DESIGN CONSIDERATIONS FOR MODERN RAILWAY STATIONS; COMPARING BERLIN, BEIJING AND ANKARA

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Submitted by **ZEYNEP ATAK** in partial fulfillment of the requirements for the degree of **Master of Science in Building Science in Architecture Department, Middle East Technical University** by,

Prof. Dr. Gülbin Dural Ünver ____________________
Dean, Graduate School of **Natural and Applied Sciences**

Prof. Dr. Elvan Altan ____________________
Head of Department, **Architecture**

Prof. Dr. Soofia Tahira Elias Ozkan ____________________
Supervisor, **Architecture Dept., METU**

Examining Committee Members:

Instr. Dr. Berrin Zeytun Çakmaklı ____________________
Architecture Dept., METU

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

Asst. Prof. Dr. Ayşegül Tereci ____________________
Architecture Dept., KTO Konya Karatay University

Asst Prof. Dr. A. Yağmur Topraklı ____________________
Architecture Dept., Gazi University

Instr. Dr. Funda Baş Bütüner ____________________
Architecture Dept., METU

Date: 06.05.2015

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: Zeynep ATAK

Signature:

ABSTRACT

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Atak, Zeynep
M.S. in Building Science, Department of Architecture
Supervisor: Prof. Dr. Soofia Tahira Elias Ozkan
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High Speed train era in Turkey has started in 2009 with the Ankara-Eskisehir high speed rail line. From 2009 until 2015, a number of high speed railway and new station construction projects haves been implemented. And new high speed rail line projects are in planned.

Location of the station in the city, its dimensions, security check points, ticket checking system, the size of the retail places within the station and some other functions are critical for the design of railway stations, however it is realized that many of the mentioned parameters are not taken into account. In this study, the parameters affecting design of modern stations are investigated.

The population of the city and the passenger capacity are the two important parameters that have to be considered while designing a railway station. Additional spaces that may or may not be necessary for passenger needs must be determined according to the location of the station and according to the requirements of the city. No matter where it is constructed, the station must be easily accessible by public and private transport means.

The location of the passenger entrance/exit doors, whether there will be a security check point or not, the location of the ticket checking system are important parameters that have to be taken into account while designing a station.

A number of new railway stations have been constructed around the world recently. Among these new stations, Berlin New Central Station in Germany and Beijing South Railway Station in China are the two famous stations. Their success is mainly due to the (1) good connection of the station buildings with their location, (2) the efficient solution in terms of passenger's access to the station buildings either pedestrian, vehicular or public transportation means, (3) the size of the stations are determined in accordance with the projected passenger capacity.

In this study, Ankara high speed railway station is compared with the Berlin and Beijing high speed railway stations in terms of spatial requirements and the parameters affecting their design.

Keywords:

Modern Station, High Speed Trains; Design criteria; Ankara High Speed Railway Station

ÖZ

MODERN İSTASYON BİNALARIN TASARIMINDA DİKKAT EDİLMESİ GEREKEN HUSUSLAR; BERLIN, PEKİN VE ANKARA KARŞILAŞTIRILMASI

Atak, Zeynep
Yüksek Lisans, Yapı Bilimleri, Mimarlık Bölümü
Tez Yöneticisi: Prof. Dr. Soofia Tahira Elias Ozkan
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Türkiye de hızlı tren dönemi Mart 2009 yılında Ankara-Eskişehir yüksek hızlı tren hattının işletmeye açılmasıyla birlikte başlamıştır. 2009 dan 2015 yılına kadar birçok yeni hızlı tren güzergâhı ve bu güzergâh üzerinde yeni gar projeleri yürütülmüştür. Bu çalışmalara yenileri eklenerek devam etmektedir.

Garın yapılacağı yerin şehir içindeki konumu, büyüklüğü, güvenlik kontrol sistemi, bilet kontrol sistemi, ticari alanların büyüklüğü, ilave fonksiyonlar vb. konuların garın tasarımını etkilediği ancak bu konuda Türkiye için referans olabilecek bir çalışmanın olmadığı görülmüştür. Bu çalışmada modern demiryolu garlarında gar tasarımını etkileyen parametreler konusunda araştırmalar yapılmış ve somut veriler sunulmuştur.

Yapıldıkları ilin nüfusu, yolcu kapasitesi garların tasarımını belirleyen önemli parametrelerdendir. Bir garda yolculara yönelik birimler haricindeki ilave fonksiyonlar; garın yapılacağı yerin konumuna göre şehrin ihtiyaçları doğrultusunda belirlenmelidir. Nerede yapılmış olursa olsun garın kent içi ulaşım modlarıyla (metro, tramvay, banliyö) entegre edilmiş, ulaşımı kolay ve yaya-araç-taksi-toplu taşıma ilişkisinin de etkili bir şekilde çözülmüş olması gerekmektedir.

Yolcuların nereden ve ne şekilde binaya girecekleri (güvenlik noktası), peronlara ulaşımda bilet kontrolünün yapılıp yapılmayacağı ya da nerede ve ne şekilde yapılacağı (bilet kontrol sistemi), gelen ve giden yolcuların peronlara ulaşımı ve tahliyesi hususları da bir garın tasarımını önemli ölçüde etkilemektedir. (Varış-Geliş –gidiş katları).

Dünyada birçok ülkede yeni garlar inşa edilmektedir. Bunlardan yapıldıkları ülkelerin başkentlerinde bulunan; Almanya'daki-Berlin Merkez Garı ve Çin'deki-Pekin Güney Garı (1) inşa edildikleri yerle ilişkileri, (2) yaya-araç-taksi-toplu taşıma yaklaşımı açısından etkili çözümleri, (3) yolcu potansiyeline göre belirlenmiş gar büyüklüğü konularında ünlü garlardır.

Bu çalışmada Türkiye'de başkent Ankara'da inşa edilmekte olan Ankara Yüksek Hızlı Tren Garı; Berlin Merkez Garı ve Pekin Güney Garı ile tasarımı etkileyen parametreler ve mekânsal gereksinimler açısından karşılaştırılmış ve bununla ilgili bir liste oluşturulmuştur.

Anahtar kelimeler:

Modern istasyon, Yüksek hızlı tren; tasarım programı, Ankara YHT garı.

Dedicated to my mother "Hatice" and my daughter "Ayşe Naz"

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I would like to express my deep gratitude to my supervisor Prof. Dr. Soofia Tahira Elias Ozkan for her invaluable guidance, support, suggestions and encouragement.
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LIST OF ABBREVIATIONS

AHSRS	Ankara High Speed Railway Station
BNCS	Berlin New Central Station
BSRS	Beijing South Railway Station
CAF	Construcciones y Auxiliar de Ferrocarriles
CIP	Commercial Important Person
DB	Deutche Bahn
FIFA	Fédération Internationale de Football Association
GMK	Gazi Mustafa Kemal
vGMP	von Gerkan and Partners
HSRs	High Speed Railways
PV	Photovoltaic
TCDD	Turkish State Railways
TFP	Terry Ferrel and Partners
TSDI	Third Survey Design Institute
UIC	International Union of Railways
UK	United Kingdom
VIP	Very Important Person

CHAPTER 1

INTRODUCTION

This chapter presents the aim and objectives of the study, the procedure followed and the disposition of the chapters.

1.1 Argument

With the development of new technologies trains started to become even faster. Today, high-speed trains have become highly competitive with airlines and highways. Even though airlines provide a very fast transportation, the actual travel duration, by taking into account waiting times in the airport and access time to the airport which are generally built outside the city, comparable or longer than the railway transportation duration at least for some routes. Highway transportation period, on the other hand, is generally longer than that of railway transportation. Since the railway stations are in general built inside the city, and there is no need to be at the station long time before the departure and since it provides a fast and secure transportation, railway transportation has a high share in the transportation industry.

Railway stations which are integrated with the city's public transportation, easily accessible to pedestrians and having enough parking slots could even increase the share of the railway transportation.

A number of issues that must be taken into account in designing a railway station are as follows:

- The passenger capacity must be taken into account.
- Whether there will be a security check point or not must be taken into account.
- Another important parameter affecting the station design is the location of the ticket checking system, if exists. In some countries there is ticket checking system and in some others especially in Europe tickets are checked inside the

train. Whether there is a ticket checking system affects the buildings total area and passenger circulation.

- The features around the station are important and must be taken into account. For example if there is no hotel, shops etc. around, these additional features must be designed as part of the station building.
- The main purpose of a station is to provide an easy path between the platform and the entrance/exit of the station.
- Inside of the station must be designed as simply as possible for passengers to perceive the direction they will go and daylight must also be used if possible.

Figure 1.1: New speed rail line map in Turkey
(Source: TCDD Etüt Proje ve Yatırım Daresi Başkanlığı, 2015)

There are numerous stations in the Ankara-Istanbul high speed line which went in operation in 2013. As is illustrated in the Figure 1.1, several new high speed lines are planned. Therefore, several high speed train stations will be constructed soon.

The new railway stations must be easily accessible for passengers, suitable to the requirements of both the city and the passengers similar to the successful examples around the world such as the Berlin and Beijing stations.

1.2 Aim and Objectives

The fundamental aim of the study is to investigate the appropriateness of the station building that will also serve high speed trains in Turkey. In this respects, the objectives of the study are three folds:

- Comparing new high speed train stations in different countries,
- Evaluating the Modern Railway Station projects
- Identifying requirements for an appropriate station building for high speed train and new demands for passenger

1.3 Procedure

The study focuses on modern railway stations in terms of design requirements the ratio of the space reserved for passengers to the total space, passenger traffic etc

Firstly the data were gathered for each station, general information was analyzed and then the requirements were listed. The outputs were compared for each station. At the end, the recommendations were given which would improve construction of station buildings for high speed trains.

1.4 Disposition

The study is presented in five chapters. The first Chapter presents the argument, aim and objectives of the study and procedure followed.

The second Chapter focuses on literature survey about the study subject. It contains information on railway history, development of railways stations, high speed train stations.

The third Chapter presents the material and method of the study. It contains three case studies on modern railway stations.

The fourth Chapter focuses on the results and discussions are presented.

The fifth chapter the conclusion of the study is given.

CHAPTER 2

LITERATURE REVIEW

This chapter presents a survey of railway technologies and railway station buildings starting from the very beginning. Also presented are their characteristics and historical development.

2.1 Birth of the Railways

In 1550, wagon ways were introduced in Europe. These wagon ways were usually used inside the mines and between the mines and smelters. These early tracks were made of stones or timber. (Figure 2.1 & 2.2) Wagons were usually pulled by horse & humans. (Connor & Schmid, 2012)

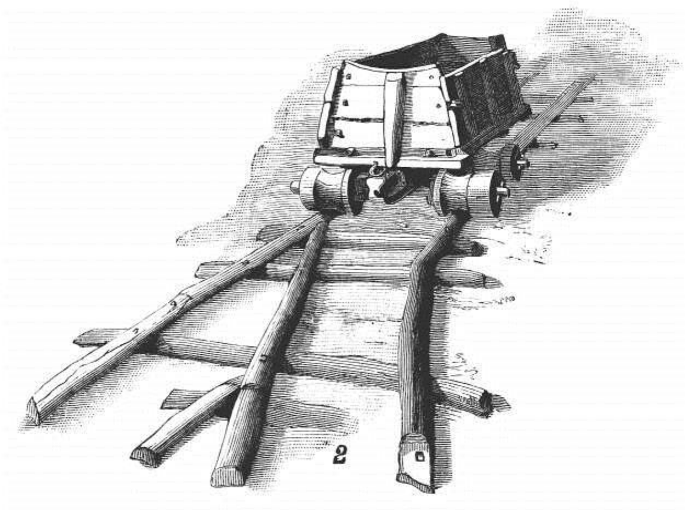


Figure 2.1: Early Tracks
(Source: //www.catskillarchive.com/rrextra/tksa.Html#anchor78961)

Before the railways, there were mainly three ways of transportation; on the open seas, canal transport and road transport. Clearly there were certain problems that gave birth to the wagon ways. These problems can be listed as follows (Connor & Schmid, 2012, pg: 3);

- *“Transportation on the open seas: it was slow, risky and expensive. English pirates caused problems and wooden “tea clippers” only lasted 3 to 4 trips around the Cape*
- *Canal transport: it was slow, small volume only in Great Britain, expensive: (high on infrastructure and operating cost with lock-keepers and horses-canal proprietors nearly strangled Manchester)*
- *Road transport: it was slow, required lots of horse changed(London had reached the maximum horse city size around 1800, expensive and resource hungry staff and food, 1 mile by two horse cart:8 hours)”*

Above mentioned problems necessitated a new way of transportation which could provide speed, reliability, safety and high transport capacity in terms of goods (such as coal, stone, fabric etc.), (Connor & Schmid, 2012)

Figure 2.2: A Section of Rail Tracks on Stone Block Sleepers
(Source:gerald-massey.org.uk/Railway/c10_construction_(IV).htm)

In Great Britain, the steam engine was first introduced in 1804 by Richard Trevithick. It can be said that; Robert Trevithick’s design was the first high pressure steam engine on the metal tracks, that made history. (Connor & Schmid, 2012)

According to Connor & Schmid, (2012, pg: 10) the impacts of the railway industry were as follows

- Railways shrink time and space at reasonable cost: people can go from and city to another for day trips to food stuff does not perish en-route,
- Railways eliminate subsistence economies,
- Agricultural products and surpluses can be brought to market in short time and can be sold at lower prices,
- Railways change labor relations,
- Employees could be moved around easily and mass produced industrial products could be marketed easily.

Connor & Schmid (2012) explains that other impacts of early railways were:

- centrally managed long distance infrastructures were designed,
- architectural feats became common place, large structure were built and engineering skills develops very fast glass &steel structures could span huge spaces,
- common educational standards for railway employees were put in place, such as hierarchy of states & uniforms,
- Creation of suburbia worldwide offered escape from crowded cities and developers started to build on the periphery of the city.

2.1.1. First Railway Lines

The railways spread from Britain to other countries rapidly. (Burman, 1997) The **first freight railway line** was opened in 1825 between Stockton and Darlington. This railway was built by George Stephenson with cast iron rails and it was used only for freight transportation, with horse or locomotives. **The first passenger railway line** was opened in 1830 between Liverpool-Manchester Railways and this line was also used for freight transportation (Thorne, 2001)

The history of railways in other countries can be summarized as follows:

- In France the first freight train line construction started in 1821 and finished in 1827. It was a 21 km rail track between Saint Etienne and Andrezieux and used for coal transportation. In this rail line, wagons were pulled by horses until 1844. First passenger train was started between Givers' and Rives de Givers line in 1832. Passenger used coal wagons and they were also pulled by horses. From Paris to Saint Germaine line was constructed especially for passengers. (Figure 2.3) (www.sncf.com/en/meet-sncf/sncf-history)

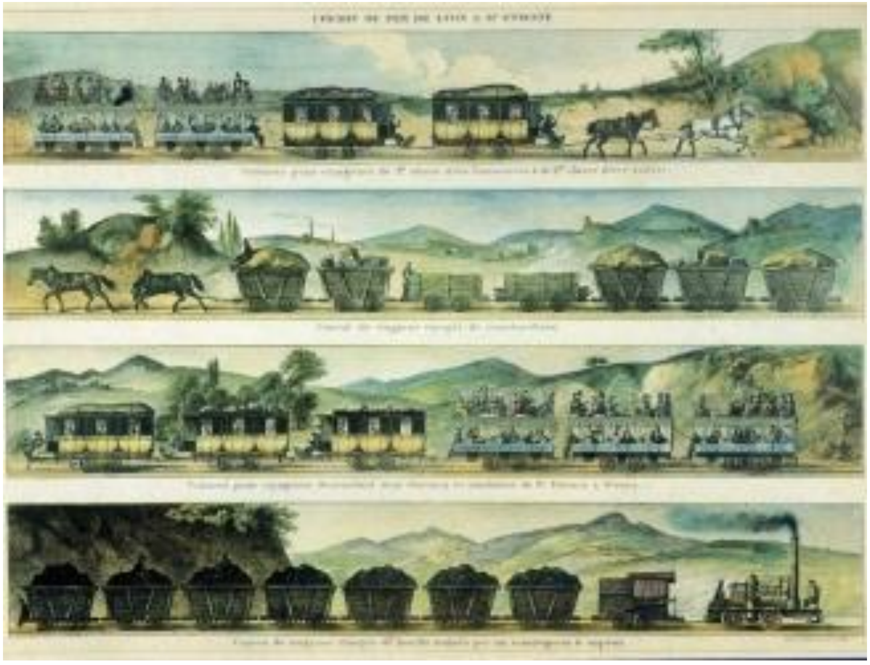


Figure 2.3: Early Railway Transportation history in France
(Source: www.sncf.com/en/meet-sncf/sncf-history)

- German railways were born in Nuremberg on 7 December 1835 when the first steam train departed from the city on a 6 km journey to the neighboring town of Furth. Passenger wagons were usually pulled by horses owing to coal shortage (Mertens, 2006)

- The history of railways in Turkey began during the Ottoman Empire era in 1851. The first railway within the current national borders started on September 23, 1856 with the İzmir-Aydın railway line. (www.tcdd.gov.tr).
- The first railway in Japan was opened between Shiodome (Tokyo) and Sakuragicho (Yokohama) in 1872.(Suzuki , 1995)
- The Chinese railway history started in 1876. First rail line, between Shanghai and Wusog was constructed by English Company but was demolished a year later. The Tang Xu railway was completed in 1881 by the Chinese government. (Xiaoli,2009)

Table 2.1 below lists some of the countries where the railways were first started along with the relevant year.

Table 2.1: Important railway lines listed by the year of construction

Country	**Year**
Great Britain	1825
France	1827
Germany	1835
Ottoman Empire	1856
Japan	1872
China	1876

2.1.2. Early Railway Stations

At the beginning no one really knew what train stations should be look like. Thus in some cases existing old buildings were used to serve as train stations. (www.uic.org/com/uic-vslider/railway-stations/)

Kido (2005) describes a railway station *"as a place where trains load or unload passenger and/or goods*". Railway stations consisted of two important parameters when they were constructed in the 19^{th} century. These are the train shed and the attached building, i.e. the train station; each of which required its own architectural characteristics(Thorne, 2001), which are described in the following paragraph:

a) The Train Sheds: were first constructed to create an industrial space that protected workers. These sheds were also used to provide protection to the passengers. (Thorne, 2001)

b) The Attached Building: which can also be called the station building proper was designed for passengers and was a gateway between the rail lines and the city (Ferrarini 2005). Inside the building, there were ticket offices, railway management offices and employee offices, and some places for passengers such as waiting rooms, etc. The building could be on one side of the rail line or on the both sides depending on the on station type (Thorne, 2001). The station building was in effect providing communication between train shed and the city. For this reason the station building can be considered as a boundary between the city and rail lines (Ferrarini, 2005).

2.2 The Development of Railway Station Architecture

The most important inventions in human history as a result of the Industrial Revolution were *"the spinning jenny, **the steam engine**, and coke smelting*" (Allen,2006) , hence, as Thorne (2001) points out the history of **train stations** dates back to the industrial revolution of early nineteenth century.

The most concrete indicator of the industrial revolution is not the factories made around the city but the railway stations which are built in the heart of the cities. Due to the functions they provide and due to their locations, railway stations have emerged as a new kind of architecture which is quite symbolic (Ferrarini, 2005).

Ferrarini (2005, pg: 5) explains that "*for many years, railway stations were the monuments around which large modern cities developed; they are the structures that reflected the nature and embodied the characteristic features of their urban location."* The author argues that these buildings *"…reveal the essence of the city because, to a certain extent, they are mirror of it…";* their size and structure reflects many characteristics of urban life, and they are also *"….an expression of the* *architectural and artistic trends of the society when they were built; indeed, sometimes they become the most significant expression of such trends*"

Alessia Ferrarini (2005, pg: 13) divided railway history into three phases; which are

a. 1830-1870
b. 1870-1930
c. After the Second World War II-1970

A. 1830-1870:

After Industrial Revolution, demand for goods transportation and communication were increased. As a response to these demands the first passenger railway line opened in 1830 between Manchester and Liverpool in Great Britain (Okyay, 1979). Modern railways started concurrently in Great Britain and the USA; the Liverpool-Manchester Railway (Figure 2.4) in Great Britain and the Baltimore-Ohio Railway in the USA, were both opened in 1830 (Thorne, 2001).

