 936 meters in length, 12.6 meters in width, and 65 meters above the sea level, the station is located in the middle of the bridge with a platform length of 180 meters(Metro İstanbul, 2019). As seen on Figure 80 the bridge spans over Golden Horn and station is located between the pylons of the bridge. The station itself provides its users a fascinating and dramatic view of the Historical Peninsula of İstanbul. Whereas transit passengers can experience the unique view of the platform area and continue their travel, passengers using the station to board a train have another experience. Despite the dramatic view of the pedestrian walkways on both sides of Golden Horn, passengers have to walk a considerable distance in order to reach the platform, and this experience is open to all weather conditions, such as rain, snow, wind, cold or heat. The only place where the bridge or the station provides cover from these weather conditions are the canopies placed at both sides of the platform (Figure 81). Given the fact that stations have to provide accessibility to all users, especially for people with reduced mobility, the Haliç subway station has its problems, particularly with its overpass and travel options. However, with its fascinating scenery and urban context, the Haliç subway station is a distinctive station example in Turkey.

Figure 81 - Haliç Station platform view showing the platform area and the canopy above (Dorsam, 2014a).

3.3.2 Ankara Stations

By looking at the subway stations' designers in Ankara, one can trace an interesting timeline originating from the Milano metro designed by Franco Albini and Bob Noorda. As mentioned before, Milano Metro set the standard for the upcoming subway station designs with its design approach, where the main intention was to color code the stations along with the architectural detailing so that the design could help the pedestrians in terms of accessibility. Consequently, at the design of the Toronto subway and refurbishments of the New York subway, the Milano metro's design influences could be traced easily *(Schrag, 2014)*.

Interestingly, when looked at designers of the first lines in Ankara, Ankaray is designed by a German firm called Light Rail Transit Consultants GmbH, and Toronto Transit Consultants had been a major contributor to the design of Ankara subway line M1 (EGO Ankara Department of Transportation Planning and Rail

System, 1987b, 1992a). Thus, we see their influences in the subway station designs. Remarkably, by looking at the sign designs and color schemes, one can see the traces of design understanding of Milano Metro, where stations are color-coded for ease of access, such as the station signs and their locations inside the station. In detail, by looking at the platform level design of Kızılay (Figure 82) and Ulus stations (Figure 83), similarities and influences can be traced easily, such as similar color selections, lighting choices, material decisions, and sign placements.

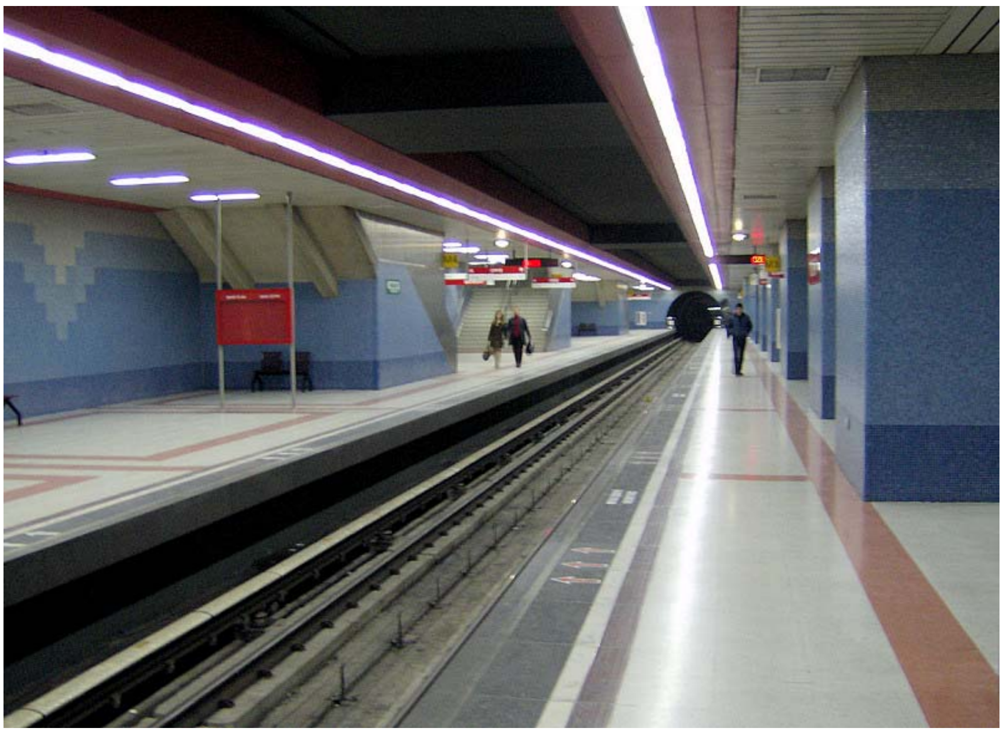


Figure 82 - Ankara M1 Line, Kızılay station platform view *(Baydin, 2007)*

Figure 83 - Ankara M1 Line Ulus station platform level *(Vikiçizer, 2014)*

In Ankara, Kızılay station stands out with its vast transportation opportunities combined with its urban context. While the existing lines intersect at Kızılay, future lines are also expected to cross or extend to Kızılay so that passengers can transfer to other lines(Ankara Büyükşehir Belediyesi, 2019; Ankara Metrosu, 2019). However, due to its urban context, we see a different approach at the station design. It is possible to see the design of the station is a combination of the two functional areas; commercial and passenger zones. While the passenger zones provide the functional organization of the building a very dense commercial activity surrounding the passenger zones at the first level of the station, this approach has enabled extend the district's urban activity into the station and created an underground connection. This connection turned Kızılay station into an alternative, underground city that resembles the Canadian Underground cities (Filion, Charney and Weber, 2015; Besner, 2017). Though Kızılay station can be criticized due to its technical design choices such as lighting, height allocations, and even the color palette of the station, it stands as a crucial design approach with its connectivity possibilities and its intention to generate the urban context of Kızılay below the street level (Figure 84).

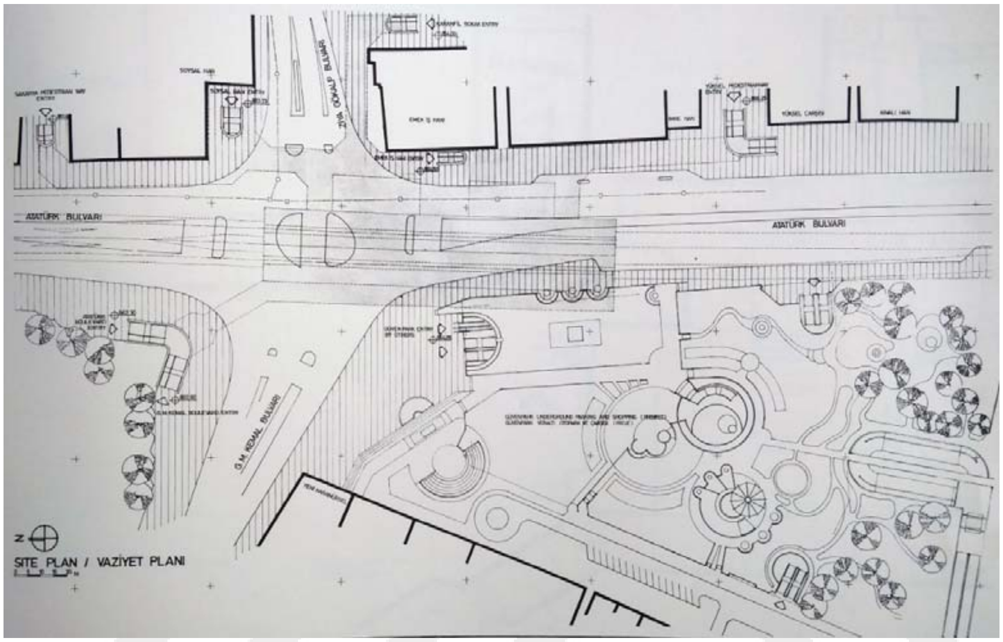


Figure 84 - Kızılay Subway station site plan showing the station entrances in its urban setting (EGO Ankara Department of Transportation Planning and Rail System, 1987a).

Unfortunately, except Kızılay station, all other stations on the line resemble those in İstanbul Subway, where stations are designed and developed with a uniform design approach. Similar to Noorda and Albini's design in Milan, the stations and some of the architectural elements are color-coded to enhance passenger experience and enable user-friendly wayfinding systems inside the stations (Figure 86). Interestingly, we also see similar murals and mosaics related to the stations' name or its urban context such as; Tarım Bakanlığı (Ministry of Food, Agriculture, and Livestock) and Middle East Technical University stations. One might even claim that this approach is very similar to Mayakovski station in Moscow with its political context, yet there is not enough evidence and documented political debate to support the claim.

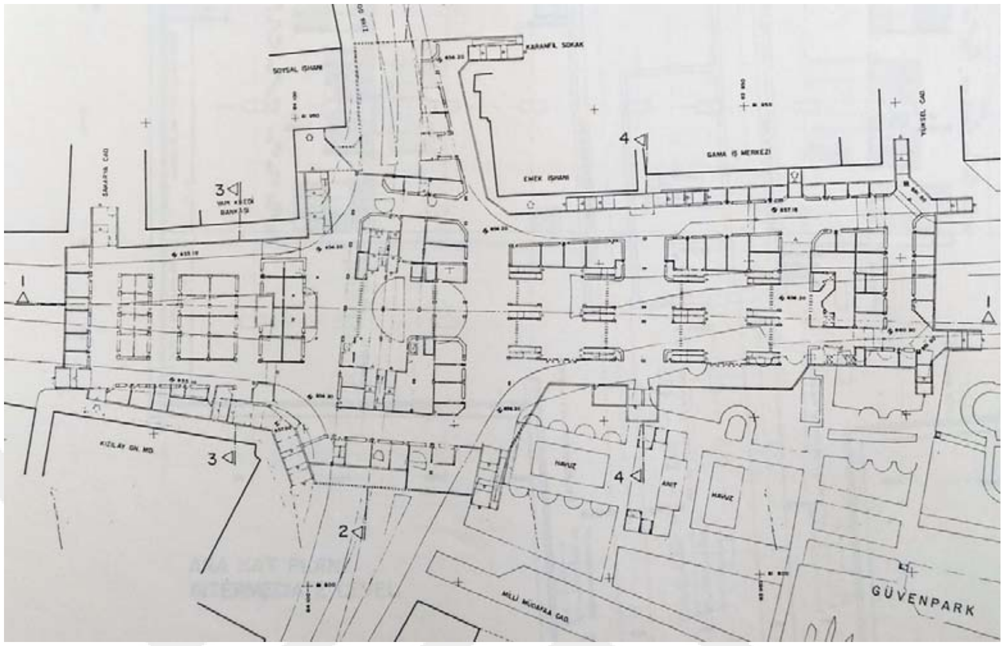


Figure 85 - Kızılay Subway station concourse plan with its urban context (EGO Ankara Department of Transportation Planning and Rail System, 1987).

Figure 86 - Ankaray line Kızılay station platform level (author).

3.3.3 İzmir Stations and Design Competitions

Interestingly, İzmir stands out with its peculiar design competitions regarding the transit hubs. Two design competitions were held in İzmir to create a more developed approach to the transit hub design. Those competitions were İzmir Transportation Integration Center Project (Bayhan, 2016) (Figure 87) and Evka 3 Social Center and Transfer Station Competition (Karakoç, 2017) (Figure 88). Even though these projects developed design approaches to the problems addressed in the competition, the design of the subway stations both in the project area or the stations in the vicinity was not included in the competition brief.

Figure 87 - Artistic rendering of İzmir Transportation Integration Center Project *(ZeO Mimarlık, 2016)*

Figure 88 - The only image that documents the subway station on the left side of the section at EVKA-3 Social Center & Transportation Hub project *(Kolektif Mimarlar, 2019)*

In conclusion, except for transportation nodes with huge passenger loads, the general approach to the design of subway stations in Turkey is a common replication of the Milan subway designs approach. It is crucial to admit from functionality and project management perspectives that the selected method is a suitable process in the public interest. However, without questioning the current design methodology locally, we witness that Turkish architects and engineers design stations in a vicious cycle. Except for a few design competitions (Yenikapı Transfer Hub, İzmir Transportation Integration Center Project, and Evka 3 Social Center and Transfer Station Competition), most of the design and construction relied on the standardized underground stations associated with various connection points of the city with the least disturbance in its urban context.

3.4 Critique of the Subway Stations

When we look at the station designs, we can divide them into two segments, the timeline of the design process and challenging contemporary examples. The timeline focuses on the design process of the stations, and we see a remarkable evolution from the time when architects were responsible only for the interior decoration of the spaces that were “designed” by engineers to become the leaders of the design teams. In other words, we trace how designers responded to the same design problems in different settings.

On the other hand, when looked at contemporary designs, the essential notion is the fact that all of the design parameters such as; platform dimensions, escalator capacities, the number of required turnstiles, fire safety distances, and similar parameters are determined according to the country-specific standards and guidelines mentioned in the literature review. Additionally, by studying the design of these stations, we can also state that their designers questioned the existing design methodology and went beyond the recommendations of these guidelines and standards. In other words, in contemporary examples, we trace the fact that standards and design guidelines are considered technical documents that provide the design minimums so that designers can develop a sense of scale and dimension. Therefore, by looking at the contemporary international examples, one can see that the design process of a station has shifted from a method where architects only beautify the spaces determined by standards, guidelines, and engineering design; to a holistic approach to the evolution of the space.

Unfortunately, the station design processes and methods adopted in the local context lack this approach. It is understandable that because of financial and project management concerns, typical station solutions were opted for, which depended mainly on standardizations. This may also be due to the fact that the political will tends to lean towards the "typical design" approach, ergo the typical hospitals and typical schools, etc. in the country. Therefore, all Turkish metropolitans have built stations and transit hubs that are in compliance with the standards and technical guidelines and did not go beyond the design minimums. Moreover, the prescriptive method of standardization adopted in Turkey is such that the design process itself could be automated or scripted easily. As a result, except for some of the debated stations and transit hubs designs, we have seen that bland and monotonous plans are implemented in Turkey that is shaped only by the design guidelines and standards.

CHAPTER 4

PROBLEMS IN THE SUBWAY STATION DESIGN PROCESS

Transit architecture is shaped around its functionality. However, while providing the complex system of functionality both for the vehicle and pedestrians, designers have to overcome various design concerns shaped by national or international design guidelines and standards. On the other hand, due to its complex nature, architectural design concerns are disregarded while the standards and guidelines are considered as the governing documents, almost with a canonical understanding.

In order to develop a detailed understanding of the station design, one must develop a critical approach to the existing standards and design guidelines. Since a majority of the subway stations are “typical” in a context where they provide transportation along with their network, it is imperative to improve the design approaches for more appropriate user experience. In addition, typical stations are regarded as a part where project managers could accelerate the design process and construction time by using standardized configurations in every aspect. However, for the typical stations in Turkey, one can trace that this mass-produced station approach has developed the existing problems where station buildings are shaped by engineering concerns generated by the technical documents, and architects beautify the station space by using decorations. As a result, cities started to have subway stations that are merely underground concrete structures that pump the population around the city from point to point.

Stations are designed for predicted passenger capacity depending on the peak-hour loads, with the help of technical documents that are, in turn, based on past experiences. Therefore, without developing a detailed approach to both the engineering and the architectural parts of the design process, it is hard to develop a suggestion for the existing problems. The following section will suggest an alternative perspective to interpret the projections as a design parameter. Therefore, this chapter will focus on the problems and discrepancies found in the design process while inspecting different documents and designs throughout the world.

During this comparative study, the selection of the standards based on their operability and applicability in Turkey's context will be the focus. As a result, most of the arguments are developed around the National and influential international standards and guidelines such as; TS 12127, TS 12186, NFPA 130, and London Underground's Station Planning Standards and Guidelines.

4.1 Problems of Design Guidelines

In order to understand the subway station design process, one should understand that these stations are shaped by technical design guidelines and standards mentioned in the literature review because of functionality purposes. Besides, due to its intricate interdisciplinary qualities and functionality concerns, it would be a mistake to take any technical design concern out of the design process. However, by looking at the dates of the issue of the local standards, one can clearly see that the national standards are slightly outdated. Primarily the major design standards TS12127 and TS 12186, which have a high impact on the architectural design process, were issued in 1997 and are still in effect. Compared to similar standards mentioned in this study, this situation is a problem that must be addressed because in a comparable time frame NFPA 130 has been updated regularly; in 2000, 2003, 2007, 2010, 2014, 2017, and lastly, in 2019 (NFPA 130 first issue date is 1983).

Inner-city railway systems are designed to operate for 50 to100 years, and designing future stations with an outdated standard could be considered as an erroneous act. Unfortunately, system failures have happened in transit buildings because of obsolete design guidelines or equipment; as in the case of the New York City subway, which had substantial problems due to its old systems combined with its financial problems (Fitzsimmons, 2017; Rosenthal, Fitzsimmons and LaForgia, 2017). One of the economic and practical solutions to respond to such a challenging problem is to design according to the most demanding standard, whether international or national. By doing so, designers could already meet the remaining criteria, and the design would be accepted as valid from a dimensional point of view.

4.2 Problems of Standardization

One of the easiest notion one can follow in different guidelines, and design standards are the capacities of various architectural and mechanical elements which have a direct effect on the station design. As seen in Table 11, capacities and quantities of various elements such as the stairs, escalators, or turnstiles are dependent on the technical documents, and they all have constant capacities similar to automobile parts while disregarding any human factor in the process.

Table 11 - System capacities of different standards(author)

	Corridors		Escalators		Stairs		Turnstile capacities	
	width (cm)	Capacity (people per min PPM)	width (cm)	Capacity ppm	width (cm)	Capacity ppm	Entry ppm	Exit ppm
TS 12127	100	80	120	80-100	100	65	30	40
NFPA	112	92	112	62.16	112	62	25	25-50
LUL	100	80	100	120	100	56	25	25

By looking at the capacities of different standards and guidelines, one can see the differences in the documents on the capacities of the same architectural or mechanical equipment. Commonly, while calculating the dimensions of these elements such as staircase width, the number of escalators, or the number of turnstiles, different articles show us these varying capacities. For instance, by looking at corridor widths, different values could be traced in different standards. Turkish standards and London Underground design guidelines suggest the same approach, while NFPA suggests a broader corridor with a higher capacity. Interestingly when the theoretical capacity of one centimeter is calculated, the same value for a corridor width can be found. However, the escalator capacity in all documents shows a possible flaw among the documents. While NFPA 130 suggests a minimum 112cm width escalator with 62 people per minute (ppm) capacity, Turkish Standard TS 12186 and 12127 suggest 80-100 ppm and London Underground claims that an escalator can carry up to 120 ppm. Therefore, even from the calculation perspective, one can see that the difference between the escalator capacity almost doubles. This change also shows us that different calculation methods give different dimensions and quantities for architectural design. In addition, one of the main arguments for the escalator capacity is shaped around the fact that personal space is a phenomenon inside the subway stations. Despite the designers provide adequate space for movement and waiting for activities while boarding the escalator, one can see that people have the tendency to protect their personal space (Hall, 1992). As mentioned by Fruin (1971), these guides and standards should be evaluated as theoretical and nominal capacities and do not bring any insights into the phenomenon of empty steps on the escalators. That phenomenon could be where the following passenger tries to create a space between the next one, to create a comfortable personal space. Therefore, it is hard to claim that every step of escalators would be occupied, and technical documents only show the potential of a mechanical component under machine-like conditions in a predicted future. Although this study was published in 1971, yet the design of the subway stations is, unfortunately, still based on using constant capacities.

Similarly, when looking at the turnstile capacities, a similar problem can be traced. According to the Turkish standard, while 30 people could use the turnstiles to enter the station, 40 could exit from the station at the same turnstiles (TSE, 1997a). However, when looking at the suggested capacities of NFPA 130 and London Underground, 25 ppm both for entering and exiting the station can be seen. Besides, according to the Transit Capacity and Quality of Service Manual (National Academies of Sciences Engineering and Medicine, 2013c), different turnstile capacities could be found depending on the fare media and reading systems of the operators. For example, systems without any barriers provide up to 50-60 ppm almost a corridor like access inside the station. However, depending on the fare collection method, we see a capacity from 15 ppm to 35 ppm. Along with the new technologies, a shift from conventional tokens or paper tickets to new fare collection types where passengers use technologies such as near field communication (NFC) and Radio-frequency identification (RFID) cards can be seen. Therefore, turnstile capacities based on former ticketing systems will see a dramatic shift both in normal and emergency conditions.

Existing suggested capacities for circulation elements help to create an idea about the dimension and quantity of various circulation elements. Even in the early stages of the design, designers have the chance to outline basic dimensions and develop a design approach. These numerical and technical approaches play a vital role, especially when constructing a station with different limitations such as budgetary concerns, allocated space, and construction time. Together with the functionality requirements of this building type, standards and guidelines help designers to achieve the much-required collaboration with different engineering disciplines. However, during the design process, these calculations are considered as the sole prescription to the design, and designers forget the fact that these values are theoretical optimal values. Especially, with a surge in the pedestrian activity, a typical station will end up experiencing demands beyond the "calculated" situation on the circulation elements of the station. Particularly in typical stations where designers apply the same layout multiple times, these theoretical values tend to be the Achilles heel from architectural design, hence the pedestrian experience of the station from the crowding perspective (Tirachini, Hensher and Rose, 2013; Haywood, Koning and Monchambert, 2017). As a result, instead of accepting the constant capacities of various components in the station design, it is imperative to accept these theoretical capacities as suggested design minimums for a projected future and develop the design of the station based on these design minimums

4.2.1 Type of the station: typical or atypical?

Transit architecture focuses on the design of train stations, subway stations, tram stations, airports, and even bridges, which are designed as a part of the infrastructural design. These buildings shaped urban patterns with different meanings while establishing interconnectivity among communes and cities. These buildings are shaped with strict design, engineering and safety standards and calculations to provide functionality, accessibility, and security not only for its users but also for its related service vehicles (train, tram, plane, and bus). Still, these building designs have to respond to every technical standard and design consideration in order to be operational. This reality shows us that transit buildings are profoundly shaped by technical design guidelines and engineering inputs combined with architectural design concerns. In other words, a station would not be operational if the train does not fit into the designated platform area, or the pedestrians could not access the vehicle. By meeting the strict technical requirements, a designer will have the first layout of transit structures. Mostly railway stations and airports, where the structure is visible, became items of prestige and significance besides their functionality and almost regarded as the monumental gateways of the cities with various meanings and symbolism. Though the local counterpart of the station typology, there are missing notions and methods because they are buried underground, and their effects such as visibility are diminished. We can rarely see any discussion on the architectural design of a subway station. Still, the metrics and calculation methods of the documents make designers question the design approach of the stations.

Railway systems and their stations should be efficient in terms of user comfort and experience, prevent service and movement bottlenecks (Sun *et al.*, 2016; Handel and Borrmann, 2017), provide adequate walking distances to other facilities (Weinstein *et al.*, 2008), provide the necessary emergency evacuations conditions (Yamashita, Matsushima and Noda, 2014; Zhang *et al.*, 2016), foresee group movement patterns (Wachowicz *et al.*, 2011), and consider construction investment, ease of maintenance and management (Rastogi, Thaniarasu and Chandra, 2011; Nielsen *et* *al.*, 2014). Still, one can clearly see that these technical studies mostly focus on egress studies and simulations rather than the expected peak conditions. Designers are expected to develop their design for emergencies. Nevertheless, sometimes events such as a surge at the peak conditions or a worker strike might lead to events when station buildings need to be evacuated. From time to time, station buildings are shown in the news with pedestrian jams just like vehicular traffic jams(Şenerdem, 2010; BBC News, 2014; İHA, 2015; Hürriyet Haber, 2016; Wong, 2016).

In addition to the literature review, to develop a critical perspective on the existing subway station design, a survey on the news related to subway station and stampedes was conducted, and some of the following incidences were traced:

- Baku fire (256 killed) (Reeves, 1995),
- Dague Metro fire (197 killed).(Brooke, 2003).
- Stampede in panic at the London subway(Lawless, 2017).
- Mumbai Metro security report (Pulido *et al.*, 2018)
- Fainting Passenger causes stampede in Shenzhen (Yan, 2015),
- Thousands stuck at stations at Holiday rush (Wong, 2016),
- Sparks from cables cause panic and stampede (NBC 4 New York, 2018)
- Pedestrian jams in Metrobus (İHA, 2015; Hürriyet Haber, 2016)
- Worker strikes-cause pedestrian jams (BBC News, 2014)

These news items underline the fact that whether the station is designed according to specific sets of standards or not, it is possible to experience some crowd-based tragic events, even causing loss of life. Mumbai's rail system had a tragic record on accidental deaths, more than 3600, which implies the importance of the security. Likewise, dramatic events caused scholars to question the existing standards and develop new security measures in subway stations like; Baku fire (256 killed) (Reeves, 1995), Dague Metro fire (197 killed). (Brooke, 2003). However, it is possible to see stampedes and pedestrian jams in subway stations even designed by the guidelines mentioned above despite the new guidelines and standards. It is unfortunate to see that disastrous events like terrorist attacks or fire-related panics still cause panic movement in subway stations in New York (NBC 4 New York, 2018) or London (Lawless, 2017). However, some of these events are ignited by some everyday activities as a fainting passenger (Yan, 2015), holiday rush (Wong, 2016), sparks from cables (NBC 4 New York, 2018) and even pedestrian jams in Metrobus (İHA, 2015; Hürriyet Haber, 2016). It is essential to keep in mind that these events occurred in ordinary stations rather than prestigious stations designed by famous design teams. Besides, recent research shows us interesting data by tracking social media content and its related tags. According to the research (PowWowNow, 2019) tags of #station, #tube, and #train on social media have been traced with the station names in London combined with the number of people using the station and the length of the delays in these stations gave them to determine which stations are more problematic to its users. Accordingly, the top five most stressful stations in London underground network were King's Cross St.Pancras, Bank & Monument, Stratford, Waterloo and Victoria stations. Interestingly, all of the five stations were designed according to the design guidelines and technical documents and accepted as working examples.

Correspondingly, JICA's approach to station design at the Cairo subway line (JICA, 2010a) and Transport from London's design idiom (Transport for London, 2019a) points out a very interesting approach to the station design. According to the JICA report, there are three types of stations, and this categorization is free from the alignment design. These are:

- Signature Station,
- Modal Interchange Station, and
- Typical stations.

Signature stations are mostly distinguishing stations along the line where the design of the station is considered as a showcase of the whole line. Stations that enable connections to touristic areas, important urban locations, airports, and train stations have more potential to be a signature station. The most iconic station design examples are considered as signature stations of their lines, such as; architect Foster's Canary Warf. In addition, these stations had higher budgets, which enabled architects to design these stations further than their capacities.

Typical stations focus on the parallel properties of different station locations and aim to develop similar design solutions to develop a cost-effective design. These stations have very similar architectural layouts, both in technical and passenger area design. Compared to the other types of stations, typical stations represent the most neglected part of the design.

Modal Interchange Stations provide a connection to the other intercity travel options such as different subway lines, trams, bus stations, taxis, and sea vehicles. In some examples, it is also possible to see additional car parking options in station designs where they provide a chance to change their transportation from private to public.

In contrast, Transport for London (TfL) categorizes stations in four types due to passenger activity; gateway, destination, metro, and local stations (2019b). Similar to JICA's Signature Station Approach, Gateway stations are main transportation hubs where high volumes visitors enter the transportation system such as King's Cross St. Pancras or Heathrow stations. The other three station types, destination, metro, and local, can be evaluated in an ordered fashion due to the passenger volume. Destination type stations highlight famous tourist and commercial destinations. Metro type stations serve inner London communities, while local stations serve communities in outer London areas.

When we look at the news about stations, these events occurred in typical or intermodal stations compared to the signature stations. Since these signature or gateway stations are studied by different design teams and presented to the public as an object of prestige, it is possible to see fewer problems about the user experience. In addition, in a typical subway line, it is expected to see multiple stations with a typical approach. However, by looking at the station designs in architectural periodicals and publications, in addition to social media, these crown jewel stations are presented as a typical station solution along the whole line. Unfortunately, as mentioned above, pedestrians experience more problems in typical and intermodal stations compared to the signature stations.

Typical station solutions have similar problems to the modernist approach defined by Lang (Lang, 1994)These are, solving the circulation problem, applying a façade if it is possible, and solving technical problems of air circulation and structure within the budget available. However, Lang also mentions that this approach lacked the ability to establish a productive connection between human needs, the environment, and their relation to each other. Similar to Lang's definitions, on the intermodal and typical station types, it is possible to see almost the same approach in a subway station context. These stations are intensely shaped with technical design guidelines based on either a fixed or pedestrian load-based solution, and the interior design elements are pushed to their limits to create a "user-friendly" station inside the *shell created by calculations*. Without creating a balance between the technical design guidelines and architectural concerns, users will only experience the same architectural layout with different color schemes even though every station has its theme or everything is identical. Apparently, for operational and management concerns, repetitive elements are a part of infrastructural projects (Allen, 1997), and stations are depicted as standardized dots on the line, shaped by capacity rules. Consequently, the existing design approach should be confronted to recognize that not only prestigious stations but also the typical stations require a progressive design approach.

4.2.2 Lack of Local Profiles: questioning the standards

The sole technical approach based on standards and design guidelines also brings us another issue in the design process. Besides the need for a revised version of these documents, it is also essential to define the local profiles and characteristics of the users. Because design manuals and egress standards, the design teams accept a single human being with universal features that could help to solve the design approaches. For instance, Fruin (1971) defines that the average walking speed is 82 m/min, yet it varies between 46 to 107m/min in the context of railway stations. NFPA 130(National Fire Protection Association., 2017b) defines an average human speed of 37m/min at platforms, corridors, and ramps and 61m/min where a lesser pedestrian density is estimated. Smith and Blewitt (2010b) claim that 72m/min is appropriate and at the Business Case Development Manual (2013) claims that 80m/min could be accepted for pedestrian walking speed, to design in London.

Additionally, pedestrian’s physical properties like the age, height, weight, or dominant direction for walking at different geographies vary dramatically (P.Grasgruber *et al.*, 2014), which also affects the walking speed of pedestrians significantly. For instance, the average height of US citizens for males aged 20 and over is around 175 cm and 161.8 cm for females aged 20 and over (Table 12 and Table 13) (Fryar, Gu and Ogden, 2012). In the same study, the weight of US average males aged 20 and over is 88 kg and 76 kg for females aged 20 and over(Table 14 and Table 15). Similarly, England has similar values for their citizens. Moody (2013)shows that average British males are 176cm high, 83.5 kg in weight, and 162cm to 70kg for females. Interestingly, when looking at design guidelines despite their physical similarities, two groups are walking at different speeds. As a result, it is possible to say that the travel speed of pedestrians varies with their geographies or context, which contradicts a universal pedestrian speed.

