



TEHRAN METRO

HISTORY

Tehran, as the capital of Islamic Republic of Iran, is the first Iranian city in terms of economic, cultural and social as well as political centralization. This eight- million people city that its population with satellite towns reaches to twelve million inhabitants faces the traffic crisis and its consequences such as fuel consumption, noise pollution, wasting time and accidents. Undoubtedly, construction of an efficient and high-capacity transportation system will be the main solution to overcoming this crisis. Today, urban rail transportation has become increasingly apparent in its role as a massive, safe, fast, inexpensive and convenient public transport network to reduce vehicle congestion, environment pollution, fuel consumption and promoting the quality of social life.

In the first comprehensive urban plan conducted in 1958, a railway transportation discussion was observed for the city of Tehran. In 1971, the study of urban transport situation was assigned to Sufreto French Company by the municipality of Tehran. This institute presented a comprehensive report titled "Tehran Transportation & Traffic Plan" based on information, collected statistics and related forecasts for the development and growth of Tehran in 1974.

A "Metro-Street" system was proposed in this comprehensive plan, based on the construction of seven subway lines with the length of 147 km, completed by developing an above-ground network toward suburb, a full bus network as a complementary for metro, a number of Park&Ride facilities around the metro stations and finally a highway belt network. Due to this, a legal bill regarding the establishment of urban and suburban railway company was submitted to the parliament by the government in April 1975, which was approved by the National Assembly and the Senate, in which the municipality of Tehran was authorized to establish a company called Tehran Urban & Suburban Railway Co. (TUSRC) in order to construct the urban rail network and its related facilities and put it into the operation.

The first statute of the Metro Company was approved in July 1975. In the same year, the construction of four subway lines in Phase 1 passed the approval of the Mayor, the City Council and the Plan and Budget Organization, and its implementation was confirmed by the government. In 1976, a new contract was signed with the same French company for studying, designing and monitoring the construction of Tehran Metro.

Executive activities of part one began in late 1977 and continued until 1981 under the supervision of French consulting engineers. Approximately 2300 meters of tunnel and a part of the structure of three stations between Shahid Haghani Highway and Shahid Beheshti Street were constructed by open trench method. In 1981, due to the special atmosphere governing major projects in Tehran with public and governmental costs and because of the imposed

war getting started, the Cabinet of Ministers approved the full stop of the subway project. But after the report of relevant experts based on the necessity of the construction of the subway, finally the re-commissioning of the subway project was approved by the government on 30 March 1986 and this resolution was implemented for notification with a delay of five months on 28 July 1986. Since 1987, due to the same plan of the consultant, TUSRC activities for the construction of two urban lines (North-South and East-West) and a suburban line toward the city of Karaj (out of the proposed network) were re-launched regarding the government approval based on the idea of establishing a metro link to the satellite town with the total length of "90 km and 52 stations ", which was completed by 2007.

Operation of three metro lines and citizens' ever increasing welcome toward this system and also its undeniable impact on the everyday life of the people has not left any doubt about the development of Tehran Metro. Considering the expansion of Tehran city, the construction of the remaining urban, high-speed and satellite lines, as well as the use of public transportation for the metropolitan of Tehran, which is one of the world's mega-cities, seemed to be necessary. Therefore, revising and updating the long-term studies of public mass transportation development in Tehran was considered necessary and approved by TUSRC's board of directors in September 2004.

GENERAL SPECIFICATIONS OF TEHRAN METRO

The selected metro system in Tehran has a roundabout tunnel in which each line is separately located. In the preliminary design, the trains have a steel wheels system composed of 8 self-propelled cars, with a length of 158 meters and a width of 2.6 meters. The length of each car is 19.52 meters and the total length of the train is 156.16 meters. The maximum train speed is 80 km/h and the average train speed is 35 km/h. The capacity of each train is 1,480 people and due to the conducted designs, the train stops at each station for 30 seconds. Also passenger capacity of each train is estimated 45000 passengers per hour per direction (pphpd).

The trains are equipped with an Automatic Train Protection (ATP) system which enables the train to communicate with the central telecommunications network to enhance the safety of the system. The movement of the trains in various lines of the network are guided and controlled by command and control center and all directions are covered by electronic, closed-circuit television (CCTV) and telecommunication systems for issuing the necessary commands. The electric power of train is supplied by an urban 20 KW distribution network of high voltage substations (HVS) which is converted to 750 VDC at rectifier-electronics post. Wireless optical-fiber systems and copper cables are used in telecommunication systems, whereas SCADA, ATP, CTC and ATS systems are used in control, signaling and communication systems. In this section, 4 high voltage substations (63/20 kV) are used to supply the main power. The voltage of trains power supply is 750 VDC and in the initial plan of the stations, the construction of rectifier electronics posts (20 kV to 750 VDC) have been predicted as well as the lighting posts in order to provide the electricity of lighting network regarding the number of designed stations in each line.