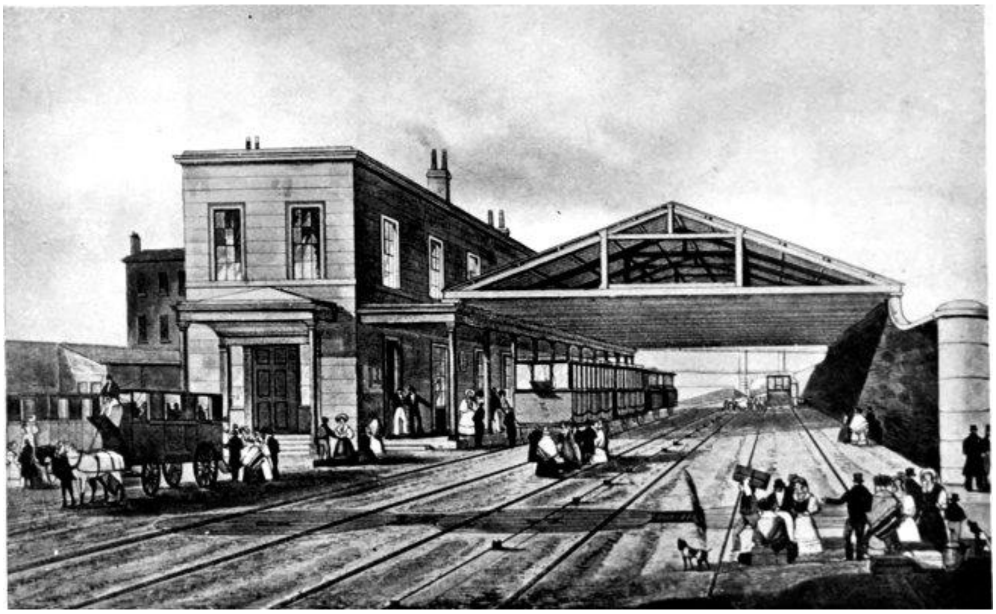


Figure 2.4: The First Railway Station in the World (Crown Street Station, Liverpool) (Source:www.victorianweb.org/art/architecture/liverpool/19.html)

The world’s first railway station, Crown Street Station in Liverpool, was built by a railway engineer George Stephenson in 1829-1830. The first railway station was comprised of an attached building and a wooden train shed (Thorne, 2001 and Ferrarini, 2005). It looked like a hostel or a rest house (Ferrarini, 2005).

The success of Manchester-Liverpool railway was, universally admired and many new lines were constructed (Okyay, 1979). New buildings, such as depots for trains and stations for passengers had to be constructed by trial and error method, because there was no example to follow (Thorne, 2001).

Euston Station (Figure 2.5), which was built in England in between 1835-1839 and survived until 1963, was the first terminal station in London (Ferrarini, 2005). There were four Doric portico and 4 lodges at the entrance (two on both sides). These memorial structures emphasize the fact that the station is the gateway to the city (Ferrarini, 2005).

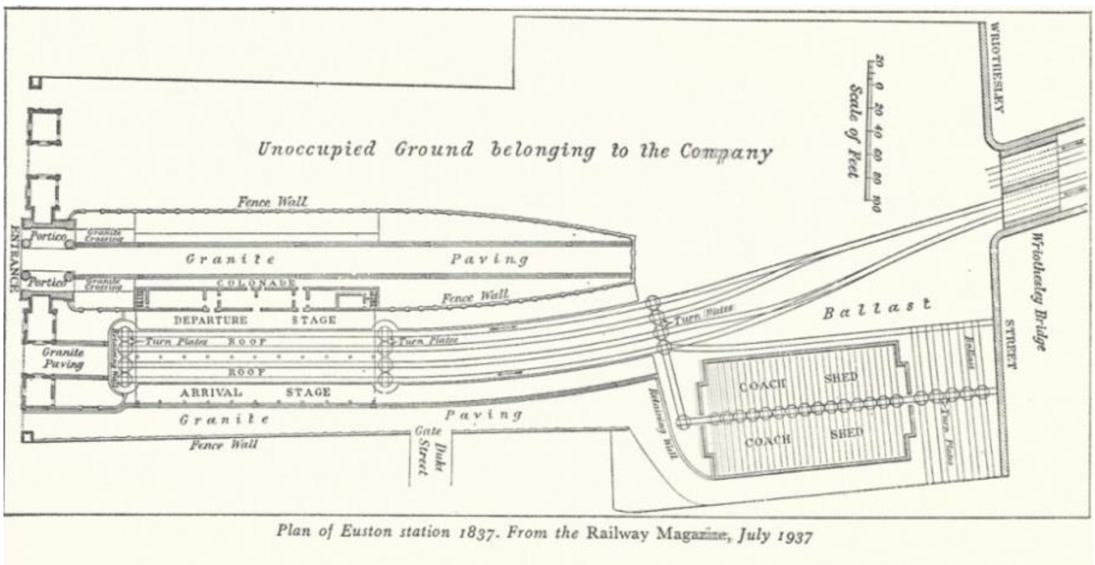


Figure 2.5: Euston Station General plan (Source: Jackson,1969)

The first London main line station had two platforms and four rail lines. (Figure 2.5) One of the platforms was for arrivals and the other one was for departures. The building comprised of waiting rooms, offices, WC, with separate entrance and accommodation for the first class passengers. Second class customers had a combined waiting room and a booking office. The station had many attached buildings to the main building until it was demolished in 1963. The double train shed, which covered the 4 rail lines and two platforms was , designed by Charles Fox and it was about 61 meter in length and 12 meters in width (Jackson, 1969).

1830 to 1860 were a period of great development in the station architecture. The advancement in material technology changed the architecture of the railway stations. The train sheds which had been made with woods, started to be made with iron and glass (Thorne, 2001 and Ferrarini, 2005). From the engineering perspective, huge train sheds were the most difficult places to design, they were also the places where the most innovative techniques are applied. The wide spread use of iron resulted in a new art of building in which bigger structures than that of Greek and medieval period. The use of iron in structure and the use of glass as a roof material resulted in a revolution in architecture. Use of iron also resulted in minimum amount of material usage, the wall mass was reduced to thin surface delimiting spaces; and concepts of light and shadow were reversed. (Before the invention of lightening with electricity, glass roofs had been used for homogenous lightening of the spaces.). Using iron and glass in station architecture created a new type of place, light and shadow. These innovative structures had impressed the people who experienced them; they were impressed from the power of this huge space. (Ferrarini, 2005)

Previously modest station buildings were built on either one or both sides of the railway line (Thorne, 2001); but after 1840s with the increase in train traffic, the station structures and the forms started to change (Ferrarini, 2005). During these years, a study about “the form of future railway stations and the functions they must provide” was conducted in England and France. In 1850s and 1860s in France, stations were designed as monumental buildings in the city center in order to highlight the core of the city compared to suburban locations. In London, on the other hand, these buildings were not designed as monumental buildings. But on a more modest scale French architects and engineers aimed to designing uniform train sheds and station buildings in order to form a consistent structure. (Ferrarini, 2005)

Figure 2.6.A: Inside the Gare de l'Est in Paris showing the large span of the train shed (Source: Ferrarini, 2005)

Figure 2.6 B:External view of the Gare de I'Est in Paris (Source: Ferrarini, 2005)

With different materials used in architecture, new spaces were added in station plans. The **concourse** was located at track end and the between the street. The concourse was first seen in Gare de I'Est (Figures 2.6 to 2.7), which was built between 1847 and 1852. (Thorne, 2001) Similarly, standardization was also seen first in Gare de

I'Est. Its façade was designed in different levels: at the street level façade the colonnade expressed the entrance to the train shed area for arrival and departure. On the other hand upper level façade represented the train shed forms (Ferrarini, 2005).

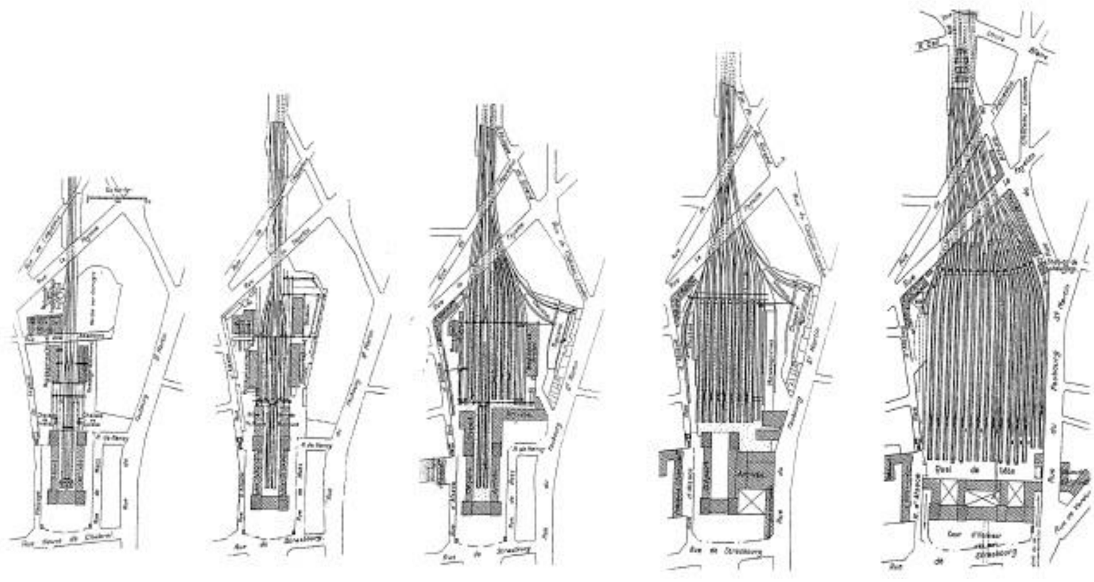


Figure 2.7: Development over time of the Gare de l'Est in Paris.
(Source: Ferrarini, 2005)

The same architectural language was seen at Gare de Nord facades (Figure 2.8), which was built between 1861 and 1864 (Ferrarini, 2005).These stations continued to change and adapt to new technologies, through additions and renovations.

Figure 2.8: Façade of Gare de Nord in Paris showing the huge structure that reflected advances in engineering.
(Source: www.parisdailyphoto.com/2014/04/the-gare-du-nord-is-150-years-old.html)

French railway stations due to the successful integration of the functional and architectural expression become important examples of that period for all of Europe. On the other hand, in England, except for the King's Cross Station (Figure 2.9), English architects did not design huge monumental station architecture nor did they use to reflection of trains of the shed on the façade. In England, railway stations were not seen as public building to finance nor did they care about architecture harmonies between station building and train sheds (Ferrarini, 2005).

Figure: 2.9: Large train shed of the King's Cross Station, London
(Source: www.networkrail.co.uk/aspx/6288.aspx)

However a hotel building was in response to passenger demands as in the Victoria Station (Figure 2.10), which is built in 1861 (Thorne, 2001).

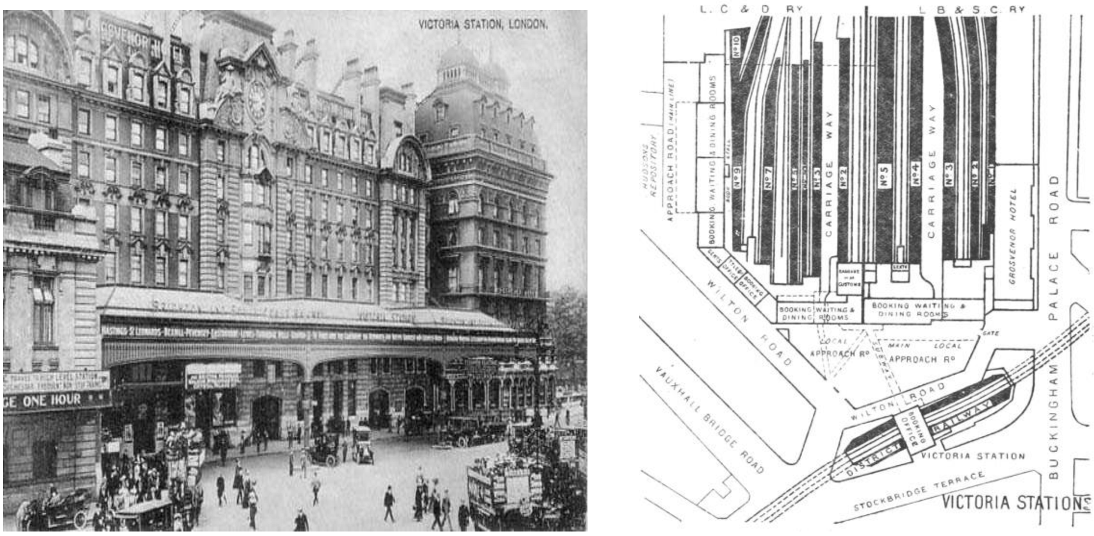


Figure 2.10: Grosvenor Hotel in London was built next to the Victorian Stations to international needs of passengers arriving in London
(Source:www.oldukphotos.com/graphics/England%20Photos/London,%20Victoria%20Rail%20Station%201910%27s%20II.jpg)

During the 1860s the length and span of the roofs covering train sheds grew. The New Station in Stuttgart had a total span of 61.6 meters and a length of 165 meters (Ferrarini, 2005). On the other hand, St Pancras Station (Figure 2.11), which opened in London on the 1st of November 1868, had a single span roof of 73.15 meters width and a length of 209 meters. Using iron girders and glass on the train shed roof, it was the longest total span on a train shed which was not surpassed for two decades (Figure 2.12). (Thorne, 2001).This train shed roof covers four platforms and eleven rail lines (Lansley, *et al* 2008).

Figure 2.11 St Pancras Station and Midland Grand Hotel, 1905 (Source:www.bbc.co.uk/blogs/legacy/thereporters/markeaston/2011/05/a_monument_to_the_british_craf.html)

The station is set on an upper level in order to cross the Regent's Canal at a suitable level. It was raised from 3.66 to 5.18 meters above the ground level. This level was decided to be used as the entrance level, because of the direct entrance from the streets. A single span roof was constructed over the train shed (Lansley, *et al* 2008).

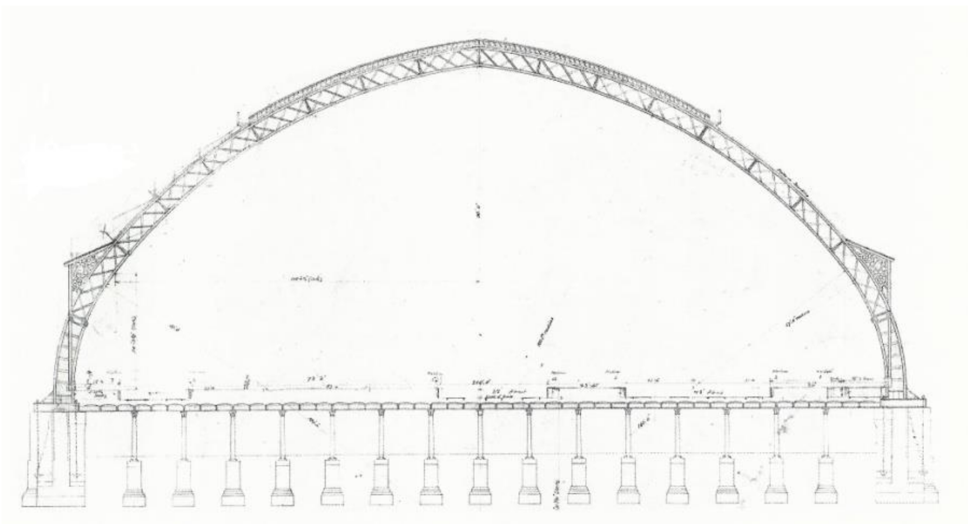


Figure 2.12: A cross section of the St. Pancras train shed 1865. (Lansey, *et al* 2008)

In St. Pancras terminal, the hotel and the station buildings were used in combination, but the train shed and the hotel building possess structures of a completely different world. While the train shed was the result of technology, the architecture of the hotel was gothic. In the train shed structure iron and glass is used to span 70 meters, a distance which was the largest at that time and remained unsurpassed until 1889 (Ferrarini, 2005).

B. 1870-1930:

A second industrial revolution took place, in 1870, after which stations became bigger than before due to the multiple rail lines and increased number of passengers. Frankfurt Station (1879-1888) (Figure 2.13) portrays the features of that period in its façade design and station layout. For example, the concourse is located at the beginning of the platforms and connects each platform to the others that are located midway between the tracks; the concourse also has shops serving the passengers (Ferrarini, 2005).

Figure 2.13: Huge structure of the train shed at Frankfurt Station
(Source:dftstammer.com/cms/index.php?id=24

Figure 2.14: Large train shed span and interior view of the Frankfurt Station (Source:www.zeno.org/Ansichtskarten/M/Frankfurt+a.+Main,+Hessen/Bahnhof,+Vestib%C3%BCl)

The period between the last quarter of the nineteenth century up to 1915 can be called the great train shed era. They were built with iron and glass; materials that were not only used in railway stations but also in the construction of exhibition halls and markets etc (Thorne, 2001). For example, iron and glass were used in the entire construction of the Alexanderplatz Station (1880-1885), (Figure 2.15). Using iron and glass for railway stations provided them with a "technological cover". The metal and glass construction style was used for other train stations also, such as the Frankfurt Station (Ferrarini, 2005).

These steel and glass structure also became popular because they were lightweights and could be used to span large areas. They were used to build large single span train sheds in many railway stations. The Pennsylvania train station had the largest single span train shed structure of its time, it was 91.5 meters wide (Thorne, 2001).

Figure 2.15 Exterior view of the Alexanderplatze Station which iron and glass were used entire station, 1882. (Source: www. Laits .utexas. edu / berlin /images/ buildings/04Alexanderplatz/c_Ansicht_des_Bahnhofs.jpg)

Steam powered trains caused dirty and unhealthy spaces due to the smoke rising from the engines. Therefore train sheds were built higher to exhaust the smoke. At the end of nineteenth century electric powered train started to be used in railways instead of steam powered trains, which did not pollute the environment. Thus, it was possible to lower the shed. Hence this invention i.e. the electric powered trains, changed the station architecture (Droege, 1969).

According to Ferrarini (2005) using electric powered trains at the end of the nineteenth century allowed lowering of the tracks beneath ground level and thus freeing vast surface areas. This led further to a significant change in design models for railway stations. In large stations like the Grand terminal and Pennsylvania Station in New York and Gare de Orsay in Paris (Figure 2.16) the train "… as machine is absorbed as part of the building, through a sort of mimesis; it is, in effect, hidden, only becoming visible within the station itself. The structure can be said to have metabolized its mechanistic appearance, transforming itself into a multi level apparatus that is disguised behind/beneath romantic traces." (Ferrarini, 2005).

The author described these stations as having impressive internal spaces with "… grandiosely decorated atria; transversal underpasses; the magnificent restaurants -all project notion of rail travel as a sort of cruise on wheels."

Train station buildings of the late nineteenth century period had large structures with symbolic spaces that contained the concourse, atrium and ticket office, which resembled an urban promenade that could be an attractive public meeting place. As the author points out there was "a paradigm shift away from linear structures characterized by transparency to gigantic and majestic structures occupying sizable areas" (Ferrarini, 2005).