Furthermore, when looking at Turkey at a similar distribution group, the average male height is 174.1cm and 158.9cm for females (Table 16)(Özer, 2008). Additionally, the same study shows that Turkish people's weight average is 77.8 kg for males and 67.0 kg for females. Thus, due to physical differences, it is possible to say that assuming the walking speeds of Turkish pedestrians the same as American or British might lead to incorrect calculations from simulation studies. There is no guarantee that the international parameters would be feasible for local cases.

Table 12 - Height in centimeters for females aged 20 and over and number of examined persons, mean, standard error of the mean and selected percentiles in the United States(Fryar, Gu and Ogden, 2012)

Race and Hispanic origin and age	Number of examined persons	Mean	Standard error of the mean	Percentile 5th	10th	15th	25th	50th	75th	85th	90th	95th
All racial and Hispanic-origin groups[1]		Centimeters										
20 years and over	5,547	161.8	0.21	149.8	152.7	154.3	156.8	161.9	166.4	169.0	170.7	173.5
20–29 years	928	162.9	0.30	151.9	154.4	156.0	158.4	162.9	167.2	169.1	171.1	174.2
30–39 years	957	163.4	0.30	151.2	153.8	155.6	158.3	163.6	168.6	170.9	172.5	175.3
40–49 years	987	162.9	0.31	150.9	153.7	155.4	158.1	163.0	167.3	169.8	171.7	174.4
50–59 years	924	161.9	0.37	150.9	152.9	154.7	156.9	162.2	165.9	168.5	170.5	173.2
60–69 years	888	160.5	0.37	149.9	152.5	153.6	156.1	160.5	164.7	167.0	168.8	171.9
70–79 years	527	159.3	0.35	147.5	150.3	152.0	154.5	160.0	163.8	166.0	167.9	170.3
80 years and over	336	155.6	0.37	144.6	146.4	148.1	151.5	155.7	160.2	161.8	163.4	166.4

Table 13 - Height in *centimeters* for males aged 20 and over and number of examined persons, mean, standard error of the mean and selected percentiles in the United *States (*Fryar, Gu and Ogden, 2012)

Race and Hispanic origin and age	Number of examined persons	Mean	Standard error of the mean	Percentile 5th	10th	15th	25th	50th	75th	85th	90th	95th
All racial and Hispanic-origin groups[1]		Centimeters										
20 years and over	5,232	175.7	0.21	163.4	166.2	168.0	170.6	175.6	180.8	183.7	185.4	188.1
20–29 years	937	176.4	0.26	164.9	166.9	168.5	171.1	176.2	181.3	184.5	186.4	188.8
30–39 years	914	176.6	0.30	163.8	167.1	168.8	171.5	176.6	181.6	184.4	186.6	189.1
40–49 years	872	176.2	0.42	163.8	166.8	168.5	171.0	176.1	180.9	184.3	185.7	187.7
50–59 years	852	176.0	0.50	164.5	166.9	168.5	170.7	175.6	181.3	183.7	185.4	188.5
60–69 years	877	175.3	0.46	162.1	165.5	167.4	170.3	175.6	180.8	183.1	184.2	187.4
70–79 years	486	173.0	0.32	162.2	164.3	165.4	168.3	172.6	177.4	180.0	182.2	185.2
80 years and over	294	171.6	0.59	159.7	163.0	164.2	167.5	171.9	176.2	179.0	180.3	182.8

Table 14 - Weight in kilograms for females aged 20 and over and number of examined persons, mean, standard error of the mean, and selected percentiles in the United States (Fryar, Gu and Ogden, 2012)

Race and Hispanic origin and age	Number of examined persons	Mean	Standard error of the mean	Percentile 5th	10th	15th	25th	50th	75th	85th	90th	95th
All racial and Hispanic-origin groups[1]		Kilograms										
20 years and over	5,425	76.4	0.42	50.1	54.3	57.5	61.7	72.1	86.7	96.2	104.0	116.5
20–29 years	853	73.4	0.85	48.6	51.7	54.3	58.4	67.9	83.7	96.5	103.7	115.8
30–39 years	915	78.4	0.87	52.1	56.3	58.4	62.5	72.8	88.9	98.9	107.8	122.1
40–49 years	979	78.5	1.00	52.5	56.6	59.3	63.0	74.4	89.3	98.8	107.6	118.5
50–59 years	923	79.1	1.05	52.3	56.6	58.6	64.0	75.9	89.5	99.5	108.6	123.1
60–69 years	889	76.6	0.90	49.0	55.6	58.8	63.7	74.6	86.7	93.8	102.0	111.4
70–79 years	527	75.2	0.94	49.1	54.5	58.1	62.9	71.9	85.5	93.3	98.2	108.0
80 years and over	339	64.4	0.74	44.0	47.1	50.2	55.2	64.0	72.8	78.2	81.8	86.5

Table 15 - Weight in kilograms for males aged 20 and over and number of examined persons, mean, standard error of the mean and selected percentiles in the United States(Fryar, Gu and Ogden, 2012)

Race and Hispanic origin and age	Number of examined persons	Mean	Standard error of the mean	Percentile 5th	10th	15th	25th	50th	75th	85th	90th	95th
All racial and Hispanic-origin groups[1]		Kilograms										
20 years and over	5,236	88.8	0.43	62.0	66.3	69.9	74.9	85.9	99.2	107.4	113.3	124.9
20–29 years	936	84.7	1.18	57.3	62.4	65.3	69.4	80.7	94.6	105.3	112.1	127.4
30–39 years	914	90.2	0.78	63.6	68.1	71.7	76.2	86.6	100.3	110.2	117.7	127.9
40–49 years	872	91.5	0.73	66.3	70.9	73.9	77.9	89.1	100.9	107.6	113.0	126.6
50–59 years	854	90.5	0.92	63.5	69.0	72.6	77.2	88.8	100.8	107.4	113.6	126.7
60–69 years	874	90.6	1.37	62.5	66.7	70.0	76.2	88.6	101.2	110.8	115.8	126.6
70–79 years	486	85.8	0.92	61.9	66.3	69.2	75.6	83.3	96.1	103.0	107.2	114.1
80 years and over	300	79.2	0.86	56.8	60.1	64.1	69.9	77.6	88.2	94.0	98.0	105.9

Table 16 – Mean values of height, weight, and BMI by sex and age group in Turkey (Özer, 2008)

Age group (years)	Height (cm)						Weight (kg)				BMI			
	Males			Females			Males		Females		Males		Females	
	n	Mean	SD	*n*	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
18–29	390	176.1**	6.3	163	162.0	7.0	77.5**	10.6	59.3	9.8	25.0**	3.0	22.9	3.6
30–39	191	172.9**	6.6	112	158.4	5.6	78.1**	10.7	67.3	11.6	26.1**	3.3	26.8	4.5
40–49	102	169.1**	6.9	177	157.1	5.5	75.9**	12.2	70.1	11.5	26.5**	3.7	28.5	4.8
50–59	20	169.7**	5.0	60	156.4	5.2	82.4**	9.7	72.1	11.3	28.4*	3.4	29.7	4.3
Total	703	174.1**	6.9	512	158.9	6.4	77.8**	10.8	67.0	11.9	25.7**	3.3	26.7	5.0

* $P < 0.05$, ** $P < 0.001$, sex difference was tested by a *t*-test.

Although there are studies focused on pedestrian behavior (Nordfjærn and Şimşekoğlu, 2013; Şimşekoğlu, 2015) and the safety of pedestrians in transit systems (Yüksekol, 2012), they are mostly in the context of vehicular traffic. Transit station oriented studies are either design guidelines for a line or a station design (Yaşdağ, 2006; Atak, 2015) or level of service studies in different settings (Karataş, 2015). As a result, it is possible to say that there is a lack of studies focusing on Turkish pedestrian behavior in the framework of not only in subway stations but also in all transit buildings.

4.3 Predicting the Future

As mentioned in different parts of this study, subway stations are designed according to the peak hour loads, and all technical documents help designers shape their space. Even though this method is called the prescriptive method, along with the difficulties of underground construction, it is essential to have an idea of the design minimum of the space. However, it is equally essential to develop a critical approach to the projections so that they will not be perceived as the ultimate parametric input for station design.

4.3.1 Problems of Projections

according to the basic definition, a station has to provide all of the technical aspects for the selected vehicle and provide the required spaces and circulation elements for pedestrians to give the necessary access to the train. Since the daily passengers have to experience at least two stations while embarking and disembarking, subway station design parameters play a vital role in the design process due to the fact that most of the architectural elements are shaped according to the pedestrian volumes. Moreover, every dimension-based suggestion or a prescriptive method, such as clearance distance, door capacity, staircase width, walking speed, the minimum level of services, is based on personal space. Hall (1992) established his view on the personal space based on Hediger's study (1964) on captive animals at zoos. According to Hall, humans have territoriality, and this territorially shapes the activities of the group. In addition, Hall highlights that "how people are feeling toward each other at the time is a decisive factor in the distance used"(1992, p. 114) and defines distances such as; intimate distance, personal distance, social distance, and public distance (Figure 89). Moreover, he gives different examples of experiments and studies, which shows us that as overcrowding increases, social and physical pathologies also increases. In other words, crowding disturbs the social functions of the society, which might even lead to extreme situations like the "behavioral sink" where the society stop functioning and drift into chaos based on overcrowding problems as in Calhoun's rat experiment in the Rockville barn(Hall, 1992). Hall's ideas were first published in the 1960s regarding crowd behavior and personal space. A more current United Nations report (2018) states that 66% of the world population is expected to live in urban areas. With this amount of population movement, it is possible to see new approaches and developments on the space requirements from different perspectives. One of the most alarming parameters in this aspect it the fact that in the TS 12127(1997a), APTA(1981), and LUL - G371A Design Guidelines (2012), it is possible to see three different values for the suggested passenger related calculations. For example, to calculate the required platform, all three standards have the same approach; passenger load is multiplied by the recommended pedestrian area. However, three standards have different recommended passenger areas, TS 12127 defines 0.5m^2 per passenger, APTA recommends 0.765 m^2 per passenger, and according to LUL - G371A same parameter is considered 0.96 m^2 per passenger. These three approaches show us that even if the same method is applied, the required area differs dramatically. An applied example is shown at Appendices A and B to highlight the differences of the calculation methods mentioned above.

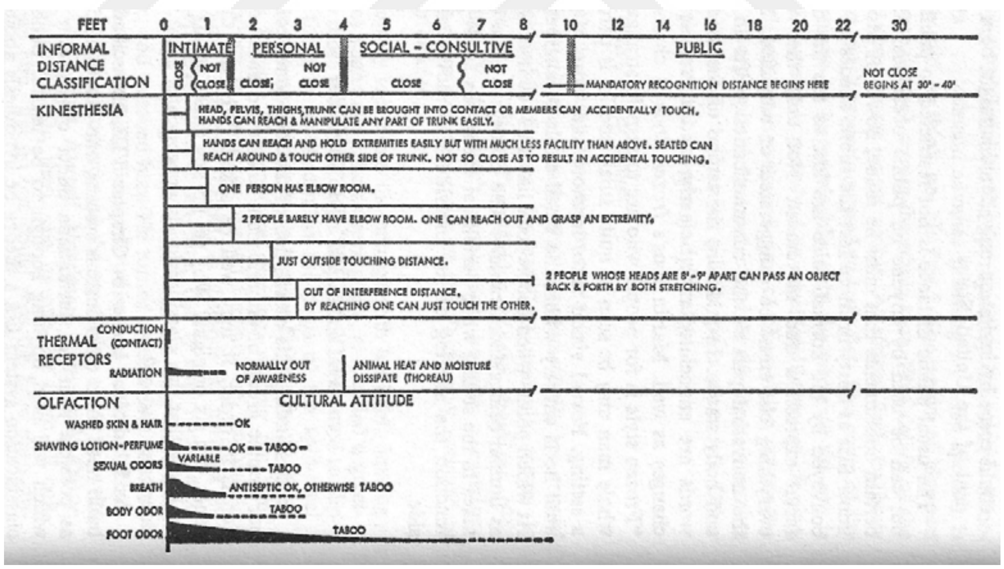


Figure 89 - Chart showing the interplay of the distant and immediate receptors in proxemic perception (Hall, 1992)

In addition to the personal space calculations, there is another very critical study that must be taken into consideration. Every professional design guideline assumes a station's lifetime to be around 50 years. In addition, the prospected pedestrian load is calculated for around 25 years for the morning peak period. Still, starting from

Fruin's research (Fruin, 1971) and Level of Service (LoS) method pedestrian ellipse and the allocated space per pedestrian method has hardly changed, which can be seen from the standards and technical design guidelines. However, a recent study made by Thompson et al. (Thompson *et al.*, 2015) shows us two critical points on models for the aging society and the larger bodies of the community.

Based on the Organization for Economic Co-operation and Development (OECD) reports (OECD, 2007, 2014, 2016), it is possible to see that the future will not be what is predicted. First of all, according to the reports, it is possible to trace the age ratios of society, which gives us information about the age structure of the population(Figure 90). Compared with the OECD countries' life expectancy rates, it is possible to trace dramatic information for future projections. First of all, when looking at the share of youth and the age of dependency in the total population, general population the old-age dependency ratio will double in the next 45 years (Figure 90), with a decrease in young people in total population (Figure 91). Besides, in the same report, it is possible to trace that life-expectancy is slightly increased (Figure 92). In parallel, the Turkish Statistics Institute declared that in 2030 12.9% percent of the population is expected to be elderly, and in 2060, this percentage is expected to rise 16.3% and 26.5% by 2080 (Gürtaş, 2019).

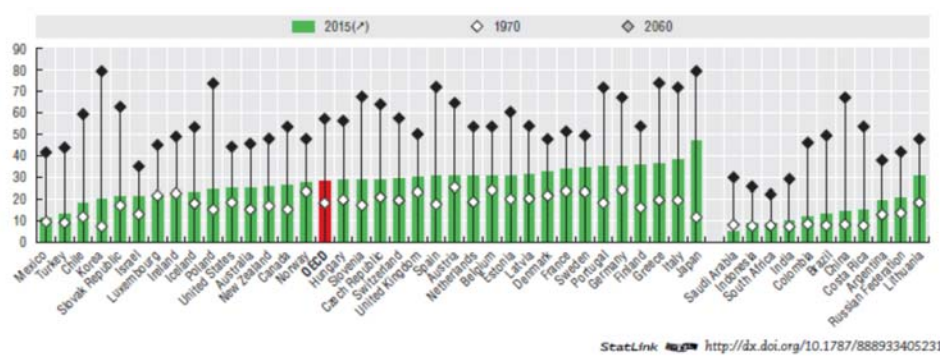


Figure 90 - Number of people of retirement age (65+) per 100 people of working age (20-64), in 1970, 2015 and 2060 (OECD, 2016)

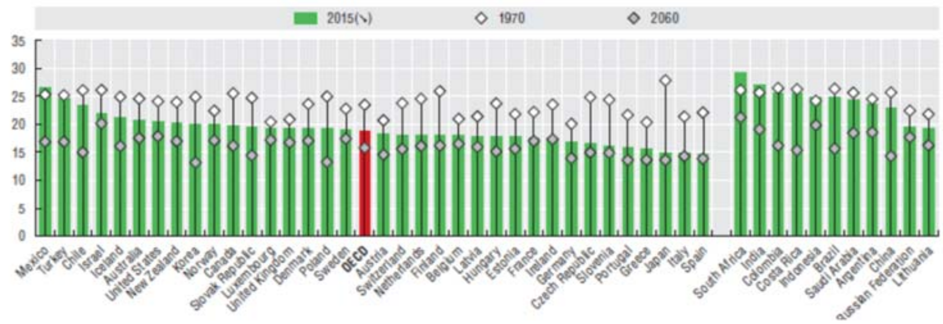


Figure 91 - Number of young people (15-29) in total population, percentages, in 1970,2015 and 2060 (OECD, 2016)

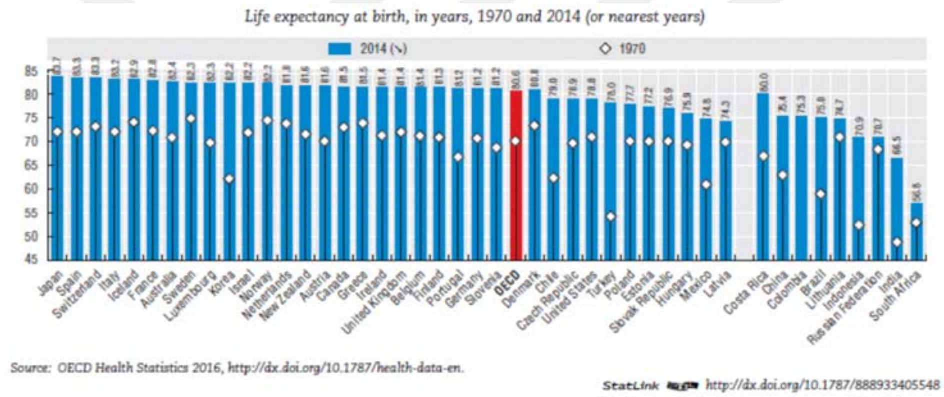


Figure 92 - Life-expectancy at birth, in years, 1970 and 2014 (or nearest years) (OECD, 2016)

By looking at the technical guidelines related to the subway station design guidelines, one might not establish a connection between subway stations and the society and its physical properties. Nevertheless, with the aging society, accessibility design concerns will be a part of the design process with higher dependencies. In addition, with the possible increases in life expectancy ratios in the countries, a surge to the accessibility elements could be experienced slightly more than the current demand for vertical circulation elements. Moreover, by looking at the aging population, it is also possible to claim that some changes in the average unimpeded walking speed, suggested area per pedestrian, and even the boarding/alighting time to the vehicles could be expected. A similar view can also be seen in Ando, Ota, and Oki's (1988) research, where they formed a relationship between the age and the walking speed of the pedestrian (Figure 93). As they lay out the relationship between these two factors, a slight decrease at the walking pace with age can be seen. This change will affect the required width for all types of staircases, platform width, number of turnstiles/faregates, number of escalators, number of elevators, ticket issuing machines, and windows. As a result, anything related to passenger activity is expected to change in time because of an aging population.

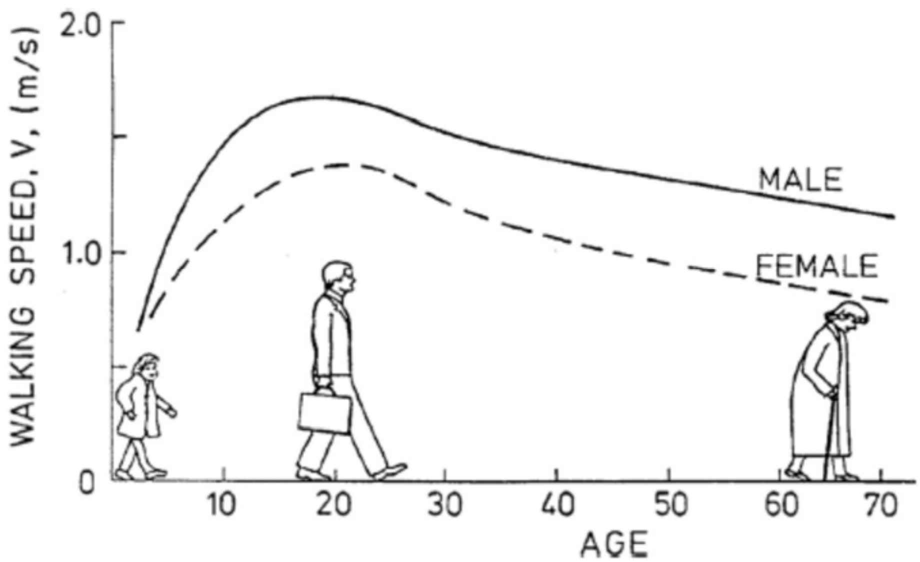


Figure 93 - Relationship between walking speed and age on a level surface (Ando, Ota and Oki, 1988)

Similar to the age problem, there is also a rising concern with the number of overweight people in different societies. According to the World Health Organization (WHO) reports in 2016, 39% of women and 39% of men aged 18 and over were overweight (2018), and 11% of men and 15% of women were obese. Over the last four decades, obesity and overweight rates have increased intensely.

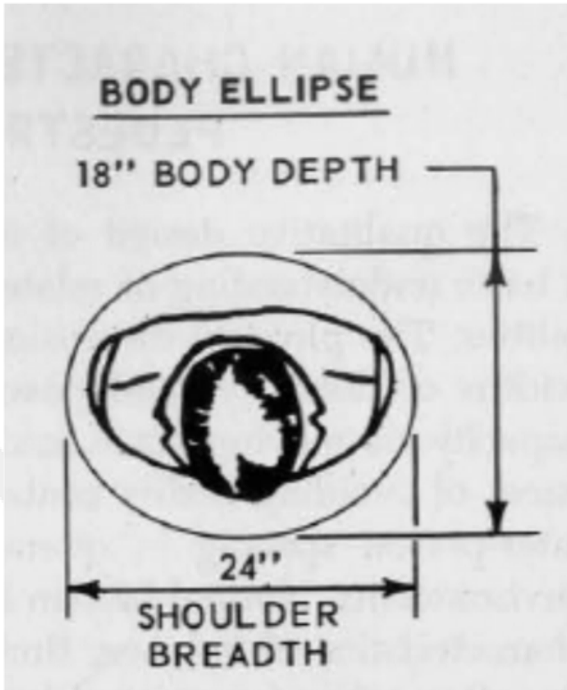


Figure 94 - Body ellipse 18 by 24 inch or 45 by 60 *centimeters* from Fruin (1971)

Moreover, recent studies show that obesity rates are higher in developing countries due to different factors, but the situation has turned into a global epidemic (James *et al.*, 2001; Caballero, 2007). With this dramatic change in the height-weight ratio, the waist size of pedestrians also increases(Levi *et al.*, 2013). Relatively, as mentioned by Thompson et al. (2015), with this slight increase, we need to question the metrics of the pedestrian ellipse method developed by Fruin (Figure 94)(1971). According to Fruin, "An 18 by 24-inch body ellipse, equivalent to an area of 2.3 square feet, has been used to determine the practical standing capacity of New York City subway cars" (1971, p. 20). Intriguingly, a revision of the Fruin's pedestrian ellipse is presented at Transit Capacity and Quality of Service Manual (National Academies of Sciences Engineering and Medicine, 2013a) (Figure 95). In this revision, Fruin's body ellipse was based on the 95th-percentile of the population in order to present an average of the population. However, according to the research, this body depth presented the 5th-percentile of the clothed males. As a result, visualization of it has been updated, as seen in Figure 95.

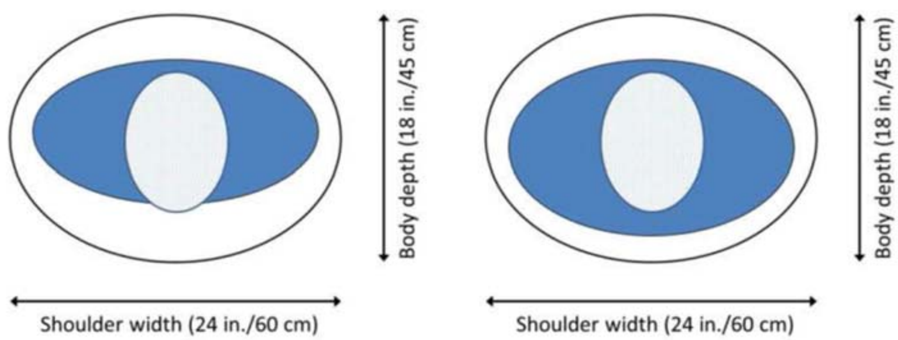


Figure 95 - Body ellipse by Fruin on the left and Body ellipse by 50th-percentile 1970s U.S. male(National Academies of Sciences Engineering and Medicine, 2013a)

Through the increased weight, it is possible to claim that the required area per pedestrian, personal space buffer zones, and movement of the crowd are also affected. According to WHO reports, the whole world is gaining weight in an unhealthy fashion. Similar to the rest of the world, Turkey also has its share in this global health problem (Bagriacik *et al.*, 2009; Erem, 2015). Starting from the 1970's obesity rates in Turkey also rose dramatically, and more than half of the population is overweight or obese (Figure 96). In view of the fact that obesity has a direct effect on the allocated area per pedestrian and the related factors such as personal space of walking speed, it is imperative to develop a critical approach to the existing national standards which recommends using 0.5m2 per pedestrian in contrast to higher values of similar standards and design guidelines from the world. Since we might have more slow pedestrians with higher rates of dependencies on accessibility, our projections for the next 25-50 years with peak hour passenger load might have some problems from the user experience perspective.

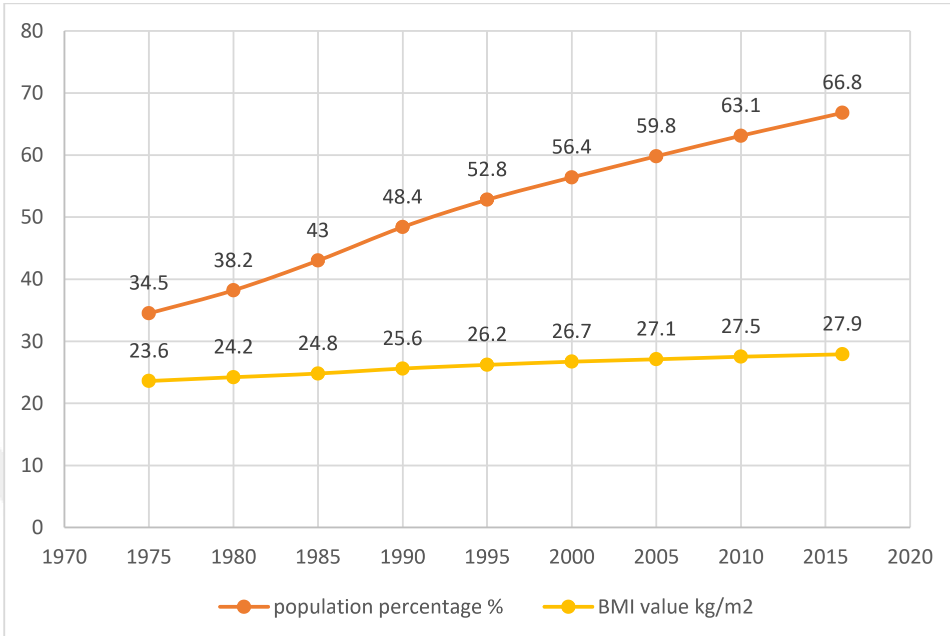


Figure 96 - Average BMI values and overweight percentage according to the WHO reports(author)

A new design methodology for subway stations should be developed beyond solely technical approaches. The current design methods can easily be converted into a software entity where one technician inputs the projected passenger load and acquires a shell to fit in the "design." However, a manual version of this method is in use for a very long time, and we can hardly see any benefit from it. So, there is no valid reason to do so. On the contrary, designers are limited to engineering calculations, financial limitations, and the available space above the ground while designing underground stations. Pedestrian simulations could be considered as an alternative approach to the existing situation where designers have the chance to test their design and shape the facilities for a better flow. However, there is a debate on the validity of the simulations and their ability to get close to reality as much as possible. This situation is a dilemma where the pedestrian parameters must be studied in detail, yet their data is based on redundant records and projections.

4.3.2 Peak Hour Period

At the beginning of the concept design phase, subway design guidelines present a projected peak passenger load for designers so that they can shape their stations. These projections usually present two case scenarios apart from 25-50 years from the design date **(**Figure 97**).** However, with the completion of subway lines, the urban pattern above the ground and traveling habits of the people changes with time. Along with that change, an increase in passenger demands may be traced earlier than expected.

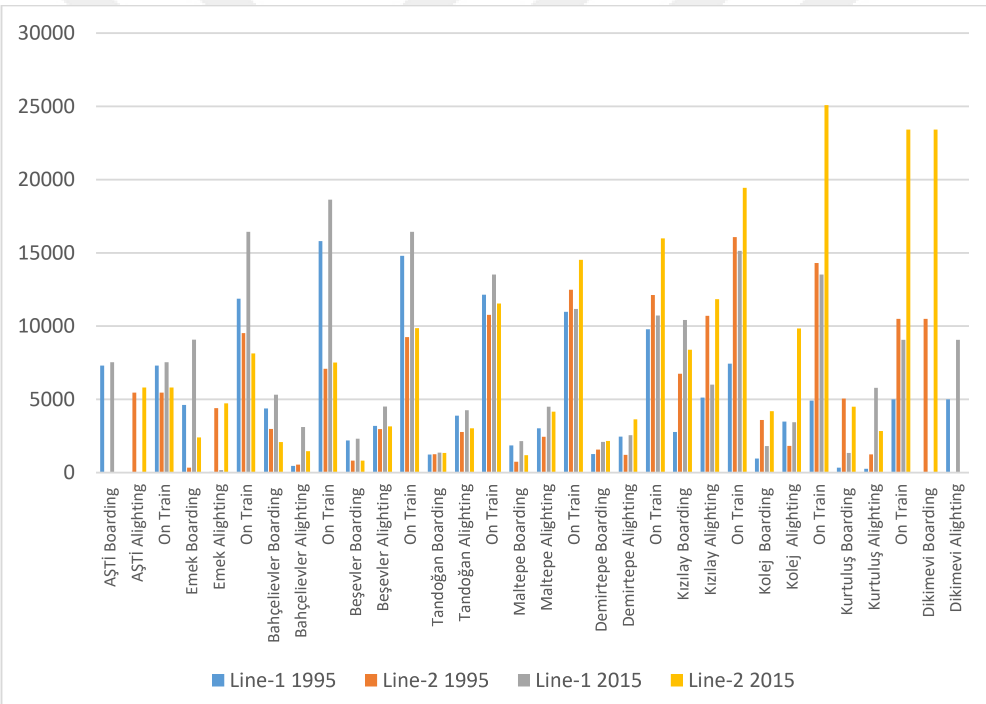


Figure 97 - Station passenger volumes for the years 1995 and 2015. The data set of the graphic is presented at Appendices D (EGO Ankara Department of Transportation Planning and Rail System, 1992b)

For example, Ankara subway lines create an outstanding example to explain this challenge. In the existing subway network of Ankara, the Dikimevi-AŞTİ (Ankaray LRT line), the Kızılay-Batıkent (M1 line) and the Kızılay Çayyolu (M2) lines were designed in 1989 – 1990 (Figure 98) (EGO Ankara Department of Transportation

Planning and Rail System, 1992b, 1992c, 1992a). Even though they were designed before the issuing date of the Turkish standards, these stations are shaped with similar design guidelines, and most importantly, both of the lines projected their peak passenger loads for 2015 (EGO Ankara Department of Transportation Planning and Rail System, 1992a). However, two stations in the Ankaray line, Anadolu (formerly known as Tandoğan) and AŞTİ Station (Ankara Intercity Bus Terminal), give us an interesting perspective on the peak hour demand on the design process. Before explaining any detail, it is essential to note that both Anadolu and AŞTİ stations were designed in 1989, so it will be an erroneous act to evaluate stations according to the TS standards or criticize the Turkish standards from these station designs where these projections have failed. Nevertheless, these stations are designed according to peak hour passenger load in the morning commute, a critical perspective on the design method needs to be developed.