The air inside the underground stations and tunnels is supplied by humidifiers and air washer systems located at the stations through the external air conditioners, and it is blown inside the spaces after filtering and adjusting the humidity and temperature with a sufficient pressure. This air is displaced by the initial pressure as well as the pressure caused by moving the trains inside the tunnels and by moving in the route, ultimately drives toward the outside of the network through the tunnel's ventilation systems located between two stations.

At each station, 4 units of the air-conditioner are anticipated for air conditioning of both tunnels and station. For the connection of different spaces of the station with each other as well as the space of the station with the level of passageways and streets, a combination of ordinary stairs and escalators is used, as in cases with a height of more than 6 meters, both kind of stairs are used and in the cases with the height of less than 6 meters, just the ordinary stairs is used.

Also at stations for the welfare of disabled people, elevators were designed and built for the use of such persons. In this section, emergency steps are also provided for the departure of passengers in case of emergency situations.

TUNNEL CONSTRUCTION METHODS

The design and construction of subway lines and their construction methods (tunnels, stations, and other metro equipment and facilities) are influenced by various factors, and the determination of the construction method and also the manner in which it is carried out is more significant and includes different ways. But these methods are influenced by various environmental factors. The most important factors influencing the station and tunnel performance method can be mentioned like: the depth of tunnel, the traffic of digging site, the distance between the stations, the gradient of the earth, the type and the stability of the soil, the level of underground waters, performance time, performance costs, as well as the amount of travels and the number of passengers. Proposed methods used to excavation of a tunnel are mainly divided into three main categories as following:

NEW AUSTRIAN-TUNNELING METHOD (NATM)

The excavation of the tunnel can cause the soil instability and, as a result, the subsidence of structures on the ground. By increasing the volume of excavation, this instability rises. Therefore, in this method, the tunnel is divided into different parts and the soil excavating is carried out step by step. In each stage, the sustainability of the soil is provided by implementing a temporary structure.

In Austrian-Iranian method, the upper half of the tunnel section is drilled first and its stability is mainly provided by steel frames, wire mesh and shotcrete. After this stage, excavation is carried out in the lower section. At this level, the formatting of steel frames on the upper part is continued and the excavation goes ahead, then, the temporary stability of this section is also provided by running the wire mesh and the shotcrete on it. In the next stage, lining the floor, reinforcement and widespread concreting (radiation) will be accomplished. By closing the armatures of body and roof and connecting them to the floor radiation armatures and

using the integrated mold, the concreting of the body and the roof will be implemented and the tunnel will be prepared. Due to the soil type and probable subsidence, excavation and temporary support of the tunnel may be divided into more pieces.

OPEN TRENCH METHOD (CUT AND COVER)

In this method, at first step, by executing the single or continuous piles to prevent the soil collapsing, and at next step, by installing the horizontal beams (Strut), the guard structure will be completed. In next steps, the execution operation of widespread concreting (radiation) will be performed on the floor, walls and ceiling of the tunnel. In this case, the arched roof or flat roof is also used.

TUNNEL BORING MACHINE (TBM)

The Tunnel Boring Machine is based on a new technology, the ability to bore through underground, creating a tunnel, as well as placing concrete components in the body of the tunnel. Due to high speed and remarkable precision, this method is technically and economically considered a favorite option. Boring method by this machine allows possibility to create underground low coverage spaces in unstable lands and provide the condition of the underground waters without significant leakage and problems on the ground.

Nowadays, tunneling with TBMs in inappropriate land containing high traffic is a suitable, economical and appropriate progress rate method. In tunneling method by TBM machine, after drilling the tunnel and in accordance with the progress of the machine, pre-fabricated concrete components, called segment, are installed on the final wall of tunnel.

Raising the safety, especially in urban areas, by reducing the risk of soil slipping and controlling the land surface subsidence and quick installation of maintenance system regarding its very high speed compared with traditional methods (12 times faster), has been increasingly welcomed this drilling technique in the advanced cities of the world. Tunneling by use of TBM in order to continuously reduce the soil falling, control and limit the surface subsidence along with controlling the volume of drilled soil and also required pressure management for protecting and maintaining the tunnel front, are the most important guarantees to put into operation and successful performance of this machine.

Earth deformations, which may have an undesirable effect on the upper structures of tunnel, will be minimized by using the final coating system implemented in mechanized tunneling under fully-watertight conditions. In this way, the concrete segments prepared at the segmentation plant by MSV device are entered the tunnel through access routes and are placed inside the device at their own place. The device replace concrete segments by its arms immediately after boring the tunnel and inserts the prepared slurry behind the segments until the body of the tunnel become integrated as a seamlessly piece and the empty space behind the segments is filled in order to prevent the subsidence. One of the most important issues regarding metro tunneling implementation by TBM is the interaction between the construction of station and the implementation of tunnel, which will be done according to the time that TBM machine arrives at station, through which the excavation of the tunnel will run before or after the station.