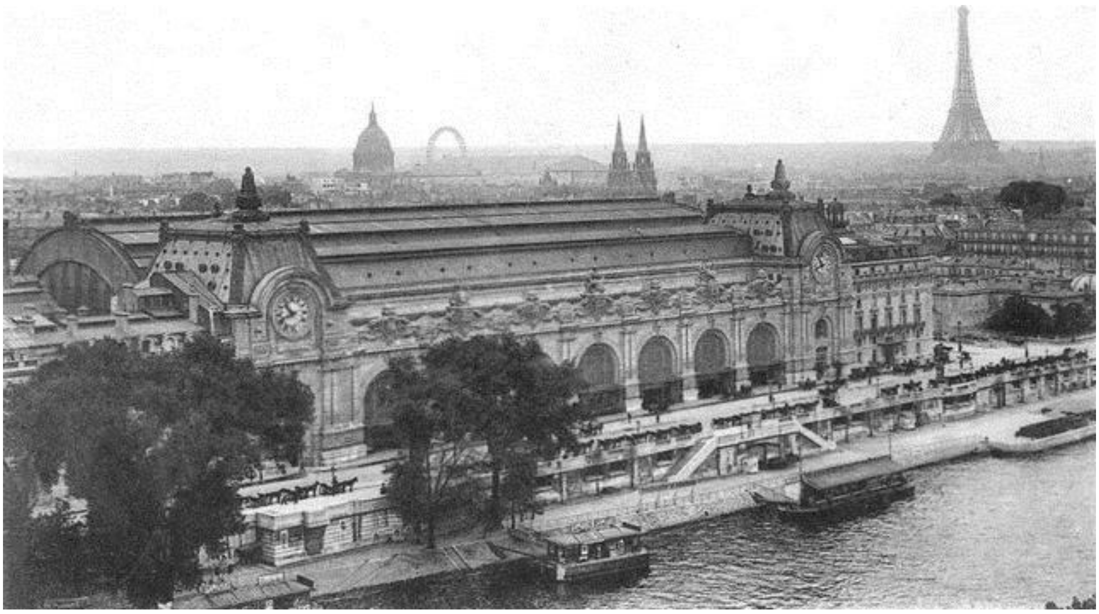


Figure 2.16 Gare de Orsay in Paris was completed in 1900 and it had lower train shed which built before (Source: http// www. christopheloustau. com/ 300 _Historique htm)

The architecture competition for the Gare de Orsay (Figure 2.16) was held in 1897. A hotel building was also included in the project which was finished in 1900. In this station modern techniques were used such as ramps and lifts for luggage, elevators for passengers, sixteen underground rail tracks, reception services on the ground floor and electric traction. The train shed was 138 meters long, 40 meters wide and 32 meters high. The station site was near Louvre museum and other historical buildings, so its façade was designed to be compatible to other buildings in the vicinity. This building used until 1969 and in 1986 it was transformed into a museum.(www.musee-orsay.fr/en/collections/history-of-the-museum/the-tation.html).

Figure 2.17 Interior view of Gare de Orsay in Paris showing train shed, concourse and platforms(Source:www.musee-orsay.fr/en/collections/history-of-the-museum/the-station.html)

Ferrarini (2005) describes the central station in Milan as being the final example of a grand station that was started in 1913 and finished in 1930. The elaborate façade of the station building hides the five arched train shed of glass and iron. Inside there is a gigantic space with two large monumental staircases leading up to the end concourse, which links the platforms (Figure 2.18). (Ferrarini, 2005).

Figure 2.18 Huge structure of the Milano Central station building
(Source: www.designboom.com/architecture/new-milan-central-railway-station/)

During the period between the two World Wars railway companies themselves concentrated on promoting images of efficiency and speed through streamlined locomotives or electric services. However, their plans to rebuild stations in a modern style were frustrated by the Second World War, (Stratton, 1995) because investments on the railways were decreased during the wars (Thorne, 2001).

Electrification and reinforced concrete were the root cause of a remarkable change in the architecture of railway stations in the words of Ferrarini (2005, pg: 9) “the large ever changing train shed was replaced by individual cantilever roofs; stations were conceived in terms of horizontal structures within which formal and functional unity was now greater thanks to the suppression of the sharp distinctions between the area allocated for machines and that designed for passengers.”

C. After world wars until the 1970s

The early 1960s were dangerous times for the historic buildings of Europe, because the craving for new things/looks took over countries that were recovering from the Second World War (Bruman, 1997).

Railway transportation was unrivaled in the 19th century; however, in the 20th century, both automobile and planes rapidly became strong competitors. With its invention, automobile technology rapidly became more popular while for long distance journeys, air travel was being preferred. Both automobile and planes caused a decrease in railway travel and the profile of the transportation industry changed. In order to take a bigger share in the transportation sector, railway companies started to work on increasing the advantages of trains by improving their speed. In order to run faster trains both the tracks and the train (locomotives and the wagons) needed to be developed (Thorne, 2001).

Due to the oil crisis in 1970s, oil prices increased and mass transit transportation systems became more economical than highways. So countries returned to railways again (Thorne, 2001):

Other reasons can be listed as below:

- Establishment of European Union

With the establishment of EU, the borders between countries have been removed and the local railway lines are made interoperable. With the unification of railways from different countries, standardization was started in safety, maintenance and investment projects (Thorne, 2001).

- Reconstruction of railways after Second World War,
- International Events,
- Special political opportunities
- The rise in the contributions of architects to station architecture. (Thorne, 2001).

2.3. Types of Stations

According to Droege (1916) stations can be classified into two groups.

1. Through or side stations
2. Head or stub stations:

These groups are described in detail in the following sections

2.3.1 Through or side stations

The principal tracks of a through or side station continue through the structure so that a train proceeding in either direction may continue its run in the same relative direction without reverse movement (Figure 2.19). In this type of stations, the platforms are either separated from the stations or close to the station. There are two tracks which are located on either side of the platform. Trains going to different direction are stopped at the same platform. Passengers reach the platforms through underpasses, overhead bridges or grade level (Droege, 1969).

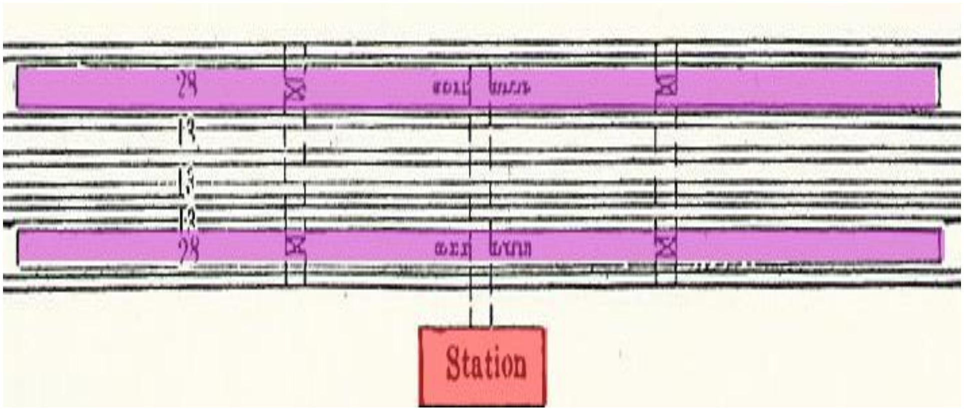


Figure 2.19: Schematic plan of showing through or side station
(Source: Droege, 1969)

Through or side station can be further divided into 3 sub-types according to the position of the tracks in relation to the street level (Droege, 1969):

1. Tracks and the streets at the same level
2. Tracks at a higher level than the streets
3. Tracks at a lower level than the streets.

Example of a through or side station: The Bangor ME station in USA was opened in 1907. Its tracks and streets were at the same level therefore it can be classified as a "through or side station". The station building façade was made of colored brick. There was a square tower rising to a height of 39.62 meters. The building had waiting rooms, a dining room, a kitchen, shops, the women's retiring room, a ticket office, agents' office, news stand, a smoking room and toilets. There was also another building for luggage, mail and express rooms (Droege, 1969).

Figure 2.20: Exterior view of the Bangor station in USA, which is an example of through or side station (Source: Droege, 1969)

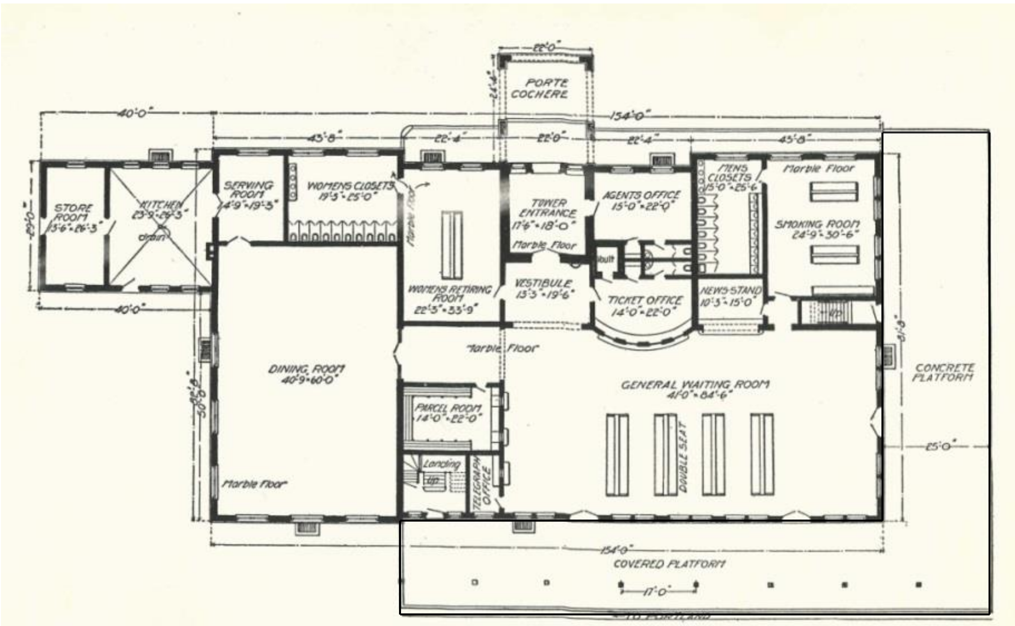


Figure 2.21: The Bangor Station ground level plan. It has a covered platform in front of the station (Source: Droege, 1969)

The train shed covered 8 tracks; five of them were stub tracks and the others were through tracks. The train shed dimensions were 152.40 meters long and 30.48 meters wide. There was a platform of 7.62 meters wide located between the station and the tracks (Droege, 1969).

2.3.2 Head or stub stations:

The head or stub station is an end of the line station, the tracks of which ends at bumpers or in loops and in which the runs of the trains of a system or division of a system terminate or are continued only after a reverse movement (Droege, 1969) (Figure 2.22).

The station type depends on the city structure, whether it is a head or stub station. These stations were not transit stations so, the journey started or ended there. Usually these types of stations serve passengers from rural area (Droege, 1969).

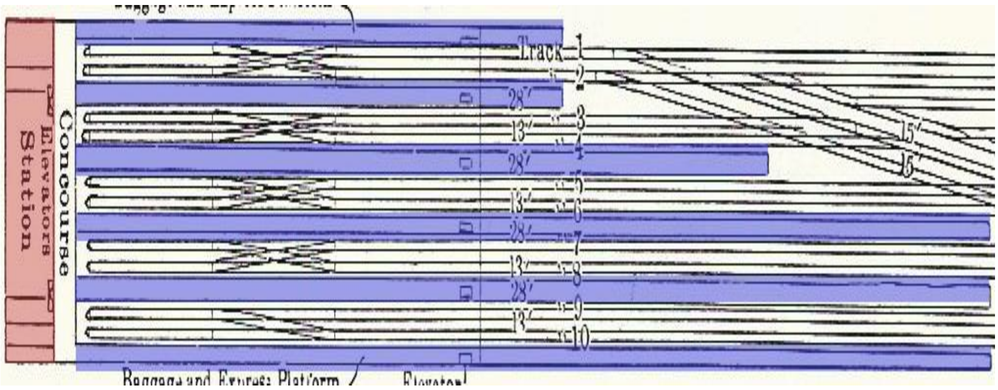


Figure 2.22: Schematic Plan of showing a railway tracks, platform station building Head or Stub Station (Source: Droege, 1969)

Head or stub stations are further classified into 3 sub- types: according to the position of the tracks in relation to the street level (Droege, 1969):

1. Tracks at or near the level of adjacent streets.
2. Tracks below the level of the streets
3. Tracks above the level of the streets.

Example of a head or Stub Station: Oregon Washington Station was built in 1910. The station was a “head or stub station” with “tracks below the level of the streets” typology. There was a concourse at the street level and it was above the tracks. Passenger could leave the station via the exit door which is opened directly to the street. The tracks were 7.31meters below the street level. (Droege, 1969)

2.4. High Speed Railways

After the 1980s railways were re-born, and people started to prefer this mode of transportation due to the vast improvement in train speeds (Thorne, 2001). The first high speed train emerged in Japan, as the 515 km long line between Tokyo and Osaka in 1964. High speed trains were put into operation in France and Italy in 1981, in Germany in 1988, in Spain 1992, in China in 2003 and in Turkey in 2009. With the high speed trains put into operation, either the transformation of existing stations or the constructions of new stations were required (www.uic.org.).

After the Second World War, innovative developments occurred in passenger transport system, railways became faster. When railways first emerged around 1830s, the speeds of the trains were about 30 mph. In those times, this speed was considered to be quite fast. In the 1930s, with the invention of American and German diesel powered engines, the standards for comfort and speed were changed. (Gourvish, 2010)

The channel Tunnel was opened in 1992 for high speed train and United Kingdom (UK) was connected to mainland Europe. New stations had to be constructed for new rail lines, both in England and France. In England the new Waterloo Station was constructed and old St. Pancras Station was renovated for this new rail line. The new Waterloo Station is designed for 15 million passengers per year and has four levels. The station has a modern train shed in the form of the great earlier examples. Whereas the St Pancras station was transformed to St Pancras International as it was the last stop for international rail line. The station platforms, and theirs length was not sufficient so the renovation also included new facilities and it was opened in November 2007.

2.4.1 Characteristics of High Speed Railways

According to the Turkish Standards (TS) 13643; rail tracks are categorized in 3 sections according to their speeds: These are listed below:

- **Conventional Rail Lines**: operating speed up to 159 km/h
- **Fast Rail Lines**: operating speeds from 160 km/ h to 249 km/h
- **High Speed Rail Lines:** operating speeds equals to or greater 250 km/h

In order to achieve high speeds, custom built rail lines have to be constructed. When two high speed trains pass each other, the speed differences between them can be up to 600 km/h. For this reason the width of the track lines become a critical parameter for speeds. So for high speed track lines width is larger than conventional track lines additionally, in order to achieve high speed, the high speed curve radius is also larger than conventional curve radius. The tunnels on high speed rail lines have to be designed to eliminate high pressure caused by high speed trains passing through in opposite directions. Also there is no level crossing across high speed rail tracks. The infrastructure for high speed railways has to be constructed in high quality and very high standards compared to conventional railways. (hizlitren. tcdd.gov .tr/home/d detail/? id=5)

2.4.2 Parameters of High Speed Railways

There are certain parameters that have to be taken into account when designing a high-speed railway line. These are described in detail in the following paragraphs:

a) Track Gauge: In different countries there are different track gauge standards. According to information obtained from the European Railway Agency (2014, pg: 8)

> "*1668 mm; which is shared between Spain and Portugal, 1600mm ;shared between Ireland and United Kingdom; 1524 mm shared among Finland, Sweden and Estonia, 1520 mm shared among Estonia, Latvia, Lithuania, Poland and Slovakia, together with 1435 mm which is regarded as the European standard nominal track gauge.*"

In Turkey high speed railway projects use 1435 mm track gauge.

b) Train Gauge: There is a limitation for minimum clearances around the train engine and carriages so that they may pass freely without danger of a collision. (www.tcdd.gov.tr).

c) Gauge for Structure and Freight: While designing railway buildings structure and freight gauge become important. Canopy, platforms etc. are placed considering the train gauge. (www.tcdd.gov.tr/home/detail/?id=302).

d) Electrification Gauge: Electrification can be defined as the generation, transmission and distribution of electricity. While designing a railway overpass the electrification gauge must considered. Since approximately 25,000 volt passes through catenaries' line, so there must a safety clearance of at least 50 cm between the overpasses and these lines. Furthermore, at the initial design stages electrification masts placements should also be considered while positioning the overpasses (TCDD, Electrification Documents, 2015)

f) Platforms: Passenger platforms for getting in or stepping out of a train should have an unobstructed width of 2.50 meters at each side of the platform.

There are two types of platforms: side platforms and island platforms. Rail lines set on each side of platforms can define an Island platform (Figure A.4); however when rail lines are set on one side of the platforms it can be called a side platform (Figure A.5) (Yüksel Proje, 2007).

According to International Union of Railways (UIC) codex there is a general definition about platforms height (Figure 2.23); these are 550 mm and 760 mm. In the UIC 741 Codex it is describe that platforms with a height greater than 760mm are high platforms and they are (UIC 741, pg: 3)

> *"...:dedicated exclusively for commuter trains specially designed for the given platform height (typically 960 mm) in order to ensure one level access and possibility of increasing number of doorways on each side of every coach", On the other hand platforms smaller than 550mm height are called low platforms and can be used for some train types"*

"... in order to fulfill particular architectural or operational requirements (some old fashioned stations, border stations, small local stations with passages locates along the useful length of the platform edges) in such cases however the minimal height of upgraded platform edge shall be 380 mm"

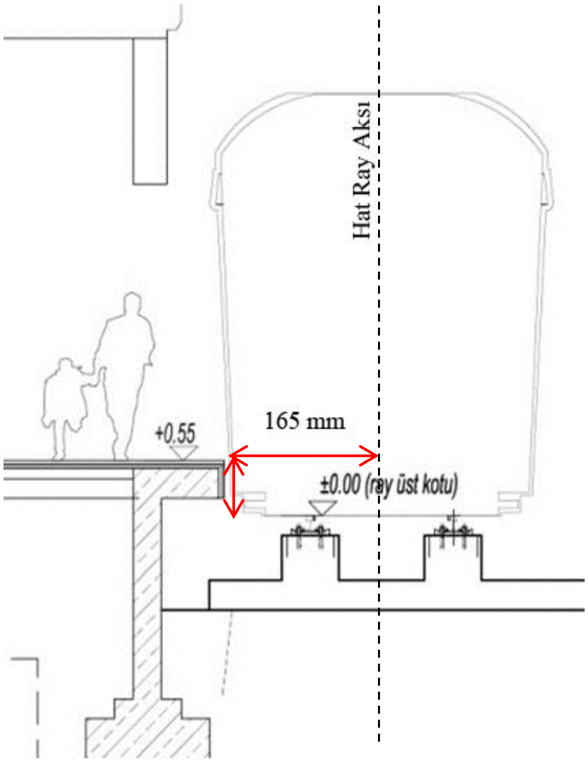


Figure 2.23 :Distance from rail line axis for high speed/ speed rail lines
(Source: TCDD projects,2015)

g) Train: In Turkey, Construcciones y Auxiliar de Ferrocarriles (CAF) and Siemens Velaro trains are used. For these trains the platform length has to be 400 meter so that two trains can use the same platform.

2.5 Special Planning Concerns for Modern Stations:

According to Krummeck (2009), a modern station must be designed in accordance with the international standards, since it triggers the development of the city, and attracts the interest of foreign investors and resources. Further local characteristic and traditional values must also be taken into consideration while designing a modern station. Furthermore stations must be easily accessible, have enough space and facilities and be sustainable; socially, environmentally and economically.