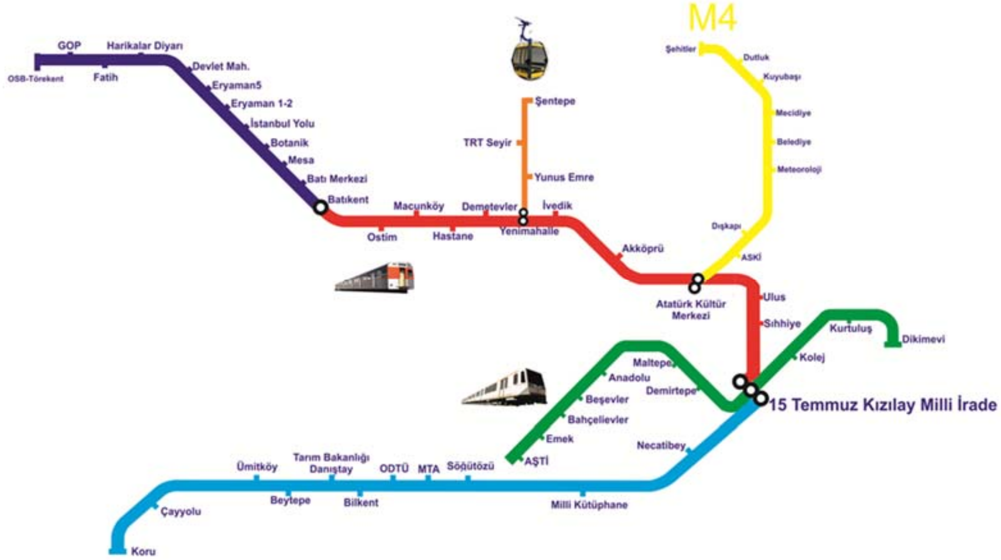


Figure 98 - Ankara Subway map showing the existing and projected lines. Green line; Ankaray, Red line M1 Kızılay-Batıkent Subway line, Light Blue Line; M2 Kızılay-Koru Subway Line,Dark Blue line; M3 Natıkent-Törekent Line and Yellow Line; M4 AKM-Şehitler Subway line (Ankara Metrosu, 2019)

Anadolu (Tandoğan) station, located in one of the city's major squares, stays as a vital transportation node. Anadolu station is a basic rectangular building consist of two floors; platform and concourse levels. While the concourse level is above the ground, the whole platform level is located under Anıt street (Figure 99 and Figure 100). Besides, the station is next to Anıtkabir (Atatürk's mausoleum), which is the resting place of Mustafa Kemal Atatürk. Especially on national days, Turkish people visit the mausoleum and pay their respects to the nation's father both in state ceremonies and informal visits. According to Anıtkabir Command, 6.5 million people visited the mausoleum in 2019 (Anıtkabir Komutanlığı, 2020), and only in November 2019, 1.5 million people visited Anıtkabir. Given the fact that some of the visitors would use the Anadolu station to access the mausoleum, a considerable passenger load on a "typical" station can be seen.

Figure 99 – Anadolu (Tandoğan) station passenger entrance (BurakOtto, 2016b).

Besides, Anadolu square is the designated area for political meetings, demonstrations, and similar activities. However, the station is designed according to the morning commute load, and it will hardly deal with any fraction of the passenger load generated by visitors to the square or Anıtkabir. As a result, on meeting or national days, which use Anadolu square or Anıtkabir as a gathering area, the Ankaray system bypasses the existing station to prevent any accidents related to the high volumes of passengers; i.e., the trains do not stop at this station to avoid stampedes. Anıtkabir was opened in 1953, and from that day onwards has been the meeting point of the national days in the Turkish Republic. After the state ceremonies, it is always opened to the public so that ordinary citizens can also pay their respects to the founding father of the Turkish Republic. Nevertheless, designers of the Anadolu station developed an inefficient station design because they could not relate the station to its urban context and anticipate any user demand besides the morning commute.

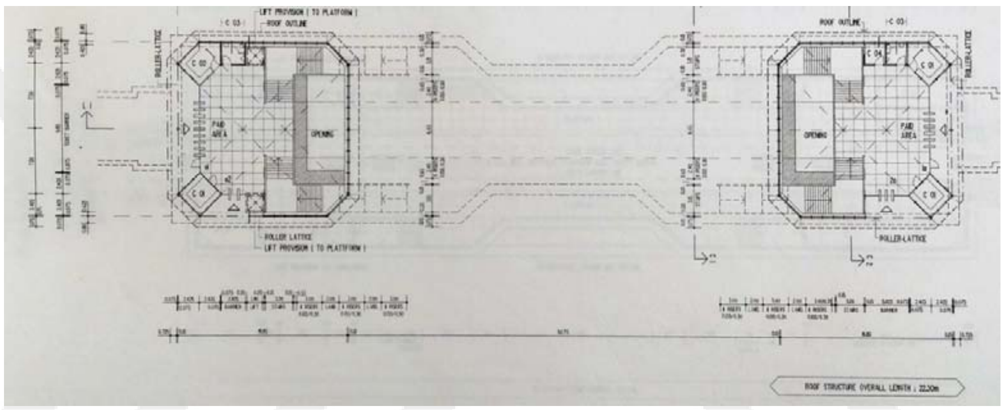


Figure 100 - Anadolu(Tandoğan) Station concourse plan (EGO Ankara Department of Transportation Planning and Rail System, 1992b)

AŞTİ station, which is located on the same line as the Anadolu (Tandoğan) station, has parallel problems. AŞTİ station is the light rail service station to the Ankara intercity bus terminal (AŞTİ), enabling railway connections to different parts of the city. Similarly, the station is designed according to the peak hour passenger load, and its layout is designed according to that (Figure 101). However, when looking at the station surges and the user profiles, a few design issues should be taken into consideration. Firstly, much higher passenger volumes using the station to go to the bus terminal can be seen during the holidays and important days. Unfortunately, the stations are designed according to the morning peak hour commute. Besides, users of similar stations could cover more areas compared to other commuters because there is a high chance that they might be carrying a piece of luggage or something similar, which requires more space and more mechanical vertical circulation elements to provide ease of access and smoother flow. A similar study conducted by

Network Rail (*Network Rail – Station Capacity Guidance*, 2014)shows us that different pedestrian types occupy different areas depending on their social context or belongings. For instance, while a typical adult with a shoulder bag could occupy $0.3m^{2,}$ an adult with a medium or a small suitcase could occupy $0.8\ m^2$, and an adult with a pushcart could occupy up to $1.2m^2$. However, almost every design guideline, which focuses on the sole technical approaches mentioned in the literature review, shows us that the designers accept a uniform pedestrian ellipse. Therefore, on an event like a holiday rush where people are going to use the station for the intercity travel options would have a problematic experience because of the allocated space and vertical circulation elements are designed for morning commuters (Figure 102). Moreover, it is also imperative to keep in mind that even though these stations are designed before the national standards were issued, their urban context and various user profiles were already in place as a design indicator. As a result, even before adopting any design guideline and calculation method to analyze the design minimums of a station, one must question the peak-hour-morning passenger load extensively within its urban context.

Figure 101 - Ankaray AŞTİ station platform level (author)

Figure 102 - AŞTİ Station- Ankara Bus Terminal Connection (BurakOtto, 2016a)

4.4 Space Requirements during Pandemics: COVID-19

In 2020, the pandemic has changed our understanding of the world as we know it. Serious precautions have been implemented to prevent the spread of the disease from mandatory face masks to complete lockdowns of countries as the scientists discovered that airborne respiratory droplets and contact routes transmit the virus. Also, the World Health Organization (WHO) issued a series of suggestions to decrease the spread (2020a). Thus, these suggestions, such as facial masks, physical distancing, and regular cleaning of hands, surfaces, and spaces, became new habits of daily life for a considerable part of society. Combined with the high number of passengers traveling at the subway networks, the closed spaces of the subway stations are deemed as potentially dangerous (UITP, 2020). So, as a safety measure, physical distancing, which suggests keeping one meter from each other, indoors ran out of space.

Although physical distancing in public spaces is recommended, the existing limited spaces in subway stations cannot provide the required personal space per user.

Depending on the personal space suggestion per person, the required minimum area is multiplied from three to nine times of that which is currently provided, thus underlining the dramatic change in space requirements and dimensions. As seen in the standard, while the Turkish standards (TS 12127 and TS 12186) allocate 0.5 m^2 per person and London Underground design guidelines (Transport for London, 2012) suggest 0.96m^2 per person. However, if we accept the pedestrian ellipse as the design indicator for both of the documentations and create similar pedestrian ellipses with one meter added between two pedestrians, one can see a significant change in space requirements. It is important to note that for the dimensions for the Turkish pedestrian, an ellipse is created based on the value given in the Turkish standards (TS 12127 and TS 12186) with the same shoulder width and body depth ratio of Fruin's Pedestrian Ellipse (Fruin, 1971).

Table 17 - Comparison of different pedestrian spaces and their change with physical distancing during Pandemics (author)

	Width per person(m)		Depth per person (m)		Area per person(m^2)		The ratio of Pandemic to Current
	Standard	Pandemic	Standard	Pandemic	Standard	Pandemic	
Pedestrian Ellipse ((Fruin, 1971; National Academies of Sciences Engineering and Medicine, 2013c))	0.45	1.45	0.61	1.61	0.27	2.33	8.63
UK (LUL)	0.95	1.95	1.29	2.29	1.23	4.47	3.63
Turkey (TS 12127)	0.69	1.69	0.93	1.93	0.64	3.26	5.09

In addition, to prevent any physical contact-based infections, different solutions are suggested to create a touch-free experience of the space such as contactless ticket payments fare collection systems and even body temperature controls (Meyer and Barone, 2020; Scott, 2020).

At the Station Planning Standards and Guidelines (Transport for London, 2012), one can see that there is a ticket issuing arrangement suggestions. These arrangements are based on peak hour load divided by the capacity of the service elements, similar to the platform area calculation methods. The calculation method suggests that transaction times for ticket issuing windows (TIW) is 60 seconds and 45 seconds for passenger operated machines (POM). However, with the current pandemic, subway operators closed the majority of the TIWs and encouraged people to use POMs and smartphone applications for transportation fare collection. Therefore, in parallel with the changed number of passengers using the subway, there is also a shift at the standard collection types and required spaces.

In addition, we see that cities such as İzmir (Eshot Genel Müdürlüğü, 2020), New York (Weaver, 2019), London (Morris, 2020), Toronto (Mok, 2020), and Warsaw(Pempel, 2020), started to place vending machines to distribute face masks and gloves. Similar to TIWs and POMs, these vending machines have missing information related to the required spaces, average purchasing time, and suggested run-off and queueing areas. Similarly, we also have the same concerns with the disinfectant dispenser placed around the station. Yet, we have to adapt to prevent the further spread of the disease.

Another essential safety precaution during the pandemic is the temperature control of the pedestrians. Before entering a closed space, the body temperature of pedestrians is suggested to be taken with temporal thermometers or thermal scanners. The procedure with the temporal thermometers requires that every individual should stand in front of the staff and get their temperature taken. Similar to TIMs and POMs, the whole procedure would take some time, and this approach could be an efficient solution in low-density stations. However, if we think about the whole procedure repeated many times, stations with higher densities thermal cameras and imaging systems give the impression to be the appropriate solution. Not only can they check multiple people simultaneously, but also pedestrians do not have to stop in the procedure, which creates a constant flow of pedestrians in subway stations.

Furthermore, at the existing stations, every architectural component shaped by the constant flow of pedestrians will equally get affected by the distancing concerns such as the corridors, staircases, escalators, and concourses. Especially with the distancing rules, one can clearly see that the accepted capacity calculations will change. For example, the suggested capacity for the escalators varies between 6000 to 7200 people per hour, and this calculation assumes that every step of the escalator is occupied by two users (TSE, 1997a, 1997b; Transport for London, 2012; National Fire Protection Association., 2017b). Even before the COVID-19 pandemic, the constant flow of pedestrians appeared a questionable topic, and with the new safety precautions, one can see a significant change in capacities. Moreover, elevators with capacities around 13-20 people-per-trip had to reduce them to 3 or 4 people per trip depending on the distancing rules. As one can see that these reductions cause considerable capacity drops. However, it is also important to note that UIC 140 Accessibility to stations in Europe (UIC, 2008) defines a wide range in depicting people with reduced mobility such as disabled people, pregnant women, parents with toddlers, or baby strollers, and older adults over the age of 65. Thus, as a security measure, a considerable part of that definition is advised to stay at home. As a result, despite the reduced capacities of circulation systems, one can also see that the demand has dropped on these systems.

In addition, natural ventilation also becomes a major concern because fresh air is as important as physical distancing. Occupying naturally ventilated spaces is encouraged and prescribed for physical activities. Especially many studies show that regardless of the building type, insufficient ventilation increases the risk of disease transmission (Atkinson *et al.*, 2009; Wen *et al.*, 2020). Hence, subway design guidelines and standards need to include criteria for natural ventilation in the stations, instead of mechanical ventilation, to provide enough fresh air for the health and wellbeing of the passengers.

The current COVID-19 pandemic risks and restrictions have raised further questions regarding the design of subway systems and stations and the related standards and guidelines. As mentioned earlier, even before the pandemic, transportation authorities were trying to develop systems such as gateless fare collections for more accessible stations. Unless these systems are adopted, the capacity problems based on the constant flow of pedestrians will continue to generate similar problems causing stampedes, the spread of infections, and even loss of lives.

4.5 Chapter Conclusion

Transit buildings require high levels of collaboration due to their complicated nature; the functionally of the building plays a dominant role in the design process while designing for emergency and evacuation situations is equally important. Therefore, designers have to deal with a vast amount of information and regulations shaping their spaces and dictating the design minimums. This situation has also caused the problem where subway stations are claimed as engineering buildings, and its architectural design is limited. This approach shifted the design of the stations towards a more mechanical approach where every element of the station is regarded as components with constant capacities. Regrettably, local counterparts of these technical guidelines are either missing or outdated, and the current situation suggests an amalgamated solution where international documents support the missing data. Combined with this situation, only technical design approaches to subway station design is just a composition of international and national guidelines borrowing solutions from around the globe. Besides, this amount of complication does not guarantee a "working" station from pedestrian movement or egress capacity. Unless the current state is challenged, cities will generate multiple copies of the same architectural *faux pax* just because they are cost and time-efficient. However, previous examples and unfortunate events show that even if the stations are designed according to standards and guidelines, they can be stressful environments and cause tragic accidents.

Moreover, with the current COVID pandemic, users and operators are experiencing challenging situations where the existing stations are put to the test with virus infection and new types of mobilities. Yet it is equally important to note that all stations are designed according to technical design guidelines and standards, and except the definitive stations, prescriptive methods have shaped the underground spaces. As a result, while looking at the technical documents and guidelines to establish a subway station design, one must understand that these documents are aides to establish the design minimums, and without accepting this fact, designers would end up as prisoners of the limited boundaries of engineering design.

CHAPTER 5

CURRENT APPROACH TO DESIGNING SUBWAY STATIONS

Designing a subway station is a complicated process due to its complex technical nature, where architects have to develop their design while dealing with demanding engineering concerns. However, by looking at different station designs throughout the world, except for some unique examples, we can trace standardized station designs located on various subway lines. As a result, this chapter will present the attempt to develop alternative approaches to subway station design and offer some guiding principles for these alternatives.

In order to develop a deeper understanding of subway stations, this research presents different understandings of “space” to designers so that stations are seen as more than a part of an infrastructural project. As mentioned in the previous chapters, design guidelines, and standards related to the subway station suggest space organization, material choices, lighting preferences, and capacity calculation methods. However, when looking at other design concerns such as designing for crowds, developing a connection between the station and its periphery, and providing alternative transportation methods before or after using the station, it is hard to find valuable information in these documents. This situation could be because of the mechanistic understanding of the subway station and its demanding engineering concerns. However, as we have seen from different examples throughout the world, it is possible to create a functional subway station and develop the existing space by going beyond the ordinary and monotonous concrete pumps that circulate people around the city.

Therefore, instead of suggesting parametric solutions to shape the space, this chapter will try to develop alternative approaches to enhance the station design because one can clearly see that designing solely with prescriptive methods and applying the same design at different places turned into a major problem. As mentioned before, even in the superstructures, modernism had once generated this problem where the typical design process was to solve the pedestrian circulation, apply a façade, and solve the technical problems along with the budget limitations (Lang, 1994). On the other hands, in the subway station setting, designers did not have to deal with any façade, and it is possible to claim that with the functionality and financial issues, subway stations had been products of mass production and repetition. Along with repetition and uniformity, they required directions and guidance for users to ease access, which turned them into non-places.

As a result, in order to prevent what the rest of this research criticized, this chapter will not develop any prescription to specific cases but show guidance to the designers to develop their criticism to enhance any space outlined by design guidelines and standards. However, it is equally important to remember that designers are also responsible for creating a safe environment, and we cannot ignore the importance of the safety guidelines and standards while defining and creating different spaces either under or above the ground.

Consequently, first, this chapter will discuss the station as space from different perspectives. By doing so, the designer can understand that the first step to designing a subway station or any other building is to understand the space being created and its influence on its periphery. Then, readers will be presented with design issues to improve their design so that subway stations can be more than a prefabricated concrete box with customized entrances. Afterward, a discussion formed around the integration of different transportation modes combined with the latest events in the world will be presented to show the readers the possibilities of the subway stations in the future. In the next chapter, an alternative design process for the subway station is presented to show where designers could implement the issues and suggestions mentioned in the process to enhance the station design.

5.1 Concepts of space, place, and non-place

Due to its infrastructural setting, subway stations are considered as engineering structures. In this respect, we also see a cornucopia of technical documents dictating the metrics of the design reviewed in the previous chapters. However, except for common suggestions related to the materials or lighting design, these guidelines do not assure the design of the station. Although there are some design suggestions regarding design in these documents, they can hardly go beyond material suggestion or design approach in broader meanings. Therefore, designers must question their approach when they accept the technical documents as the only solution to the existing problems. Even by looking at different station designs throughout the world, one can see that unless the designers question the notion of the station, we can hardly see any design challenge. Unfortunately, most designers have used only these documents to find out their design concerns and shape the form with the help of a systematic approach.

As the development of underground systems in cities continues, as Gamayunova and Gumerova (2016) mention, providing new underground spaces poses new challenges from various aspects such as urban, technical, social, and economical. Along with the financial and operational concerns, a subway station has to respond to various standards mentioned in the previous chapters due to its functional nature. Along with this approach, pedestrian-related spaces are organized as transitory spaces and placed in a simplistic fashion. Yet, one can see that some of the subway stations mentioned before have turned into tourist destinations in addition to being transitory spaces. In addition, with its technical spaces to empower the systems, one can see the pragmatist design schemes where spaces are arranged according to their attributes within a mechanical approach. This approach resembles placing food stands, portable toilets, or vending machines where prefabricated components and elements are used to provide services to its users for a limited amount of time.

Consequently, stations designed according to this mentality are perceived as connection dots along a line both from the urban and pedestrian viewpoint.

Nevertheless, when looking at contemporary subway stations examples, one can see that they are a sophisticated system that combines different scales of design and integrates various systems to the stations. As a result, questioning the space could bring an alternative perspective on the subject.

Overlooking subway stations as part of an infrastructural project has developed the current condition where stations are considered ports for pedestrians to board and alight from trains. In order to develop a coherent design approach, however, we should question the monumental scale of the project besides the functionality and feasibility concerns. Thus, we must consider stations as superstructures ignoring their geographical context, whether they are under or above the ground structures. It is imperative to accept infrastructure projects as essential to the vitality and the experience of contemporary metropolises as well as the town hall or the city square.

However, designers forget to ask a simple question; how these buried dots become such substantial landmarks? They are signified with simple signs on poles, yet our cities and daily life are shaped according to this signage. From fundamental transportation decisions to retail advertisements, stations progressively shape their periphery. Notably, when users see a subway station sign, they have an idea about the user experience they will have even before entering the station. Even without the experience of the specific station, users will have a distinct awareness about the possible experience about the interior design of the station also. This experience could be considered as an advantageous situation from the ease of movement perspective. First, they will enter into an uncontrolled area, and after passing through a fare collection system, they enter the controlled areas. Then, along with different vertical and horizontal circulation elements, passengers reach the train from a platform area (Figure 103). However, in various subway lines, some of the stations are a repetition of the same building in different locations. It could be related to various design decisions such as optimized project delivery methods, similar passenger loads, or construction methods. Though it is also one of the reasons, transportation-related buildings are associated with the concept of non-place.

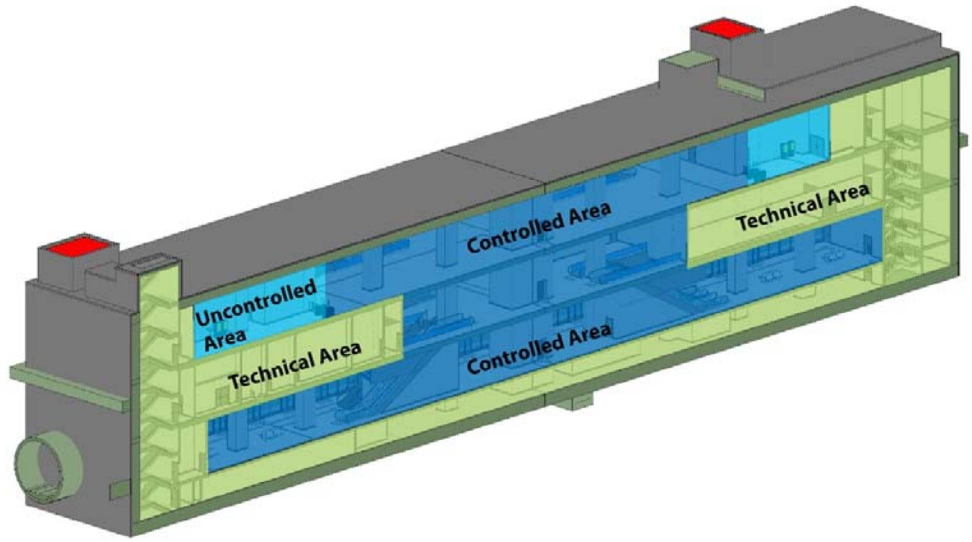


Figure 103 - A subway station with its spaces divided into functional zones (author)

In this respect, the concept of non-place could be defined as places where people separate their identity while creating mass groups in places such as stations, airports, and shopping malls (Augé, 2006). Given the notion of travel itself is an experience on the urban scale, travelers' space is considered a non-place. Augé (2006) also fortifies his views by claiming that non-places have "instructions for use," which can be seen in transportation-related structures regardless of their scale. As he underlines, users are always directed with color-coded signage systems to achieve ease of access and prevent any confusion from navigating in a fast-moving environment. Conversely, defining transit-related buildings as non-places in an escapist attitude just reinforces the prescriptive approach to the subway station and the related archetypical design understanding.

Transportation buildings are essential artifacts in cities where the meaning of the buildings have gone beyond their function. Especially, inter-city train stations, airports, and cruise passenger terminals have created an exterior image as monumental gateways and source of inspiration to its users both in artistic and technical perspectives. As mentioned before, in the history of art and architecture, one can see that the notions of transportation, transportation buildings, and vehicles had been essential sources of inspiration in artistic creation. Various art movements and periods have designed transportation-related buildings from their perspective and suggested alternatives for such inspirational buildings. Furthermore, with their speed, efficiency, and accessibility, stations have turned into essential pointers of daily activities and interactions. Besides, a considerable part of these buildings is named after influential people to commemorate their contributions to society.

On the other hand, in the everydayness of subway stations, they have turned into places of interest in the area so that people can navigate under the ground. In this context, subway stations have turned into a sophisticated urban entity that corresponds to Lynch's elements path, edge, district, node, and landmark in Image of the City (Figure 104) (Lynch, 1984).

Figure 104 - From left to the right path, edge, district, nodes, and landmark according to Lynch (1984)

Through the pedestrian movement, one can see several paths that occur inside the station naturally and create a complex network of paths and nodes. However, one should not forget that in paths, "people observe the city while moving through it and along these paths the other environmental elements are arranged and related" (Lynch, 1960, p. 47). Naturally, in a single subway station, this is a challenging experience to achieve. On the other hand, when looking at the experience of travel, one can see that the stations are also paths in the experience of the city. On the other hand, they also act as edges in different dimensions where they work as the borders or boundaries in different dimensions, both virtually and as reality, such as ground versus underground. Remarkably, subway stations are already acting as nodes on different scales, with their transportation capabilities on different layers of the city. Interestingly, as the stations are named according to their location, starting from the conceptual design phase, they become a crucial and vital part of the locality with their functions. Lastly and most importantly, they act as landmarks.

According to Lynch (1960), landmarks are external, and they could be a building, sign, store, or mountain. Some of them could be distant, and others could be seen from different points. They could be the dome of a building or a local and visible sign on the street level. Most importantly, “They have frequently used clues of identity and even of structure and seem to be increasingly relied upon as a journey becomes more and more familiar.”(Lynch, 1960, p. 48). Along with its nonexistent exterior image, except simple signposts on the street level, not only do they become vital signs for the people around but also as an important transportation location.

5.2 Design approach to underground spaces

Uniform design approaches in subway stations support the concept of non-place from various viewpoints. First of all, starting with the Milano Metro, unified design in subway stations enhanced user experience remarkably inside the underground station. Pedestrians were guided by colors, fonts, and directions placed at the same places of the stations so that when they entered a station, they already had an idea of where to look for information. Especially when the physical context of the subway stations is considered, this approach is a critical design approach to nonfamiliar users of the system where they can navigate in the underground. However, the repetitiveness and the guidance systems for its use also brings in a problem where familiar users start to perceive the stations as non-places.

Secondly, even though subway stations are a part of daily activity, they are not the destination itself, except for the people working at the station. Naturally, people use stations to go to their destinations, which makes the station transitional locations. What is more, with the current prescriptive station design approach, stations will be perceived as non-places for a while unless a design team challenges it. On the other hand, when looked at various examples mentioned in the previous chapters, various stations had become destinations for different activities. Moreover, by looking at transportation possibilities of subway stations and real estate advertisements, one can see that they are not simple transitional spaces but more of a reference point or even a landmark from Lynch's (1960) perspective. Therefore, it might be an erroneous act to claim subway stations as non-place but a different kind of space.

In this respect, Rasmussen's (1964) approach to the experience of architecture starts with highlighting an apparent subject. According to him, when users have a distinct idea of the space beforehand, it becomes more comfortable to perceive things, and with the repetition, we start to ignore the rest. Interestingly we convert the observed into something familiar and coherent. This perception is also related to the exterior image or the structure of the buildings where users trace familiarities from former experiences. However, in the subway station context, where the whole structure consists of underground structures, the perception of the space relies on the cavity rather than the structure. Even though Rasmussen developed his approach to superstructures, in subway stations context, we can quickly develop a similar approach for subway stations where cavities form the station so that users can perceive the structural pattern of the underground structures.

Likewise, Carmody and Sterling (1984) suggest similar approaches while designing underground structures. According to them, one of the most challenging design concerns in underground structures is related to the absence of natural light and ventilation inside the station in addition to its lack of an exterior image to its users. Even though this situation generates a negative psychological effect on its users, it is also the core of the design approach where designers confront the problems of the demanding situation. As a result, we see some intriguing examples where designers found different solutions or completely ignore the situation for financial and project management concerns. For example, at Moscow Metro or Washington DC metro lines or the Bolhao Station in Porto, the main design concerns were different from illuminating the spaces with daylight. Yet their designers brought forth different alternatives to shape urban underground spaces. On the other hand, at Canary Wharf station, Toronto-York Spadina Subway stations, and Grand Paris Express stations, one can see that designers integrated daylight as a very crucial part of the design.

Another alternative approach could be related to the space-syntax theory to develop an alternative understanding of the subway station design. Hillier (2015) shaped his approach, starting from an anthropological view by using Lévi-Strauss's idea of space before he developed the criticism of his idea. As Lévi-Strauss (2009) suggests a fundamental distinction in the analysis of social structure, which is either mechanical or statistical, in mechanical models, the elements of the model are on the same scale as the phenomena, while in statistical models the elements are on a different scale. However, Hillier criticizes Strauss's approach when he tries to formulate the problem of space and emphasizes that space is more like Lévi-Strauss' statistical model instead of his own mechanical model. This approach is also important to perceive the underground space generated in a design process. Because similar to Hillier's approach to understanding the sophisticated interiors from the space syntax perspective, we must review our perspective on the station design.

It is possible to find different perceptions of subway stations, and it is a mistake to consider them only as structures within an infrastructural project. As we can see in the case in the Istanbul Yenikapı transportation hub design competition (Yazman, 2011a, 2012; Kaptan, 2012), where the jury's primary concern was not the design of specific spaces because they were considered as non-places. Thus these spaces are deemed unnecessary to develop them. However, subway stations have turned into vital components of our cities with their fast and reliable connection capabilities. Along with their multi-layered structure, they provide movement around them in a fast and efficient way, and the spaces they have created have turned into urban and public spaces under the city, instead of being non-places as defined by the technical guidelines.

Consequently, to develop an additional understanding of the concept of space from the infrastructural perspective, Allen's seven propositions on infrastructure and urbanism (1997) is an intriguing suggestion to analyze. Firstly, Allen suggests that infrastructure shapes the site rather than adapting to its site. Given the possible vertical organization of the stations, designers could generate “the networks for movement, communication, and exchange” (Allen, 1997, p. 54) by creating various surfaces not only for the current operations but also for the future activities and movements. Since stations are designed in accordance with peak hour projections of thirty-forty years, even though they are not mentioned in standards and design guidelines, designers are expected to suggest solutions for future expansions.

Interestingly, this anticipation from the designers also corresponds to Allen’s second proposition, where infrastructures are seen as flexible and anticipatory. It is possible to see this anticipatory action on the operation and management aspects. However, due to its geographical situation, it is a technical challenge to make modifications in an underground space. Besides, foreseeing the design of an infrastructural project is also a challenge because of its programmed projection for the future use of the space. Consequently, it is possible to see conventional or prescribed design solutions instead of the intended designs, such as the Yenikapı Transfer Hub project.

One can also see the suggested collaboration in infrastructural designs from Allen’s point of view on his third and fourth propositions. While maintaining the regularity in its own contexts, projects require substantial work participation among different collaborators, which could also be related to the functionality of the projects. As well as its practical nature, it is possible to see various creative attempts to achieve an integrated solution that make the system operational.

However, in most of the subway station projects, every discipline draws its boundaries and only focuses on them, including the architectural design of the stations. Nevertheless, even in this design process, designers have to overcome *“complex systems of flow, movement, and exchange.”* Systems such as walkways, escalators, gates, turnstiles, ticket issuing machines, locks, valves, and fire safety precautions are designed according to capacities. One of the most critical part in this approach omits the fact that these capacities are very crucial to determine the design minimums both for the technical and overall designs. Hence it is possible to say that these prescriptive methods also cause the problematic linear designs of the stations. However, by looking at the exemplary design cases in the world, we can see that their designers always questioned the notion of a station and found surprising design solutions.