The construction of the tunnel is carried out by TBM machine in Tehran metro lines 3, 6 and 7. Daily drilling by this machine can be about 15 meters. By this method and using 4 provided machines, we can build at least 20 kilometers of metro tunnels annually.

STATION CONSTRUCTION METHODS

Station construction is done by two ways namely above the ground and underground.

ABOVE GROUND STATION

When the path profile is placed on the ground surface, the station is executed as an above ground method. Such stations are designed and implemented as a conventional building.

UNDERGROUND STATION

If the route is located below the ground, the station is designed and implemented underground. Underground stations are divided into 3 categories depending on the location:

Shallow Depth Stations: The depth of the rail to the ground level is between 10 to 15 meters.

Medium Depth Stations: The depth of the rails to the ground level is between 15 to 25 meters.

Deep Stations: The depth of the rail to the ground is more than 25 meters.

PLATFORM EXECUTION METHOD

The method of tunnel implementation, in addition to influencing the type of the station structure also influences the type of the platform design and consequently, the station design. In condition that a tunnel or two parallel tunnels is/are considered for train's round track, the way in which the platform will be operated and placed at the side of the rail will be different.

Side Platform: When a tunnel is designed for train's round track, the train path continues inside the station in the same way and the platforms form alongside the rails.

Island Platform: By separating tunnels for round-track trains, the platform is formed between two rails and is located as an island between the two rails. In this case, it should be considered that passengers' round-traffic should not disturb the commuting, and the corridors and communicating stairs are designed according to the passenger load in two areas. In addition, it is also used on both sides of the lines to reduce the trains' headway.

TEHRAN METRO LINE 1:

This Line with the length of 42 km and 29 stations starts at Tajrish square and after passing Shariati and Mirdamad districts and crossing Shahid Beheshti Ave, enters Shahid Mofatteh St. and by passing through Enghelab Ave. and Talaghani St. reaches Imam Khomeini Square and by passing Panzdah-e-Khordad St. and Rey- City area ends at Holy Shrine in Behest-e-Zahra and Kahrizak Station in Kahrizak district. It should be noted that the south extension of this line has been connected to Tehran-Imam Khomeini Airport-Parand Line.

TEHRAN METRO LINE 2:

Line 2 with the length of 26 km and 22 stations starts at southwest of Sadeghiyeh in west of Tehran, goes toward Azadi Ave. and after crossing Azarbaijan Ave. and Imam Khomeini Ave. intersects Line 1 in Imam Khomeini Sq. By passing through Mellat Ave. and Baharestan Sq., enters Shahid Ayatollah Madani St. and after going on Resalat highway extends to Eshragh Cultural Center area.

TEHRAN METRO LINE 3:

Tehran Metro Line 3 with the length of 37 km and 28 stations, as one of the longest metro lines, starts at Azadegan Terminal in southwest of Tehran and ends at north districts of Tehran, passing Ozgol, Ghaem Town, Shahid Mahallati Town and Niyavaran.

This Line has 3 intersectional stations:

1. With Line 4 at Valiasr Crossroad Station.
2. With Line 6 at Valiasr Square.
3. With Line 1 at Shahid Beheshti Station.

Northern half of Line 3, the urban rail management biggest project of the year in terms of technical, executive and financial operating volume, was inaugurated on September 22, 2015 in honor of President's presence and won international golden clay award.

TEHRAN METRO LINE 4:

Line 4 with the length of 22 km and 19 stations starts at Shahid Kolehdoz (Afsariyeh workshop and terminus) in the East of Tehran and ends at Ekbatan Station (Eram-e-Sabz) and intersection with Line 5 in West of Tehran.

The entire line is currently operating with 19 stations. Also a branch station called Bimeh Station was put into operation in winter 2015 and connected this line to Mehrabad Airport Line.

LINE 4 EXTENSION TO MEHRABAD AIRPORT:

This Extension of Line 4 to Mehrabad Airport with the length of 2.5 km includes the route, 3 stations and connection structures to Express Line 4. This section divaricates from Bimeh Station in Line 4 located at the beginning of Karaj Special Road and after passing by the Airlines Central Office, Airport Square and Pilgrims Flight Terminus will be connected to Express Line 4.

The length of station's platform is 62 meter and all tracks and stations have been constructed underground.

TEHRAN METRO LINE 5:

This suburb line with the length of 43 km and 11 stations connects Sadeghiye Metro Station in west of Tehran to Golshahr Station in Golshahr district located in Karaj.