Krummeck (2009) has listed the following design considerations for modern railway stations:

"1. City wide strategy: the role of the railway station in the urban fabric: urban integrated solution

2. *Modern Travel Port: complexity of the contemporary station*
3. *Megalopolis: connect up with cities to make a world super city*
4. *Property integration: creating innovative, cost efficient developments*
5. *Context driven design: response to the environment, culture, demand and scale"* (Krummeck , 2009 , pg:3)

City Wide Strategy:

Mara (2010) state city wide strategy that

> *"Railway stations have opportunities to regenerate, develop and repair urban districts and create new focal points and gateways as well as to improve transportation links. Railway projects are often seen as a way of stimulating the economy. ….*

And he continuous

> *….."Improving the public realm and enhancing the civic character of the area to provide a catalyst for new development to the surrounding urban areas. Simple, balanced and unifying forms provide an integral architectural solution to complex functional and contextual requirements of this type of site.*

Modern Travel Port:

Rail journey is an alternative to air travel. Therefore, it is desirable to build modern stations similar to airports. The incoming and outgoing passengers must be routed efficiently for the optimization of the passenger traffic (Krummeck, 2009).

Suburban Hub:

Where stations in neighboring cities are connected with each other they can integrated them into a Megapolis e.g. Guangzhou, Shenzhen, Zhuhai, Hong Kong. In China, a Megapolis was created by joining four cities (Krummeck, 2009).

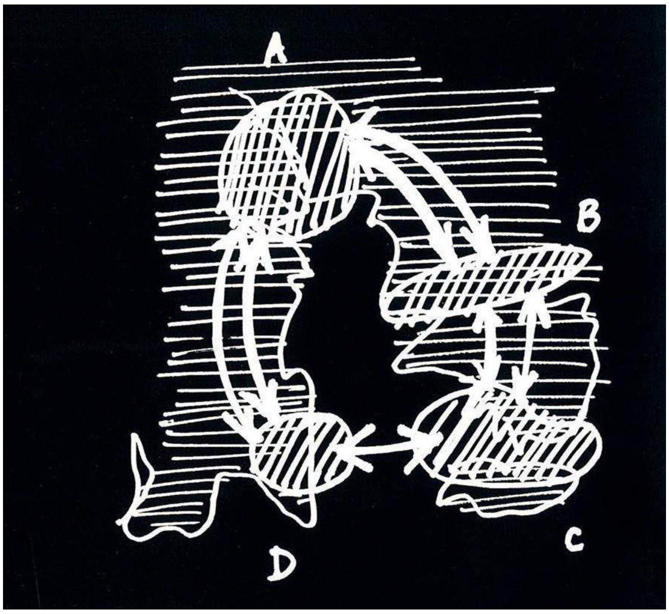


Figure 2.24 Railway stations create a Megapolis in China:
A. Guangzhou, B. Shenzhen, C. Zhuhai, D. Hong Kong

On the other hand, peripheral stations are crucial for the development of the city big creating a new center for its expectations (Krummeck, 2009).

Context driven design

Krummeck (2009, pg: 37) state that:

> *"The design of the contemporary railway station requires study and research into local conditions, be culturally, sensitive, respond to location (station master plan), demand and scale."*

For example system for rain water collection, Photovoltaic for energy production, natural ventilation and daylight have been provided by careful design of the New Delhi Station (Figure 2.25) (Krummeck, 2009).

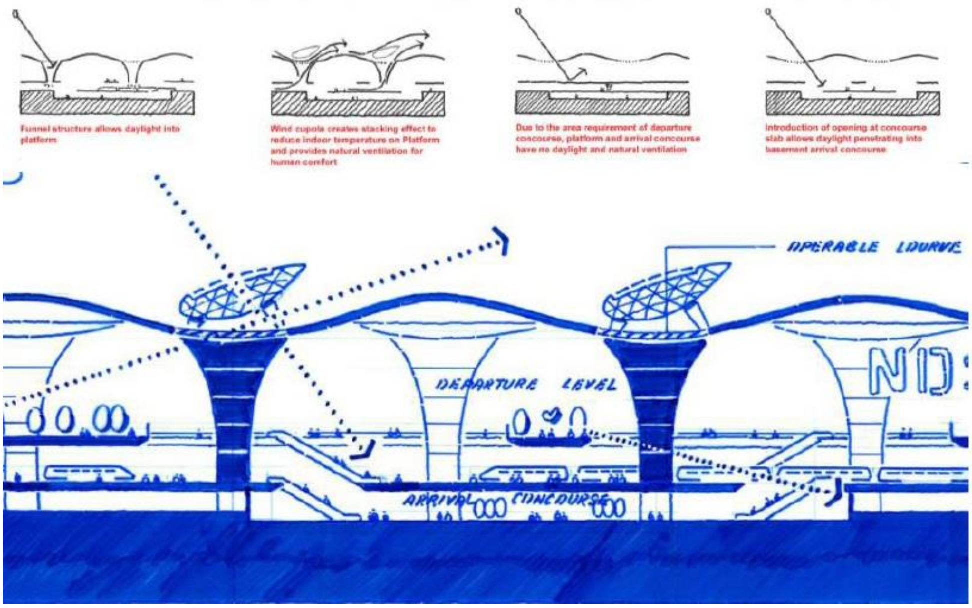


Figure 2.25 Rain water collection, natural light and ventilation, PV, New Delhi Station (Source: Krummeck, 2009)

Station roofs uses for design parameter for example in New Guangzhou it responds various factors such as weather, light and spatial need. (Figure 2.26) (Krummeck, 2009).

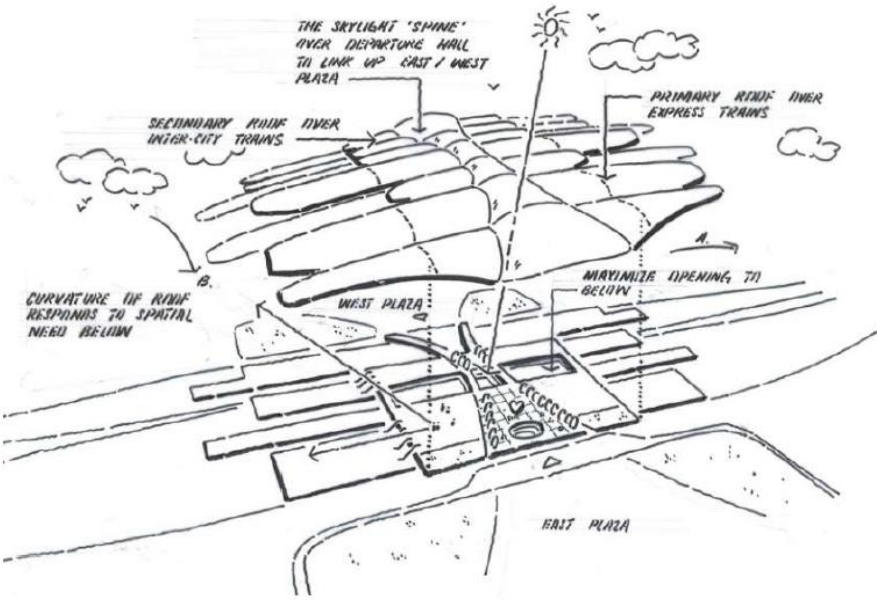


Figure 2.26 Stations roof responds to various factors, New Guangzhou Station
(Source: Krummeck, 2009)

2.6 Station Categorization

Classification of the stations makes the station design simpler it was used in determining minimum standards in a consistent manner, prioritizing enhancements, and managing asset condition and maintenance. Great Britain and Germany classify stations into six categories while Switzerland classifies into four categories. (DfT Better Rail Stations Report, 2009).

In England, stations were categorized into six with after the privatization in 1996; the following six types depending on “journeys per annum” and “ticket income per annum” (DfT Better Rail Stations Report, 2009).

These categories are defined by the Network Route Utilization Strategies (RUS) (2011) follows:

*“**National Hub**: These are the most important stations, providing a gateway to the rail network from a large area and acts as significant interchange hub.*

***Regional Hub**: Regional hub stations are providing a gateway to the rail network from a large area. Often served by more than one Train Operating Companies (TOC) with a mix service types*

***Important Feeder:** Important feeder stations on a busy trunk route or as subsidiary hub station. Often with services from more than one TOC and a regular long distance service.*

***Medium Staffed**: Medium sized, staffed stations with a core inter urban business or high volume inner suburban business.*

***Small staffed:** Small staffed stations often with just one member of staff at any one time, or for only part of the day.*

***Small Unstaffed Stations:** Small un-staffed station."*
(Source: Network Rus Station, 2011, pg: 17)

Dft Better Station Reports (2009) defined this categorization at journeys per annum and ticket income per annum for the year 2009. (See Table 2.2)

Table 2.2: Station Listing for 2009 (Source: DfT Better Rail Station Reports, 2009)

Type Of Station	**Journeys per annum**	**Ticket income per annum**
National Hub	more than 2 million	more than £20 million
Regional Hub	more than 2 million	More than£20 million
Important Feeder	500,000 to 2 million	£2 to £20 million.
Medium Staffed	250,000 and 500,000	£1 to £2 million
Small staffed	Up to250,000	up to £1 million
Small Unstaffed	Up to250,000	Up to £ 1 million

At Dft Better Rail Stations reports "Minimum Station standard" are determined with the station categorization and requirements in a station should proposed according to incremental standards as shown Figure 2.27.

While all stations have their own properties in accordance with the location they are built, categorization provides a guidance for both the internal design such as whether there will be the luggage, the security point or not, and for the design of the stations surrounding such as parking lots. (Source: DfT Better Rail Station Reports, 2009).

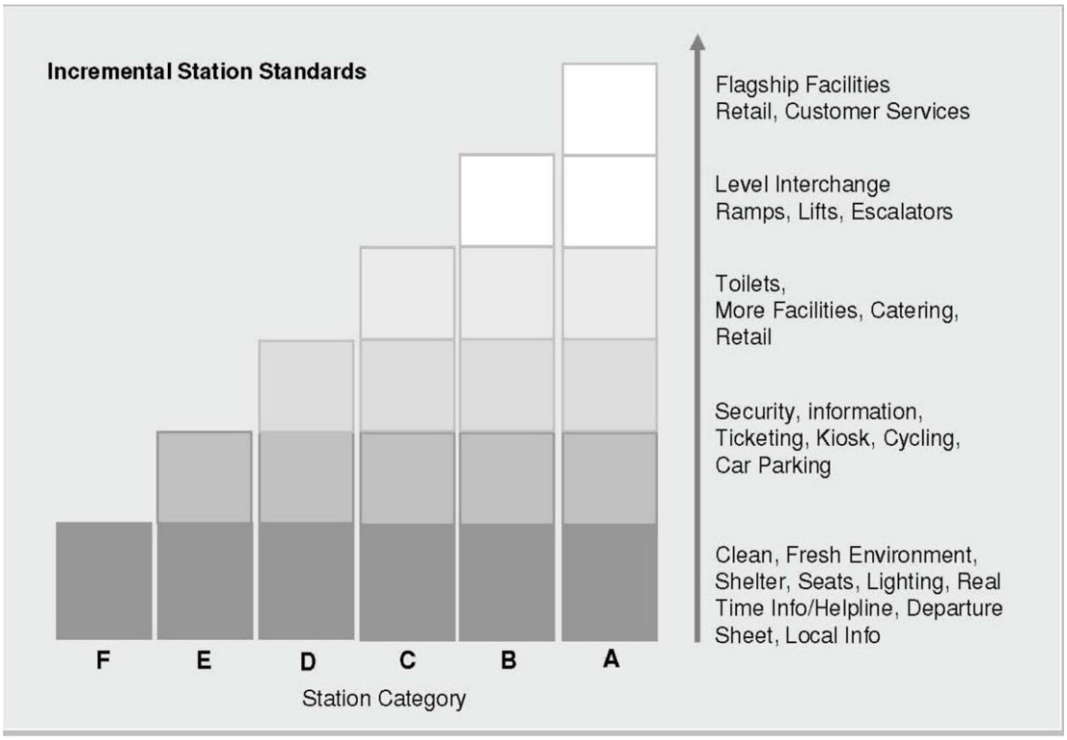


Figure 2.27: Incremental Standards (Source: Better Rail Stations Report, 2009)

CHAPTER 3

MATERIAL AND METHOD

In this chapter is presented the material used in the research and the methodology of research in two sections. The section on material describes the three case studies. The methodology section describes the evaluation criteria about case studies.

3.1 Materials of the study

Materials related to case studies are given separately. First case study was selected from a European country; it is the Berlin New Central Station which is located in the capital city of Germany. The second case study is chosen from the Far East; Beijing South Railway Station is located in the capital city of China. The last case study is selected from capital city of Turkey, Ankara; the High Speed Railway Station in Ankara is still under construction.

These stations were selected because all three of them are located in the capital cities of their countries and at the same they have been constructed on the site on the old train stations. Pertinent information on these modern railway stations buildings were obtained from architectural offices, railway authorities, publications and the websites. The details on these three case studies are presented in the following section.

3.1.1 The Berlin New Central Station

Berlin New Central Station (BNCS) is the largest and the most modern interchange station for long distance regional and local transport in Europe. It is located on the site of the old demolished Lehrter Station area (DB Lehrter Bahnhof Report, 2005).

Figure 3.1 Berlin New Central Stations (Source: Google Maps)

3.1.1.1. Historical Survey

Germany built its first railway line in 1835, and Berlin got its first railway line in 1838. More lines were soon constructed all around the country. Lehrter Station, which was replaced by BNCS, was built between 1869 and 1871 in Berlin. The platforms in the old station building were covered with an impressive train shed. Old Lehrter Station was a head stub type of station built for the north to east main line. In 1882, Lehrter Urban Station was built north of the Lehrter Station. This Urban Station served both local and main line, although only in the east to west direction (DB Lehrter Bahnhof Report, 2005).

Figure 3.2: Old Demolished Lehrter Station
(Source: www.snugu.de/ak/berlinlehrterbf.htm)

After the division of Germany the Lehrter Station lost its importance and in 1952 it was closed down completely. Unfortunately, World War II and the division of Germany destroyed the Berlin rail network and this magnificent building was also bombed during the war; later its ruins were blown up in 1959. After demolishing the Lehrter Station, Lehrter Urban Station was constructed (DB Lehrter Bahnhof Report, 2005).

After the reunification of Germany, owing to increasing passenger numbers and transportation volume, a new rail line concept had to be developed for Berlin to join Germany's rail network. Accordingly, a new north-south rail line was planned so that the railway lines from the north to south passed through a tunnel under the Spree River. This new concept was called a mushroom concept (Figure 3.3). (DB Lehrter Bahnhof Report, 2005).

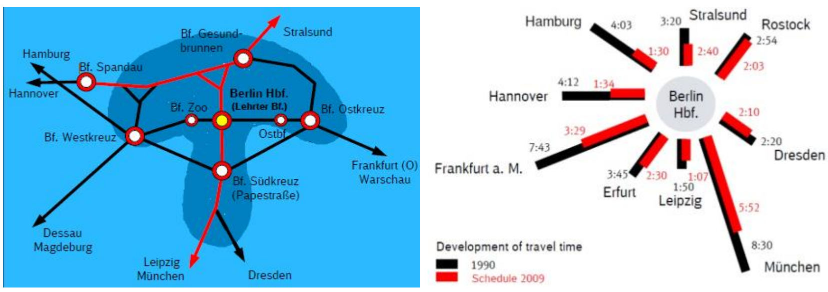


Figure 3.3 Mushroom Concepts for reduce travel time in Germany
(Source: Albert, 2009)

3.1.1.2 General Information about BNCS

BNCS place was decided to be at the intersection between former east-west line and new north-south line. The site of the old Lehrter Station combined with the in use Lehrter Urban Station area was chosen for the construction of the new station.

Figure 3.4 Berlin New Central Station General View
(Source: www.gettyimages.ca/detail/news-photo/an-aerial-image-of-berlin-hauptbahnhof-berlin-news-photo/152477584)

BNCS is situated in the city center; near the central business district and industrial official buildings e.g. the Germany Challegry, Reichstag building and Tiergarten. In1993 a competition was held for the BNCS projects and von Gerkan und Partners (vGMP's) design won the first prize, the architect was Meinhard von Gerkan. (Olsen and Namara, 2014).

According to the DB Lehrter Bahnhof report (2009, pg: 17)

> *"…The new Berlin Hauptbahnhof-Lehrter Bahnhof is embedded in a newly developing city district with several blocks of buildings and the historic port of Humboldt Hafen. The station plays an important role in filling the surrounding*

area with life: it is the motor, the initial ignition sparking off the entire development of the surrounding area."

BNCS is a connecting station designed for 300,000 passengers and 1200 trains per day. (Olsen and Namara, 2014) The older east-west rail tracks were removed and shifted northwards (Figure 3.5). The railway station is comprised of a train shed which covers the new east-west rail track and platforms, two 12 levels office buildings (crossing over the east west train shed) and the station building, which is between the two office buildings and intersects the east west rail lines, extending from north to south (DB Lehrter Bahnhof Report, 2005).

Figure 3.5 Existing rail tracks were removed and shifted northward
(Source: DB Report, 2005)

The train shed over the east west rail tracks and platforms is covered with a glass structure. This train shed has 23 steel roof trusses. It is 16 meters high and its width changes between 59 to 68 meters due to positioning a curve rail line. At first it was 450 meters long but then it was shortened to 321 meters in order to build in time for the 2006 Fédération Internationale de Football Association (FIFA) World Cup in Germany. The new east - west rail line with the train shed opened in June 2002. There are two bow shaped office buildings which cross the east west rail lines' train shed. These were designed for offices and also these buildings facade were made of glass like the other parts of the building. The 12 levels buildings height is 46 meters and the core height is 48 meters (DB Lehrter Bahnhof Report, 2005).

Figure 3.6 Berlin New Central Station Section: Daylight penetrate from all levels (Source DB Lehrter Bahnhof Report, 2005)

3.1.1.3 Station Layout

The station building has five levels:

- Street level: is arranged as the entrance level,
- 2nd Basement Level: New underground north south rail lines are set below 15 meters from the street level,
- 1st Basement Level has shops for passengers
- Level +1 has shops for passengers as well and is 7.5 meters above from the street level,
- Level +2 is east-west rail line 10 meters above from the street level

a) Street Level:

The floor dimensions are 40 meters wide and 160 meters long. Passengers and public can come here by public transportation such as buses, motorcycle, bicycle or private car and also pedestrian can. (DB Lehrter Bahnhof Report, 2005)

There is no rail line in this level. This level is a passage way at the same time. There are two entrances from north and south; and four separate entrances for the two office buildings. There is no X-ray machine or security check point at the entrances.

There are many different shops to meet the passengers' needs. In the middle of the building a circulation area was designed which has escalators, staircase and panoramic lifts. Passengers can directly access the 15 meters underground level by escalators and staircases and they can reach the platforms 10 meters above for the east-west rail line by escalators and stair cases too. The panoramic lifts also transport the passengers directly to these levels. (Figure 4.2 a)

b) Level +1:

There is no rail line on this level as it was designed for shopping and other amenities. Here a police station, business class lounge, luggage room, shops, station related area and Deucthe Bahn (DB) offices are located Passengers can reach the platforms on level 2 by escalator, lifts and staircases (Figure 4.2 b)

c) Level +2:

Level +2 is platform level that serves two S-Bahn and six long distance rail lines. There is one platform for S-Bahn and two platforms for the long distance trains. The S-Bahn platform is shorter than the others. There are ticket machines on this level. The curved train shed covers the rail lines and the platforms. Passengers can reach the underground levels by panoramic lifts and escalators. There are no shops on this level (Figure 4.2 c).

d) 1st Basement Level

There is no rail line on this level as it is designed for passenger and public amenities. There is a passage to connect to the U-Bahn metro. Passengers can reach directly this level from the car parks (Figure 4.2 d).

e) 2nd Basement Level

There are eight rail tracks and four platforms. The new north-south rail line reaches here by passing the Spree River through a tunnel. There are no shops on this level. The U- Bahn area is also at the same level with the 2nd basement, but there is no direct link to it. The U Bahn platform is shorter than other platforms. (Figure 4.2 e).