Subway stations create the much-needed transportation space under the ground with the help of cavern-like structures. It is related to facts of the linear nature of infrastructure and security concerns for possible pedestrian crossings. Taking into the consideration of dense urban patterns on the surface, the practical character of the infrastructures generates new spaces or *artificial ecologies* on different levels of the cities. Depending on the elevation, we encounter lifted or buried structures from the ground connected with a fast and reliable network dedicated to public transportation with their inner intricate movement patterns.

As Allen mentions in his seventh proposition, along the long lines of the subway lines, one can trace the repetitive elements and structures, which could be related to project management, economic and operational concerns. Yet it could also be related to the nature of engineering, where almost every component of the project is designed according to the stringent standards and technical guidelines. Correspondingly, a similar design approach can be traced in the architectural design of spaces in subway lines, which is one of the problems highlighted in the study. Therefore, in the design process of the station, designers have developed a balanced design approach between the technical nature of the building coming from its infrastructure part and architectural design from their design concerns.

As a result, by looking at different and remarkable examples showing the possibilities of an underground space design while providing technical design concerns, we can claim that subway stations turned into more than stopping places for vehicles, even only with their existence. Therefore, while creating this underground space, designers should take into consideration that they are creating new urban spaces and should not redact the design and its process to the space generated by technical standards and guidelines. Conversely, a different understanding needs to be developed for the passenger areas.

5.3 Scales of the Subway Stations

Subway stations are multifaceted urban entities with their complex systems requiring coordination among different disciplines. Just as they are a part of a bigger infrastructural project providing the required connections, they are also important structures for their vicinity. In order to develop a systematic approach and organize the suggestions, this research suggests scales in the subway station context. Accordingly, three scales are adopted to develop a systematic approach to underline the design issues in subway stations and develop design guidelines. These scales are human scale, station scale, and urban scale.

As one can understand from the name of the first scale, the human scale will focus on the design from the users' perspective and highlight concerns. At this scale, issues and suggestions will try to develop alternative approaches instead of parametric approaches. The main focus of the human scale issues and suggestions will be to understand the dynamics of the pedestrians and then the crowd. However, suggestions based on the human scales will not try to develop a universal design or set of rules. On the contrary, these issues and suggestions advise using the metrics of design guidelines and standards then develop their design beyond the suggested schemes.

Secondly, the station scale focuses on the design of the station and organization of the spaces inside the station. This scale shows us that instead of designing a repetitive part of an infrastructure, stations should be designed as superstructures. Despite being underground, stations stand out as important buildings with their high number of users along with its engineering complexity.

Lastly, the design of the stations should be perceived from the urban scale. Even though the physical structure of a subway station is limited by its construction area, its effective ranges are extraordinary. Along with the existence of the subway stations, one can see the dramatic change in their neighborhoods. It is possible to trace the tangible changes with different activities are shaped according to the existence of the station, such as new commercial additions around the stations. Moreover, one can also see similar changes in the travel activities of pedestrians to the station and around the station. Therefore, urban scale stands out as an important scale to trace the importance of a subway station along with its connections to its urban setting.

5.4 Design Issues in Subway Stations

It is imperative to list various design issues to develop a more comprehensive understanding of the design of subway stations. By looking at the pioneering examples from the previous chapters, one can trace that even fundamental architectural design issues such as; integrating the subway station into the urban fabric, placing the subway station within its urban periphery, organizing spaces underground, pedestrian flow and crowding, use of daylight and our most recent concern travel safety during pandemics. This section will highlight these design issues to develop an alternative design guideline.

5.4.1 Pedestrian flow and crowding issues

It is possible to find interesting studies conducted in vehicles focused on space invasion and crowding (Evans and Wener, 2007; Haywood, Koning and Monchambert, 2017). Especially when inside the vehicles, it is possible to see unpleasant reactions to each other due to overcrowding. Crowding is one of the experienced problems both in transit-related buildings and their servicing vehicles. In order to prevent any problems related to the issue, designers are guided by various standards and technical design guidelines mentioned before. In this respect, Evans and Wener (2007, p. 92) suggest that "personal space is a boundary control mechanism to optimize the degree of social interaction” and emphasize that intrusion of personal space might be the key in the experience of overcrowding. With this invasion of personal space, pedestrians tend to experience the space as more unpleasant, disturbing, cluttered, and chaotic in vehicles (Jiang *et al.*, 2009).

Similarly, the same space invasion has the possibility of creating similar experiences in stations where pedestrians have to share an allocated space with the rest of the users. Along with this invasion of the personal space, it is possible to see some attributes to the stations such as smelly, crowded, noisy, unpleasant, and stressful. Nevertheless, from the architectural perspective, space definitions of the subway stations are determined by technical guidelines mentioned before, which do not take care of the overcrowding or pandemic related distancing problems. Interestingly, the crowd itself is the first factor that helps the designers to determine the basic minimums and shape the space even from the early stages of the design (Tirachini, Hensher and Rose, 2013). However, the crowd and its effect are reduced to numeric data where designers only determine bare design minimums such as platform width, staircase width, number of escalators, turnstiles, and ticket issuing machines.

It is the designers’ responsibility to establish an alternative or a solution to overcome such a challenge and break the monotonous, repetitive station perception. Even with its infrastructural setting, designers can enhance the spaces by integrating fundamental architectural design concerns such as daylight, natural ventilation, or ease of access and provide the design minimums stated by standards and design guidelines. However, it also does not mean that stations should be designed with excess spaces with ample amenities where people lose the sense of scale. Nevertheless, similar solutions and integrations could be traced at the case studies mentioned in the previous chapters where designers question and improve the basic understanding of the subway station. For example, station designs of Toronto TTC extension line, Grand Paris Express line stations, Canary Wharf station, and Bilbao subway stations, one can see that integration of spaces also simplified the pedestrian movements. As seen in the longitudinal section of the Canary Wharf station (Figure 105), the whole movement of the station had been organized above the platform level. Along with every entrance structure illuminating the underground space, pedestrians can easily access different levels of the station.

On the contrary, at the New York 2nd Avenue & 72nd Street Subway every design aspect was designed according to the expected crowd and relying on the constant flow of the pedestrians, like gas molecules in a science experiment, shifted the space away from the ideal because of the failing mechanical systems (Martinez, 2019). As mentioned before, pedestrians were trapped in elevators, or pedestrian jams started to occur because of broken-down escalators (Barone, 2019; Guse and Tracy, 2019). Therefore, instead of creating unnecessarily spacious places under the ground, designers could improve their approach just by organizing the crowd movement even at the conceptual design phase.

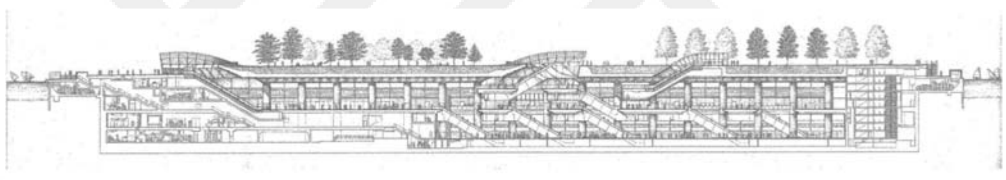


Figure 105- Longitudinal section of Canary Wharf station showing the linear organization of the pedestrian movement (Foster + Partners, 1999)

5.4.2 Space Organization Under the Ground

Due to its functional concerns, the movement inside the stations is a linear system where pedestrians transfer from one space to another. As the pedestrians move from one space to another, the station relies on its circulation elements predefined by the technical design guidelines. In a typical station context, from the surface to the vehicle a typical journey, passengers are expected to enter a concourse area divided by a fare collection system into controlled and uncontrolled areas. Afterward, either by connection tunnels or vertical circulation elements (stairs, ramps, escalators, and elevators), passengers are guided to platform areas where they can board to the trains. Depending on the station design and location, there is a possibility that people cannot see their final destinations. In order to overcome the situation, signs, directions, and even staff could help to way find to users.

While the movement of pedestrians could be traced in a framework, one can see different organizations of spaces at different station designs. One of the most iconic examples of this case is the Washington D.C. subway, where Weese and his team organized the whole stations inside a single spacious tunnel (Schrag, 2014) and gathered all activities inside. Similarly, Bilbao Subway developed a very similar design where almost every activity of the station was gathered inside a single tunnel. As Tengborg and Sturk (2016) underline, designers should be aware of the possibilities of the underground space that should be planned in an organized way, not in a prescriptive method. Therefore, it is essential to note that this research does not suggest a singular solution to the space organization. Instead, these design suggestions show us that practical design suggestions could be developed by questioning the existing design methodologies.

For instance, the current trend shows us that with the new internet technologies and ticketing systems, users and operators are experiencing slight changes (Hallenhe, 2020; Karjalainen, 2020; Long, 2020; Weinstein, 2020). People used to buy their tickets from ticket issuing windows and get validated by a ticket officer or a turnstile at the concourse area. Nevertheless, smart cards and even smartphones have started to be integrated into ticketing systems, and it is a high possibility that turnstiles, ticket machines, and ticket windows will become obsolete. Interestingly, even if a hypothetical station is designed today, the whole space organization is created following the technical design guidelines and standards, even though all of the technical documents will be updated according to new technologies in the lifecycle of the station.

Nevertheless, new technological developments do not require to be futuristic or hi-tech to change the perception of space. Even small modifications and additions to the current systems will make the push for significant changes in design considerations. As a result, it is the designers' responsibility to arrange and even question the space organization whenever possible. Unless the designers challenge the space, organization, and accept technical design guidelines are helpers to find the design minimums, station designs will end up as the predesigned engineering structures. Due to its functional and infrastructural context, it is possible to trace repetitive elements and even station designs along the subway line. Standardized elements are combined with the peak hour passenger load as a design parameter shaped according to the top of the rail and the surface levels.

5.4.3 Daylight Penetration into Underground Spaces

As Güneş (2007) mentions, the underground is associated with negative aspects such as misconduct, secrecy, the afterlife, and death. It is also possible to see various approaches suggest the integration of daylight to develop a design approach to overcome psychological, physiological, and energy efficiency problems (Carmody and Sterling, 1984, 1993; Sterling et al., 2012). As seen in different technical guidelines, the top of the rail and the platform level is defined by alignment, and structural designers and architects are expected to adapt to the technical design decisions. Correspondingly, cities with rich archeological backgrounds have a long history of unearthing precious findings giving information about the history of the city. Cities such as London (Smith, 2016), Rome (Povoledo, 2018), Athens (Chelminski, 2002), and İstanbul (Rose and Aydingün, 2007) have experienced similar endeavors while building subway lines.

Consequently, except for the deep underground stations, it is always possible to integrate daylight as a part of the design process. Notably, in the stations designed by Foster and Partners, one can see that the natural light had been integrated into the station design step by step. Firstly, the Bilbao subway station designs attempt to bring the daylight inside the station. While, Canary Wharf station, with its famous canopy, sets out as an exemplary design case where daylight turned into a crucial design concept. It is possible to take plenty of photographs of the station focusing on the daylight illuminating the underground station. Subsequently, York University station had similar design methods where daylight could be provided for the lower levels of the station.

Eduardo Souto de Moura provides another interesting design suggestion to provide daylight at the lower levels of the station at the Casa de Musica station. Along with its considerably big lightwells, the platform levels are illuminated with daylight changing the experience of an underground station (Figure 106). Besides, by inspecting the forthcoming design projects like the Grand Paris express line stations, we see that integration of natural light inside the station had been a part of the design regardless of the depth of the station. For example, at Pont de Bondy and Saint-Denis Pleyel Stations, one can trace that by integrating gallery spaces at the vertical circulation zones, designers had the chance to provide daylight almost at every level of the stations. Even by looking at these examples, daylight should be a part of the design when it is possible to overcome the difficulties of being underground.

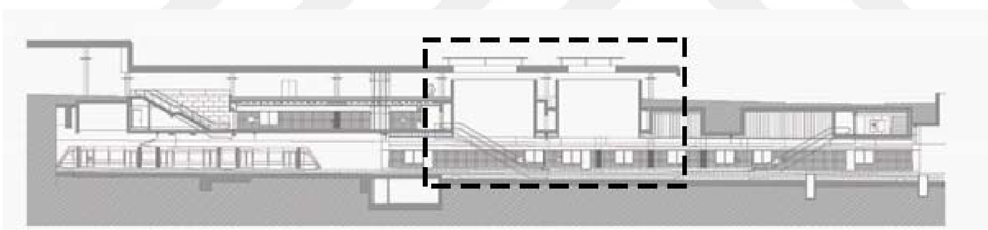


Figure 106 - Longitudinal section of Casa de Musica Station dashed rectangle bordering the lightwells (Souto Moura, 2011)

5.4.4 Integrating the subway station into the urban fabric

Griffin (2004) shows that, even though project areas of subway stations are limited with the construction areas, they are interconnected with their urban setting ranging up to 1.5 kilometers. Whether they are designed in a standardized method or not, stations intertwine with their urban settings acting as focal points, which signifies the importance of subway stations within their urban contexts. Even a station sign on top of pole shows that despite being under the ground, stations are noticeable entities in city life. As expressed in the Transport for London document, “a station supports the local area and the local area should support the station” (2019a, p. 57).

However, except for some groundbreaking design examples, one can hardly see any design suggestions on the urban context. Current prescriptive design suggestions for underground stations are mostly shaped around the idea of building the structure underground and restore the surface to its formal appearance. This approach has two strategic explanations. First, the station area is just below a considerable pedestrian or vehicle traffic zone, where the lanes and walkways are essential for operational traffic on the surface. Secondly, in the dense urban fabric, the only available area for the station is public property, and the surface needs to be given back to the public. Obviously, when stations are located under dense urban areas with massive loads of both pedestrian and vehicle traffic, one of the suggested design solutions could be the restoration of the former condition unless a solution is developed with urban and traffic planners. For example, AŞTİ station on Ankaray line is an example of a situation where designers have to provide secure connections in a dense urban setting. As seen from the site plan below in Figure 107, the station (1) is located next to a very dense existing roadway called Mevlana Boulevard and nearby the intercity bus terminal of Ankara. As a result, besides its function, the station also provides a secure underground connection to the bus terminal under Mevlana Boulevard.

Furthermore, the area above the station is designed as bus stations providing connections to alternative transportation lines. Combined with the fact that AŞTİ station is the terminal station in the Ankaray line, the whole area was expected to become an important transportation node. Also, a canopy covering the whole station area was built to provide protection to its users and signify the area (Figure 113).

Consequently, it is possible to claim that AŞTİ station has been designed to develop the existing situation. What is more, by reshaping the station area with additional functions, it is possible to claim that design concerns for that station were not only limited to the station but also with its surroundings.

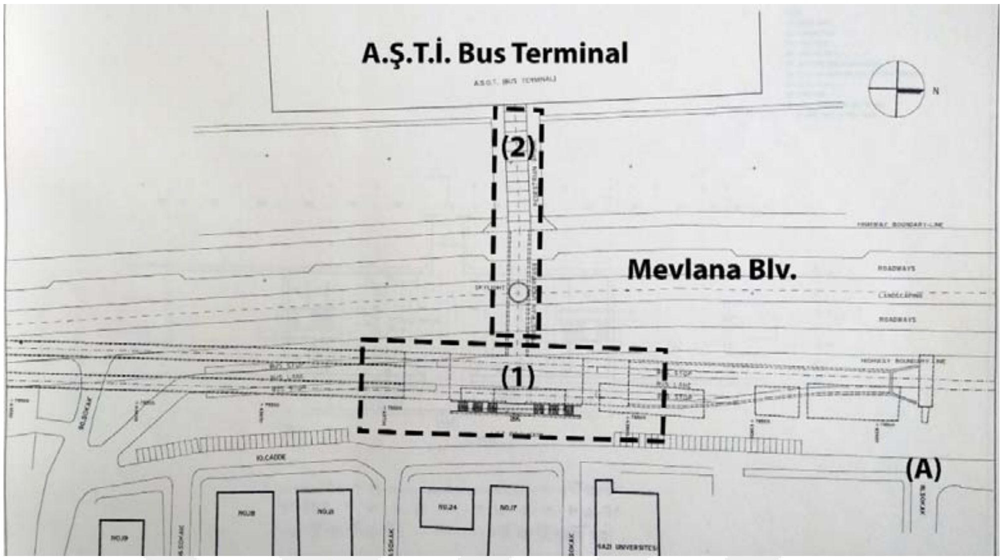


Figure 107 - Ankaray AŞTİ Station site plan, AŞTİ station (1) connects to AŞTİ Bus Terminal with the pedestrian underpass (2) (EGO Ankara Department of Transportation Planning and Rail System, 1992c)

Figure 108 - AŞTİ Station with its canopy form viewpoint (A) to station area (1) shown in Figure 108 (author)

5.4.5 Placing the subway station within its urban context

Interestingly, while the stations create interconnected underground spaces for their urban settings, the design of a station is limited in its construction area, and one can hardly see any design suggestions for the surface level. As mentioned above, the most common approach is to restore the previous situation. Nevertheless, contemporary suggestions highlight a very critical aspect of station designs.

In order to support this approach, it is also imperative to inspect a fundamental notion to understand the urban importance of the stations, their names. Stations are named after their urban settings because there is no other alternative to name it, unlike the train station and airports. However, the mass-produced spaces are only separated from each other with their names on station the signs.

Notably, on the surface levels, users experience a subway sign or a logo and a parapet wall circling the entrance, usually with a canopy on top unless the station is at-the-grade or elevated, only signifying the function of the building at the same repetitive nature of the infrastructure. However, with their insertion to the urban contexts, stations from their surroundings and create new urban forms. Therefore, the standardized design approach of the stations has the potential of ignoring its urban context while generating an optimized project.

While designing the underground map for the London subway, Beck's graphic design revolutionized the graphic communication. Regarding his design process, he says, "If you are going underground, why do you need to bother about geography? It is not so important. Connections are the thing" (Hadlaw, 2003, p. 32). Geography, from a functional design approach in a graphic communication interface, can be disregarded. Pedestrians use the station to get from one point to another in cities, and when they are underground by lacking any visual connection, the situation turns into isolation. In its two-dimensional environment, subway maps could be isolated from its geography to provide a functional and secure transportation experience. On the other hand, connecting different underground levels to the surface is alone a challenge. Yet, after connecting these levels, designers either choose to extend the reach of their stations or leave it as it is.

Underground stations, like superstructures, should be connected with their urban setting. Especially, contemporary designs such as the Toronto TTC extension line and Grand Paris Express line stations stand out as the leading examples where designers question the same problem. For example, Downsview Park Station stands with its unique roof and landscape design, where the whole station is a part of the park it was built. Similarly, with its terraced landscape design, the York University station stands out as a landmark at the whole university campus while providing daylight inside the station with its terraces. Comparable design suggestions can be seen at the Paris Grand Express line stations, where the design concerns for the urban pattern defined the station's characteristics.

Another alternative approach could be developed by looking at the London Station Design Idiom (Transport for London, 2019a). While freestanding stations are a challenge in dense cities, stations could be incorporated with the existing buildings. The design could suggest to renew a building and integrate a station to the structure while providing a superstructure on the ground level with various functions and facilities. Interestingly while building a station in dense urban patterns, instead of using public property to construct an underground station, designers could suggest an integrated station structure where a station is combined with a nearby building (Figure 109). Similar design suggestions can be seen in the underground cities of Montreal, Toronto, and Calgary (Hopkins, 1996; Singer and Burda, 2014), where stations are also a part of the urban patterns instead of connection dots shaped by engineering design. However, it is essential to note that Canadian cities have shaped another level of underground, acting as a surface level instead of the surface itself.

Figure 109 - London Subway entrance proposal from London Station Design Idiom showing a station design as a part of an existing or a new building with facades and signified entrances (Transport for London, 2019a).

On the other hand, the new design suggestions in Grand Paris Express support the idea that while positioning a station, the urban context and its connections play a vital role as a design input. In other words, subway stations have much potential to generate an urban space under the ground and reshape the surface level with its connection to the rest of the city. Along with this connectivity and multidimensionality, designers have the chance to enhance their station design.

5.4.6 Travel safety concerns during the pandemic

By looking at the current and the former pandemic, one can easily claim that some of the temporary precautions and habits are going to be a part of society for a long time. While virus concerns created a negative impact on the daily spaces such as offices, commercial areas, and public spaces (O'Sullivan, 2020b), even by looking at the countries at the transition phase, it is hard to find crowds even at sporting events, concerts or exhibitions. However, since transportation is a very crucial part of the cities, crowds started to occur in transit-related buildings combined with security measures such as distanced seating and thermal readings of the passengers.

As a result, one can see the slight change both in the passenger experience and the organization of the space. When we looked at the suggested precautions and safety measures, one quickly sees that our current experience is going to stay with us for a while hence the safety measures should be noted for the design process. Since, the probability of another pandemic in the foreseeable future exists, it is essential to trace how a subway station experience will change in such conditions. Most importantly, protective face masks turned into a mandatory safety precaution, and one of the methods to acquire these masks were to set up vending machines in stations distributing them. As for the second safety rule imposed, physical distancing will redefine the capacity of the spaces inside the stations. After complying with these conditions, pedestrians are able enter any space of the stations. Besides, the fare collection systems and security controls by the station staff have also changed radically. With a reduced number of ticket issuing windows and increased passenger operated payment solutions, the station experience has shifted into a touchless experience. This touchless experience also includes body temperature control systems. Either by thermal cameras or temporal thermometers, all passengers get checked to prevent the further spread of the disease. Moreover, after all these controls, pedestrians have to experience physical distancing in all circulation elements, stairs, corridors, elevators, escalators, and moving walkways. At the end of their journey, they reach to the platform area to board reduced capacity vehicles to go to their destinations.

In addition to the pedestrian experience, one can also see the change in different stations' different spaces. Firstly, the existing elements have converted into the new reality where vending machines provide face masks, hand sanitizers, and protective gloves instead of drinks and snacks (Figure 110). Yet, as designers, we have to question how it will affect the built environment and the necessary precautions for future events.

Figure 110 – New vending machines distributing face masks, hand sanitizers, and protective gloves (Eshot Genel Müdürlüğü, 2020)

CHAPTER 6

DESIGN CONCERNS FOR SUBWAY STATIONS

By looking at the design issues traced from different guidelines, standards, and examples, it is imperative to create design alternatives for subway stations for further uses. However, it is vital to keep in mind that these suggestions are based on the design issues mentioned in the previous section. As mentioned before, these design guidelines will not propose any universal design suggestion but underline critical design approaches that can enhance the design of the stations. So information on where to place the fire safety equipment or required minimum distances for fare collections systems will not be provided. However, alternative design approaches are presented starting from the first design idea of the station, designing an urban space in the underground, designing the surface, illumination and the use of daylight, organizing the space, multimodal transportation, and lastly, designing for disease controls.

6.1 Starting the design process

The suggested workflow for a challenging design from an architectural perspective could be based on a simple understanding of separating the engineering and architecture disciplines from each other. As mentioned before, in a subway station project, architects are expected to develop a functional circulation while providing the required safety and security precautions dictated by guidelines and standards. Different engineering and architectural design teams are established in collaboration to make the station functional and comfortable. Nevertheless, due to its geographical and operational context, technical room requirements are much bigger compared to superstructures. Therefore, the architectural design team has two options in the process: design a rectangular reinforced concrete box defined and optimized by guidelines or “draw a pervious border” between engineering and architectural concerns.

In the first situation, design teams mostly limit themselves to technical design guidelines and standards and create a universal design where every component of the station along the line, the city, and even in the country is the same. In the process, the most common concern is the fact that designers will only be limited by spaces where they are responsible to “beautify” or “put some ornaments” on different surfaces. However, it is very important to note that a detailed and well-studied design suggestion, even in this setting, could also create significant impacts on the design process of stations such as Milano, New York, and Toronto subways.

In the second approach, designers have the chance to confront the prescriptive methods and, while creating their own spaces, provide the much-needed technical support systems concurrently with the design. The most critical part of this approach is to draw the “pervious border” between the engineering and architecture teams. Given the complex nature of subway stations, the design team has to deal with more complicated design concerns to create an operational station. They have to enhance the existing stations while complying with every safety and operation standard and guideline. Even though this approach looks favorable for architectural design concerns, it also requires experienced and sophisticated approaches due to the concurrent designs of different systems.

6.2 Integrating Standardized Components

Infrastructure projects have many repetitive components are part of their network, and these repetitive components enable considerable advantages from project management and system operation perspectives. As Kishii (2016) highlights, the design of a station is not only limited to its project boundaries. However, generating the same concrete boxes and burying them along the subway line sounds problematic and has similarities to ready-to-assemble furniture but on an architectural scale. As mentioned before, Lang (1994) criticizes the modernist approach and its design process where designers develop circulation and technical problems along with a façade design yet ignoring to establish a creative connection between the human needs, environment, and their relation to each other. This human and environment relation could be developed by investigating every station location with its urban patterns and its users. For instance, a single subway line could provide transportation to transportation hubs, central business districts, various diverse residential areas, touristic destinations, universities, concert halls, and shopping malls.

Along with this variety, diverse geographies and communities would demand and require different design solutions. In order to break monotonous design approaches to the stations, a balanced approach is highly required between the technical design guidelines and the design ideas mentioned before. By doing so, designers can develop an alternative approach to the existing idea of a typical station.

Even by looking at the contemporary design suggestions in Paris and Toronto, one can see design teams started to develop a balanced approach between the technical, security, and architectural design concerns. In other words, while designers provide the design minimums and much-required security measures for a functional station, by combining the station with their urban fabrics, they go beyond the common understanding of a subway station. As one can see from these examples, stations provide extensive urban integration with their surroundings while creating a spatial organization shaped by technical guidelines and standards.

In other words, the current design approach could be explained as interlocking systems where a required space is created for engineers to provide the services and systems to make the building operational and the architectural interface designed as a superstructure rather than infrastructure. As seen in Figure 111, the suggested approach for the Grand Paris Express (Société du Grand Paris, 2014) is based on two parts; underground station operated by Paris Metro and the related project as a part of the station. This approach shows that the allocated space for the station could also have additional functions and activities not only for the pedestrians using the station but also for its urban setting.

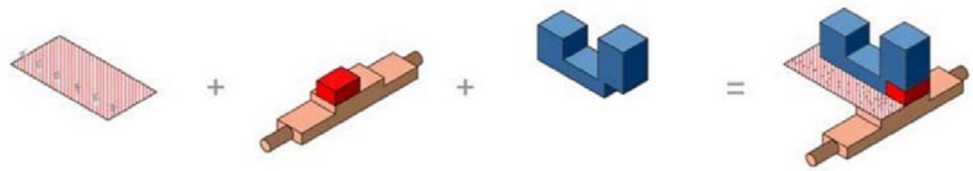


Figure 111 - Station design approach of Grand Paris Express. From left to right; Area for the project, underground station and the "related project" (Société du Grand Paris, 2014)

One sketch from D'ascia and the BIG group's design shows this approach at the point where the station is divided into two interlocking parts. As seen on the sketch (Figure 112), the passenger movement and related areas are the main focus of the design, one can see that a bridge connecting both sides turns into the concourse area of the station. Similar design approaches are also available at TTC's designs at the Toronto extension line stations (Toronto Transit Commission (TTC), 2009b, 2009c, 2009d, 2010e, 2010b, 2011).

Accordingly, all contemporary suggestions show us that organization and connection of the passenger related spaces must be the priority of the design process, and then shaping the technical spaces could help us to create functional underground spaces. Thus, when looking at the interlocking systems as a design approach of the different station designs, one can suggest that technical spaces of stations have the potential to be standardized in designs that will give the opportunity to provide the same functionality yet different designs in various locations.

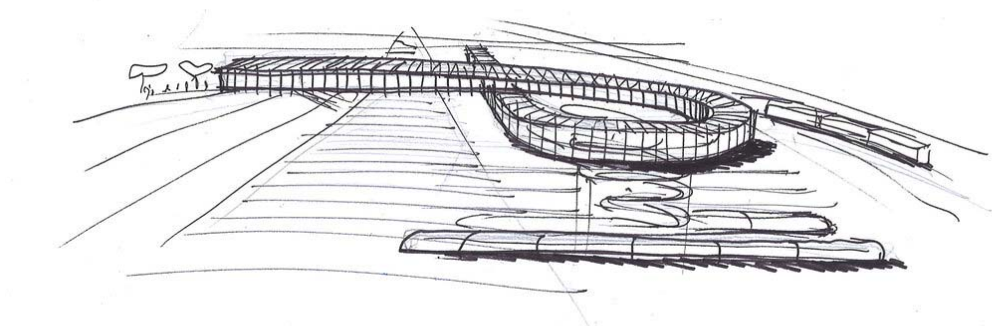


Figure 112 - Artistic sketch of Pont de Bondy station showing the main concept of the station; a pedestrian bridge turning into a station and connecting various transportation nodes each other while organizing is vertical circulation (Silvio d'Ascia Architecture – BIG, 2016)

6.3 Enhancing Passenger Experience

In subway stations, one can see a linear organization of spaces can be seen when the whole passenger experience mapped out (Figure 113). Starting from the surface to the vehicle, passengers enter the concourse area where they can purchase tickets or other necessities from different shops and vending machines. This area is also called an uncontrolled area because there is no fare collection. After that, passengers enter a controlled area through turnstiles or a similar fare collections system. In this process, pedestrians can also encounter various security controls. After entering the controlled area with different horizontal and vertical circulation elements such as stairs, escalators, elevators, and moving walkways, they move towards the platform area. During this movement, there is the possibility of where pedestrians cannot see their destination from the start, and by selecting paths or transitional nodes, they can reach their destination. In view of the fact that the building is underground, the most common way finding option is through guidance with signage. Thus, at the end of the travel, pedestrians reach to the platform area to board the trains. In every type of underground station, the pedestrian movement can be simplified as in shown Figure 113except interchanging stations with complex guidance and signage systems.