TEHRAN METRO LINE 6:

Tehran metro Line 6 with the length of 31 km and 27 stations extends from southeast in Dowlat-Abad to Sologhan in Northwest of Tehran. It covers important city populated districts and areas such as: Hefdah-e-Shahrivar Ave., Khorasan Sq., Shohada Sq., Imam Hossein Sq., Sepah Sq., Haft-e-Tir Sq., Valiasr Sq. According to the estimates it covers more than one million daily trips. Also due to the fact that this line will have intersectional station with all lines in Tehran Metro network, it will play an important role in network balancing.

The plan of Line 6 South extension between Dowlat-Abad to Holy Shrine Abdul Azim is also on the agenda. Taking into account this section, line 6 will be in the category of one of the longest Metro lines in Tehran.

Line 6 tunnels were constructed by two NATM and TBM methods and Southern tunnels were implemented by mechanized method (TBM). Northern part Tunnels have been constructed also by NATM method. The stations of Line 6 are underground and only Dowlat-Abad station has been constructed as an open-trench station. The depth of line 6 varies depending on the position of the lowest in Dowlat-Abad, which is 14 meters to the highest in Valiasr Sq., with the depth of 37 meters.

TEHRAN METRO LINE 7:

Based on the comprehensive feasibility studies of Tehran urban rail transportation which has been conducted by Systra Consulting Inc., Line 7 was considered as one of the densely traffic corridors. Approved route of Line 7 starts at Southeast of Tehran (Amir-al-Mo'menin Town) Takhti Stadium and by passing through East to west includes passing through the main arteries of the city such as Shahid Mahallati Sq., Mohammadiyeh Sq., Molavi St. (market area), reaches to Navvab Highway and Ghazvin Ave. intersection (Beryanak) and then extends from South to North by passing through Navvab Ave., Tohid Tunnel, Milad Hospital and Sana't Sq. and finally ends at Boostan Sq. (Sa'adat-Abad)

Tehran Metro Line 7 with the length of 27 km and 23 stations is divided into two parts namely North-South and East-West and has a parking lot in the North, a repair terminal in the Southeast as well as three power substations along the route. This line connects important places such as Milad Tower and Milad Hospital in North and Tehran Market and other commercial and cultural centers in South districts of Tehran.

TEHRAN METRO LINE 1 EXTENSION:

Shahr-e-Aftab – Imam Khomeini International Airport – Parand New Town

To enhance services in the field of rail transportation and in order to satellite coverage of Tehran Metropolitan, construction and completion of Tehran Metro Line 1 South Extension with the length of 52 km and 4 stations to Parand New Town was put on the agenda.

Following the agreement dated on April 14, 2010 between the Ministry of Roads and Transportation and Tehran Urban & Suburban Railway Co. (TUSRC), the construction and completion of Line 1 south extension with the length of about 52 km to Parand New Town was assigned to Tehran Metro Co. Using the fleet with maximum speed of 120 km/h was predicted in the initial design of this project. This project will be entirely put into operation in two phases according to government plans and financial policies.

In geometric design of the route, 12 bridges and intersections have been included due to the presence of natural and abnormal phenomena such as river, canal, local roads and other obstacles, particularly, the proximity with Tehran-Qom expressway. Also in the preliminary location design of this line, 5 stations have been considered at various locations containing International Fair of Shahr-e- Aftab, Vavan Town, as well as 2 stations at Imam Khomeini International Airport and eventually the final station in Parand Town.

Meanwhile, for the benefit of Railway passengers to connect to Tehran Metro network and based on the coordination with Islamic Republic of Iran Railways, an intersection station has been added to this collection between Subway and Railway companies at the beginning of Imam Khomeini Airport connecting road. Part of this line was officially opened in summer 2016.

First Phase:

The stations' construction of Shahr-e-Aftab International Expo and Imam Khomeini International Airport along with the 5.32 km route between Shahed Station to Imam Khomeini International Airport

This phase covers important centers such as Islamic Azad University of Shar-e- Rey, Shahed University and Shahr-e-Aftab International Exhibition, Saalehabad and Shekarabad villages, Vavan districts and Imam Khomeini International Airport. The path of this phase includes a set of gallery underground routes, the surface route and a bridge. This route starts as a concrete box from Shahed Station and proceeds through tunneling method using the precise tool and soil behaviorial testing by passing below Tehran-Qom Freeway toward Shahr-e-Aftab International Exhibition Station and finally leads to an above ground path and extends to Imam- Khomeini International Airport consist of 3 different levels including above ground, bridge and underground gallery.

Second Phase:

The station's construction of Parand New Town and about 20 km route between Imam Khomeini International Airport to Parand New Town along with the terminal

The route of this phase which is mainly aboveground, has mostly considered serving the residents of Parand New Town. It should be noted that in addition to completing Parand station and 20km route, the stations along the route including Vavan station and railway intersectional station have also been predicted in this phase. In order to put this line completely into operation, a set of terminal and workshop has also been considered adjacent to Parand station.

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