3.1.1.4. Environmental Design Features

Berlin New Central Station has been designed with certain environmental features; such as natural light and ventilation to conserve energy as well as Photovoltaic (PV) for producing energy. (DB Lehrter Bahnhof Report, 2005)

The station is designed in a way that allows natural light/ daylight to penetrate to all levels of the building. The train shed and the entrance facade and its roof are all made of glass, so daylight can reach even 15 meters below the ground where the north-south line platforms are located. This feature allows passengers to find their way easily.

BNCS has a 60 meter high exhaust air stack to facilitate natural ventilation. The car parking area has three levels and has a direct entrance from the road that passes under the Spree River, and continues along the station before coming up to the ground level. The exhaust air stack provides fresh air for the car parking area. (DB Lehrter Bahnhof Report, 2005)

Photovoltaic to produce electricity for the train station are located on the south side of the train shed. There are 780 solar modules and their sizes are various because of the curvilinear shape of the building. Every year averagely 160,000 kilowatt hours are produced by PV solar cell systems and it supplies approximately 2% of the BNCS total energy resumption. (DB Lehrter Bahnhof Report, 2005)

3.1.2. Beijing South Railway Station

Beijing South Railway Station (BSRS) is one of the largest intermodal railway stations in Asia (Figure 3.7), and is situated 500 meters from the old demolished

Yongdingmen Station (Figure 3.8). BSRS is located between the second and third southern ring – roads, outer part of the city (Leemans A. & Ivkovic M., 2011).

Figure 3.7: Beijing South Railway Station (Source: Google maps)

3.1.2.1 Historical Survey

The Majiapu Railway station was built in 1897, then its name was changed to Yongdingmen Railway Station in 1901.The old Station was operational until it was demolished in 2006. It had served the public for 109 years before being replaced by the BSRS.

Figure 3.8 Old Yongdingmen Railway Station (Source: Krummeck, 2009)

Beijing is one of the world's oldest cities. It was planned in hierarchy with the Emperor's Forbidden City at the hub and the progressive outer concentric *"rings based on the cardinal points. Intersecting roads lead to a fairly north-south/ east-west planning grid"*(Arup, 2011).

There are six main railway stations in Beijing. These are; Beijing Main, Beijing North, Beijing West, Hepingu, Guang'ammen and Beijing South." (Arup, 2011).

All large Chinese railway stations have been constructed outside the city center, including the BSRS. The old Yongdingmen station area was chosen as the location for the new railway station because of its place in Chinese railway network.

3.1.2.2. General Information

The Chinese government wanted to build a station which was to be heart of the 2008 Beijing Olympic Games and to show China's new face to the world. So an international competition was held in 2003 for new south railway station (Arup, 2011).

Terry Farrell and Partners (TFP) and Third Survey Design Institute (TSDI) collaborated for this competition. This was two stage competition and TFP/ TSDI project, which was inspired by the Hall of Prayer for Good Harvest Temple of Heaven, won this competition (www.terryfarrel.co.uk).

Figure 3.9: Exterior view of the Beijing South Railway Station. It comprised of three parts; the station building in the middle (Source: www.terryfarrel.co.uk)

The building was designed for 287,000 passengers per day. It is estimated to serve 150 million passengers per year by 2015 and 190 million passengers per year by 2020. The BSRS design was a hyperbolic dome which is arranged on a square diagonal axis and covers the platforms with a 400m diameter roof set on a 32 acre area (Arup, 2011).

Building roof is divided into 3 parts; a large central roof and two side canopies, which provide rhythm to the internal spaces. Central roof dimensions are 350m in length and 190 m wide, its highest point is at 40 meters height and at the eaves the height is 20 meters. The canopies height changes from 35 meters to 16.5 meters. The building was opened on 1st August 2008. The design approach is similar to an airport, with check point at the entrance. The building has 3 levels; and there are two underground levels integrated with BSRS. In this station arrival and departure are at different levels, so there is a vertical separation (Arup, 2011).

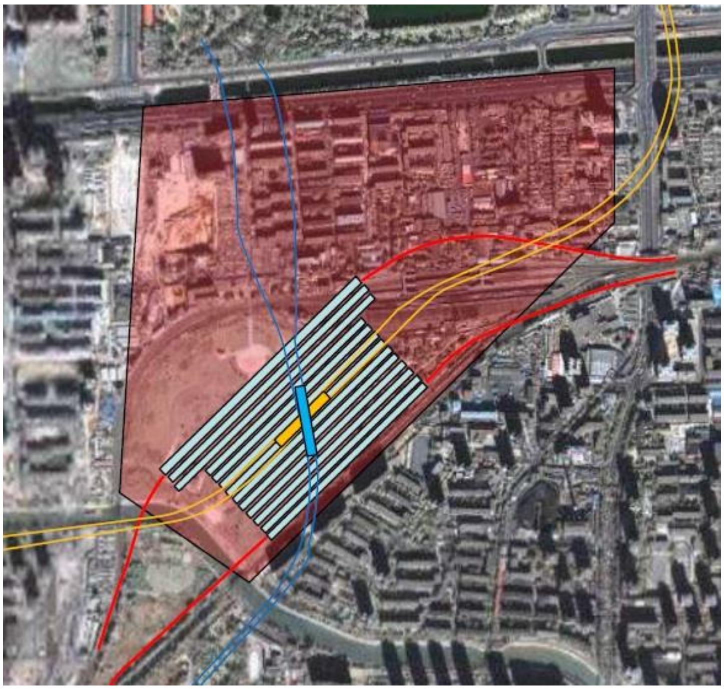


Figure 3.10 Beijing South Railway Station Site Plan
(Source: Krummeck, 2009)

3.1.2.3. Station Layout

The building has three levels (Figure 3.11):

Platform Level is at street level,

Arrival Level and Departure level has shops

B1 Level: interchange level for passengers.

B2 Level: underground for M4 line,

B3 Level: underground for M14 line, (under construction)

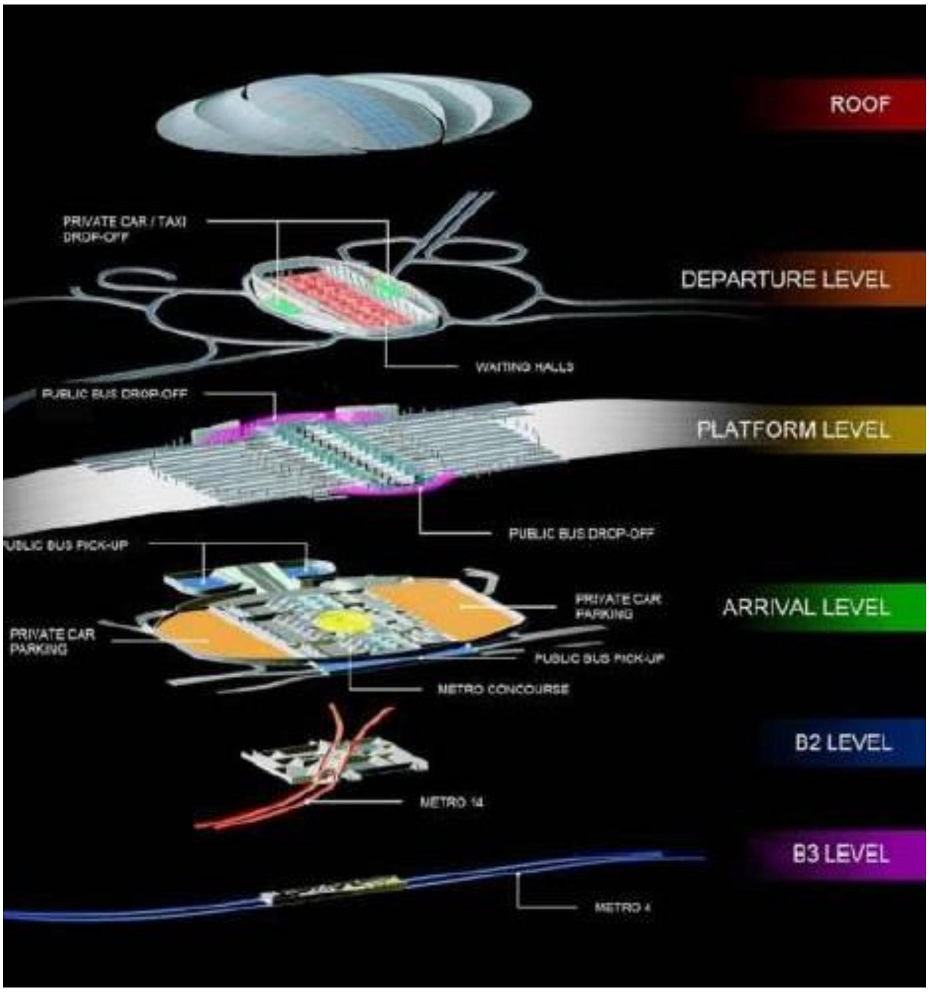


Figure 3.11 Beijing South Railway Station Section (Source: Krummeck, 2009)

a) Platform level

There are 13 platforms and 24 rail tracks at the platform level. Three of the platforms are 550 meter long, for suburban trains, and others are 450 meters long for high speed trains and regional trains. There are no shops on this level. There are two entrances at north and south for pedestrians and public buses, but taxis are not allowed. Passengers arriving by car can reach this level from the arrivals or departure levels. There are offices for station management and plant rooms on this floor. (Figure 4.3 a).

b) Departure level

The departures level is above the platforms level. There are ticket offices, shops, book stores, markets, business class lounges, aid offices, toilets, luggage room, etc. on this floor. There is also a waiting area in the middle of this level. It is the core of the BSRS, and serves 10,000 passengers on important days such as festivals etc. The layout of this central core makes it easy for the public to find their way about the station (Arup, 2011) (Figure 4.3 b)

There are two entrances at east and west facades. Passengers can enter the BSRS by taxi or private car from these entrances. There is no pedestrian and bus approach at this level. There is an X-ray machine and security check point. There is no direct entrance from north and south. Passengers who enter the building from north and south have to use the escalator or elevators to reach the departure level. There is a ticket check point before the escalators.

Departure level dimensions are 350mx190m. . The station plan is flexible enough to cope with excessive passenger loads during festivals. An overland road goes around the departure level hall for drop-offs by private cars or taxis. The central hall has a total area of 54,000 m2 and includes the entire 50,000 m2 departure hall (Arup, 2001).

c) Arrival level:

The arrival hall is also the interchange hall and is located one level below the platform level. This level is also used as a transfer concourse for passengers between the long distance trains at ground level and the metro lines at the two basement levels. There are entrances to this level from car the parking area and the metro. (Figure 4.3 c)

3.1.2.4. Environmental Design Features

The environmental design features were provision of daylight in interiors, thermal comfort, air quality monitoring, energy efficiency, and green power generation. With this aim the design was simulated for its performance in order to construct a sustainable building. Additionally, 3246 PV solar panels were installed on the roof of the railway station to produce electricity.(Arup, 2011)

3.1.3. Ankara High Speed Railway Station

The Ankara High Speed Railway Station (AHSRS) will be the largest interchange station in Turkey. Its construction has started in 2014 and it is estimated to be finished in 2016. Its location is the field in front of the current Ankara railway station.

3.1.3.1. Historical Survey

The first train arrived in Ankara in 1892. From 1892 to 1937, a double storied station building was constructed in Ankara on the same plan as the one in the neighboring city of Eskisehir.

After the proclamation of the Republic, the passenger traffic grew and a new station was needed. Şekip Akalın, an architect in the Ministry of Public Works, was assigned to design the new station. The demolition of the old station building was completed on 6 August 1935, and the construction of the current station began on the 10^{th} of August 1935. The construction of the new Ankara station was completed on 2 September 1937. And the opening ceremony was held on 10 November 1937.(TCDD, Architectural Report, 2006)

Ankara station is 150 meters long, was built in 5 parts. The station building is composed of a large hall which contains ticket offices and waiting room and two blocks on both sides of the hall which contain, station manager room, barber, mosque, Very Important Person (VIP) room, police station and other Turkish State Railways (TCDD) offices. There are 6 flats for the railway staff on the first floor of this building. The refuge has been converted into a sports hall for the staff.

The first platform is located right in front of the station and is 10 meters wide and 460 meters long. There are a total of 3 platforms, the 2nd platform is 440 meter long and the 3rd .platform is 383 meter long. Celal Bayar Boulevard is located toward the commuter train platform; these platforms are connected with each through the passage to the subway. The subway extends to the Gazi Mustafa Kemal (GMK) Boulevard as well (TCDD, Architectural Report, 2006).

It is planned to construct new high speed lines, and it is expected that the passenger traffic will rise. Since the existing Ankara train station will not be able to cope with this increase a new high speed train station is planned to be constructed on the same land toward the Celal Bayar Boulevard (Figure 3.12). The current Ankara station building will not be demolished since it is a protected building of historical value. (Source: TCDD, Architectural Report, 2006)

Figure 3.12 Ankara High Speed Train Station Site (Source: Google Maps)

3.1.3.2 General Information

AHSRS will be constructed behind the existing Ankara station, in the city center. The design of the new Ankara station was tendered by the TCDD Construction Department. The tender has been awarded to a consortium of SUDOP-Praha and SUDOPAK International Mime. Eng and architect was Serdar Akünal.

The contractor company for the project has designed two alternatives for the AHSRS. The first option consisted of three main blocks; the terminal building, the shopping center and a business center that was designed as a high-rise building (Figure 3.13) (Source: TCDD Architectural Report, 2006).

Figure 3.13: First Design Alternative (Source: TCDD Architectural Report, 2006)

The second option consisted of all facilities, including the terminal and a business center, under the same roof (Figure 3.14). This building was to be located across the existing railway line. The second option was chosen by the TCDD; which underwent many revisions to reach the final design (Figure 3.15). (Source: TCDD Architectural Report, 2006).

Figure 3.14: Second Design Alternative (Source: Architectural Report, 2006)

Figure 3.15: Final design of the New AHSRS

Being the first high-speed railway station in Turkey, AHSRS, will serve 30,000 people daily.It is estimated 50,000 people daily by 2023. The Construction of the AHSRS was tendered in 2012 with Build-Operate-Transfer method. The Construction tender was won by Limak-Kolin-Cengiz Joint Venture Group which will operate the YHT station for 19 years 7 months. Since it is tendered with the build-operate-transfer method, some changes have been made on the preliminary project, before starting the construction.

The train shed is not a separate from the main building in the AHSRS. The building is being constructed as a single structure on top of the railway lines (Figures 3.16).

Inspired by the fast train view the AHSRS consists of 5 blocks containing passenger spaces, administrative units, shopping centers, a hotel with 60 rooms and 2 suites, and rentable office units.

The current Ankara station building will continue to be used for new functional after the construction of the new station. There are both underpass and overpass connections between the old and the new stations, and the two underground train lines (Ankara and Keçiören Metro) will be extended to reach the station. The platforms and the railway lines between the current and the new train station will be re-arranged to be compliant with the underground standards in the scope of the "suburban railway modernization project (BAŞKENTRAY)" and will be used for both suburban and regional passenger transportation.

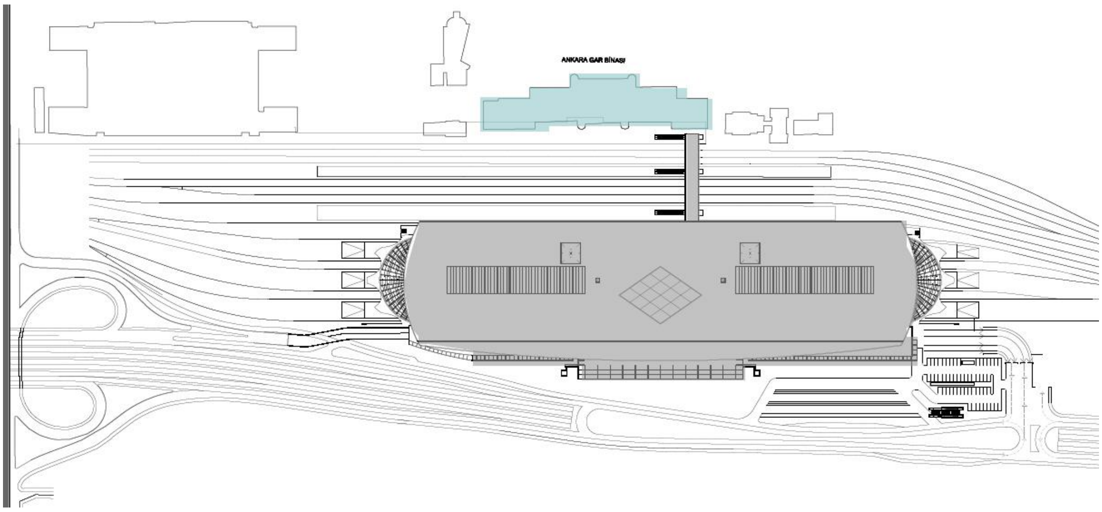


Figure 3.16: Ankara High Speed Station plan. It is situated opposite of the old Ankara station (Source: TCDD projects, 2014)

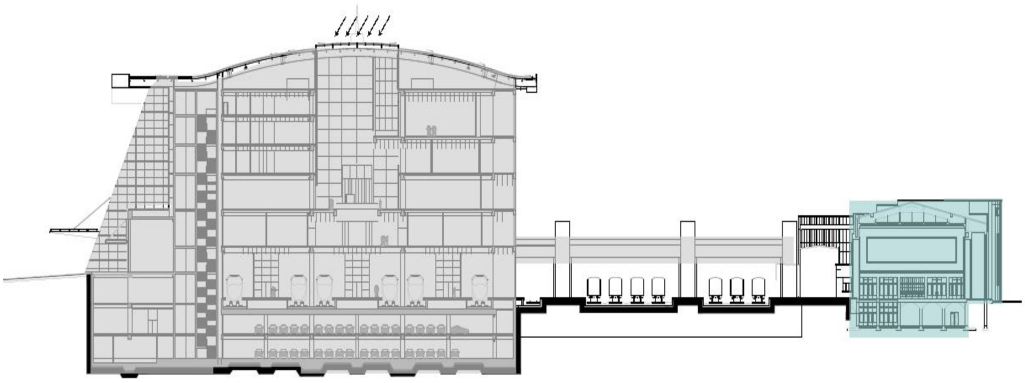


Figure: 3.17 Ankara High Speed Station Section. Overpasses will connect old and new station (Source: TCDD projects, 2014)

3.1.3.3. Station Layout

There are 9 levels of which 3 of are underground levels and 6 are above the ground and they are:

Lower Ground Level is arranged on the street level

Upper Ground level: has shops, restaurants,

Level +1: shops, restaurants

Level +2 fast foods, restaurants and hotel

Level +3, +4: offices and hotels

Level +5: Technical equipment level

3rd Basement Level: Car Parking Area

2nd Basement Level: Car Parking Area and subways

1st Basement Level: Has shops

a) Lower Ground Level

High-speed train station will be reached by bus, taxi and private car through Celal Bayar Boulevard on the lower ground level. Since the pedestrian access will also be from the same facade, a double storied shopping area has been planned on this facade, accessible from the street level. Inside the building there is a large entrance hall, which is also visible from the outside, in the center of the building (Figure 4.4 a). Passengers coming from underground stations, from current Ankara station, from parking lots and from the platforms of Baskentray light train are transferred from the underground levels to the entrance level hall through escalators or elevators, after passing the security controls.

b) Upper Ground level:

This level is used by the arriving and departing passengers. Departing passengers reach this level after passing the security point. There are shops, ticket offices, and luggage storage areas here. (Figure 4.4 b)

c) Level +1:

There exists a gallery hall which faces the main entrance hall on the first level. A shopping mall is located on this level and the units related to the passengers are not included in this level. Additionally, there are offices and cafeteria for the TCDD staff on this level, as well as terraces on both sides of the building. (Figure 4.4 c)

d) Level +2:

On the second level is a gallery hall which looks down on the main entrance hall and the first level. There are restaurants and fast food eateries around the gallery. Although the building consists of a single structure, it is divided into two blocks internally, starting on the level with offices and hotels, and continuing to the upper levels. On the left to the gallery space there are rentable offices and on the right there is the hotel block having rooms on each floor. There are entertainment areas and three balconies one from the center of the building and the remaining two from the sides. This level is the upper most level for shopping facilities. (Figure 4.4 d)

e) Level +3:

There are office and hotel blocks on this level. Opposite to the office block are the two-floors of building services and seminar rooms which can be partitioned when needed. (Figure 4.5 a)

f) Level +4:

Only office and hotel blocks exist on this level. (Figure 4.5 b)

G) Level +5:

Only the building services and equipment exist on this level. (Figure 4.5 c**)**

h) 1st Basement Level:

The platforms are also located on this level. There are some shops serving passenger needs, on this level. Passengers can reach the upper and lower levels through escalators. There are also some TCDD units and facilities for the shopkeepers and sales staff. (Figure 4.6 a**)**

I) 2nd Basement Level:

The second basement level is used for transfer passengers from current Ankara station, regional and suburban stations, ANKARAY light train and the Keçiören metro line. There are security points at all passenger entrances to the station. There are 591 parking lots 28 of which are for the disabled. There are shops, markets, open rest areas and kiosks on this level. (Figure 4.6 b**)**

j) 3rd Basement Level:

There are a total of 650 parking spaces, including 30 disabled parking lots. Additionally, there are storage spaces, archive rooms and emergency shelter on this level. Shops and other facilities for passengers are not provided on this level. (Figure 4.6 c**)**

3.2 Methodology

At first a thorough survey of literature was carried out and information on each case study was gathered under the following headings.