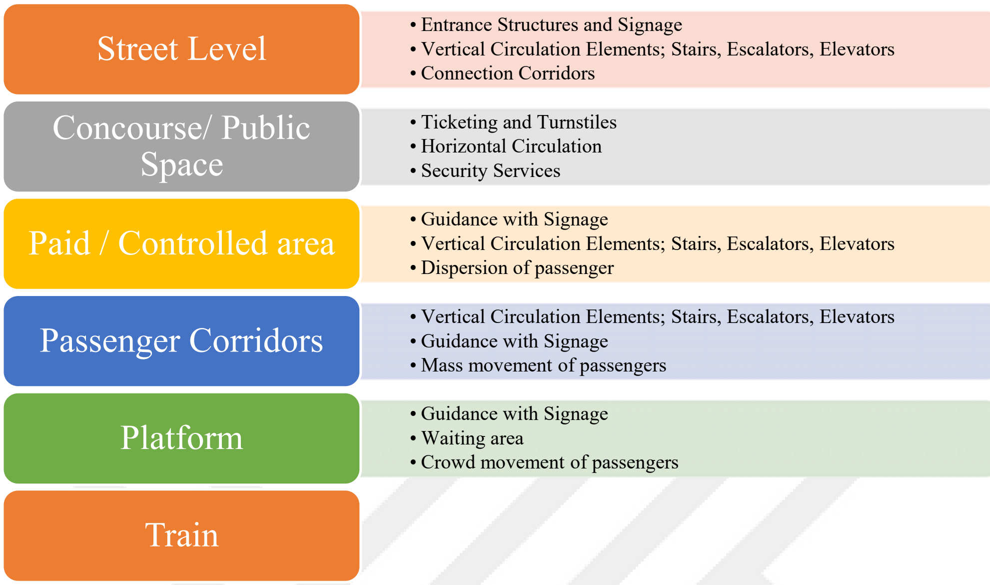


Figure 113 - The linear movement scheme of pedestrians in a subway station with stations zones stacked in order from the surface to the train along with the movement factors and assistants in the process (author)

Even in this simple journey, pedestrians move according to a decision-making process, which can also be defined as cost-of-travel or walkability attributes, and they can be divided into two; repelling and attracting factors. An attracting factor can be defined as a stimulus where its users choose these paths because not only it is the shortest route, but also the experience of that path is attractive for some reason. For example, possibilities of social interaction, street artists, street markets, temporary exhibitions, and street festivals can be described as appealing factors. Repelling factors can be defined as socially insecure places, areas known for misconduct, loitering, begging, alcohol, and drug abuse, where pedestrians do not intend to pass from that area and instead choose alternative routes (Figure 114). In the subway station context, one can see that there is a balance between these factors. Different commercial and cultural functions could be integrated along this linear movement to enhance both the station design and the pedestrian experience. By doing so, stations could also reinforce their urban settings. Yet, the designers are also responsible for foreseeing any possible repelling factors in the design process.

Figure 114 - Attracting and repelling factors in a pedestrian decision-making process to select the route (author)

Moreover, in different settings, an attractive factor could turn into a repelling factor. For instance, possibilities of social interactions and crowds could be both attracting and repelling factor in subway stations. Therefore, while organizing the space organization in the subway station, it is not an erroneous act to design a conventional or straightforward space organization. Yet, it is imperative to develop a balanced approach. By doing so, designers could create more vivid spaces with alternative functions supporting the stations and break the "transitory space" understanding towards them.

6.4 Illuminating with daylight

One of the most challenging design concerns for the subway station is providing daylight to its different spaces and parts. First, one should understand that providing daylight inside stations is not only provides energy efficiency to their operators but also breaks down the psychological effects of being underground. However, bringing daylight with different technical solutions turned into an important issue.

Two alternatives could be applied in the design process, skylights and lightwells. Skylights provide light and natural ventilation in some cases, with more straightforward solutions and enable natural lighting in different structures. Basically, they are openings to the exterior of the buildings and provide natural light with shafts and spaces. On the other hand, lightwells are more complex systems, which consist of three parts in principle, collector, funnel, and diffuser. Similar to pedestrians, daylight should be collected from the surface at external collectors, then the flux should be transported in funnels and afterward distributed at its destination at internal diffusers (Bouchet and Fontoynont, 1996; Molteni *et al.*, 2001). A basic scheme showing the illumination process of the systems can be seen in Figure 115.

Even though the systems seem like a natural process, in detail, placing lightwells or skylights in subway stations is a complicated process both from lighting, structural and architectural design. Lightwells have multiple parameters from the lighting design concerns, such as the reflective coefficient, internal reflections, and external collector. On the other hand, holes at the structural systems in an underground setting is an engineering challenge. From the architectural point of the most challenging situation is the diverse functions of the surface and the station area. Because when stations are located under roads, streets, or any similar area where accessibility is the primary concern, one cannot place a lightwell or a skylight in the middle of the street. Yet, with a complicated and segmented funnel design, lightwells have to potential to provide daylight indirectly to their destinations, which will help to overcome the mentioned hardships.

On the other hand, pedestrians and vehicles also create security concerns for both of the systems. For example, any vehicular activity damaging the external collector or the funnel of the systems would render the whole element uses. Besides, any pedestrian activity over lightwells and skylights, like walking over or putting trash over collector areas, could create safety-related problems both for the pedestrians and the lighting systems.

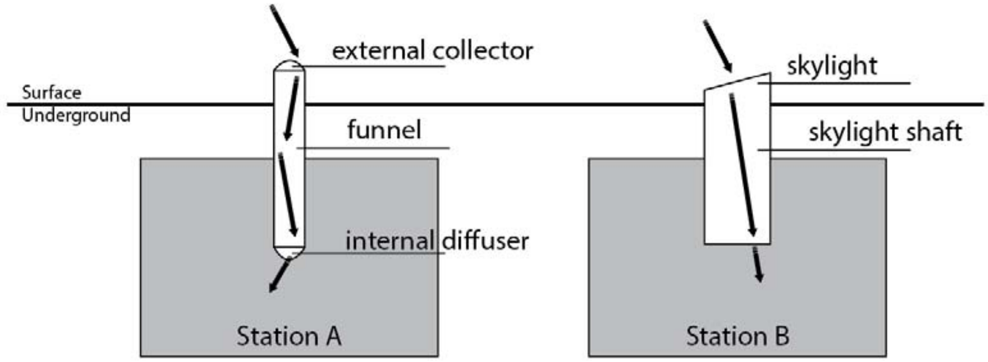


Figure 115 – Basic schemas of a lightwell in a subway station based on (Molteni et al. (2001) and skylight to show their illumination principles (author).

If the designers could develop solutions to the complex nature of the skylights or lightwells, it might be possible to face one the biggest design issue for underground buildings. Nevertheless, providing daylight as much as possible does not have the intention to substitute the lighting alternatives in the subway station but create a visual comfort to pedestrians both from physiological and a psychological aspect in addition to its energy savings. As a result, by integrating lightwells or creating an alternative opening with different landscape designs, designers can enhance their stations not only from an architectural perspective but also from the mental comfort of pedestrians using the station.

6.5 Designing the Urban Structure Under the Ground

Given the fact that thousands of people use stations on a daily basis, one could wonder how do we perceive other building types with similar user loads. For instance, in an ordinary subway station case, this number is around 10-15 thousand people, and in important stations, this number could go up to 55-60 thousand people at the peak hour period. On the other hand, for a hypothetical service-related superstructure with similar pedestrian demands (office building, hospital, mall, or exhibition hall), design teams have to develop various alternative pedestrian access points. In addition, multiple entrances have to be developed both for private and service vehicle entrances. Alongside the building, various additional services and designs would be located around this design. As a result, when buildings with a similar amount of user demands, a hospital, sports facility, or a commercial building, are evaluated with its significance and importance in the urban context. However, on subway stations, in a typical layout, if the station is signified with a pole (which turned into a landmark) with entrances wide enough to handle the passenger capacity, it is considered an acceptable solution.

On the other hand, when a station is placed in an urban setting, they turn into very powerful urban nodes (re)shaping the urban patterns with their design decisions. Depending on the situation, a station could generate an urban center from scratch, restore an existing one, reform or regenerating the existing situation

Generally, the subway stations are designed and developed around the existing urban patterns and settings. However, there are also design cases where different infrastructural elements are designed in new locations to generate new urban settings, which is also parallel to Allen's (1997) suggestions. However, in this approach, we can see a wide range of variety at the contents of the stations, from sole stations to complex urban centers with subway connections.

Though, at the Toronto extension line and its stations, it is possible to see that both the designers and operating organizations wanted to improve the existing conditions rather than restoring or reforming the urban patterns of the station locations. At every station, while they provide the functional demands, adding minor design features to the area, they tried to improve the existing condition.

Namely, at Yenikapı transfer hub, the site was considered as the only available site for such operations in dense Istanbul background, and one can trace the design decision of integrating to its urban pattern by extending pedestrian paths to the transfer hub. Moreover, the rich historical background of the site also helped the designers to suggest a new urban organization at the project site. Along with that, rich heritage, museums, libraries, and exhibition spaces are incorporated into the transportation hub to regenerate the existing urban settings. Thus, similar design developments could be used in different settings to generate the existing urban patterns with additional uses such as offices, art galleries, and public areas, these stations, and turn them into new urban focal points.

On the other hand, subway stations with extensive embedded building programs could reform the existing urban settings. The main design concern of such an approach could be based on shaping the subway station as an urban center to start a much denser urban context around it. By providing not only cheap and reliable transportation but also different services in one location, these stations could help to thrive in new economies around them. Hence, the Grand Paris express stations stand out as reforming the existing settings with their design intentions.

Regrettably, with prescriptive design methods and project management concerns such as project budgets and timelines, the design of the stations focuses on the beatification of the spaces created with the engineering design. However, given the sophisticated space generated both underground and the surface levels of subway stations stand out as a unique chance to transform the urban patterns with infrastructural projects. Until now, except for contemporary examples, it is hard to trace different projects which take hold of the opportunities and possibilities of designing an underground station as an urban entity.

Nevertheless, it will be an erroneous effort to design a building isolated from its urban context lacking its connections to its users. As a result, instead of creating problematic buried concrete boxes that provide transportation to various parts of the city, the general understanding of a subway station should change to the design process of underground urban space with transportation possibilities. By doing so, we can overcome the reductionist attitude, which only focuses on the functionality or the stations.

6.6 Connecting with the Street Level

As mentioned above, the surface of the underground station is one of the most important design issues. It is possible to find design guidelines claiming that land disruption should be minimum, and the construction firm is responsible for restoring the site to its former state (EGO Ankara Department of Transportation Planning and Rail System, 1992a; JICA, 2010b). However, restoring the surface to its original state is only one option that could be developed. We can see conventional solutions and a combination of different approaches in the process.

Typically, the most common approach to the surface of subway stations is to restore the former condition after the construction of the project. This approach creates a border between the surface and the underground, and pedestrians can only see signposts on the surface level to find the station in urban settings. This design approach could be selected if the surface of the station area is an integral part of the city. For example, when the station is under an important urban site, such as a historic city square that needs to be restored or under a street, highway, railway, and even airports, this method could be adopted to reinstate the former connections of the city. As seen in Figure 116, the restored area could be part of a park, road, or the local square; however, subway stations and their surfaces are disconnected from each other and except entrance structures placed around stations.

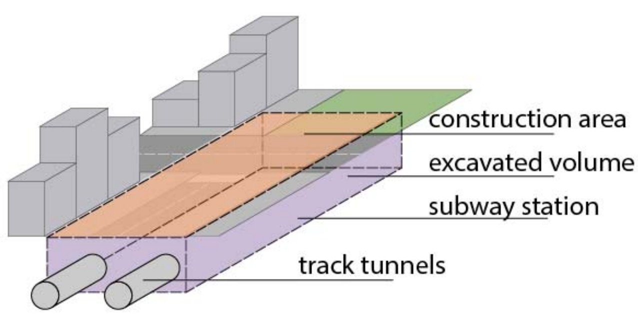


Figure 116 - Schematic view of a typical station where designers restore the station's surface to its former condition as a design decision (author).

Moreover, when designing a new landscape on the surface level, it is possible to change the design approach. As we can see, there are alternative approaches and developments in the process. Even though there will be countless alternatives from the design perspective, it is possible to highlight two different approaches. Firstly, instead of restoring the former conditions, designers could create alternative landscapes and elevations for users aimed at different purposes. Especially with new transportation opportunities coming with the stations, public landscapes could be enhanced or reshaped instead of restoring its former condition. Especially with the excavated soil for the stations, designers have plenty of possibilities for different landscapes. Along with the different sustainability certification systems that are concerned with the excavated soil at the construction site, designers could create alternative suggestions and developments to enhance their designs. Moreover, given the fact that building a superstructure on top of a subway station is an engineering challenge due to foundation design, the station area could turn into important public spaces providing different activities.

What is more, depending on the elevation changes and the depth of the station along with the available area, one could create alternative landscape forms where the new landscape provides multiple activities to its society besides its transportation functions. Moreover, these elevation changes could also create new surfaces that were to be buried in conventional solutions. Besides, these new surfaces can provide daylighting and natural ventilation possibilities to enhance the station design as we have seen an example at the York University station in Toronto.

On the other hand, in different urban contexts, one can create alternative suggestions to enhance the urban context. In dense settings, subway stations usually have multiple entrances to increase its accessibility, which consists of stairs, escalators, and elevators bundled together. These entrances could be apart from the station or next to them, depending on the surface conditions (Figure 117). Moreover, it is possible to see entrances with canopies providing protection and signifying the entrance in various projects. However, depending on their urban contexts, these entrances could be more than simple. These powerful nodes could be enhanced with additional functions, such as passenger operated machines, shopping, ATMs, touristic information mediums, waiting areas, and other transportation possibilities.

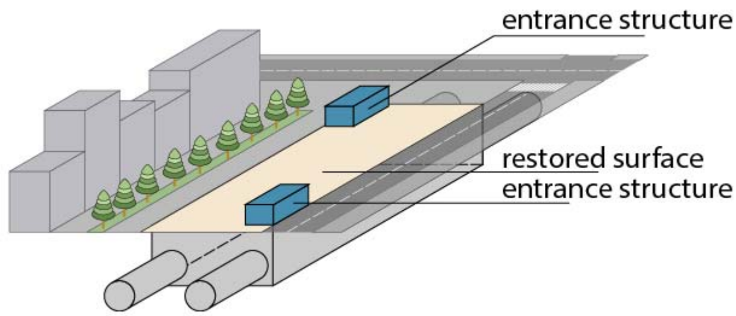


Figure 117 - Schematic view of a station with multiple entrances (highlighted with blue) on the surface level (author)

Additionally, the surface of the station area in urban settings could be enhanced with additional functions besides reshaping. These approaches could be divided into three; open-air solutions, extending the station as a superstructure, and hybrid solutions.

Open-air solutions create a public space at the surface levels and depending on the design decision. These spaces could be covered with canopies and temporary protections for different activities (Figure 118). Even though the most common solution is placing bus stops and similar transportation options in this area, different functions could be added, such as marketplaces, meeting areas, sports fields, and community areas. Designing such spaces on top of newly created underground spaces could help designers enhance their station and support the existing communities.

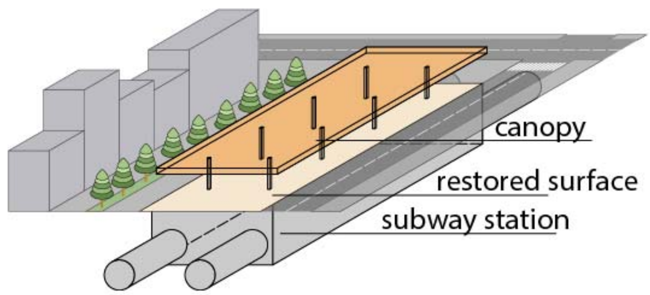


Figure 118 - View of an open-air surface solution where the surface helps to enhance the urban setting (author)

In contrast, instead of creating open-air solutions, designers could also extend the station to the surface as a superstructure. By doing so, the station becomes the part of a more significant entity and thus creating complex design concerns for multiple functions placed at the suggested design (Figure 119). Different parts of the design have to comply with multiple safety and operation standards and guidelines. This solution could be applied in dense zones where the land is much valuable or where the designers want to place numerous activities in the station area and turn it into a focal point. For example, these buildings could contain government institutions, offices, public services, shopping areas, meeting places, places of worship, and hotels so that they create their own economic ecosystem and influence its setting.

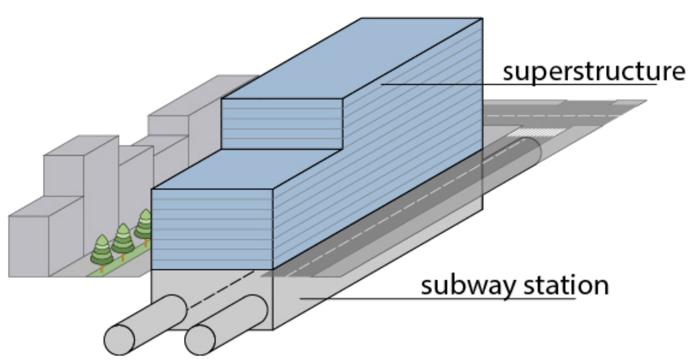


Figure 119 - View of a superstructure solution where the surface helps to reshape the urban setting (author).

Naturally, one can also combine both of the suggestions and develop a hybrid approach to the design issue. Even though the approach increases the complexity of the situation, a well-organized design suggestion could combine the advantages of both design suggestions and enhance the station and its urban context. Yet, it is important to keep in mind that designers have to deal with sophisticated problems not only with the station itself but also with their suggested building programs.

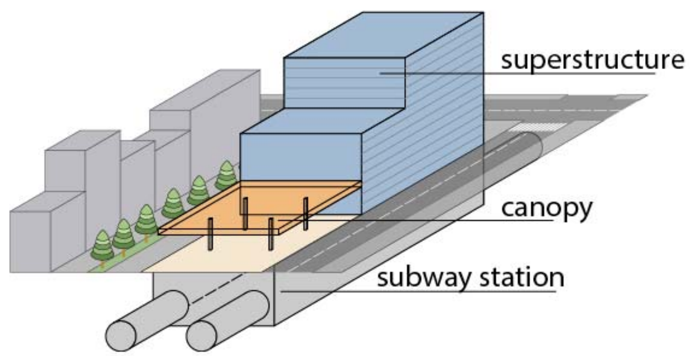


Figure 120 – View of a Hybrid solution where designers can combine open-air solutions and superstructures for their surface design (author).

6.7 Integrating Multimodal Transportation

The design of the station could be enhanced with its variety of transportation possibilities. As mentioned before, the effective range for a subway station could be between 1 to 1.5 kilometers (Kenneth W. Griffin, 2004). People can access the station with various transportation options, from walking to driving to the station in their own car. Subsequently, one can see different multimodal options such as park and ride, kiss and ride, and bicycle amenities (Queensland Government, 2015; Lang, 2017). Naturally, park and ride enable users to park their car at the subway station's parking area and then use the subway network for further movements. On the other hand, despite its original name, the kiss and ride option stands as an option where users dropped at the station with a car driven by another individual. In addition, one can also see that bicycles are also essential vehicles in various cities, and bicycle amenities have started to show up at different stations. Consequently, to its urban importance, another critical design notion is the intermodal possibilities of provided by the subway stations.

These integrations require different facilities and designs to incorporate any suggested solutions such as car parks, bus stops, and bicycle storage facilities (Blow, 2005). It is interesting to see the allocated space for any suggested facility is shaped by technical guidelines and standards to achieve functionality similar to the challenging typical subway stations mentioned in this dissertation. However, as Stones and Heng (2016) underlines, gathering similar functions together while providing the infrastructure and utilities also creates advantages for cost, space, time, and resources.

On the other hand, there are different scales of mobility options not only for subway stations but also for different daily uses, such as micro-mobility. Transportation possibilities include bike-sharing, carsharing, scooter sharing, and e-bike sharing (Lazarus *et al.*, 2020; Moran, Laa and Emberger, 2020; Shaheen *et al.*, 2020) enable pedestrians increased accessibility in dense urban settings in a fast and efficient way. Along with the sharing systems, not only the pedestrians have more accessible options but also economic systems where they spend less for more comfortable transportation possibilities. For instance, Shaheen et al. (2020) show that when North American cities adapted bike-sharing policies and options, 5.5% of the users sold or postponed a vehicle purchase, and 50% of the bike-sharing members reduced personal auto usage. In addition to the current sharing systems, together with the smartphones and internet technologies, users can use their smartphones to gain access to the vehicle and travel in short distances and leave it in a secure position for its next user.

Even at the early stages of the COVID-19 pandemic, the negative attitude towards mass transportation and physical distancing concerns, systems started to operate with decreased capacities (O’Sullivan, 2020b) as an alternative people have started to develop different solutions to the inner-city transportation without interacting with the crowd or the motorways. Especially bicycles have turned into an alternative transportation method with highly increased demand (Landis-Hanley, 2020). Moreover, shared mobility systems such as bike-sharing and e-bike sharing alternatives had enormous demands as a mode of transportation (Liu and Ren, 2020), and cities are expecting an increase in cycling and walking between 10 to 5-fold (Bliss, Lin and Patino, 2020; London City Hall, 2020).

Especially during the pandemic, one can trace that while the non-essential workers started to work from their homes, the demand for personal vehicles has increased(Lee *et al.*, 2020). Moreover, some of the earlier studies focusing on the possibilities of home offices had the chance to compare their researches, such as Giovanis(2018), Shabanpour *et al.* (2018). Though the shift from the mass transportation options to personal vehicles could only be a temporary solution, this approach is unsustainable for urban design and climate change concerns. Even in former conditions, cities suffer significantly with the traffic load on their roads, and with the shift from public transportation systems to private transportation would render the whole existing road network congested. The increased number of private vehicles on the roads would also worsen the climate change crisis. Notably, during the lockdown, we have witnessed a slight reduction in air pollution (Berman and Ebisu, 2020)

As the cities have gone into lockdowns, the cities' most significant action for the transportation perspective was to prepare the mass transportation network for the upcoming changes. For instance, Milan announced to reduce car usage (Laker, 2020). Meanwhile, London started to extend its bicycle network (London City Hall, 2020), and New York started to update its whole infrastructure during the lockdown (Hu and Goldbaum, 2020). Besides, with the authorities, communities, and civic groups started to participate in developing new strategies to improve the existing situation (Florida, 2020a). Still, in the effort to make our cities safer, as mentioned by Florida, "...the most enduring changes will likely be in the built form and infrastructure of cities, even as mask-wearing and social distancing fade from our collective memory" (2020b, para. 6).

As a result, the recent experiences of mass transportation and enclosed spaces are likely to define the future design considerations and approaches on the subway station design. Therefore, along with its flexible and sustainable transportation possibilities, micro-mobility combined with the existing public transportation network is perceived as an alternative and even a solution to the existing traffic problems despite causing some arguments over access, safety and speed, as well as rider behavior (Brown et al., 2020; Gössling, 2020). Aside from the concerns, micromobility options stand as promising architectural design points for designers yet to be discovered where alternative solutions contribute to the organization of the space with their sustainability and mobility potentials. Therefore, subway station designs should include major integrations not only to the current multimodal options but also for future possibilities. Also, these integrations should be achieved in architectural design perspective and be a part of the station space organization instead of temporary solutions installed in the available area. Therefore, different docking and charging stations for electric-powered scooters or enhanced bicycle parking facilities with auxiliary services should be a part of new subway station designs to increase the accessibility of the stations.

6.8 Protecting Users During Pandemics

During the pandemic, cities started to state interesting reports regarding their mass transportations. Especially in France and Japan, authorities did not detect any virus clusters related to the transportation network (O'Sullivan, 2020a). According to their reports, despite the challenging environment of the buildings combined with limited ventilation, daylight, and crowd, no infection was found related to the stations or the trains. Yet, as O'Sullivan (2020a) highlights, they could be also be related to various complexities such as; the passengers following the safety rules, the difficulty tracing every passenger using the system, or the limited amount of the time people spend in stations with safety precautions.

Therefore, it is important to note the three major concerns regarding the current or any possible future pandemic and consider our design according to that risky situation. These three concerns are natural light, natural ventilation, and a decreased amount of time in closed spaces.

As providing daylight possibilities has been discussed in detail in previous sections, one can also use the same shafts to provide natural ventilation inside the stations. Despite the difficulties with the light funnels, skylights have the chance to provide natural ventilation with simple solutions. Yet similar to the collection of light from the surface, natural ventilation openings have similar problems where these connection structures should be isolated from pedestrian and vehicle flows at the surface. Moreover, unlike the light collectors, these air intakes should be collecting clean air, which does not contain vehicle exhaust fumes or any other related pollution. Thus, finding such spots in dense urban settings is a big challenge for designers.

Lastly, starting with the current pandemic, spending time in closed spaces is a potentially dangerous action, and one of the suggested actions was either staying away from such spaces or moving through them as quickly as possible with the suggested safety precautions. In this respect, well-organized stations that provide efficient movement inside stations can provide the demanded safety combined with other safety measures such as touchless fare collections, decreased capacities for circulation elements, and body temperature control checkpoints.

However, it is important to keep in mind that humans have survived every pandemic and learned valuable lessons from them. Through the current one we are all experiencing, it is sufficed to say that our current understanding of closed spaces, which relies solely on mechanical ventilation and artificial lighting, requires immediate attention to develop alternative suggestions. Thus, it is the designers' core responsibility to create livable and healthy spaces for users.

6.9 Design Guideline for Subway Stations

This research has highlighted various issues and concerns for subway station design and underlined the need to develop an alternative design process instead of using the current linear approaches. As mentioned in the earlier chapters, the design process for the subway stations is not only linear but delineated with boundaries between the engineering and architectural processes, where the former supersedes the latter. The existing design process is presented here to summarize the various stages and components of the design, which are generally under the jurisdiction of the engineering teams.

6.9.1 Current Design Process

The currently prescribed linear workflow, as a rational approach to the subway station design, is presented in Figure 121, showing the design inputs by the engineering disciplines. These inputs can be divided into three parts; Site surveys, Transportation surveys, and operational information. Site surveys focus on gathering information about the possible transportation corridors both from the surface level and underground layers. Map surveys present use, access, coordinate data, height and orientation information about urban setting on the surface level. Geotechnical surveys present information about the underground, seabed, or subsurface, where the major construction activity takes place in subway stations. These surveys provide the much-needed information for designers regarding the physical properties, i.e., the soil and rock structure of the earthwork.

Transportation surveys are important studies that show the movement paths of the cities along with the points of future developments, which also shows the possible locations for subway stations. From these surveys, designers also acquire vital statistics regarding passenger loads and peak hour passenger loads, which directly affects the station design in the conventional method.

In addition, operation information, which contains vital information to shape the technical aspects of the stations, is provided by the line operator. This information includes vehicle headway, vehicle dimensions, vehicle capacity, ancillary spaces requirements, and fare collection system. Vehicle headway is the time period between two consecutive vehicles passing from the same location (Dowling *et al.*, 2016). In addition, vehicle dimensions and their capacity are also provided the line operator so that various technical concerns and calculations could be determined. For example, vehicle dimensions play an important role in defining the platform length and determine the doors of the platform separating doors (PSD), a system designed to separate the passenger area from train tracks. In addition, operating systems also provide information regarding their ancillary spaces, which shows the required number of staff and the related spaces on every station. Lastly, information related to the fare collection system of the subway line is provided so that designers can shape the pedestrian flow accordingly both for new and transfer passengers with their accurate capacities.

In addition to preliminary design inputs, engineering inputs are created to define the basics of the subway stations. This process includes transportation systems design engineers, geotechnical engineers, structural engineers, and geomatic engineers, where they create extensive reports and documentations to create the necessary setting both for the subway line and its stations. In this part of the process, track alignment, geotechnical survey report, track tunnel, construction operation planning, retaining wall design, and foundation designs are created in addition to the station and platform types. Even though engineers shape all of these processes, the station type and the platform types are crucial parts of the architectural design process.

Accompanied by these figures, the architectural design of the subway stations employs a sole technical approach where standards and technical design guidelines define every design feature. As different standards and guidelines are mentioned in the literature review, the most critical space definition and organization are defined in this process. Parameters such as platform width, concourse area, staircase width, number of turnstiles, number of escalators, number of ticket machines, number of ticket issuing windows, and required ancillary spaces are defined in this process. Along with these space and quantity definitions, architects generate a generic underground space organization where three different types of spaces are organized; technical, ancillary, and passenger spaces. This space organization is distributed among structural, mechanical, and electrical engineering teams for its design reviews. By doing so, a predefined underground space shaped by standards and guidelines is organized with engineering inputs to provide the service systems to make the station operational. The design process chart in Figure 121 summarizes these inputs and flows.

Figure 121 - Existing design flow of subway stations showing the linear workflow of the prescriptive methods. (author).

Nevertheless, as a result of this process, designers have a defined station outline that can be implemented in any available space along the suggested line. Especially in typical stations with their recurring architecture, one can see some extreme cases where the only difference of the stations is the entrance structures due to its urban settings. Because of that, the most common suggested landscape design of the subway stations ends up being restoring the surface to its former condition unless a mass transportation integration is designed. As a result, this process ends up creating mass-produced concrete pumps that push people around the city.

6.9.2 Proposed Design Process

The proposed design process is based on the idea that the space organization and design should not be based on the technical approach only, which is controlled by the engineering teams, and the architectural design process should start before some of the major engineering inputs, such as the decision on the station and platform typology (Figure 122). The preliminary design should start with the site surveys and station locations to acquire more information about the urban settings of the stations. By doing so, every station location starts to provide unique information regarding its urban context. Followed by the design of passenger spaces and site layout organization, this approach suggests developing the passenger areas not only in the station but also in the urban context. As the process develops these integrated spaces, they can be combined with the technical concerns of the station to define the design scheme for the stations.

In the standardized design process, one of the most critical notions was the fact that pedestrians were the objects of the design. With their transportation demands and loads, they determine the number of various elements, yet they shape the underground space as a transitionary space. In contrast, with the suggested workflow, pedestrians turn into the subjects of the design. Thus, the station design turns into the medium to provide the required connections and activities and challenges the familiar repetitive transitory spaces spread around the city.

Moreover, instead of creating passenger spaces within the allocated spaces in parallel with technical and ancillary space demands, an urban entity could be generated if the systems of the standards and guidelines are criticized. As mentioned above, the surface of the stations has different possibilities where designers could adopt different designs for different purposes. However, due to the standardized space generations lacking urban connections, the typical design ends up restoring the surfaces to their former states. On the other hand, by taking into consideration the same concerns at the earlier stages of the design process, not only the design of the surface at street level but also the station space can be enhanced.

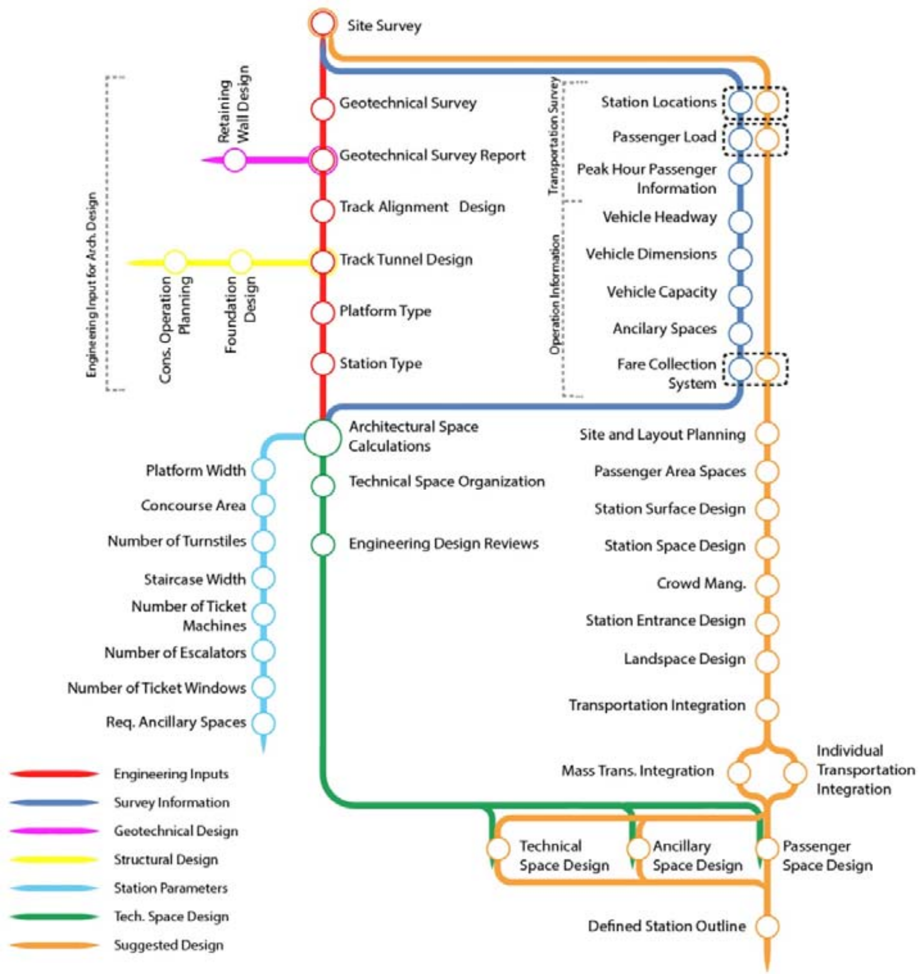


Figure 122 - Suggested subway station design workflow showing an alternative for the existing prescriptive design approach (author).

6.10 Chapter Conclusion

Along with its technical difficulties and challenges, designers also encounter fundamental design questions and concerns while designing a subway station. Unlike the alignment or the route map design, they have to provide solutions in multiple dimensions, both from the engineering and architectural aspects. Moreover, they are also expected to develop a design that corresponds to operational and safety measurement concerns of technical design guidelines and standards while generating urban spaces under the ground. Thus, one can see remarkable design suggestions throughout the world in which one can make inferences for future designs. Therefore, this chapter focuses on the possible considerations in different scales and proposals for future designs with an alternative design flow while preventing any universal design environment. As a result, instead of giving prescriptive methods even to the specific situations, potential design solutions and alternatives in different scales are presented to enhance the architectural design of the subway stations.

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CHAPTER 7

CONCLUSION

Subway stations are a part of the everyday routine, and millions of people use them on a daily basis since they provide economic and time-efficient travel options in dense cities. They are perceived as crowded spaces that hold a dynamic pedestrian movement both inside and around the building. This dissertation studied the subway station design process and scrutinized the current misconception, where subway stations are considered as engineering buildings. It explored how a subway station is designed by different national and international standards and design guidelines. Subsequently, by looking at the history of the station design, this dissertation highlighted the fact that even at the early examples of this building type, designers were questioning the space generated underground. The current design guidelines and standards generate a more mechanical approach to the station design more than ever. Every aspect of the design is shaped by capacity-based rules dictating dimensions and quantities in stations. This study investigated problems and discrepancies found in the technical design of the subway stations from different viewpoints and reports. By doing so, we have a clearer understating of the possible problems and pitfalls in the future if a sole technical approach is applied to the design of the station. Lastly, while avoiding any prescriptive information, a series of design suggestions have been discussed with the existing or upcoming designs.

This study investigated the design process of subway stations by inspecting the design standards and suggested guidelines. Therefore, national and international documents related to the subway station design are inspected in detail. Even though the building's function and system are similar in different parts of the world, every country set their own set of rules and standards to shape the required space and design for safety in addition to various international documents aiming to integrate railways systems. Consequently, documenting information from different parts of the world and comparing them to each other had been vital in this research. In this respect, a large number of operators and designers have been contacted to collect information regarding different guidelines and standards. The most important finding was that the existing documents create a linear design process where designers are responsible for designing a space determined by quantitative methods. Moreover, it is equally hard to find any design inputs for the designers both in the station and urban scales except for some ambiguous definitions and suggestions. As a result, designers should recognize that the existing standards and guidelines related to the subway station design are just helpful documents to find the design minimums.

Following the technical design guidelines and standards, pioneering approaches and design concerns are documented as a history of the subway stations after an extensive station selection process. The main concern was to document the design decisions and highlight how the design has evolved. Starting from the early 20th century examples from Moscow and Milan, the main concern was to trace how different design teams responded to the same design question. Especially at the contemporary examples, either local or international, highlighting the contrasts and similarities had been necessary because they are shaped by the same or similar standards.

Thus, one of the most important findings of the study was that the current standards and guidelines are interpreted as a canonical design approach, and one can trace their influence on the design at these examples. In addition, the history of subway stations in Turkey is also documented to trace the design influences and similarities with the pioneering examples. However, the existing situation in Turkish cities showed that except for a couple of stations, the majority of the stations are developed with sole technical approaches while lacking design concerns at different scales.

As mentioned before, one of the biggest pitfalls in the subway station design process is the sole technical approach with prescriptive methods. This approach also created the misunderstanding that these building types are regarded as engineering structures due to their infrastructural settings. However, this detailed study showed us that the existing standards and guidelines have various problems and conflicting situations, such as; lack of local profiles, problems related to the projections and peak hour calculations, and space requirements. Every society has different physical attributes and behavior patterns. However, by looking at the problems mentioned in this research, one can see that the existing design parameters for Turkish subway stations are a collage of international documents from different countries. Moreover, stations are designed in a prescriptive method will encounter different problems such as different pedestrian loads other than the peak-hour-period load and different user occupation areas bigger than the suggested minimums.

Along with the ongoing pandemic, these problems and discrepancies became more critical than ever. Thus, within the current context, the most important approach is to question the existing acceptances and solutions. Because even though the current pandemic had a significant impact on the global scale, most of the studies highlighting the current problems were identified and addressed at interpandemic phases even before the current events. Even in past pandemics, designers were aware of the problems and their potential impact. Yet, designing the subway stations based on the design guidelines and standards focusing mainly on the safety and engineering concerns brought the same problematic designs which were implemented repeatedly.

7.1 Contribution of this Research

This research has developed both the design issues and suggestions for the subway stations, along with its reviews and studies. The main intention of underlining the design issues was to highlight the future designs' challenges and develop design alternatives, and insights are presented to establish an alternative approach. In the process, different issues, both from technical and theoretical aspects, are highlighted from how to evaluate the subway stations as a space and place both in the architectural and urban design concerns to travel safety concerns during the pandemics. One can easily comprehend the shift from the traditional strict design approach to the contemporary design approaches where stations are interpreted as urban focal points with additional transportation options. Contemporary station designs have tried to develop alternative solutions to the existing problems from their own understanding. However, problems of the exiting design methodology are not a subjective debate; on the contrary, it is an objective one shaped by contradicting design guidelines. Consequently, the problematic spaces created by a prescriptive method had collapsed during the current pandemic. People tried to avoid these underground public spaces because of the crowd and close contact situations even though these buildings are a crucial part of daily life.

Lastly, combined with the current pandemic, alternative design concerns are featured starting from the first design idea of the station, designing an urban space in the underground, designing the surface, illumination, and the use of daylight, organizing the space, multimodal transportation, and designing for disease controls. In addition, by showing the current strict design process, an alternative design flow is developed. By doing so, designers have a chance to challenge the prescriptive methods even in typical station layouts. Yet, the most important part of the research is the general idea that even though the subway stations are part of large infrastructural projects, with their important transportation possibilities, station designs should be handled like any other design project instead of prescriptive methods. Combined with the current pandemic, it is an excellent opportunity to revise our perception of the subway station to develop a new understanding of it and its design process while avoiding universal design suggestions.

In conclusion, this research presented the existing design methodology suggested for the subway stations and a review of the subway stations from different time periods. Followed by a critical approach to the existing standards and guidelines for the subway stations, it highlights the problems of a sole technical approach by comparing the information suggested by the documents to the future projections and other related reports showing that the sole technical approach is the main problem in the design process. Subsequently, different design suggestions with different scales and aspects are underlined for future designs. As a result, these features helped to evaluate the subway station in architectural, urban, and infrastructural contexts and show design concerns for future designers in the process.

7.2 Recommendations for Future Work

By looking at the literature conducted on subway stations, one of the most interesting situations is that building type is hardly questioned from the architectural design point of view. On the other hand, there is a rich literature from the urban design or building performance-based (quotative) studies on subway stations. Along with the civil, mechanical, and electrical engineering studies focusing on mass transportation, the current lack of studies subway stations still supports the problematic belief claiming subway stations as an engineering building. Consequently, this framework focusing on the performance of the building alone created mass-produced concrete pumps in our cities implanted established term as a non-place instead of underground public space. As the standards and guidelines rely on former experiences and suggestions, even the existing standards, design guidelines, and databases should be continuously studied so that they can help to anticipate the future. However, it is equally important and critical to approach to the subway stations from a theoretical design perspective so that future studies do not make the same criticized approach. As a result, future studies should be conducted both in the technical and theoretical perspectives of the stations.

The need for a more sophisticated understanding of subway stations is essential to enhance the built environment and our daily life since the current design approach of the stations are based on technical solutions while ignoring the architectural design concerns. However, it is ironic that when a building type is located under the ground, related discussions and understandings shaped around the building performance studies rather than how an invisible structure, along with its newly generated underground urban spaces, have such impact and importance on daily lives. Through the Covid-19 pandemic, we all noticed that spaces only shaped by technical design concerns have increased the infection rates and converted these spaces into harmful environments. Somehow, we need to revise our understanding of this building type and support it with enhanced technical design concerns rather than outdated solutions or based on outdated design guidelines. As architects, we are all responsible for enhancing our built environment into more sustainable and livable spaces while providing much-needed connectivity. As a result, approaches suggested in this research are the first steps to improve the complex nature of the subway stations and an indicator of the problems of a sole technical approach to any building type in our built environment.

REFERENCES

Adams, J. S. (2008) ‘Monumentality in Urban Design: The Case of Russia’, *Eurasian Geography and Economics*. Taylor & Francis Group, 49(3), pp. 280–303. doi: 10.2747/1539-7216.49.3.280.

Adana Ulaşım (2019) *Adana Ulaşım |Metro*. Available at: https://adanaulasim.com/ (Accessed: 24 November 2019).

Aksman, B., Grigson, R. and Giffen, R. (2019) ‘Second Avenue Subway Project, New York: Design of New Underground Stations’, *Structures Congress 2012*. (Proceedings), pp. 1293–1304. doi: doi:10.1061/9780784412367.116.

Allen, S. (1991) *Points + Lines: Diagrams and Projects for the City*, *Urban Patterns and Meanings Through History, London*. New York City,NY, NY: Princeton Architectural Press (Architecture, urban studies). doi: 10.1002/ad.1821.

Allen, S. (1997) ‘From Object to Field’, *AD (Architectural Design)*, (5–6), pp. 24–31.

American Public Transit Association. Rail Transit Committee.; Transit Development Corporation. (1981) *Guidelines for design of rapid transit facilities*. Washington, D.C.: APTA.

American Railway Engineering and Maintenance-of-Way Association (AREMA) (2018) ‘Buildings and Support Facilities’, in *AREMA Manual*, p. 334.

Amin, R. (2017) *The Caltrain Corridor Vision Plan*. Edited by K. Steen. San Francisco, CA: SPUR.

Andersson, T. and Lindvert, D. (2013) *Station design on high speed railway in Scandinavia*. Chalmers University of Technology.

Ando, K., Ota, H. and Oki, T. (1988) ‘Forecasting the flow of people’, *Railway Research Review*, 45(8), pp. 8–14.

Anıtkabir Komutanlığı (2020) *Anıtkabir Ziyaretçi Sayıları*. Available at: https://www.anitkabir.tsk.tr/05_etkinlikler_duyurular/anitkabir_ziyaretci_sayilari.html (Accessed: 12 February 2020).

Ankara Büyükşehir Belediyesi (2019) *Raylı Sistemler Dairesi Başkanlığı Ankaray*. Available at: https://www.ego.gov.tr/tr/sayfa/2156/rayli-sistemler-dairesi-baskanligi-ankaray (Accessed: 24 November 2019).

Ankara EGO (2017) ‘Raylı Sistem İşletmeleri 2016 Yılı Yolcu Sayısı’. Ankara. Available at: http://www.ego.gov.tr/dosya/indir/13918.pdf (Accessed: 25 April 2017).

Ankara Metrosu (2019) *Ankara Metrosu*. Available at:

http://www.ankarametrosu.com.tr/geneltnt.aspx (Accessed: 24 November 2019).

Arroyo, K. K. (2017) 'Creative Policymaking: Taking the Lessons of Creative Placemaking to Scale', *Artivate*. University of Arkansas Press, 6(2), pp. 58–72. doi: 10.34053/artivate.6.2.058.

ARUP (2016) *Second Opininon on the proposed high speed rail in Sweden*. London.

Atak, Z. (2015) *Design considerations for modern railway stations; comparing Berlin, Beijing and Ankara*. Middle East Tehhnical University (METU).

Atkinson, J. *et al.* (eds) (2009) *Natural ventilation for infection control in health-care settings*, *WHO*. Geneva: World Health Organization. Available at: http://www.who.int/water_sanitation_health/publications/natural_ventilation/en/ (Accessed: 25 June 2020).

Augé, M. (2006) *Non-places : introduction to an antropology of supermodernity*. Translated by J. Howe. London; New York: Verso.

Bagriacik, N. *et al.* (2009) 'Obesity profile in Turkey', *Int J Diabetes Metab*, 17(1), pp. 5–8.

Banham, R. (1960) *Theory and Design in the First Machine Age*. 2nd edn. Massachusetts: The MIT Press.

Banham, R. (1984) *The Architecture of the Well-tempered Environment*. 2nd edn. The University of Chicago Press.

Barone, V. (2019) 'MTA can't explain escalators outages in Second Avenue subway stations', *AM New York*, 16 July. Available at: https://www.amny.com/transit/subway-escalator-status-1.33871254.

Baydin, G. A. (2007) 'A photo of the Kızılay station of Ankara Metro', *Wikimedia Commons*, 21 January.

Bayhan, B. (2016) *1. Ödül, İzmir Büyükşehir Belediyesi Ulaşım Entegrasyon Merkezi Yarışması - Arkitera*. Available at: https://www.arkitera.com/proje/1-odul-izmir-buyuksehir-belediyesi-ulasim-entegrasyon-merkezi-yarismasi/ (Accessed: 1 December 2019).

BBC News (2014) 'Sao Paulo metro strike suspended for two day'. Available at: http://www.bbc.com/news/world-latin-america-27761723.

Belanger, P. (2009) *Landscape As Infrastructure*, *Landscape Journal*. doi: 10.3368/lj.28.1.79.

Berman, J. D. and Ebisu, K. (2020) 'Changes in U.S. air pollution during the COVID-19 pandemic', *Science of The Total Environment*, 739, p. 139864. doi: https://doi.org/10.1016/j.scitotenv.2020.139864.

Bernstein, P. G. (FAIA) (2013) 'Design ProjectDelivery', in *The Architect's Handbook of Professional Practice*. 15th edn. Wiley, pp. 508–519. Available at:

https://books.google.com.tr/books?id=5XTrAQAAQBAJ.

Besner, J. (2017) 'Cities Think Underground – Underground Space (also) for People', *Procedia Engineering*. Elsevier, 209, pp. 49–55. doi: 10.1016/J.PROENG.2017.11.129.

Bliss, L., Lin, J. C. F. and Patino, M. (2020) *Global Data Reveals Inequality of Pandemic Travel*, *Bloomberg CityLab*. Available at: https://www.bloomberg.com/graphics/2020-coronavirus-transportation-data-cities-traffic-mobility/?cmpid=BBD061920_CITYLABMP&utm_medium=email&utm_source=newsletter&utm_term=200619&utm_campaign=citylabmostpop (Accessed: 20 June 2020).

Blow, C. J. (2005) *Transport terminals and modal interchanges : planning and design*. Oxford: Architectural Press.

Boeing, G. (2016) *Honolulu Rail Transit: International Lessons from Barcelona in Linking Urban Form, Design, and Transportation*, *Planext*. doi: 10.17418/planext.2016.3vol.02.

Booledozer (2017) 'Opening day at the TTC's Highway 407 station', *Wikimedia Commons*, 17 December. Available at: https://commons.wikimedia.org/w/index.php?curid=64893007.

Bouchet, B. and Fontoynont, M. (1996) 'Day-lighting of underground spaces: design rules', *Energy and Buildings*, 23(3), pp. 293–298. doi: https://doi.org/10.1016/0378-7788(95)00954-X.

British Standards Institute (2004) *PD 7974-6:2004 The application of fire safety engineering principles to fire safety design of buildings. Human factors. Life safety strategies. Occupant evacuation, behaviour and condition (Sub-system 6)*.

Brix, G. W. and Hayes, R. L. (2013) 'Defining Project Services', in *The Architect's Handbook of Professional Practice*. 15th edn. Wiley, pp. 952–987. Available at: https://books.google.com.tr/books?id=5XTrAQAAQBAJ.

Brooke, J. (2003) 'Final Calls Add to Anguish Over Korean Subway Fire', *The New York Times*, 20 February.

Brown, A. *et al.* (2020) 'Impeding access: The frequency and characteristics of improper scooter, bike, and car parking', *Transportation Research Interdisciplinary Perspectives*, 4, p. 100099. doi: https://doi.org/10.1016/j.trip.2020.100099.

BurakOtto (2016a) 'AŞTİ Şehirler Arası Otobüs Terminali, Ankara, 2015.', *Wikimedia Commons*, 26 March.

BurakOtto (2016b) 'Tandoğan Metro', *Wikimedia Commons*, 26 March. Available at: https://commons.wikimedia.org/wiki/File:Tandoğan_Metro.jpg.

Burulaş (2019) *Burulaş*. Available at: https://www.burulas.com.tr/Hakkimizda.aspx

(Accessed: 24 November 2019).

Byrnes, M. (2016) *The Undervalued Simplicity of Bob Noorda's Vision for Milan's Metro - CityLab*. Available at: https://www.citylab.com/design/2016/05/the-undervalued-simplicity-of-bob-noordas-vision-for-milans-metro/483782/ (Accessed: 12 September 2019).

Caballero, B. (2007) 'The Global Epidemic of Obesity: An Overview', *Epidemiologic Reviews*, 29(1), pp. 1–5. doi: 10.1093/epirev/mxm012.

Capital Metropolitan Transportation Authority (2017) *Transit Design Guide: Standards & Best Practices*. Austin, Texas.

Carmody, J. and Sterling, R. (1984) 'Design considerations for underground buildings', *Underground Space*, 8(5–6), pp. 352–362.

Carmody, J. and Sterling, R. (1993) *Underground space design / John Carmody, Raymond Sterling*. 1st edn. Wiley.

CeeGee (2014) 'Golden Horn Metro Bridge', *Wikimedia Commons*, 9 April. Available at: https://commons.wikimedia.org/w/index.php?curid=32082256.

Çelik, Z. (1993) *The remaking of Istanbul : portrait of an Ottoman city in the nineteenth century*. Berkeley: University of California Press.

Centers for Disease Control and Prevention (CDC) (2020) *Protect Yourself When Using Transportation* . Atlanta. Available at: https://www.cdc.gov/coronavirus/2019-ncov/daily-life-coping/using-transportation.html (Accessed: 19 August 2020).

Certeau, M. de (2011) *The practice of everyday life*. Berkeley u.a.: Univ. of California Press.

Chen, S. *et al.* (2017) 'Modelling and Analysis on Emergency Evacuation from Metro Stations', *Mathematical Problems in Engineering*, 2017, p. 11.

Clear, C. (2016) *Station modelling with Legion Spaceworks: Best Practice Guide*. 3rd edn. London: Transport for London.

Dondina, F. (2015) 'Signal Design', in *Bob Noorda*. Milan: University of Udine, pp. 44–54.

Dorsam, B. D. P. (2014a) 'Haliç Istanbul metro', *Wikimedia Commons*, 14 September. Available at: https://commons.wikimedia.org/w/index.php?curid=37500909.

Dorsam, B. D. P. (2014b) 'YenikapıM2', *Wikimedia Commons*. Available at: https://en.wikipedia.org/wiki/File:YenikapıM2.jpg.

Dorsam, B. D. P. (2019) 'Yenikapi M1', *Wikimedia Commons*, 19 December. Available at: https://commons.wikimedia.org/wiki/File:Yenikapi_m1.jpg.

Dosseman (2014) ‘Yenikapi metro station’, *Wikimedia Commons*, 13 May. Available at: https://commons.wikimedia.org/w/index.php?curid=76750681.

Dowling, R. G. *et al.* (2016) *Planning and preliminary engineering applications guide to the highway capacity manual*.

EDSA Inc. (2006) *South Florida East Coast Corridor (SFECC) Transit Analysis: Station Design Guidelines*. Tallahassee.

EGO Ankara Department of Transportation Planning and Rail System (1987a) *Ankara Kentsel Ulaşım Çalışması,, K.8 Avan Proje Teknik Çizimleri*. Ankara: Municipality of Greater Ankara.

EGO Ankara Department of Transportation Planning and Rail System (1987b) *Ankara Kentsel Ulaşım Çalışması*. Ankara: Municipality of Greater Ankara.

EGO Ankara Department of Transportation Planning and Rail System (1992a) *Ankaray Ankara Light Rail System, Vol. 1 Transportation Survey*. Ankara: Municipality of Greater Ankara.

EGO Ankara Department of Transportation Planning and Rail System (1992b) *Ankaray Ankara Light Rail System, Vol. 2 Project Report*. Ankara: Municipality of Greater Ankara.

EGO Ankara Department of Transportation Planning and Rail System (1992c) *Ankaray Ankara Light Rail System, Vol. 3 Transportation Survey*. Ankara: Municipality of Greater Ankara.

EGO Genel Müdürlüğü Hizmet İyileştirme ve Kurumsal Gelişim Dairesi Başkanlığı (2020) *COVID-19 Salgını Sürecinde Alınan Tedbirler ve Yapılan İletişim Çalışmaları*. Ankara. Available at: https://koronavirus.ego.gov.tr/katalog/pages/katalog.pdf.

Eisenman Architects (2012) *Yenikapi Archaeological Museum and Archeo-park 2012-current - EISENMAN ARCHITECTS*. Available at: https://eisenmanarchitects.com/Yenikapi-Archaeological-Museum-and-Archeo-park-2012-current (Accessed: 25 November 2019).

Equinox, V. (2018) ‘VMC Station two levels’, *Wikimedia Commons*, 14 May. Available at: https://commons.wikimedia.org/w/index.php?curid=70589728.

Erem, C. (2015) ‘Prevalence of Overweight and Obesity in Turkey’, *IJC Metabolic & Endocrine*, 8, pp. 38–41. doi: 10.1016/j.ijcme.2015.07.002.

Eriksson, R. (2018) ‘Downsview Park Station’, *Wikimedia Commons*, 20 May. Available at: https://commons.wikimedia.org/w/index.php?curid=70560700.

Eshot Genel Müdürlüğü (2020) *Eshot Genel Müdürlüğü Resmi Web Sitesi*. Available at: https://www.eshot.gov.tr/tr/Haberler/3761/91?AspxAutoDetectCookieSupport=1 (Accessed: 19 August 2020).

Evans, G. W. and Wener, R. E. (2007) ‘Crowding and personal space invasion on the train: Please don’t make me sit in the middle’, *Journal of Environmental Psychology*. Academic Press, 27(1), pp. 90–94. doi: 10.1016/J.JENVP.2006.10.002.

Filion, P., Charney, I. and Weber, R. (2015) ‘Downtowns that Work’, *Canadian Journal of Urban Research*. Institute of Urban Studies, University of Winnipeg, 24(2), pp. 20–42. Available at: http://www.jstor.org/stable/26195290.

Fitzsimmons, E. G. (2017) ‘Key to Improving Subway Service in New York? Modern Signals - The New York Times’, *New York Times*, 1 May. Available at: https://www.nytimes.com/2017/05/01/nyregion/new-york-subway-signals.html (Accessed: 17 June 2020).

Florida, R. (2020a) *Cities Will Survive Pandemics and Protests*, *Bloomberg CityLab*. Available at: https://www.bloomberg.com/news/features/2020-06-19/cities-will-survive-pandemics-and-protests?cmpid=BBD061920_CITYLABMP&utm_medium=email&utm_source=newsletter&utm_term=200619&utm_campaign=citylabmostpop (Accessed: 20 June 2020).

Florida, R. (2020b) ‘The Lasting Normal for the Post-Pandemic City’, *Bloomberg CityLab*, 25 June. Available at: https://www.bloomberg.com/news/features/2020-06-25/the-new-normal-after-the-coronavirus-pandemic.

Foster + Partners (1999) *Canary Wharf Underground | Foster + Partners*. Available at: https://www.fosterandpartners.com/projects/canary-wharf-underground-station/ (Accessed: 10 August 2020).

Foster, N. (2019) *Bilbao Metro | Architecture Projects | Foster + Partners*. Available at: https://www.fosterandpartners.com/projects/bilbao-metro/ (Accessed: 18 November 2019).

Friedman, J. (2000) ‘Soviet Mastery of the Skies at the Mayakovsky Metro Station’, *Studies in the Decorative Arts*. The University of Chicago Press, 7(2), pp. 48–64. doi: 10.1086/studdecoarts.7.2.40662740.

Fruin, J. J. (1971) *Pedestrian Planning and Design*. 2nd edn. New York, NY: Metropolitan Association of Urban Designers and Enviromental Planners, Inc. Available at: https://books.google.com.tr/books?id=vrckAQAAMAAJ.

Fryar, C. D., Gu, Q. and Ogden, C. L. (2012) *Anthropometric reference data for children and adults: United States, 2007-2010.*, *Vital and health statistics. Series 11, Data from the national health survey*. Available at: http://www.ncbi.nlm.nih.gov/pubmed/25204692.

Fuji Electric Global (2020) *Face Mask Vending Machine*. Available at: https://www.fujielectric.com/products/can_pet_vending_machine/mask/ (Accessed: 20 August 2020).

Gabriel, D. (2018) ‘Revolution from 360 Feet Below: Form and Ideology in the

Pyongyang Metro', *Journal of Korean Studies*, 23(1), pp. 111–133. doi: 10.1215/21581665-4339080.

Gamayunova, O. and Gumerova, E. (2016) 'Solutions to the Urban Problems by Using of Underground Space', *Procedia Engineering*, 165, pp. 1637–1642. doi: https://doi.org/10.1016/j.proeng.2016.11.904.

Garavito-Bruhn, E., Napoli, A. and Towell, N. (2019) 'Second Avenue Subway Project, New York: Refurbishment of an Existing Underground Station', *Structures Congress 2012*. (Proceedings), pp. 1258–1269. doi: doi:10.1061/9780784412367.113.

Geology of Sweden (2019). Available at: https://www.sgu.se/en/geology-of-sweden/ (Accessed: 14 April 2019).

Giffen, R., Ezzeldin, K. and Towell, N. (2019) 'Second Avenue Subway Project, New York Reconstructing Existing Buildings for New Station Entrances', *Structures Congress 2009*. (Proceedings), pp. 1–8. doi: doi:10.1061/41031(341)219.

Giovanis, E. (2018) 'The relationship between teleworking, traffic and air pollution', *Atmospheric Pollution Research*, 9(1), pp. 1–14. doi: https://doi.org/10.1016/j.apr.2017.06.004.

Google Earth and Maxar Technologies (2020) *Google Earth, Yenikapı İstanbul, 41° 0'19.79"N 28°57'6.09"E Elevation 1000m*. Google.

Gössling, S. (2020) 'Integrating e-scooters in urban transportation: Problems, policies, and the prospect of system change', *Transportation Research Part D: Transport and Environment*, 79, p. 102230. doi: https://doi.org/10.1016/j.trd.2020.102230.

Government of South Australia Department of Planning Transport and Infrastructure (2013) *Public Transport Services Engineering Management System Technical Standard AR-PW-PM-SPE-00129003*. Adelaide.

Gravit, M., Vaititckii, A. and Shpakova, A. (2016) 'Subway Constructions Fire Safety Regulatory Requirements', *Procedia Engineering*. Elsevier, 165, pp. 1667–1672. doi: 10.1016/J.PROENG.2016.11.908.

Griffin, Kenneth W. (2004) *Building type basics for transit facilities*. Hoboken, New Jersey: John Wiley & Sons (Building type basics series).

Griffin, K W (2004) 'Station Types and Configurations', in *Building type basics for transit facilities*. Hoboken, New Jersey: John Wiley & Sons (Building type basics series), pp. 63–80.

Griffiths, M. (2016) '"Imagine if our cities talked to us":', in Griffiths, M. and Barbour, K. (eds) *Making Publics, Making Places*. University of Adelaide Press, pp. 27–48. Available at: http://www.jstor.org/stable/10.20851/j.ctt1t304qd.8.

Grigson, R., Ho, C. and LeMus, P. (2019) 'Second Avenue Subway Project: Deep

Excavation Support of a Cut-and-Cover Station', *Geotechnical and Structural Engineering Congress 2016*. (Proceedings), pp. 402–415. doi: doi:10.1061/9780784479742.033.

Güneş, S. (2007) *The Influence of Design Considerations of Metro Stations in the Context of City Identity: the Case of Ankaray and Ankara Metro*. Middle East Technical University (METU).

Gürtaş, M. A. (2019) *Turkey's elderly population rises to over 7M in 2018*. Available at: https://www.aa.com.tr/en/economy/turkey-s-elderly-population-rises-to-over-7m-in-2018/1421534 (Accessed: 12 February 2020).

Guse, C. and Tracy, T. (2019) '17 people trapped when Second Ave. subway elevator gets stuck', *New York Daily News*, 31 May. Available at: https://www.nydailynews.com/new-york/nyc-crime/ny-second-ave-train-elevator-stops-20190531-yrob36ikybfmrk7npazlat3g74-story.html.

H, T. (2016) 'Lawrence Station Platform', *Wikimedia Commons*, 1 September. Available at: https://commons.wikimedia.org/w/index.php?curid=51043770.

Hadlaw, J. (2003) 'The London Underground Map: Imagining Modern Time and Space', *Design Issues*. MIT Press, 19(1), pp. 25–35. Available at: http://www.jstor.org/stable/1512052.

Hafter, B. O. (tran.) (2008) *BOStrab: German Federal Regulations on the construction and operation of light rail transit systems*. Federal Ministry of Transport and Digital Infrastructure. Available at: file:///C:/Users/oo_oz_000/Downloads/BOStrab-EN_Version_2008-05-12.pdf.

Hall, E. T. (1992) *The Hidden Dimension*. Anchor Books. Available at: https://books.google.com.tr/books?id=HlmqAAAACAAJ.

Hallenhe, M. (2020) 'Just the ticket: Skåne's new approach to regional travel', *Intelligent Transport*. Edited by L. Antoniou. Kent, 04(01), pp. 12–14.

Handel, O. and Borrmann, A. (2017) 'Service bottlenecks in pedestrian dynamics', *Transportmetrica A: Transport Science*. Taylor & Francis, pp. 1–14. doi: 10.1080/23249935.2017.1280712.

Harris, J. E. (2020) 'The Subways Seeded the Massive Coronavirus Epidemic in New York City', *National Bureau of Economic Research Working Paper Series*, 27021. doi: http://www.nber.org/papers/w27021.