1-Historical Survey:

Since all of the three new stations have been constructed on the old station locations. a historical survey of these areas was undertaken from published sources and the design of the previous train stations were investigated.

2-General Information:

Regarding the cities, their population, passengers per a day, total gross area etc. was gathered. The critical parameters on designing such as station location, the project type and the time period from designed to constructed are examined information about building are given.

The case studies are examined in terms of project type (tender or competition), duration from project start to end of the construction finished. The critical parameters for design such as city population, passengers per day, number of platforms and rail lines, total gross area, shopping area, other uses area, net station area, area for passenger per meter, integrated with metro, security check at entrances, ticket check points, turnstiles, waiting room, environmental design criteria, first class, VIP, CIP were gathered.

3-Station Layout:

All levels were analyzed in terms of functions, spaces for passengers' use, the approach of pedestrian, car, taxi and buses, etc, are examined. The platforms level is investigated too, because of passengers flow.

Schematic plans of Beijing and Berlin station were re-drawn in AutoCAD and the zoned in terms of functions were identified the same process was used for AHSRS preliminary project, also using these drawings following data was information are gathered through calculations of the pertinent spaces. These are:

1. Passenger demand area (m^2)
2. Station related area (m^2)
3. Additional functions area (m^2)
4. Waiting area (m^2)
5. Covered Car parking area (m^2)
6. Circulation area (m^2)
7. Covered train shed area (m^2)

4-Environmental Design Features:

Because station buildings are huge buildings their energy needs for lightening, heating, cooling and ventilating higher than others. In order to meet this energy demand, if possible, station buildings should produce energy and take into consideration this feature at the preliminary project stage. For this reason solution concerning energy efficiency in the case studies were also examined.

Finally, all the gathered information and data about the three case studies, Berlin, Beijing and Ankara were tabulated for comparison.

CHAPTER 4

RESULTS AND DISCUSSION

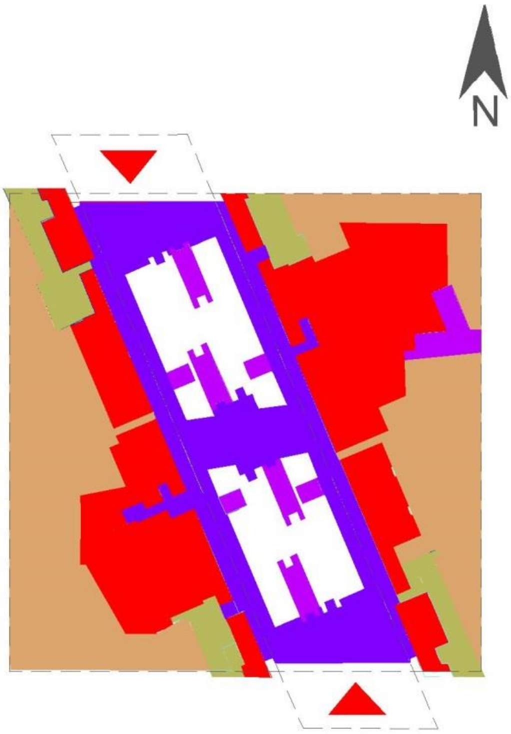
In this chapter are presented firstly result and secondly discussion and then a comparison of the three case studies with respect to design considerations for modern railway stations.

4.1 Results:

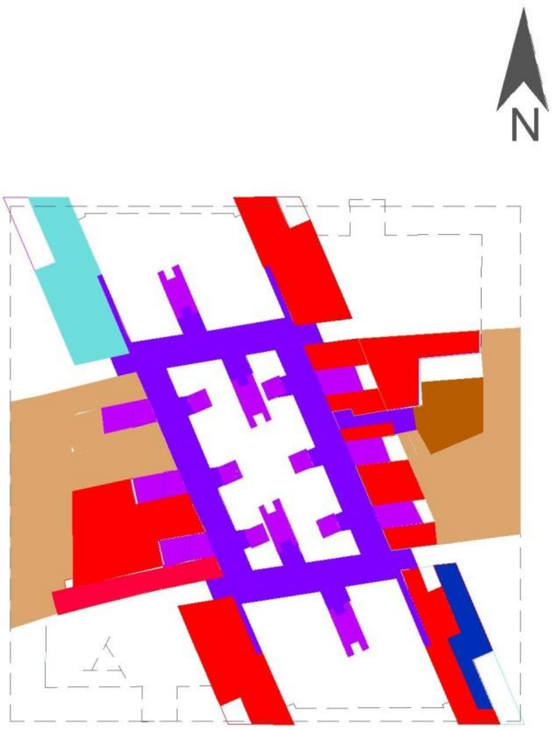
The three railway stations, Berlin, Beijing and Ankara, were investigated according to design criteria, which are described in detail in the following sections. The floor plans of all three railway stations were re-drawn according to space use, while each space type is indicated with a unique color; e.g. vertical and horizontal circulation, platforms, waiting, retail, station administration, plant rooms, car parking, security/police, offices, hotel, etc.

The plans showing these spaces are given in Figures 4.2- 4.6. The color coding key is given below (Figures 4.1):

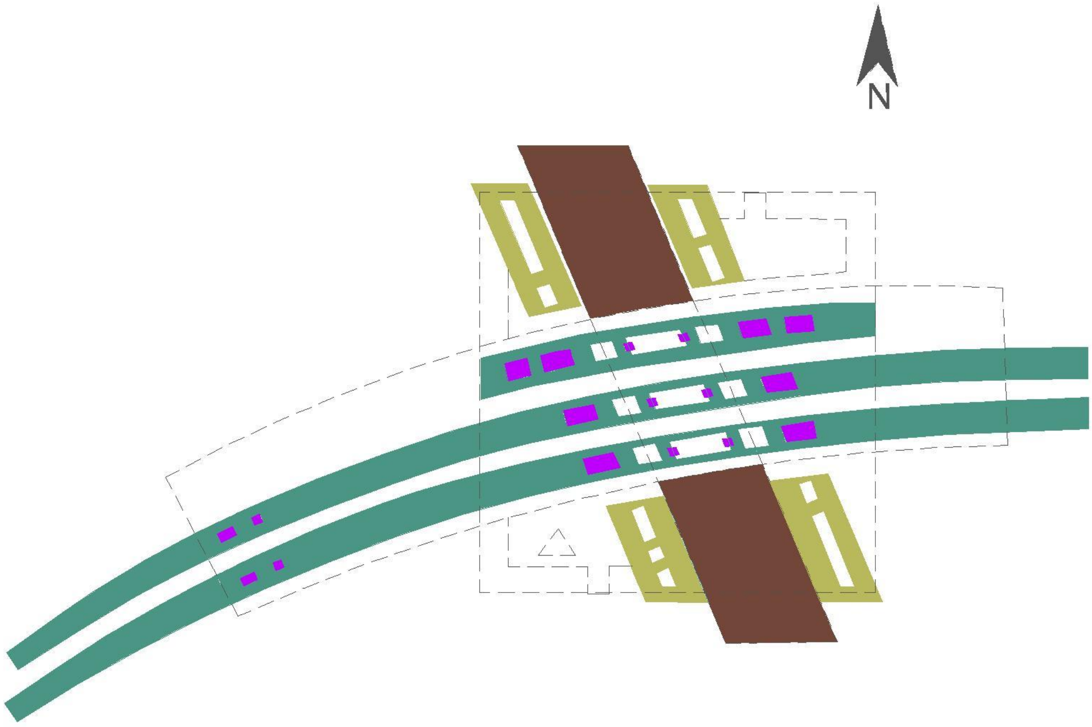
Figure 4.1: Key to color coding of spaces shown in plans of the three case study stations