Haywood, L., Koning, M. and Monchambert, G. (2017) 'Crowding in public transport: Who cares and why?', *Transportation Research Part A: Policy and Practice*. Pergamon, 100, pp. 215–227. doi: 10.1016/J.TRA.2017.04.022.

Hediger, H. (1964) *Wild Animals in Captivity*. 2nd edn. New York City,NY: Dover Publications.

Hillier, B. (2015) *Space is the machine : a configurational theory of architecture*.

Cambridge University Press. Available at: https://books.google.com.tr/books/about/Space_is_the_Machine.html?id=8CygHAAACAAJ&source=kp_book_description&redir_esc=y (Accessed: 9 December 2018).

Hopkins, J. (1996) 'Excavating Toronto's Underground Streets:', in CAULFIELD, J. O. N. and PEAKE, L. (eds) *City Lives and City Forms*. University of Toronto Press (Critical Research and Canadian Urbanism), pp. 63–81. Available at: http://www.jstor.org/stable/10.3138/j.ctt2ttmhz.9.

Hu, W. and Goldbaum, C. (2020) *With Fewer People in the Way, Transportation Projects Speed Ahead - The New York Times*, *The New York Times*. Available at: https://www.nytimes.com/2020/06/05/nyregion/coronavirus-ny-transportation-work.html (Accessed: 17 June 2020).

Hürriyet Daily News (2018) *Yenikapı shipwrecks in need of museum*, *Hürriyet*. Available at: http://www.hurriyetdailynews.com/yenikapi-shipwrecks-in-need-of-museum-138520 (Accessed: 1 December 2019).

Hürriyet Haber (2016) 'Metrobüs üst geçidinde izdiham!' Available at: http://www.hurriyet.com.tr/metrobus-ust-gecidinde-izdiham-40299330.

IBB Raylı Sistem Daire Başkanlığı Raylı Sistem Projeler Müdürlüğü (2019) *Metro Tasarım Kriterleri ve Genel Esasları*. 1st edn. Istanbul.

İETT (2017) *İstanbul`da Toplu Ulaşım*. Available at: http://www.iett.istanbul/tr/main/pages/istanbulda-toplu-ulasim/95 (Accessed: 19 April 2017).

İHA (2015) 'Metrobüs durağında insan seli !', *Milliyet Haber*. Available at: http://www.milliyet.com.tr/metrobus-duraginda-insan-seli--gundem-2127126/.

Île-de-France Mobilités (2017) *Rapport D'activité 2014*, *PrimaryCare*. Paris. doi: 10.4414/pc-f.2015.01082.

İstanbul Büyükşehir Belediyesi (2020) *İstanbul'un Metrosu - Raylı Sistemler*. Available at: http://istanbulunmetrosu.ibb.gov.tr/Home/rayliSistemler?Lang=tr-TR (Accessed: 4 July 2020).

İzmir Metro (2019) *İzmir Metro A.Ş.* Available at: https://www.izmirmetro.com.tr/Sayfa/13/1/tarihce (Accessed: 24 November 2019).

Jacobs, J. (2011) 'The death and life of great American cities'. New York: Modern Library. Available at: https://archive.org/details/deathlifeofgreat0000jaco.

James, P. T. *et al.* (2001) 'The Worldwide Obesity Epidemic', *Obesity Research*. John Wiley & Sons, Ltd, 9(S11), pp. 228S-233S. doi: 10.1038/oby.2001.123.

Jenks, A. (2000) 'A Metro on the Mount: The Underground as a Church of Soviet Civilization', *Technology and Culture*. [The Johns Hopkins University Press, Society for the History of Technology], 41(4), pp. 697–724. Available at:

http://www.jstor.org/stable/25147594.

Jia, J. and Fang, Y. (2016) ‘Underground Space Development in Comprehensive Transport Hubs in China’, *Procedia Engineering*. Elsevier, 165, pp. 404–417. doi: 10.1016/J.PROENG.2016.11.716.

Jiang, C. S. *et al.* (2009) ‘Crowding in platform staircases of a subway station in China during rush hours’, *Safety Science*. Elsevier, 47(7), pp. 931–938. doi: 10.1016/J.SSCI.2008.10.003.

JICA (2010a) ‘JICA Preparatory Survey on Greater Cairo Metro Line No.4 in the Arab Republic of Egypt Final Report Volume 3 Feasibility Study Report 3/4’, p. 905.

JICA (2010b) ‘Preliminary Design (Phase 1)’, in *JICA Preparatory Survey on Greater Cairo Metro Line No.4 in the Arab Republic of Egypt*, pp. 1–461.

Jodidio, P. and Foster, N. (2001) *Sir Norman Foster*. Köln; London: Taschen.

Jones, K. B. (2016) *Suspending modernity: The architecture of Franco Albini*, *Suspending Modernity: The Architecture of Franco Albini*. doi: 10.4324/9781315611433.

Kaptan, H. (2012) *Atelye70 | Yenikapı Transfer Noktası*. Available at: http://atelye70.com/project/yenikapi_transfer_noktasi/ (Accessed: 1 December 2019).

Karakoç, N. (2017) *1. Ödül, Evka 3 Sosyal Merkez ve Aktarma İstasyonu Yarışması - Arkitera*. Available at: https://www.arkitera.com/proje/1-odul-evka-3-sosyal-merkez-ve-aktarma-istasyonu-yarismasi/ (Accessed: 1 December 2019).

Karataş, P. (2015) *Determination of pedestrian level of service for walkways: Metu campus example*. Middle East Technical University (METU). Department of Civil Engineering. . Available at: http://library.metu.edu.tr/search~S15?/Xpedestrian+&searchscope=15&SORT=DZ/Xpedestrian+&searchscope=15&SORT=DZ&extended=0&SUBKEY=pedestrian+/1%2C32%2C32%2CB/frameset&FF=Xpedestrian+&searchscope=15&SORT=DZ&2%2C2%2C.

Karjalainen, P. (2020) ‘Tackling the Challenge’, *Intelligent Transport*. Edited by L. Antoniou. Kent, 04(01), pp. 16–19.

Kazda, T. and Caves, B. (2010) ‘Air Transport and Airports’, in *Airport Design and Operation*. Second Edi. Oxford: Elsevier, pp. 1–20. doi: 10.1108/9780080546438-001.

Kengo Kuma & Associates (2016) *Saint-Denis Pleyel Emblematic Train Station (on going) | Architecture | Kengo Kuma and Associates*. Available at: https://kkaa.co.jp/works/architecture/saint-denis-pleyel-emblematic-train-station/ (Accessed: 3 December 2019).

Kettering, K. L. (2000a) ‘An Introduction to the Design of the Moscow Metro in the

Stalin Period: "The Happiness of Life Underground"', *Studies in the Decorative Arts*. The Bard Graduate Center for Studies in the Decorative Arts, 7(2), pp. 2–20. doi: 10.1086/studdecoarts.7.2.40662738.

Kettering, K. L. (2000b) 'Sverdlov Square Metro Station: "The Friendship of the Peoples" and the Stalin Constitution', *Studies in the Decorative Arts*. The University of Chicago Press, 7(2), pp. 21–47. doi: 10.1086/studdecoarts.7.2.40662739.

Kholshevnikov, V. V. V. *et al.* (2008) 'Recent developments in pedestrian flow theory and research in Russia', *Fire Safety Journal*. Elsevier, 43(2), pp. 108–118. doi: 10.1016/J.FIRESAF.2007.05.005.

Kishii, T. (2016) 'Utilization of underground space in Japan', *Tunnelling and Underground Space Technology*, 55, pp. 320–323. doi: https://doi.org/10.1016/j.tust.2015.12.007.

Ko, Y. (2017) 'Vaughan Metropolitan Centre', *Wikimedia Commons*, 19 December. Available at: https://commons.wikimedia.org/w/index.php?curid=64912098.

Kolektif Mimarlar (2019) *EVKA-3 Social Center & Transportation Hub*. Available at: http://kolektifmimarlar.com/projects/evka-3-2/ (Accessed: 4 August 2020).

Korotaev, V. (2016) 'Spatial Organization of Russian Cities. Underground Development', *Procedia Engineering*. Elsevier, 165, pp. 622–626. doi: 10.1016/J.PROENG.2016.11.758.

Kretzmann, J. P. *et al.* (1993) *Building communities from the inside out : a path toward finding and mobilizing a community's assets*.

Kutkan-Ozturk, Y. (2019) *The Albinian way of design at the Milan Metro*. doi: 10.1201/9780429424441-10.

Kutkan, Y. (2010) *Franco Albini and His Approach on Metropolitan of Milan with Franca Helg and Bob Noorda*. Politecnico Milano. Available at: https://www.politesi.polimi.it/handle/10589/1361.

Laker, L. (2020) *Milan announces ambitious scheme to reduce car use after lockdown*, *The Guardian*. Available at: https://www.theguardian.com/world/2020/apr/21/milan-seeks-to-prevent-post-crisis-return-of-traffic-pollution (Accessed: 3 June 2020).

Landis-Hanley, U. (2020) *'Bicycles are the new toilet paper': bike sales boom as coronavirus lockdown residents crave exercise*, *The Guardian*. Available at: https://www.theguardian.com/lifeandstyle/2020/apr/22/bicycles-are-the-new-toilet-paper-bike-sales-boom-as-coronavirus-lockdown-residents-crave-exercise (Accessed: 3 June 2020).

Lang, J. (1994) *Urban Design: The American Experience*. New York, NY: Van Nostrand Reinhold.

Lang, J. T. (2017) *Urban design : a typology of procedures and products : illustrated* *with over 50 case studies*. New York: Routledge.

Lanzl, C. (2020) 'TOWARD A NEW PARADIGM: Public Art and Placemaking in the Twenty-First Century', in Henseler, C. (ed.) *Extraordinary Partnerships*. Lever Press (How the Arts and Humanities are Transforming America), pp. 51–72. doi: 10.3998/mpub.11649046.7.

Lawless, J. (2017) *Reported explosion and stampede at London subway station*, *The News-Herald*. Available at: https://www.news-herald.com/news/reported-explosion-and-stampede-at-london-subway-station/article_fcca139c-c38f-55bd-948c-06a831a612f5.html (Accessed: 4 May 2019).

Lazarus, J. *et al.* (2020) 'Micromobility evolution and expansion: Understanding how docked and dockless bikesharing models complement and compete – A case study of San Francisco', *Journal of Transport Geography*, 84, p. 102620. doi: https://doi.org/10.1016/j.jtrangeo.2019.102620.

LeDuc, J. W. and Barry, M. A. (2004) 'SARS, the First Pandemic of the 21st Century1', *Emerging Infectious Diseases*. Centers for Disease Control and Prevention (CDC), 10(11), pp. e26–e26. doi: 10.3201/eid1011.040797_02.

Lee, H. *et al.* (2020) 'The relationship between trends in COVID-19 prevalence and traffic levels in South Korea', *International Journal of Infectious Diseases*, 96, pp. 399–407. doi: https://doi.org/10.1016/j.ijid.2020.05.031.

Lemon, A. (2000) 'Talking Transit and Spectating Transition: The Moscow Metro', in Berdahl, D., Bunzl, M., and Lamp, M. (eds) *Altering States Ethnographies of Transition in Eastern Europe and the Former Soviet Union*. Ann Arbor: The University of Michigan Press, pp. 14–39.

Leonard, B. (ed.) (2000) *Americans With Disabilities Act: Accessibility Guidelines for Buildings & Facilities Cadaag*. Diane Publishing Company. Available at: https://books.google.com.tr/books?id=CKp_0dfy2-AC.

Leung, E. (2017) 'Cavernous', *Wikimedia Commons*, 25 December. Available at: https://commons.wikimedia.org/wiki/File:Cavernous_(27523453249).jpg.

Lévi-Strauss, C. (2009) *Structural anthropology*. New York: Basic Books.

Levi, J. *et al.* (2013) *F as in Fat*. Edited by S. Kahn and M. Vinluan. Trust for America's Health/Robert Wood Johnson Foundation.

Liu, R. and Ren, S. (2020) 'Chinese Cities Today: Modal Shifts & Private Sector Responses', 28 May.

London Bus Services Limited and London Buses (2002) *Operational and construction guidelines*. London: Transport for London.

London City Hall (2020) *Mayor's bold new Streetspace plan will overhaul London's streets*, *Mayor of London*. Available at: https://www.london.gov.uk/press-releases/mayoral/mayors-bold-plan-will-overhaul-capitals-streets (Accessed: 29

June 2020).

London, M. (1940) *London Underground during bombing raids Guardian Century*, *The Guardian*. Available at: https://www.theguardian.com/century/1940-1949/Story/0,,127366,00.html (Accessed: 18 August 2020).

Long, J. (2020) 'Connecting urban mobility and passenger experience', *Intelligent Transport*. Edited by L. Antoniou. Kent, 04(01), pp. 22–23.

Lucan, J. and Bru, E. (1998) *Eduardo Souto de Moura : obra reciente = recent work*. Barcelona: Gustavo Gili.

Lykke, S. and Belkaya, H. (2005) 'Marmaray project: The project and its management', *Tunnelling and Underground Space Technology*. Pergamon, 20(6), pp. 600–603. doi: 10.1016/J.TUST.2005.08.004.

Lynch, K. (1960) *The Image of the City*. Harvard U.P.; Oxford U.P (Harvard-MIT Joint Center for Urban Studies Series). Available at: https://books.google.com.tr/books?id=_phRPWsSpAgC.

Lynch, K. (1984) *Good city form*. Massachusetts: MIT Press (Architecture, urban studies). Available at: http://www.amazon.co.uk/Good-City-Form-K-Lynch/dp/0262620464.

Martinez, J. (2019) 'Steep Descent For Subways' Worst Escalator and Elevator', *The City*, 21 May. Available at: https://thecity.nyc/2019/05/steep-descent-for-subways-worst-escalator-and-elevator.html.

Maslak, V. and Boytsov, D. (2016) 'Modular Design of Subway Facilities', *Procedia Engineering*. Elsevier, 165, pp. 782–787. doi: 10.1016/J.PROENG.2016.11.775.

Mecanoo (2012) *Yenikapi Transfer Point and Archaeo Park*. Available at: https://www.mecanoo.nl/Projects/project/109/Yenikapi-Transfer-Point-and-Archaeo-Park?t=13 (Accessed: 1 December 2019).

Von Meiss, P. (2014) 'Place', in *Elements of architecture: from form to place.* Routledge.

Metro İstanbul (2017) *Metro İstanbul Yolcu İstatistikleri*. Available at: http://www.metro.istanbul/hakkımızda/yolcu-istatistikleri.aspx (Accessed: 25 April 2017).

Metro İstanbul (2019) *Hakkımızda*. Available at: https://www.metro.istanbul/icerik/hakkimizda (Accessed: 24 November 2019).

Metro İstanbul (2020) *Metro ve tramvaylarda sosyal mesafe önlemi…*, *Metro İstanbul* . Available at: https://www.metro.istanbul/haber/detay/metroda-sosyal-mesafe-onlemi (Accessed: 19 August 2020).

Metropolitan Council (2012) *Station and Support Facility Design Guidelines User GuideA Supplement to the Regional Transitway Guidelines*. Saint Paul.

Meyer, D. and Barone, V. (2020) *MTA suspends employee fingerprint scans to combat coronavirus*, *New York Post*. Available at: https://nypost.com/2020/03/10/mta-suspends-employee-fingerprint-scans-to-combat-coronavirus/ (Accessed: 20 August 2020).

Miller, M. and Raines, S. (2000) 'elements of a continuity: THE WASHINGTON D.C. METRO', *PRAXIS: Journal of Writing + Building*. Temporary Publisher, 1(1), pp. 116–123. Available at: http://www.jstor.org/stable/24328861.

Ministry of Housing and Urban-Rural Development (2013) *GB 50157-2013 Code for Design of Metro (English Version)*. Beijing.

De Mira Correa, J. (2011) *The 2011 Pritzker architecture prize : Eduardo Souto De Moura.* North Point: DesignMedia Pub.

Mok, T. (2020) 'There are now face mask vending machines in Toronto malls', *blogTO*, 3 August. Available at: https://www.blogto.com/city/2020/08/face-mask-vending-machines-toronto-malls/ (Accessed: 20 August 2020).

Molteni, S. C. *et al.* (2001) 'Design of anidolic zenithal lightguides for daylighting of underground spaces', *Solar Energy*, 69, pp. 117–129. doi: https://doi.org/10.1016/S0038-092X(01)00065-2.

Moody, A. (2013) 'Adult anthropometric measures, overweight and obesity', in *Health Survey for England - 2012*. London: The Health and Social Care Information Centre, p. 39.

Moran, M. E., Laa, B. and Emberger, G. (2020) 'Six scooter operators, six maps: Spatial coverage and regulation of micromobility in Vienna, Austria', *Case Studies on Transport Policy*, 8(2), pp. 658–671. doi: https://doi.org/10.1016/j.cstp.2020.03.001.

Morris, N. (2020) *UK's first face mask vending machines launch in London |* , *Metro News*. Available at: https://metro.co.uk/2020/06/15/uks-first-face-mask-vending-machines-launch-london-12854051/ (Accessed: 20 August 2020).

MTA (2015) *mta.info | Facts and Figures*. Available at: http://web.mta.info/nyct/facts/ffsubway.htm (Accessed: 25 April 2017).

Nadler, J. (2001) *Congressman Nadler Calls for New Second Ave. Subway Funds | U.S. Representative Jerry Nadler*. Available at: https://nadler.house.gov/news/documentsingle.aspx?DocumentID=392421 (Accessed: 22 May 2019).

National Academies of Sciences Engineering and Medicine (2013a) 'Quality of Service Methods', in Kittelson & Associates, I. et al. (eds) *Transit Capacity and Quality of Service Manual*. 3rd edn. Washington, DC: The National Academies Pres, p. 101. doi: 10.17226/24766.

National Academies of Sciences Engineering and Medicine (2013b) 'Station

Capacity', in Kittelson & Associates, I. et al. (eds) *Transit Capacity and Quality of Service Manual*. 3rd edn. Washington, DC: The National Academies Press, p. 126. doi: 10.17226/24766.

National Academies of Sciences Engineering and Medicine (2013c) *Transit Capacity and Quality of Service Manual, Third Edition*. Edited by I. Kittelson & Associates et al. Washington, DC: The National Academies Press. doi: 10.17226/24766.

National Fire Protection Association. (2017a) *NFPA 101, life safety code*. Available at: https://books.google.com.tr/books?id=9r3QoAEACAAJ&dq=nfpa+101&hl=tr&sa=X&redir_esc=y (Accessed: 26 April 2017).

National Fire Protection Association. (2017b) *NFPA 130 : Standard for fixed guideway transit and passenger rail systems.* National Fire Protection Association.

NBC 4 New York (2018) *Frantic Subway Riders Stampede as 'Ball of Fire' Erupts in Manhattan Station - NBC New York*, *NBC 4 New York* . Available at: https://www.nbcnewyork.com/news/local/Subway-Stampede-Fire-Manhattan-Upper-West-Side-MTA-FDNY-New-York-476276123.html (Accessed: 4 May 2019).

Neff, J., Dickens, M. and Public Transportation Association, A. (2015) *2015 APTA Public Transportation Fact Book*. Available at: https://www.apta.com/resources/statistics/Documents/FactBook/2015-APTA-Fact-Book.pdf (Accessed: 25 April 2017).

Nelson, H. E. "Bud" and Mowrer, F. W. (2002) 'Emergency Movement', in DiNenno, P. J. and Walton, W. D. (eds) *The SFPE Handbook of Fire Protection Engineering*. 2nd edn. Quincy: National Fire Protection Association, pp. 367–380.

Network Rail – Station Capacity Guidance (2014). London: Network Rail.

New York City Transit (2017) *Fast Forward: The Plan to Modernize New York City Transit*. New York City,NY.

Nielsen, S. Z. *et al.* (2014) 'Taking the temperature of pedestrian movement in public spaces', in *Transportation Research Procedia*. doi: 10.1016/j.trpro.2014.09.071.

Nordfjærn, T. and Şimşekoğlu, Ö. (2013) 'The role of cultural factors and attitudes for pedestrian behaviour in an urban Turkish sample', *Transportation Research Part F: Traffic Psychology and Behaviour*. Pergamon, 21, pp. 181–193. doi: 10.1016/j.trf.2013.09.015.

O'Sullivan, F. (2020a) *Japan and France Find Public Transit Seems Safe - CityLab*, *City Lab*. Available at: https://www.citylab.com/transportation/2020/06/coronavirus-risk-transit-france-japan-trains-subway-buses/612841/ (Accessed: 10 June 2020).

O'Sullivan, F. (2020b) 'Londoners Have Become Afraid of Public Transit', *Bloomberg CityLab*, 12 June. Available at: https://www.bloomberg.com/news/articles/2020-06-12/fear-of-public-transit-remains-high-in-london.

O'Sullivan, F. (2020c) *Trains, Planes and Buses: How to Avoid Coronavirus*, *CityLab*. Available at: https://www.citylab.com/transportation/2020/05/coronavirus-protection-travel-planes-trains-buses-subway/611656/ (Accessed: 10 June 2020).

OECD (2007) *Society at a Glance 2006*. Paris: OECD (Society at a Glance). doi: 10.1787/soc_glance-2006-en.

OECD (2014) *Society at a Glance 2014*. Paris: OECD (Society at a Glance). doi: 10.1787/9789264261488-en.

OECD (2016) *Society at a Glance 2016*. Paris: OECD (Society at a Glance). doi: 10.1787/9789264261488-en.

Özer, B. K. (2008) 'Secular trend in body height and weight of Turkish adults', *Anthropological Science*, 116(3), pp. 191–199. doi: 10.1537/ase.061213.

Özgür Cevher, Ö. (2014) *The Link between station area design and transit usage: the case of Ankara*. Middle East Technical University (METU). Available at: http://library.metu.edu.tr/search~S9?/Xpedestrian+&searchscope=9&SORT=DZ/Xpedestrian+&searchscope=9&SORT=DZ&extended=0&SUBKEY=pedestrian+/1%2C3%2C3%2CB/frameset&FF=Xpedestrian+&searchscope=9&SORT=DZ&2%2C2%2C.

P.Grasgruber *et al.* (2014) 'The role of nutrition and genetics as key determinants of the positive height trend', *Economics and Human Biology*. North-Holland, 15, pp. 81–100. doi: 10.1016/j.ehb.2014.07.002.

P h n (2014) 'Platform view of San Babila station, line 1, Milan metro', *Wikimedia Commons*, 31 May.

Parikh, A., Phillips, D. and Sykes, M. (2019) 'Second Avenue Subway Project History and Construction Challenges', *Geotechnical Engineering for Transportation Projects*. (Proceedings), pp. 1534–1546. doi: doi:10.1061/40744(154)145.

Park, J. (2020) 'Changes in Subway Ridership in Response to COVID-19 in Seoul, South Korea: Implications for Social Distancing', *Cureus*. Cureus, 12(4), pp. e7668–e7668. doi: 10.7759/cureus.7668.

Pauls, J. (2003) 'Evacuation and other movement in buildings: some high-rise evacuation models, general pedestrian movement models and human performance data needs', in *Second International Conference in Pedestrian And Evacuation Dynamics (PED)*. London: The University of Greenwich.

Pempel, K. (2020) 'Vending machines selling face masks appear on Warsaw streets - The Globe and Mail', *the Globe and Mail*, 10 April. Available at:

https://www.theglobeandmail.com/world/article-vending-machines-selling-face-masks-appear-on-warsaw-streets/ (Accessed: 20 August 2020).

Piazza, M., Anceschi, G. and Baule, G. (2015) *Bob Noorda : design*.

Pokorny, C. (2019) *Second Avenue Subway Escalators Outages MTA/OIG #2018-61*. New York.

PowWowNow (2019) *London's most stressful Tube stations*. Available at: https://www.powwownow.co.uk/smarter-working/londons-most-stressful-tube-stations (Accessed: 21 May 2019).

Predtechenskiĭ, V. M. and Milinskii, A. I. (1978) *Planning for foot traffic flow in buildings*. New Delhi.

Project for Public Spaces (2000) *How to turn a place around : a handbook for creating successful public spaces*. New York, NY: Project for Public Spaces.

Pulido, D. *et al.* (2018) *The Urban Rail Development Handbook*. Washington, D.C. Available at: http://documents.worldbank.org/curated/en/583011538651181032/The-Urban-Rail-Development-Handbook.

Quantrill, M. (1999) *The Norman Foster studio : consistency through diversity*.

Queensland Government (2015) *Public Transport Infrastructure Manual (PTIM) 2015*. Brisbane: Department of Transport and Main Roads – TransLink Division.

Rasmussen, S. E. (1964) *Experiencing Architecture*. Cambridge: The MIT Press.

Rastogi, R., Thaniarasu, I. and Chandra, S. (2011) 'Design Implications of Walking Speed for Pedestrian Facilities', *Journal of Transportation Engineering*, 137(10), pp. 687–696. doi: 10.1061/(ASCE)TE.1943-5436.0000251.

Reeves, P. (1995) 'Old wiring caused worst metro disaster', *Independent*, October.

Rose, M. and Aydingün, S. (2007) 'Under Istanbul', *Archaeology*, 60(4), pp. 34–40.

Rosenthal, B. M., Fitzsimmons, E. G. and LaForgia, M. (2017) 'How Politics and Bad Decisions Starved New York's Subways - The New York Times', *New York Times*, 18 October. Available at: https://www.nytimes.com/2017/11/18/nyregion/new-york-subway-system-failure-delays.html (Accessed: 17 June 2020).

Sahin, T. (2013) *Lost Ottoman projects*.

Schneekloth, L. H. and Shibley, R. G. (1995) 'Placemaking : the art and practice of building communities'. New York: Wiley. Available at: http://books.google.com/books?id=RpGxAAAAIAAJ.

Schrag, Z. M. (2014) *The Great Society subway : a history of the Washington Metro*.

Scott, T. (2020) *Continued Safe Operation of the London Undergroundtrain Service Through the Coronavirus Pandemic*. London. Available at: http://content.tfl.gov.uk/london-underground-change-assurance-plan-and-risk-assessment-covid19.pdf.

Seibert, T. (2011) *New Istanbul bridge sparks criticism*, *The National*. Available at: https://www.thenational.ae/world/europe/new-istanbul-bridge-sparks-criticism-1.412884 (Accessed: 1 December 2019).

Şenerdem, E. D. (2010) 'Pedestrian jam follows closure of Istanbul's Çağlayan Square', *Hurriyet Daily News*. Available at: http://www.hurriyetdailynews.com/pedestrian-jam-follows-closure-of-istanbuls-caglayan-square.aspx?pageID=438&n=pedestrians-the-least-thought-after-traffic-closed-in-caglayan-square-2010-10-26.

Shabanpour, R. *et al.* (2018) 'Analysis of telecommuting behavior and impacts on travel demand and the environment', *Transportation Research Part D: Transport and Environment*, 62, pp. 563–576. doi: https://doi.org/10.1016/j.trd.2018.04.003.

Shaheen, S. *et al.* (2020) 'Chapter 13 - Sharing strategies: carsharing, shared micromobility (bikesharing and scooter sharing), transportation network companies, microtransit, and other innovative mobility modes', in Deakin Land Use, and Environmental Planning, E. B. T.-T. (ed.). Elsevier, pp. 237–262. doi: https://doi.org/10.1016/B978-0-12-815167-9.00013-X.

Silvio d'Ascia Architecture – BIG (2016) *Pont de Bondy Metro — Silvio d'Ascia Architecture*. Available at: https://www.dascia.com/pont-de-bondy-metro-1 (Accessed: 3 June 2019).

Şimşekoğlu, Ö. (2015) 'How Do Attitudes, Personality Traits, and Driver Behaviors Relate to Pedestrian Behaviors?: A Turkish Case', *Traffic Injury Prevention*. Taylor & Francis, 16(1), pp. 84–89. doi: 10.1080/15389588.2014.880785.

Sinclair, D. (2013) *RIBA Plan Of Work 2013*. 1st edn. London: RIBA Publishing.

Singer, G. and Burda, C. (2014) *Fast Cities*. Toronto: Pembina Institute. Available at: http://www.jstor.org/stable/resrep00211.

Smithson, A. (1963) 'TEAM 10 PRIMER 1953-62', *Ekistics*. Athens Center of Ekistics, 15(91), pp. 349–360. doi: 10.2307/43616184.

Société de Calcul Mathématique SA (2011) *Le métro du 'Grand Paris' Livre blanc à l'attention des décideurs*. Paris.

Société du Grand Paris (2014) *Le Cadre Conceptuel Des Projects Connexes aux Gares du Grand Paris*. Paris.

Société du Grand Paris (2016) *Grand Paris Express, the largest transport project in Europe | Société du Grand Paris*. Available at: https://www.societedugrandparis.fr/info/grand-paris-express-largest-transport-project-europe-1061 (Accessed: 4 December 2019).

Société du Grand Paris (2019a) *Métro de demain | Société du Grand Paris*. Available at: https://www.societedugrandparis.fr/info/metro-de-demain-202 (Accessed: 3 December 2019).

Société du Grand Paris (2019b) *Pont de Bondy | Société du Grand Paris*. Available at: https://www.societedugrandparis.fr/gpe/gare/pont-de-bondy (Accessed: 4 December 2019).

Société du Grand Paris (2019c) *Saint-Denis Pleyel | Société du Grand Paris*. Available at: https://www.societedugrandparis.fr/gpe/gare/saint-denis-pleyel (Accessed: 3 December 2019).

Sorokina, A. (2019) *What went down in the Moscow Metro during WWII?*, *Russia Beyond*. Available at: https://www.rbth.com/history/331256-moscow-metro-wwii-history (Accessed: 18 August 2020).

Speck, J. (2018) *Walkable city rules : 101 steps to making better places*.

Station (2018a) 'Merriam-Webster's Online Dictionary', in. Available at: https://www.merriam-webster.com (Accessed: 25 May 2018).

Station (2018b) *Oxford Dictionaries*. Available at: https://en.oxforddictionaries.com (Accessed: 25 November 2018).

Stockholm läns Landsting (2017) *Stockholm´s new Metro: our contracts*. Stockholm.

Stones, P. and Heng, T. Y. (2016) 'Underground Space Development Key Planning Factors', *Procedia Engineering*, 165, pp. 343–354. doi: https://doi.org/10.1016/j.proeng.2016.11.709.

Ström, M. (1994) *Metro-art in the Metro-polis*. ACR edition. Available at: https://books.google.com.tr/books?id=cOkxz36ITdoC.

Sun, L.-S. *et al.* (2016) 'Subway Corridor Curve Effects on Pedestrian Characteristics Based on the Legion Studio-Enabled Simulation', in *CICTP 2016*. Reston, VA: American Society of Civil Engineers, pp. 965–975. doi: 10.1061/9780784479896.088.

Swedish Transport Administration (2016) *Network Statement 2017*. Stockholm.

Swedish Transport Administration (2018) *Railway Stations - Planning Manual*. 1st edn. Edited by L. Lingqvist, H. Rundquist, and A. Undén. Borlänge: The Swedish Transport Administration.