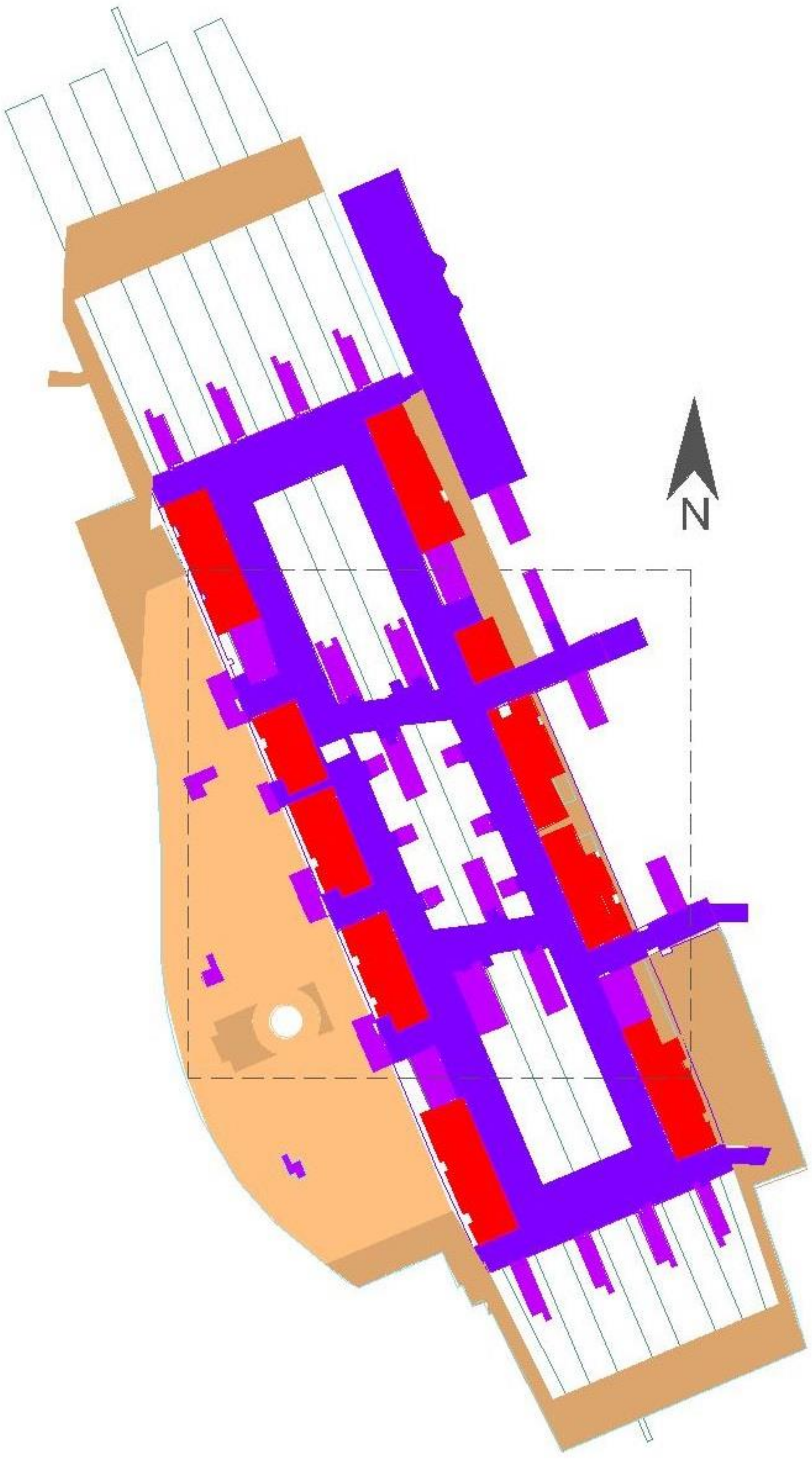
(a): Street Level Plan



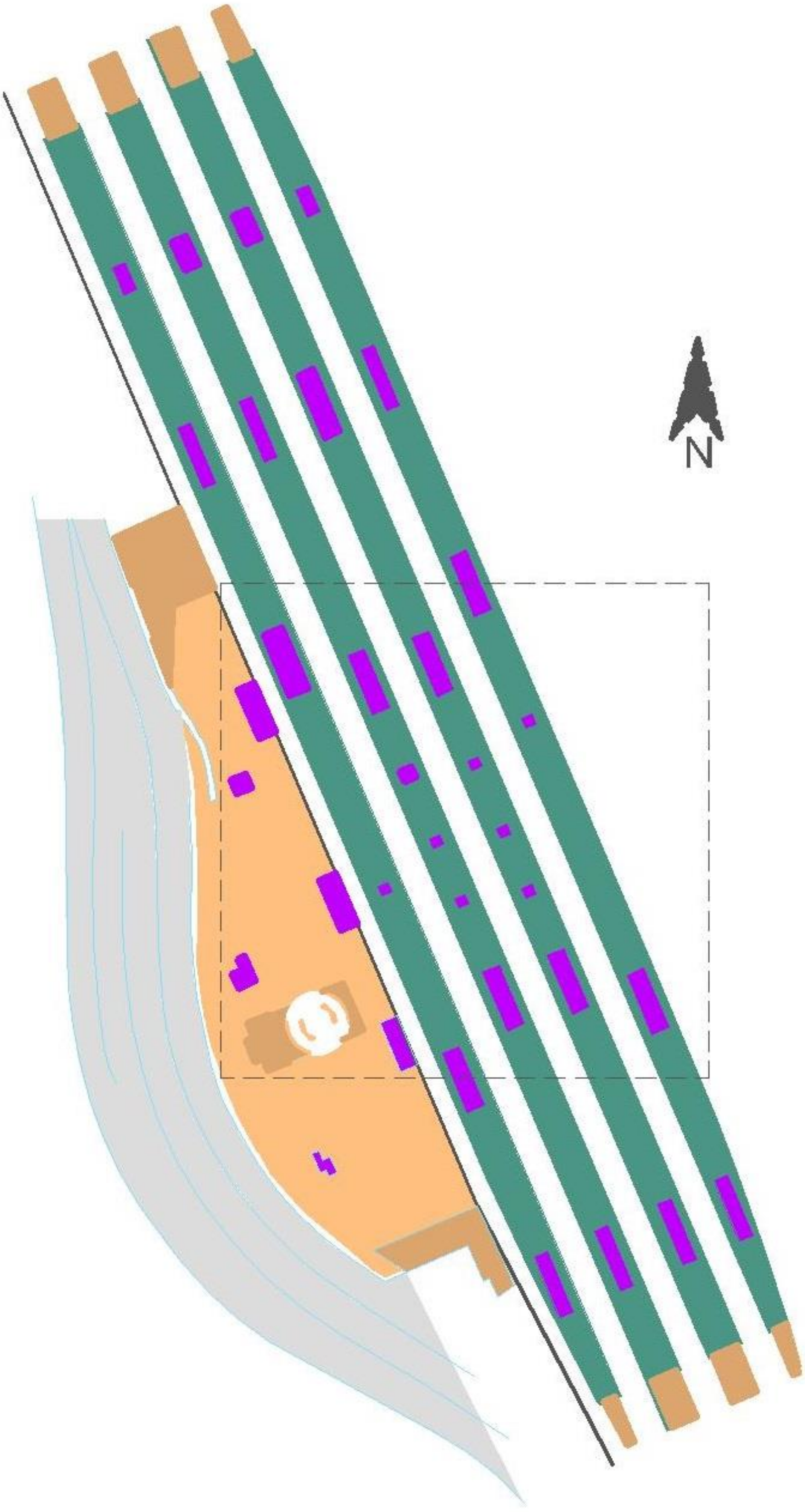
(b): Level +1 Plan



(c) Level +2 Plan

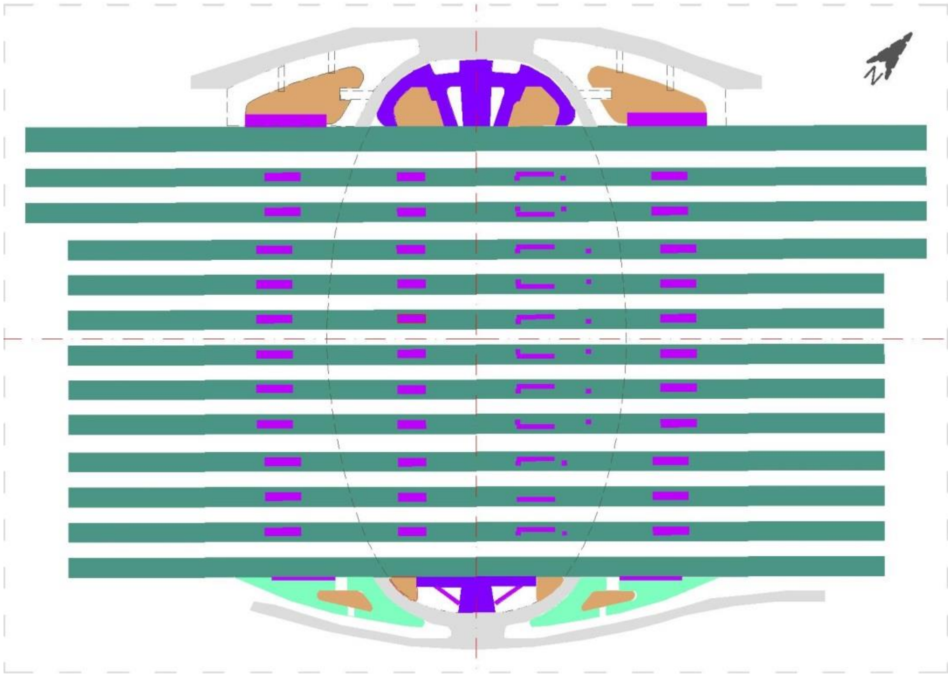


(d): 1st Basement Level Plan

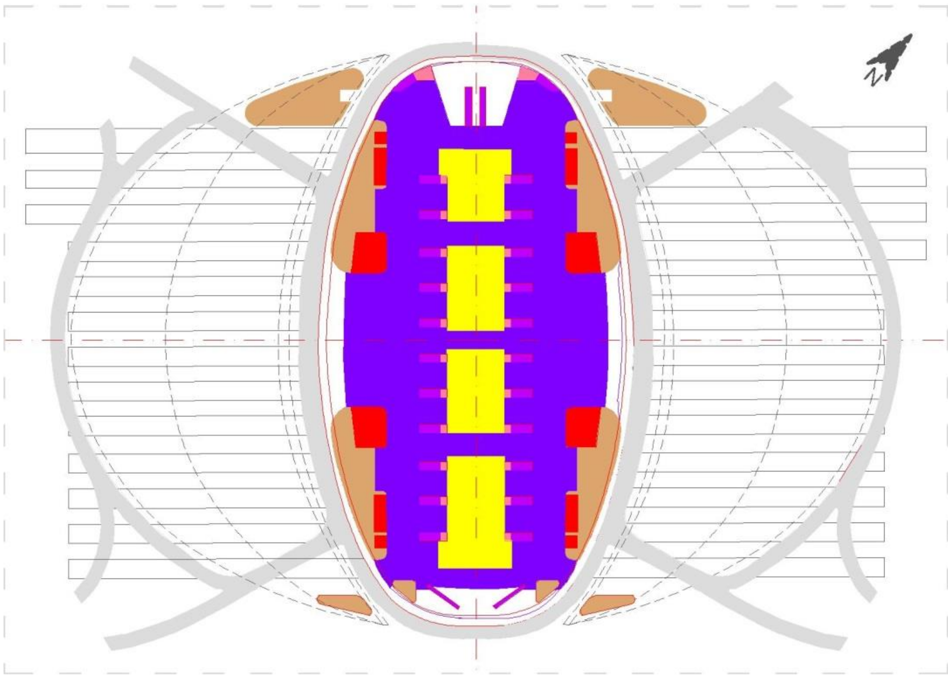


(e) 2 nd Basement Level Plan

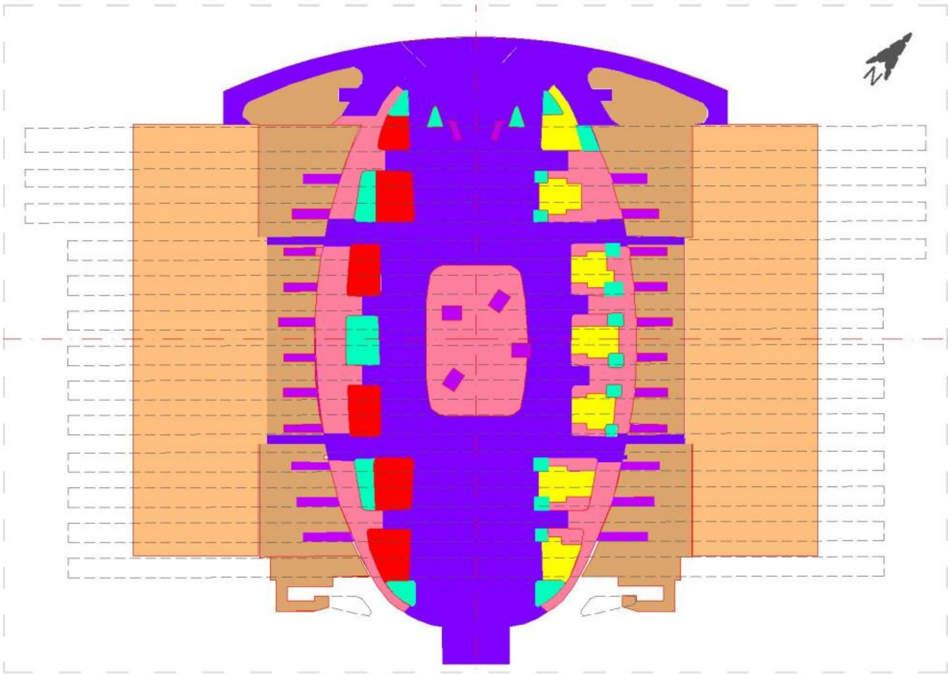
Figure 4.2: Floor Plans of Berlin station showing spatial configurations;
(a) Street level (b) Level 1 (c) Level 2 (d) 1st Basement Level (e) 2nd Basement level



(a) Platform Level Plan

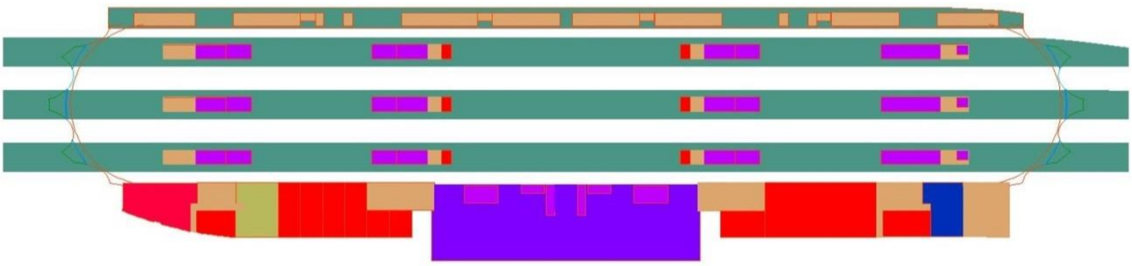


(b) Departure Level Plan

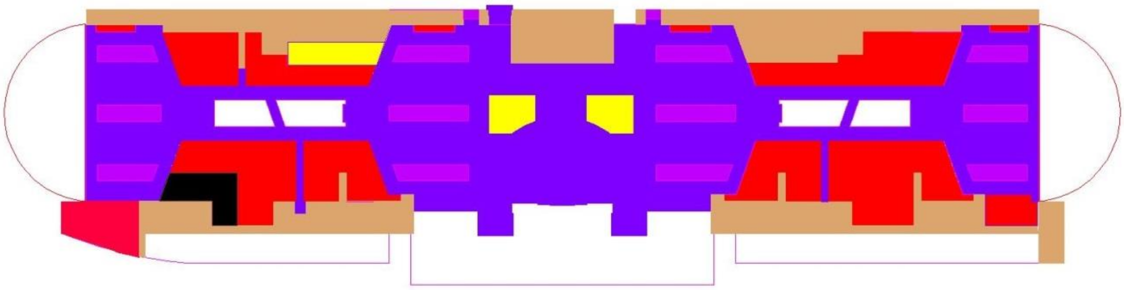


(c) Arrival Level Plan

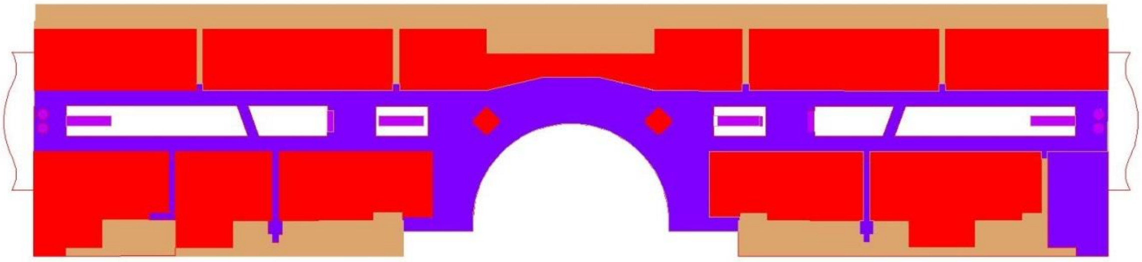
Figure 4.3: Floor Plans of Beijing station showing spatial configurations; (a) Departure Level Plan (b) Platform Level Plan (c) Arrival Level Plan



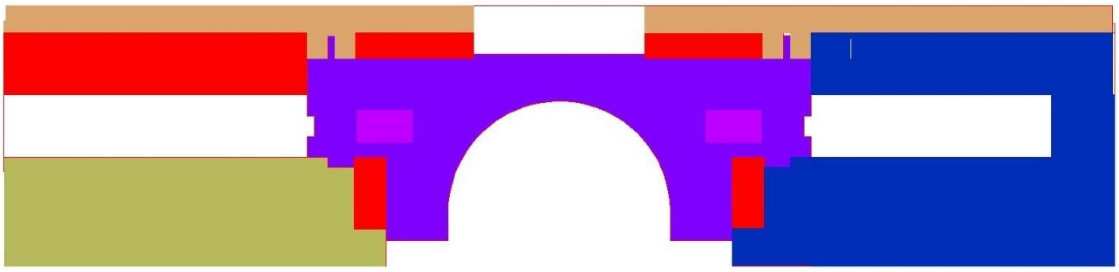
(a) Lower ground Level Plan



(b) Upper ground Level Plan

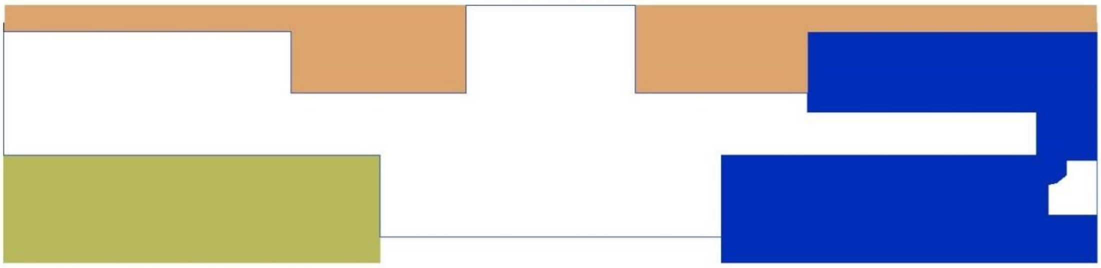


(c) Level +1 Plan

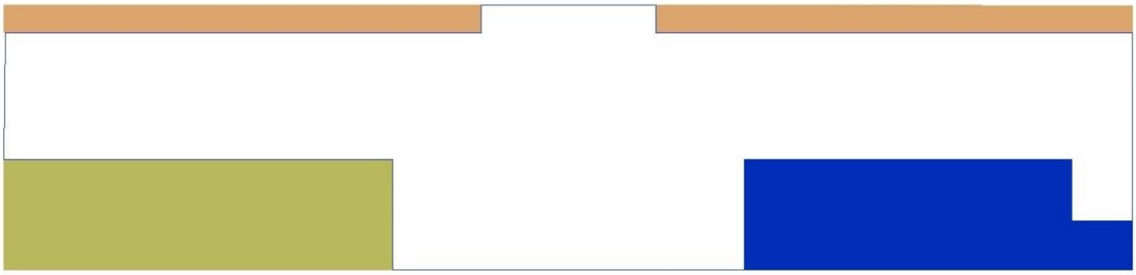


(c) Level +2 Plan

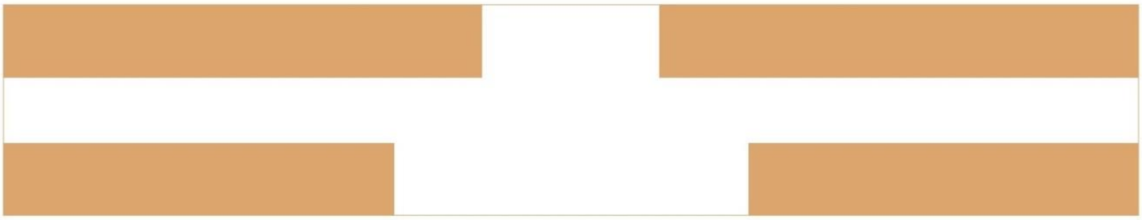
Figure 4.4: Floor Plans of Ankara station showing spatial configurations;
(a) Lower Ground Level (b) Upper Ground Level (c) Level +1 Plan (d) Level +2 Plan



(a) Level +3 Plan

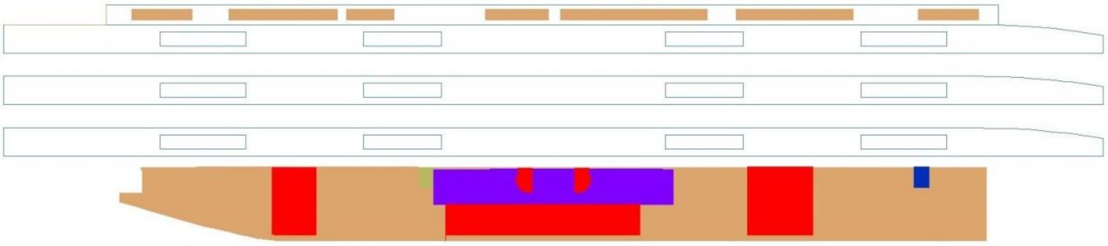


(b) Level +4 Plan

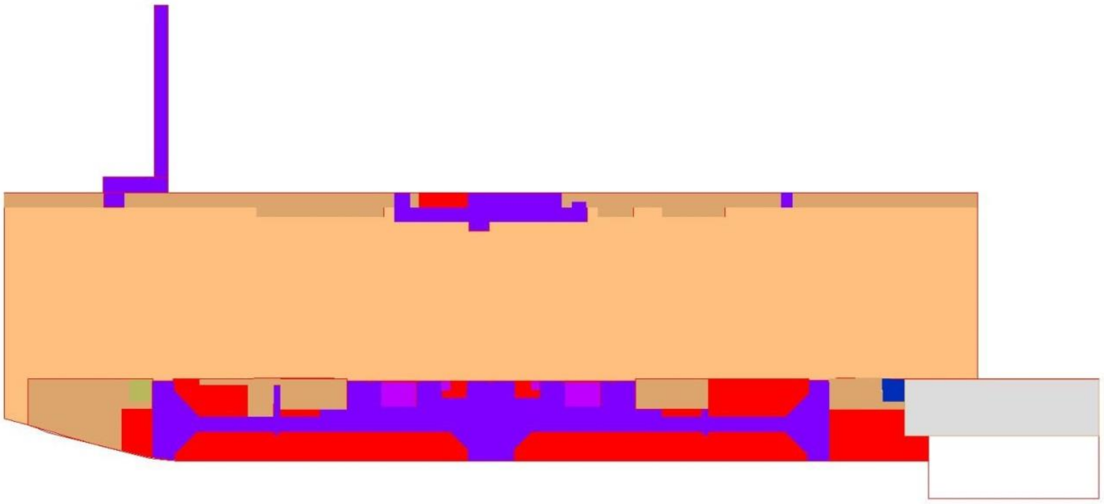


(c) Level +5 Plan

Figure 4.5: Floor Plans of Ankara station showing spatial configurations;
(a) Level +3 Plan (b) Level +4 Plan (c) Level +5 Plan



(a) 1st Basement Level Plan



(b) 2nd Basement Level Plan

(c) 3rd Basement Level Plan

Figure 4.6: Floor Plans of Ankara station showing spatial configurations;
(a) 1st Basement Level Plan (b) 2nd Basement Level Plan (c) 3rd Basement Level Plan

4.1.1 Project type and duration

All three high speed train stations were constructed on existing land of the old stations. However, old Berlin and Beijing stations were demolished whereas the old Ankara station is being preserved for other uses. BNCS and BSRS high speed stations projects were determined with international competition whereas AHSRS project was determined through a tender. The consortium winning the tender had offered two alternatives for the station project, as presented in the last chapter.

BNCS project started in 1993 and was completed in 2006; with the aim of making it ready for the FIFA World Cup. BSRS project was started in 2003 and made ready for Beijing Olympic Games to be held in 2008. AHSRS project has started in 2006 and the project procurement was managed through a “build-operate-transfer” model in 2010. It is expected that the construction works will be completed in 2016 and station will start to operate within 10 years period, in 2016.

4.1.2. Space Planning

In order to serve 300,000 passengers per day in Berlin, which has a population of 3,520,000 people, BNCS is constructed on an area of 175,000 m2. An area of 50,000 m2 of the station is allocated for two office areas; which corresponds to 28.57 % of the gross floor area. Another 125,000 m2 area is designed as station spaces for passengers. There are 7 platforms and 14 railway tracks to meet potential passenger needs.

In order to serve 287,000 passengers per day in Beijing, where 20,180,000 people are living, BSRS was constructed on an area of 144,190 m2. This station contains spaces and facilities only for transportation purposes; and the whole area (100%) is allocated to train management and passengers. There are 13 platforms and 24 rail lines in this station.

In order to serve 30,000 (50,000 in 2023) passengers per day in Ankara, where 4,890,893 people are living, AHSRS is designed to be building on an area of 171,000 m2. In this station project, 11,000 m2 is reserved for commercial office space, 14,000 m2 is for a hotel, while the rest of the area, approximately 146,000 m2 is designed as the station. There are 3 platforms and 6 rail lines, and the size of each platform is 11 x 400 meters.

4.1.3 Station Security

In Berlin there is no security check point (X-ray) in BNCS. There are no separate levels for arrival and departure and also a specific waiting room or waiting area. There is only X-ray surveillance for baggage to be stored in the luggage room.

In Beijing, there are security check points at the four entrances of the station. The arriving and departure levels are separate in BSRS. Passengers are collected in the arriving level, from where they are directed to the various train platforms. There is 9,000 m2 waiting area at the departure level and 4,000 m2 waiting room at arrival level. Luggage storage is provided in a room and there is an X-ray security scanner in front for the bags.

In Ankara there is no separate arrangement for arrivals and departures in AHSRS. All passengers are collected on the upper ground level regardless of whether they are arriving or departing. There are security check points at all entrances. There is a waiting area and also a closed waiting room at the upper ground level. According to regulations in Turkey a “refuge” is set on 3rd basement level.

4.1.4 Cultural Requirements

In Berlin and Beijing stations there are separate lounges for first class passengers. . The entrance to this lounge is accessible from inside the station; and there is no separate car parking area that serves VIPs exclusively. However, in the Turkish railway station there are separate VIP and Commercial Important Person (CIP) lounges in AHSRS. Additionally, VIPs have a separate entrance and also exclusive car parking area.

4.1.5 Ticket Checking System

At BNCS passengers can reach platforms directly without a ticket check point or toll gate. Sporadic ticket checks are in the train. At BSRS and AHSRS stations Passengers can reach the specific platforms by passing a ticket checks or toll gate.

There is paid and unpaid area. (There is a toll gate at some entrances at BSRS at the same time)

4.1.6 Vehicular and Pedestrian Traffic

The street level is arranged as the entrance level in BNCS. There are direct approaches for pedestrians, buses, taxis and bicycles from the street and it is also integrated with the metro and suburbia network. The station will also be integrated with tram-lines in the future. In the Chinese train station the approaches with taxis and private vehicles, are from different levels than those of pedestrians and public busses, in BSRS. The ground level which is the arrivals level has direct access for pedestrians and passengers reaching by public busses. This station integrated with the metro lines too.

In Turkey's train station, private cars, pedestrians, busses and taxis will all approach the AHSRS from Celal Bayar Boulevard. There are no separate levels for busses and other vehicles. There is a pedestrian approach from the old Ankara Station. AHSRS is also integrated with the city's metro lines.

4.1.6. Environmental Design Features

Stations in Berlin and Beijing (BNCS and BSRS) both have photovoltaic solar panels installed on their roofs to produce electricity from solar energy. These PV panels are supplying a certain percentage of the total energy resumption of the two railway stations. However, in Ankara, where there is more solar energy throughout most of the year there has been no attempt to take advantage of this free renewable source and hence there are no solar panels on the building.

All these factors were investigated in the three Railway Stations and the information obtained and data derived from the plans has been brought together for comparison in the Table 4.1 and these results are discussed in detailed in the following section.

4.2 Discussion of Results

The three railway stations are examined in terms of five main parameters; namely: space planning, station security, ticket checking system, vehicular and pedestrian circulation and approaches, and cultural requirements. The information gathered is discussed in the following sections while data gathered is tabulated and presented in Table 4.1 for comparison.

4.2.1. Space planning

BSRS has large gross floor area but it has effective organization between levels and passenger circulation. There is segregation between the arrival and departure of trains and passengers. Outgoing passengers are gathered at departure level, and they reach the platforms from this level. Incoming passengers are gathered at arrival level, which is set below the lower platforms level. There is no segregation for departure and arrival levels at AHSRS. All passengers are gathered at upper ground level and distributed from that level.

Depending on the location of the station, it is observed that waiting rooms were designed differently. While there is no specific waiting room in Berlin Station, which is located inside the city, BSRS has a waiting area of approximately 9,000 m2 at the departure level and approximately 4,000 m2 waiting room area on the arrival level. In Ankara the new station will also have a small waiting room and some waiting places.