Tengborg, P. and Sturk, R. (2016) 'Development of the use of underground space in Sweden', *Tunnelling and Underground Space Technology*, 55, pp. 339–341. doi: https://doi.org/10.1016/j.tust.2016.01.002.

The City of Edmonton (2012) *LRT Technical Design Guidelines, Engineering Consulting Services for Preliminary Engineering for Edmonton's Southeast to West*

Light Rail Transit. Edmonton.

The City of Edmonton (2014) *Valley Line LRT Design Guideline*. Edmonton.

The City of Edmonton (2017) *City of Edmonton – LRT Design Guidelines*. Edmonton.

'The Paris Metropolitan Underground Railroad' (1900) *Scientific American*. Scientific American, a division of Nature America, Inc., 83(8), pp. 120–121. Available at: http://www.jstor.org/stable/26121422.

Thompson, P. *et al.* (2015) 'Evacuation models are running out of time', *Fire Safety Journal*. Elsevier, 78, pp. 251–261. doi: 10.1016/J.FIRESAF.2015.09.004.

Tirachini, A., Hensher, D. A. and Rose, J. M. (2013) 'Crowding in public transport systems: Effects on users, operation and implications for the estimation of demand', *Transportation Research Part A: Policy and Practice*. Pergamon, 53, pp. 36–52. doi: 10.1016/J.TRA.2013.06.005.

Toronto Transit Commission (TTC) (2005) *Toronto-York Spadina Subway Extension Project Sheppard West Station, Approval of Conceptual Design*. Toronto.

Toronto Transit Commission (TTC) (2009a) *Toronto-York Spadina Subway Extension Project Highway 407 Station, Approval of Conceptual Design*. Toronto.

Toronto Transit Commission (TTC) (2009b) *Toronto-York Spadina Subway Extension Project Steeles West Station, Approval of Conceptual Design*. Toronto.

Toronto Transit Commission (TTC) (2009c) *Toronto-York Spadina Subway Extension Project Vaughan Corporate Centre Station, Approval of Conceptual Design*. Toronto.

Toronto Transit Commission (TTC) (2009d) *Toronto-York Spadina Subway Extension Project York University Station, Approval of Conceptual Design*. Toronto.

Toronto Transit Commission (TTC) (2010a) *Toronto-York Spadina Subway Extension Project Finch West Station, Approval of Conceptual Design*. Toronto.

Toronto Transit Commission (TTC) (2010b) *Toronto-York Spadina Subway Extension Project Finch West Station, Approval of Finishes and Artwork*. Toronto.

Toronto Transit Commission (TTC) (2010c) *Toronto-York Spadina Subway Extension Project Highway 407 Station, Approval of Finishes and Artwork*. Toronto.

Toronto Transit Commission (TTC) (2010d) *Toronto-York Spadina Subway Extension Project Sheppard West Station, Approval of Finishes and Artwork*. Toronto.

Toronto Transit Commission (TTC) (2010e) *Toronto-York Spadina Subway Extension Project Vaughan Corporate Centre Station, Approval of Finishes and Artwork*. Toronto.

Toronto Transit Commission (TTC) (2011) *Toronto-York Spadina Subway Extension Project Steeles West Station, Approval of Final Design, Finishes and Artwork*. Toronto.

Transport for London (2010a) *Pedestrian Comfort Guidance for London*. 1st edn. Edited by E. Finch. Transport for London.

Transport for London (2010b) *Traffic Modelling Guidelines TfL Traffic Manager and Network Performance Best Practice*. 3rd edn. Edited by D. J. Smith and R. Blewitt. London: Transport for London.

Transport for London (2012) *LUL - G371A Station Planning Standards and Guidelines*. London.

Transport for London (2013) 'Business Case Development Manual', in. London: Mayor of London, p. 263.

Transport for London (2019a) *London Underground Station Design Idiom*. London: Transport for London.

Transport for London (2019b) *Station types and trivia - Transport for London*. doi: TFL.

Transport for New South Wales Asset Standards Authority (2010a) *ESB 000 Introduction*. Sydney.

Transport for New South Wales Asset Standards Authority (2010b) *ESB 001 Design Context and Process*. Sydney.

Transport for New South Wales Asset Standards Authority (2010c) *ESB 002 Design Principle*. Sydney.

Transport for New South Wales Asset Standards Authority (2016a) *ESB 003 Station Functional Spaces*. Sydney.

Transport for New South Wales Asset Standards Authority (2016b) *ESB 004 Station Services and Systems*. Sydney.

Transportes Publicos Portugal e Espana (2013) *Transportes Publicos Portugal e Espana | Public Transport Portugal and Spain - Andante Ticket System*. Available at: https://transportespublicos.pt/en/glossary/andante/ (Accessed: 17 July 2019).

Transportfan70 (2019) 'Finch West station main entrance building and bus terminal', *Wikimedia Commons*, 21 April. Available at: https://commons.wikimedia.org/w/index.php?curid=78240027.

TSE (1997a) 'TS 12127: Şehir içi yollar-Raylı taşıma sistemleri bölüm 1: Yer altı istasyon tesisleri tasarım kuralları'. Ankara: TSE, p. 32.

TSE (1997b) 'TS 12186 Şehir içi yollar-Raylı taşıma sistemleri, bölüm 2: Yer üstü istasyon tesisleri tasarım kuralları'. Ankara: TSE, p. 27.

TSE (2011) 'TS 9111: Özürlüler ve hareket kısıtlılığı bulunan kişiler için binalarda ulaşılabilirlik gerekleri'. TSE, p. 132.

TSE (2014) 'TS EN 81-20: Safety rules for the construction and installation of lifts - Lifts for the transport of persons and goods - Part 20: Passenger and goods passenger lifts'. Ankara: Türk Standartları Enstitüsü.

TTC (2017) *TTC Line 1 Extension Now Open!* Available at: https://www.ttc.ca/Spadina/Project_News/News_Events/News_by_Date/2017/December/SubwayOpens.jsp (Accessed: 23 September 2019).

Türk Mühendis ve Mimarlar Odaları Birliği (TMMOB) (2011) *Mimarlik Hizmetleri Şartnamesive En Az Bedel Tarifesi*. Ankara.

UIC (2008) *140 (2001)(O-Obligatory) EUROSTATIONS-Accessibility to stations in Europe*. 2nd edn. Paris: Union Internationale des Chemins de Fer (UIC).

UITP (2014) 'Statictics Brief World Metro Figures'. Available at: http://www.uitp.org/sites/default/files/cck-focus-papers-files/Metro report Stat brief-web_oct2014.pdf (Accessed: 24 April 2017).

UITP (2015a) 'Light Rail in Figures', (october), pp. 13–16. Available at: http://www.uitp.org/sites/default/files/cck-focus-papers-files/UITP_Statistic_Brief_4p-Light rail-Web.pdf (Accessed: 24 April 2017).

UITP (2015b) 'World Metro Figures 2014 Outlook and Focus on Automated Lines'. Available at: http://www.uitp.org/sites/default/files/cck-focus-papers-files/UITP-Statistic Brief-Metro-A4-WEB_0.pdf (Accessed: 25 April 2017).

UITP (2018) *Statictics Brief World Metro Figures 2018*. Brussels.

UITP (2020) *Management of Covid-19 Guidelines for Public Transport Operators*. Brussels.

UNESCO (2009) *State of conservation of World Heritage properties inscribed on the World Heritage List*. Sevilla.

UNESCO (2012) *World Heritage Centre and ICOMOS Joint Reactif Monitoring Mission Report:Historic Areas of Istanbul (356)*. Phnom Penh, Cambodia.

United Nations (2018) *World Urbanization Prospects 2018*.

United States Department of Justice (2012) *2010 ADA standards for accessible design.* 2nd edn.

Vähäaho, I. (2014) 'Underground space planning in Helsinki', *Journal of Rock Mechanics and Geotechnical Engineering*. Elsevier, 6(5), pp. 387–398. doi: 10.1016/J.JRMGE.2014.05.005.

Vignelli, M. and Noorda, B. (1970) *Graphics Standard Manual: New York City Transit Authority*. Edited by J. Reed and H. Smyth. New York City,NY: Unimark lntematlonal Consultant Designers.

Vikiçizer (2014) ‘Batıkent metrosundan bir görüntü’, *Wikimedia Commons*, 28 March. Available at: https://commons.wikimedia.org/w/index.php?curid=32828531.

Voorwinde, M. and Giffen, R. (2019) ‘Second Avenue Subway Project, New York: Design of a New Elevator Only Entrance’, *Structures Congress 2012*. (Proceedings), pp. 1282–1292. doi: doi:10.1061/9780784412367.115.

Vuchic, V. R. (2007) ‘History and Role of Public Transportation in Urban Development’, in *Urban Transit Systems and Technology*. Hoboken, New Jersey: John Wiley & Sons, Inc., pp. 1–44.

Vujosevic, T. (2012) ‘Soviet Modernity and the Aesthetics of Gleam: The Moscow Metro in Collective Histories of Construction’, *Journal of Design History*, 26(3), pp. 270–284. doi: 10.1093/jdh/eps035.

Wachowicz, M. *et al.* (2011) ‘Finding moving flock patterns among pedestrians through collective coherence’, *International Journal of Geographical Information Science*. Taylor & Francis, 25(11), pp. 1849–1864. doi: 10.1080/13658816.2011.561209.

Wang, Z., Chen, F. and Li, X. (2012) ‘Comparative Analysis and Pedestrian Simulation Evaluation on Emergency Evacuation Test Methods for Urban Rail Transit Stations’, *Promet - Traffic & Transportation*, 24(6), pp. 535–542. doi: https://doi.org/10.7307/ptt.v24i6.1205.

Washington Metropolitan Area Transit Authority (2005) *Guidelines for Station Site and Access Planning*. Washington, D.C.

Way, C. (2010) *California High-Speed Train Project Technical Memorandum High-Speed Train Station Platform Geometric Design TM 2.2.4*. California, LA.

Weaver, S. (2019) *Vending machines are now selling masks on the Lower East Side*, *TimeOut*. Available at: https://www.timeout.com/newyork/news/now-theres-a-face-mask-vending-machine-in-midtown-060920 (Accessed: 20 August 2020).

Weinstein, A. *et al.* (2008) ‘How Far, by Which Route and Why? A Spatial Analysis of Pedestrian Preference’, *Journal of Urban Design*. doi: 10.1080/13574800701804074.

Weinstein, J. (2020) ‘Upgrading San Francisco’s Clipper system’, *Intelligent Transport*. Edited by L. Antoniou. Kent, 04(01), pp. 10–11.

Wen, Y. *et al.* (2020) ‘Environmental and Health Effects of Ventilation in Subway Stations: A Literature Review’, *International Journal of Environmental Research and Public Health*, 17, p. 1084. doi: 10.3390/ijerph17031084.

WHO (2018) *WHO | Overweight and obesity*, *World Health Organization (WHO)*. World Health Organization. Available at: https://www.who.int/gho/ncd/risk_factors/overweight/en/ (Accessed: 12 May

2019).

Wolf, W. K. (1994) ‘Russia’s revolutionary underground : the construction of the Moscow subway, 1931-35 /’. Available at: http://rave.ohiolink.edu/etdc/view?acc_num=osu1487861396025444 (Accessed: 3 August 2019).

Wong, M. H. (2016) ‘Tens of thousands trapped at Chinese train station in holiday travel rush’, *CNN International*. Available at: http://edition.cnn.com/2016/02/02/travel/china-guangzhou-railway-station-chunyun-crowds/.

World Health Organization (2004) *WHO guidelines for the global surveillance of severe acute respiratory syndrome (SARS)*.

World Health Organization (2010) *Recommendations for the post-pandemic period, Pandemic (H1N1) 2009 briefing note 23*, *World Health Organization*. Geneva: World Health Organization. Available at: https://www.who.int/csr/disease/swineflu/notes/briefing_20100810/en/ (Accessed: 24 June 2020).

World Health Organization (2017) *Pandemic influenza risk management: a WHO guide to inform and harmonize national and international pandemic preparedness and response*. Geneva PP - Geneva: World Health Organization. Available at: https://apps.who.int/iris/handle/10665/259893.

World Health Organization (2020a) *Considerations in adjusting public health and social measures in the context of COVID-19: interim guidance, 16 April 2020*. Geneva PP - Geneva: World Health Organization. Available at: https://apps.who.int/iris/handle/10665/331773.

World Health Organization (2020b) ‘Key planning recommendations for mass gatherings in the context of the current COVID-19 outbreak’. Geneva PP - Geneva: World Health Organization.

Yamashita, T., Matsushima, H. and Noda, I. (2014) ‘Exhaustive analysis with a pedestrian simulation environment for assistant of evacuation planning’, in *Transportation Research Procedia*. doi: 10.1016/j.trpro.2014.09.047.

Yan, A. (2015) *Nine passengers hurt in rush-hour subway stampede in Shenzhen | South China Morning Post*, *South China Morning Post*. Available at: https://www.scmp.com/news/china/society/article/1772011/nine-passengers-hurt-rush-hour-subway-stampede-shenzhen (Accessed: 4 May 2019).

Yaşdağ, S. (2006) *Achieving a Pedestrian Oriented Transportation System in Ankara*. Middle East Technical University (METU). Department of City and Regional Planning. Available at: http://library.metu.edu.tr/search~S15?/Xpedestrian+&searchscope=15&SORT=DZ/Xpedestrian+&searchscope=15&SORT=DZ&extended=0&SUBKEY=pedestrian

+/1%2C32%2C32%2CB/frameset&FF=Xpedestrian+&searchscope=15&SORT=DZ&7%2C7%2C.

Yazman, D. (2011a) *'Yenikapı Transfer Noktası ve Arkeopark Alanı Uluslararası Mimari Avan Projesi'; Davetli Hizmet Alımı - Arkitera*. Available at: https://www.arkitera.com/yarisma/yenikapi-transfer-noktasi-ve-arkeopark-alani-uluslararasi-mimari-avan-projesi-davetli-hizmet-alimi/ (Accessed: 30 November 2019).

Yazman, D. (2011b) *'Yenikapı Transfer Noktası ve Arkeopark Alanı Uluslararası Mimari Avan Projesi'; Davetli Hizmet Alımı ile Elde Edilecek! - Arkitera*. Available at: https://www.arkitera.com/haber/yenikapi-transfer-noktasi-ve-arkeopark-alani-uluslararasi-mimari-avan-projesi-davetli-hizmet-alimi-ile-elde-edilecek/ (Accessed: 30 November 2019).

Yazman, D. (2012) *Yenikapı Projesi'nin Final Değerlendirme Raporu Yayınlandı - Arkitera*. Available at: https://www.arkitera.com/haber/yenikapi-projesinin-final-degerlendirme-raporu-yayinlandi/ (Accessed: 30 November 2019).

Yıldırım, G. (2020) 'Hava limanları ve metrolar için "maskematik"', *Anadolu Ajansı*, 13 March. Available at: https://www.aa.com.tr/tr/bilim-teknoloji/hava-limanlari-ve-metrolar-icin-maskematik/1764690 (Accessed: 20 August 2020).

Yüksekol, İ. (2012) *Evaluation of pedestrian safety around bus stops using geographic information systems*. Middle East Technical University (METU). Available at: http://library.metu.edu.tr/search~S15?/Xpedestrian+&searchscope=15&SORT=DZ/Xpedestrian+&searchscope=15&SORT=DZ&extended=0&SUBKEY=pedestrian+/1%2C32%2C32%2CB/frameset&FF=Xpedestrian+&searchscope=15&SORT=DZ&5%2C5%2C.

ZeO Mimarlık (2016) *Ulaşım Entegrasyon Merkezi Proje Yarışması*. Available at: http://zeomimarlik.com/tr-TR/proje/411/izmir-Yarisma-1.odul.html (Accessed: 4 August 2020).

Zhang, L. *et al.* (2016) 'Simulation-based route planning for pedestrian evacuation in metro stations: A case study', *Automation in Construction*. doi: 10.1016/j.autcon.2016.08.031.

APPENDICES

A. Platform Area and Turnstile Connection According to TS 12127 and TS 12186

Station capacity calculations according to TS 12127 Rail Rapid Transit System in Urban Areas Part I: Design Criteria of Underground Station Facilities and TS 12186 Rail Rapid Transit System in Urban Areas Part; 2 Design Criteria of Ground Station Facilities (TSE, 1997a, 1997b). In order to develop a more comparative study and highlight differences, same vehicle lengths and similar passenger loads are given to London Underground Station Planning Standards and Guidelines

Station Data		
Boarding Passengers (Line-1) =	4000	person per hour
Alighting Passengers (Line-1) =	1000	person per hour
Boarding Passengers (Line-2) =	2500	person per hour
Alighting Passengers (Line-2) =	1000	person per hour
Platform Width		
Total number of boarding-alighting passengers (Line-1 L1) =	5000	person per hour
Total number of boarding-alighting passengers (Line-2 L2) =	3500	person per hour
Total Passenger Numbers (Y) =	8500	person per hour
Headway Train (P) =	2.00	(frequency - minutes)
magnification factor =	1.30	
missing train =	2.00	
Platform Area Calculation		
Platform Area for Central Platform (m^2) =	0.5x(P/60x(Y)) x1,3 (magnification factor) x 2 (missing train)	
Central Platform Area	368	m^2
Platform Area for Side Platform (m^2) =	0,5x (P/60x (Max Value of Either L1 or L2)) x1,3 (magnification factor) x 2 (missing train)	
Side Platform	217	m^2
Vehicle Length=	60	meters
Platform Separating Doors =	0	meters
Required Platform Width =	6.14	meters

Staircase and Escalator Capacity Calculation		
Total Passenger Numbers =	8500	person per hour
Total Passenger Load (TPL) =	Total Passenger Numbers x 1.25 peak hour factor	
TPL=	10625	person per hour
Escalator Capacity (EC)=	7200	person per hour
Number of Escalators=	1	
Total Escalator Capacity (TEC)=	7200	person per hour
Number of passengers to use stairs (SC) =	TPL-TEC	
SC=	3425	person per hour

Stair Width Calculation		
Width of Staircase =	Number of passengers (SC) / 60 (min) / stair capacity (v = 20-40 person per meter min (ppm))	
=	3425	60
=	2.85	meters if the capacity is 20 ppm
=	1.43	meters if the capacity is 40 ppm

Number of Turnstiles		
According to TS 121217 and TS 12186 turnstile can reach 30 passengers per minute in the direction of entry and 40 passengers per minute in the direction of exit;		
Boarding Passengers (Line-1) =	4000	person per hour
Alighting Passengers (Line-1) =	1000	person per hour
Boarding Passengers (Line-1) =	2500	person per hour
Alighting Passengers (Line-1) =	1000	person per hour
Total Number of Boarding Passengers (TBP)=	6500	person per hour
Total Number of Alighting Passengers (TAP)=	2000	person per hour
number of entry gates=	TBP/60 x 40	
=	3.61	
Round up=	4	Turnstiles for Entry
number of exit gates=	TAP/60 x 30	
=	0.08	
Round up =	1	Turnstiles for Exist

B. London Underground Station Planning Standards and Guidelines

Add

Station capacity calculations, according to London Underground Station Planning Standards and Guidelines (Transport for London, 2012). In order to develop a more comparative study and highlight differences, the same vehicle lengths and similar passenger loads of Appendices A are given to the example below. For the station fare zone, zone 1,2 and 3 is selected from

Station Data		
Peak three-hour Boarding Line1	8889	person per three hours
Peak three-hour Alighting Line1	2222	person per three hours
Peak three-hour Boarding Line2	5556	person per three hours
Peak three-hour Alighting Line2	2222	person per three hours
Peak three-hour Total Alighting (A)	4444	person per three hours
Peak three-hour Total Boarding (B)	14444	person per three hours

Table 18 - Zones and their coefficient according to London Underground Station Planning Standards and Guidelines

Peak	Station fare zone	Factor applied to peak three-hour flow to give peak hour flow	Factor applied to peak hour flow to give peak 15-minute flow	Factor applied to peak 15-minute flow to give peak five-minute flow
AM peak	Zones 1, 2 & 3	0.45	0.27	0.4
	Zones 4, 5 & 6	0.48	0.27	0.4
	Other zones	0.53	0.27	0.4
PM peak	Zones 1, 2 & 3	0.41	0.26	0.4
	Zones 4, 5 & 6	0.39	0.26	0.4
	Other zones	0.39	0.31	0.4

Reference Line#	Definition	Formula	Value	Unit
	Entry gates			
1	AM Peak three-hour entry flow (future year demand)	Value = A	14444	passengers
2	AM Peak one-hour entry flow	B= A x peak hour factor	6500.0	passengers
3	AM Peak 15-minute entry flow	C= B x peak 15-min factor	1755	passengers
4	AM Peak five-minute entry flow	D= C x peak 5-min factor	702	passengers
5	Number of entry gates	round up {5 min entry flow/25x5} + round up {total alighting load/25x2} + X	5.62	units
6	Round-up number of entry gates		6.00	units
Reference Line#	Exist Gates			
	Line One northbound train service Line-1			
7	AM Peak three-hour alighting load (future year demand)	Value = A	2222	passengers
8	Peak hour alighters	B= A x peak hour factor	1000	passengers
9	Peak 15-minute alighters	C= B x peak 15-min factor	270	passengers

10	Train service headway (28 trains per hour)	60 mins / headway count	2.00	mins
11	Number of exiting passengers	(C-C1)/15 x Headway	36	passengers
	Line One southbound train service Line-2			
12	AM Peak three-hour alighting load (future year demand)	Value = A	2222	passengers
13	Peak hour alighters	B= A x peak hour factor	1000	passengers
14	Peak 15-minute alighters	C= B x peak 15-min factor	270	passengers
15	Train service headway	60 mins / headway count	2.00	mins
16	Number of exiting passengers	(C-C1)/15 x Headway	36	passengers
	Establish train service to be increased by 25% before determining the number of exit gates			
17	Maximum number of exiting passengers comes from which train service?		36	passengers
18	Total number of exiting passengers in peak 15 minutes		81	passengers
19	Number of exit gates		1.620	units
20	Round-up number of exit gates		2.000	units
Size of gate line		**Minimum wide aisle gates required**		

21	Up to 6 gates		1	unit
22	Up to 12 gates		2	units
23	Up to 18 gates		3	units
24	More than 18 gates		4	units
	Total number of gates Required in AM peak			
25	Determine the number of gates		8	units
26	Minimum wide aisle gates		2	units
27	Determine the final number of gates		10	units
Reference Line#	Concourse unpaid area calculation			
28	AM Peak 15-minute entry flow	A	1755	passengers
29	Total number of exiting passengers in peak 15 minutes	B	81	passengers
30	Load	A+B=C	1836	passengers
31	Concourse area	C/15 x 1.2	146.88	m^2

Reference Line#	Number of Ticket Issuing Windows (TIW) and Passenger operated ticket machines (POM)			
32	peak hour entry flow	A	6500	passengers
33	Peak hour ticket sales	A x 0.1 = B	650	sales
34	Peak hour ticket sales TIW	B x 0.38 = C	247	tickets
35	Peak hour ticket sales POM	B x 0.62 = D	403	tickets

36	TIW average action time		60	seconds
37	Ticket Issuing Windows (TIW)	Bx 0.95x60 / Headway x 180	2.61	units
38		Round up	3.00	units
39	POM average action time		45	seconds
40	Passenger operated ticket machines	D x 0.95x60 / Headyway x 180	3.19	units
41	(POM)	Round up	4	units
Reference Line#	Two-Way Passageway Width Calculation:			
42	Peak 15-minute flow	A	1836	passengers
43	Peak minute flow	A/15=B	122.40	passengers
44	Passageway width @ 40 people per minute per meter, without ‘edge effects’	B/40=C	3.06	meters
45	‘edge effects.’		0.30	meters
46	Width + ‘edge effects’	C + (2 x 0.3) =	3.66	meters
Reference Line#	Stairs and Escalators Calculation:			
47	Peak minute flow	A/15=B	122.4	passengers
48	LoS stair one-way	C1	35	person per meter
49	one-way staircase width	B / C1	3.50	meters
50	LoS stair two-way	C2	28	person per meter

51	two-way staircase width	B / C2	4.37	meters
52	escalator capacity (people per min)	EC	100	ppm
53	peak minute flow to surface	RL 9 + RL14 = D	36	ppm
54	peak minute flow to train	RL 4 / 5 minutes = E	140.4	ppm
55	number of escalators to surface	EC / D	0.36	units
56		Round up	1	escalator
57	number of escalators to train	EC / E	1.404	units
58		Round up	2	escalators
Reference Line#	Platform Width			
59	Peak three-hour platform load Alighting (A)	RL 7 + RL 12	4444	passengers
60	Peak three-hour platform load Boarding (B)	RL 1	14444	passengers
61	peak hour flow		0.45	
62	15-minute flow		0.27	
63	headway train-per-hour	train-per-hour	30	
64	platform load		35%	
65	platform length		60	meters
66	The busiest section of platform length		25%	

67	area per passenger		0.93	m²
68	Peak three-hour platform load	A+B=C	18889	passengers
69	Peak hour platform load	C x 0.45 =D	8500	passengers
70	Peak 15-minute platform load	D x 0.27 = E	2295	passengers
71	Peak minute platform load	E/15 =	153.0	passengers
72	Train service headway	60 / 20 = t	2.00	minutes
73	Peak headway platform load	E x t = F	306.00	passengers
74	The busiest section of platform load	F x 35% = G	107.10	passengers
75	Space requirement (area)	G x 0.93m2 = H	99.6	m²
76	Busiest section of platform length	120m x 25% = P	15.00	meter
77	Width (without 'edge effects')	H m2 / P m = J	6.64	meter
78	Edge effects	1m	1.00	meter
79	Total platform width	J m + 1m =	7.64	meter

C. Stations Data in Turkey

List and type of the Subway Station in Turkey based on the information their operators provide to its users.

City	Station Type	Count
İstanbul	Underground	76
	Elevated	5
	On the Ground	8
	Total	89
Ankara	Underground	45
	Elevated	6
	On the Ground	5
	Total	56
İzmir	Underground	11
	On the Ground	1
	Elevated	5
	Total	17
Bursa	Underground	7
	On the Ground	31
	Elevated	0
	Total	38
Adana	Underground	4
	On the Ground	4
	Elevated	5
	Total	13
Total	Underground	143
	On the Ground	50
	Elevated	20
	Total	213

D. Peak Hour Passenger Load of ANKARAY

Figure 97 is generated from the data set below. Tables below are the peak hour passenger loads of for ANKARAY line in Ankara (EGO Ankara Department of Transportation Planning and Rail System, 1992c).

Station passenger volumes for the year 1995

Train Direction

Train Direction

Line-1		Station		Line-2
Boarding	7314	AŞTİ	5466	Alighting
Alighting	0		0	Boarding
On Train	7314		5466	On Train
Boarding	4622	Emek	4409	Alighting
Alighting	64		349	Boarding
On Train	11872		9526	On Train
Boarding	4385	Bahçelievler	549	Alighting
Alighting	455		2984	Boarding
On Train	15802		7091	On Train
Boarding	2193	Beşevler	2977	Alighting
Alighting	3196		816	Boarding
On Train	14799		9252	On Train
Boarding	1243	Tandoğan	2783	Alighting
Alighting	3896		1257	Boarding
On Train	12146		10778	On Train
Boarding	1862	Maltepe	2457	Alighting
Alighting	3032		743	Boarding
On Train	10976		12492	On Train
Boarding	1267	Demirtepe	1216	Alighting
Alighting	2459		1579	Boarding
On Train	9784		12129	On Train
Boarding	2785	Kızılay	10697	Alighting
Alighting	5128		6752	Boarding
On Train	7441		16074	On Train
Boarding	967	Kolej	1829	Alighting
Alighting	3488		3596	Boarding
On Train	4920		14307	On Train
Boarding	348	Kurtuluş	1256	Alighting
Alighting	264		5062	Boarding
On Train	5004		10501	On Train
Boarding	0	Dikimevi	0	Alighting

Alighting	5004		10501	Boarding
On Train	0		0	On Train

Station passenger volumes for the year 2015

	Line-1	Station	Line-2	
Boarding	7540	AŞTİ	5814	Alighting
Alighting	0		0	Boarding
On Train	7540		5814	On Train
Boarding	9075	Emek	4737	Alighting
Alighting	180		2412	Boarding
On Train	16435		8139	On Train
Boarding	5319	Bahçelievler	1466	Alighting
Alighting	3120		2089	Boarding
On Train	18634		7516	On Train
Boarding	2315	Beşevler	3166	Alighting
Alighting	4519		819	Boarding
On Train	16430		9863	On Train
Boarding	1359	Tandoğan	3031	Alighting
Alighting	4261		1346	Boarding
On Train	13528		11548	On Train
Boarding	2158	Maltepe	4168	Alighting
Alighting	4510		1198	Boarding
On Train	11176		14518	On Train
Boarding	2102	Demirtepe	3640	Alighting
Alighting	2553		2163	Boarding
On Train	10725		15995	On Train
Boarding	10422	Kızılay	11841	Alighting
Alighting	6005		8391	Boarding
On Train	15142		19445	On Train
Boarding	1816	Kolej	9837	Alighting
Alighting	3436		4199	Boarding
On Train	13522		25083	On Train
Boarding	1345	Kurtuluş	2847	Alighting
Alighting	5795		4512	Boarding
On Train	9072		23418	On Train
Boarding	0	Dikimevi	0	Alighting
Alighting	9072		23418	Boarding
On Train	0		0	On Train

Train Direction

Train Direction

CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: Öztürk, Özgür
Nationality: Turkish (TC)
Date and Place of Birth:
Marital Status: Married
Phone:
email:

EDUCATION

Degree	Institution	Year of Graduation
MA	METU History of Architecture	2011
BA	ITU Architecture	2008
High School	Nuh Mehmet Baldöktü Anadolu Lisesi, Kayseri	2003

WORK EXPERIENCE

Year	Place	Enrollment
2019-Present	Abdullah Gül University	Part-time Lecturer
2019-Present	VGCG Design	Founding Partner
2005-Present	New York University Institute of Fine Arts Excavations at Aphrodisias	Anastylosis Architect
2013-2019	Yüksel Proje International	Project Architect
2012-2013	Gökhan Aksoy Architecture	Project Architect
2011-2012	NKY Architecture	Project Architect
2008	Tanart Architecture	Project Architect

FOREIGN LANGUAGES

Advanced English, Intermediate German, Beginner French

PUBLICATIONS

1. Avanoğlu-Çetin, B. and Öztürk, Ö. (2019) 'Reflecting the art, culture and history into the interior design of underground metro stations, case study: Dnipro metro extension line', in Tunnels and Underground Cities. Engineering and Innovation

Meet Archaeology, Architecture and Art: Proceedings of the WTC 2019 ITA-AITES World Tunnel Congress (WTC 2019), May 3-9, 2019, Naples, Italy. CRC Press, p.

2. Öztürk, Ö. (2012) 'A Digital Reconstruction of Visual Experience and The Sebasteion Of Aphrodisias', in ICONARCH-I Architecture and Technology International Congress Proceedings Book. Konya: Selcuk University Faculty of Architecture Department of Architecture, pp. 375–389.

Archery, Motor Sports, Cooking, Computer Technologies,