4.2.2. Station Security:

Depending on the location of the station and expectations, the design of the stations can be different. A station in the center of the city is more open to public use and therefore there is no security point, on the other hand a station which is located outside the city has a security point, and the whole station building is designed accordingly. Security check points should be considered if the station is designed for passengers only. If public use becomes important then security check point should be integrated with ticket checking system before the platforms. It will be a deterrent for terrorist attacks considering the global threats to security of people.

4.2.3. Ticket checking system

One of the most important features for modern railway stations is the scenario for the ticket checking system (where and how it will be done) since it is the starting point for passenger circulation. In Berlin, tickets are checked on the trains after boarding, therefore, there were no checking points before the platforms. But, in Ankara and Beijing tickets are checked on the station so the design of these two railway stations considered this parameter. Passengers can access some areas only after the turnstiles or passing through the ticket check points. This is one of the most important features that affect the total gross floor area of the station and its design.

4.2.4. Vehicular and Pedestrian Traffic

Depending on whether it is built inside or outside the city, the priorities in the design of modern stations can change. Berlin station is built in the center of the city; therefore, in the design of the station priority is given to the passengers. However, the station is integrated with all public transportation means (suburban, metro, tram, and shuttle). This station connects two regions and the street level of the station is a public thoroughfare; there is no security point since it is desired that the station is open to public use. Since BSRS in China was built outside the city, it was estimated that the vehicular traffic will be larger than that of pedestrian traffic. Therefore, the station was designed to segregate vehicle and pedestrian traffic at different levels. Similar to Berlin station, AHSRS (Ankara) is also located in the center of the city. It is also integrated with public transportation means, however there is no segregation between the pedestrian and the vehicular traffics.

4.2.5. Cultural Requirements

Station design has to respond to various local cultural requirements also. For instance in certain countries there is segregation between government officials and the public at large; and the concept of VIP is important. This is also the case in Turkey where VIP lounges and separate entrances and car parks are important parameter in Ankara. Whereas, they did not affect railway station designs in Berlin and Beijing.

On the other hand, in China people drink hot water only, hence providing hot water drinking fountains at appropriate locations was considered at the design stage.

Table 4.1 Comparison of the Three Case Study Railway Station Buildings

	Berlin New Central Station (BNCS)	**Beijing South Railway Station (BSRS)**	**Ankara High Speed Railway Station (AHSRS)**
Location	Old station site	Old station area	Old station area
Fate of old station building	Existing building was demolished and new station was built its place	Existing building was demolished and new station was built 500 meter away from it.	Existing building is preserved and new station will be built on area behind it.
Project Type	Competition	Competition	Tender
Designed for	2006 FIFA World Cup	2008 Beijing Olympics	No special event
Duration Project Start –Finish Date	13 years 1993-2006	5 years 2003-2008	Estimated as 10 years; 2006-2016
Population (2012)	3,520,000	20,180,000	4,890,893
Passengers per day	300,000	287,000 520.000 (in 2020)	30,000 50,000 (in 2023)
No. of Platforms	7 6 for regional, high speed trains, etc. One for suburban trains	13 10 for regional and high speed trains and 3 for suburban trains	3 All for high speed trains
No. of Rail lines	14	24	6
Gross Floor Area (station building)	175,000 m2	144,190 m2	171,000 m2
Covered platform area	Approx. 59,000 m2	Approx. 127,500 m2	Approx. 24,000 m2
Covered car parking area	Approx. 25,500 m2	Approx. 40,000 m2	Approx. 40,000 m2
Retail area	15,000 m2	6,250 m2	Approx. 25,600m2
Additional use areas	Commercial offices 50.000 m2	None	Commercial offices & Hotel 25.000 m2
Net station area (including retail & excluding "additional uses ")	125,000 m2	144,190 m2	146,000 m2
Area per passenger	0.42 m2	0.50 m2	4.86 m2
Ratio of retail area to net station area	12 %(Approx.)	5 % (Approx.)	17.53 % (Approx.)
Ratio of additional uses to gross floor area	28.6%	All areas devoted to passenger use only	14.61%

Table 4.1 (Continued)

Different entrances for taxis, private cars, bicycles, pedestrians and public transportation. (Car parking area has separate entrance)	Pedestrian can reach the station from all directions. There is no segregation for taxi, private car, or public transportation; they all approach the station from the northern façade.	Taxis and private cars Can approach the departure level; while public buses and pedestrian can approaches the station from the arrivals levels.	Taxi, private car, public transport and pedestrian can all reach the station from north façade. Pedestrians can also use the under or overpasses.
Integrated with metro or suburban trains	1 metro line (U-55) and suburban lines	Two metro lines	Two metro lines (Keçiören and ankaray) and Suburban lines
Security check at entrances (X-ray)	Does not exist	Security check points at entrances	Security check points at entrances
Ticket check points	Does not exist	At every entrance to platforms	At every entrance to platforms
Turnstiles	Does not exist	Turnstiles at regional train platforms	Does not exist
Separate arrivals/departures levels	There is no segregation	Arrival and departure areas are located on different level	Arrival and Departure levels are on same level, (upper ground floor)
Waiting room	Does not exist	There is approx. 9,000 m2 waiting area at departure level and app. 4,000 m2 waiting rooms at arrival level Total area: 13,000 m2	There is a waiting room and waiting area on the upper ground level (600m2)
X-ray in Luggage room	Exists	Exists	Does not exist
Refuge area	Does not exist	Does not exist	Refuge area on 3rd Basement Level (3,600m2)
Energy production (Solar PV panels)	PVs on south side of the east west roofs	PVs on station building roof.	Does not exist
Environmental design criteria	Exhaust air, natural ventilation and daylighting	Natural ventilation and daylighting	Daylighting
First class/CIP lounges	First Class lounge is on the second floor level. (334 m2)	First Class lounge is on the departure level	CIP is on upper ground level. (300m2)
VIP lounge	Does not exist	Does not exist	VIP lounge on ground level (715 m2)
Separate VIP entrance & car park	VIP and CIP do not exist. There is a first class lounge but without a separate entrance or special car parking area	VIP and CIP do not exist. There is a first class lounge but without a separate entrance or special car parking area	The VIP lounge has a separate entrances and special car parking area.

CHAPTER 5

CONCLUSION

Innovative developments started in the railways after 1980s. These developments have been reflected on the railway stations as well. These developments were studied to understand the state of the art. From the case studies it was seen that in Turkey Ankara's station will serve only 30,000 passengers a day which is less than 10% the capacity of Berlin's train station and 10.5 % the capacity of Beijing's station; yet the size of Ankara's station is larger than Beijing and almost equal to Berlin . Hence we can say that while designing a high speed railway station, the population of the city, and the daily passenger rates should decide the size of the station. Additionally, the city's dynamics and future development should be considered.

Another factor that was seen to be important while analyzing the three case studies was **accessibility** of the station. Stations must integrate other transportation networks, so that passengers can easily access the trains. Higher accessibility will encourage the public to use trains and so taxis, private car, buses and pedestrian approaches should be considered right at the initial design stage. **Mobility** in the station becomes another important parameter. Number of passenger's increase every year so railway stations have to be well organized for passenger's movement. There is a need to study movement patterns in crowded places to ease the flow of traffic.

Ticket check and security systems significantly affect a railway station's design. At the initial stage a scenario should develop for these systems as to where and how will the passengers be subjected to security and /or ticket checks; the station layout design can then be develop according to this procedure.

A station layout design has to be "**plain and simple**" to facilitate way-finding. Passengers need to be able to see where they are going; hence visual connectivity between levels can be integrated in the space design. In BNCS, when passengers enter the station, they are able to see the platforms, which are 10 meters above ground level and also those that are 15 meters below ground level. In BSRS passengers recognize the waiting area, which is located in the middle of the station at the entrance level; once there they are guided easily to the various platforms.

The envelope design of the station can help achieve maximum daylight penetration; the internal circulation is helped by allowing more natural light into the building. Hence the station’s façade design should not only address aesthetics but also functional concerns. The **natural light/daylight** through transparent roofs or transparent facades, blending with artificial light, would provide passengers with clarity of orientation in the building more effectively than internal signs only. Using natural light will also reduce the energy loads of the building by reducing dependence on electric lights.

Today, railway stations are designed not only for passengers but also the general public so new spaces have to be included in the station programmed in terms of their needs and expectations. **Shopping** areas have to be integrated and not designed as shopping centers.

Modern Railway Stations are very large buildings so their energy demands are higher than others; such as lightening, heating, cooling and ventilating. At preliminary project stage architects should design the station to reduce its energy consumption and integrate energy production systems, such as wind energy turbines or photovoltaic solar panels on façade or roof of the building. Furthermore solar heating systems can be used for hot water needs.

This study focused on the design of modern railway stations from the point of view of space allocations; transport links; vehicular and pedestrian flows; and security. Although, environmental concerns were a by-product of the analysis they are very significant in the design of sustainable buildings. Hence further studies should be undertaken on this aspect of railway station design.

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APPENDIX A

FIGURES

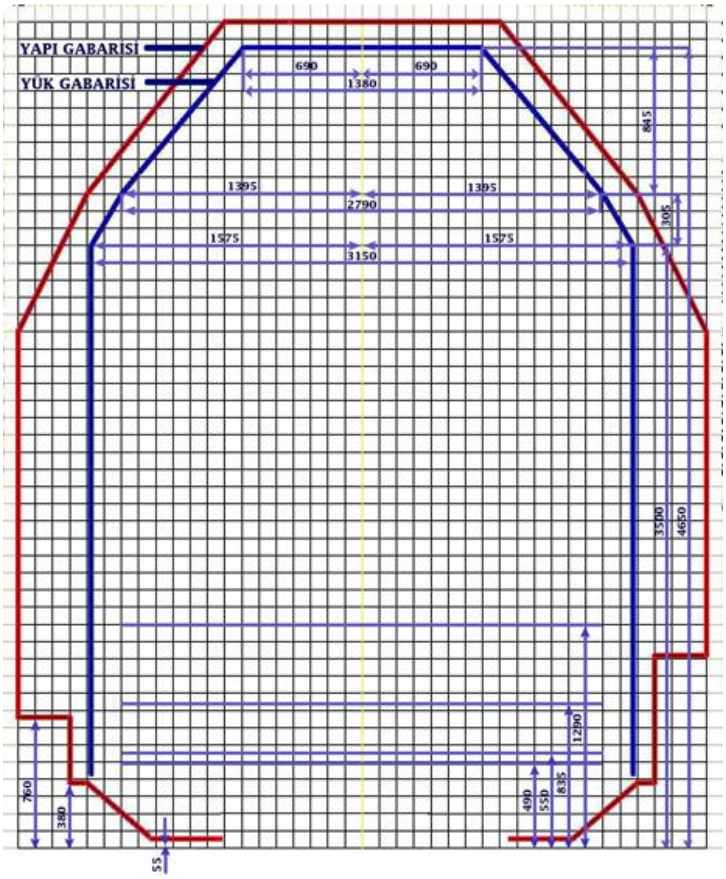

Figure A.1: Shape, dimensions and clearances for the train passage.
(Source: www.tcdd.gov.tr/home/detail/?id=302)

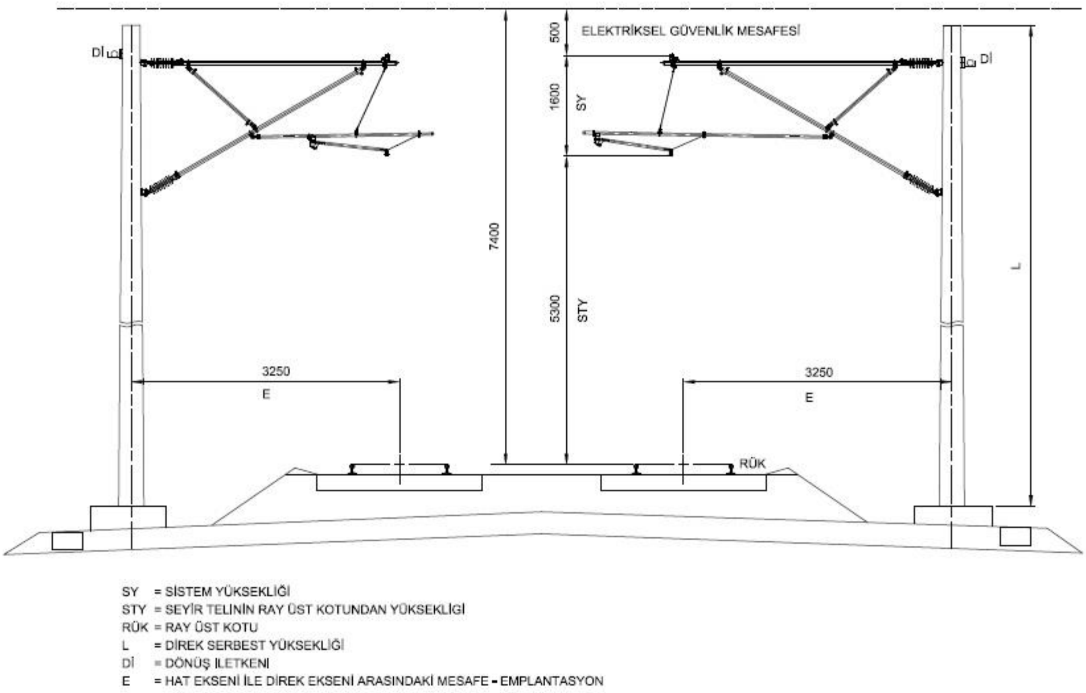

Figure A.2: Dimensions of the train tracks and clearance for the electrification lines (TCDD, Electrification Documents, 2015)

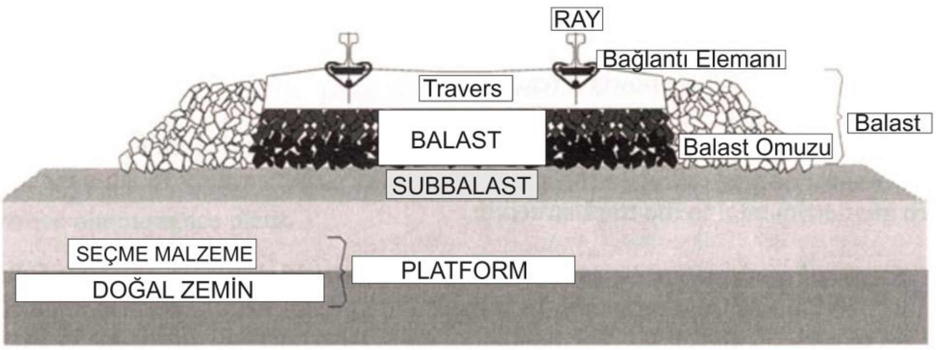

Figure A.3: Section drawing showing the layers used for the construction of routes rail lines (TCDD, New route section, 2015)

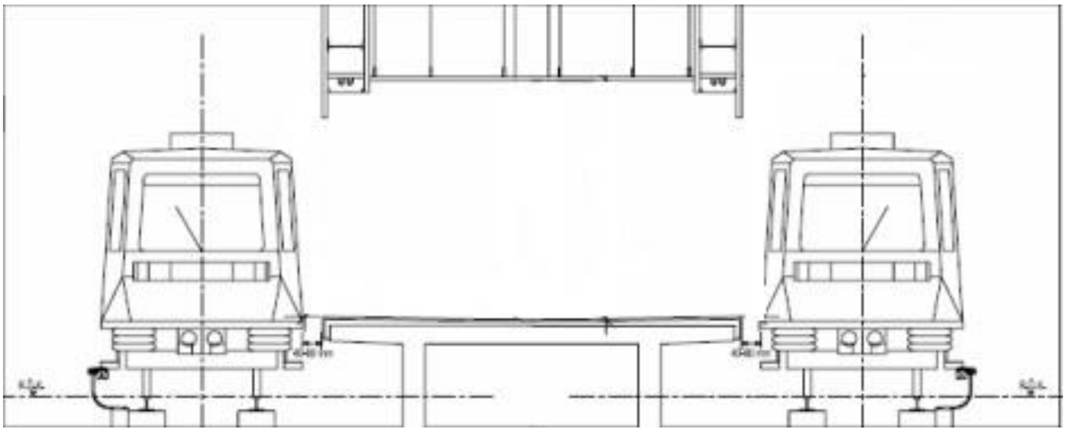

Figure A.4: an Island Platform (Source: Yüksel Project, 2007)

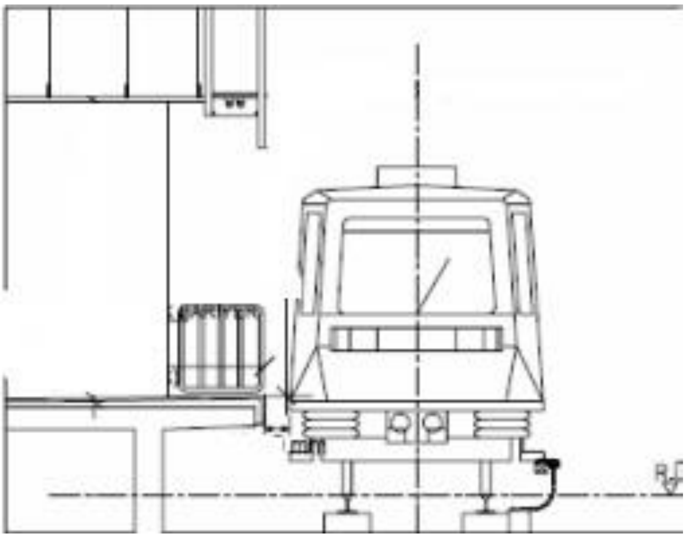

Figure A.5: A Side Platform (Source: Yüksel Project, 2007)

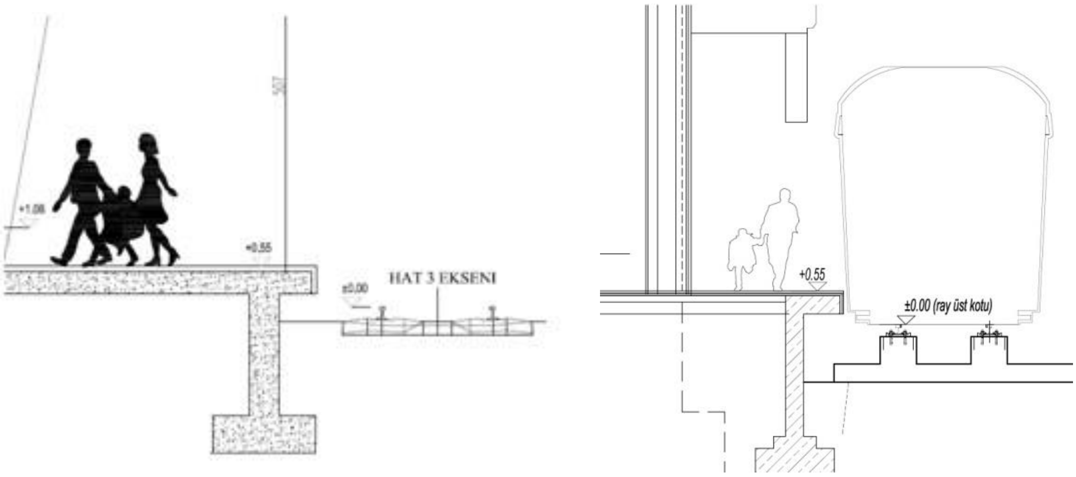

Figure A.6: Platform Heights (TCDD High Speed Railway Station Projects, 2015)

Figure A.7: CAF Train

Table A.1: Caf Train properties.

(Source: www.caf.es/en/productos-servicios/proyectos/proyectodetalle.php?p=24)

Train length	158, 22 mm
Passenger capacity	411
Maximum Speed	250 km/h

Figure A.8 VELARO Train

Table A.2: Velaro Train properties

Train length	200, 00 mm
Passenger capacity	
Type Velaro D	460
Type Velaro TR411	516
Maximum Speed	
Type Velaro D	320 km/h
Type Velaro TR	300 km/h