Budapest Underground Line 4

Underground Line 4 in Budapest has been the largest infrastructure project of the city for the last decades. Led by FŐMTERV Co., the engineering and design team worked on the project for almost twenty years. The project has been finished in March of 2014.

General information

Length of line: 7,34 km
Number of stations: 10
Journey time: 12 min
Headway: 2,5 min
Maximum velocity: 80 km/h
Traveling velocity: 32 km/h

Preconceptions

In order to ensure the sustainable development and transport, together with the effective environment protection, the measure of the preference plays a dominant role to be highlighted in the public traffic transport. With the aim of satisfying the passengers' using the public transport possibilities on a high level, providing travel parameters being more favourable comparing to the individual transport modes shall be necessary. The track-based transport modes can be completely suitable for influencing the modal choice in order to support the achievement of this objective.

The feasibility study examined the environmental characteristics of the existing transport system and analysed the development opportunities. As an EU funded project, the preparation of environmental assessment was necessary to control the environment pollution (especially noise and vibration, air pollution; nature reservation etc.).

It can be stated, that the petrol usage, as well as the emission increase globally; the direct environment protection interventions are not eligible. Further issue of high importance, which has to be taken into consideration regarding to the environment protection is the issue of occupation. The roads and (rail) tracks, connecting facilities, territories used by the vehicles, polluted areas being inappropriate for other use due to the fact, that the facilities make them enclaves, and the rearrangement emerged as the consequence of the transport all form part of the occupation. The occupation is capable to influence the environment characteristics by itself; therefore, it is highly important to manage this issue during the environment centred transport design.

With the above-mentioned in mind as well, the necessity of the underground transport mode emerges – as everywhere in the world – from the capacity lack of the public transport. Within a dense built urban surrounding, the expensive underground transport comes into focus, when the capacity extension of the surface transport facility is no further solvable. The critical section of the underground was between the Móricz Zsigmond körtér and the Kálvin tér, where, due to the density, the deterioration had occured already in the second half of the 1960s. The characteristic of the critical section was the terrain elevation, as being wedged between the Gellért Bridge and the River Danube, only one solution was acceptable to manage the public transport (the inner Bartók Béla road). In addition, this line serves not only the South-Buda-City Centre (Városközpont) direction traffic, but also the part of the Middle-Buda – Óbuda direction traffic.

The dominant element of the track alignment was the Móricz Zsigmond tér and Kálvin tér section; in this section, the surface public transport had been completely exhausted. The direction of the continuance in Buda was determined by the already built housing estates, the location of the traffic flowing from the surrounding settlements, as well as by the town development plans. The line alignment through the city centre was also defined by the town developments with the intention of extension of the

narrow city centre to south direction. The maximization of the passenger volume and demand for fitting into the urban transport network determined the station allocation. There is no station along the line, which has not got connection to at least one other element of the transport network.

Construction method

The watertight Oligocene clay soils of Buda had allowed the use of all three methods of construction available; however, the much younger Miocene and Pleistocene soils of Pest have necessitated the use of front-braced shields, due to the water pressure in real depth and the unfavourable layering of soils. Based on renowned experts' opinion and propose, the shield construction method had been chosen, without front bracing in Buda, and with soil bracing under the River Danube and in Pest (EPB, TBM). The dense pasty mixture prepared from the soil excavated by the milling wheel and from blowing agent ensured the support of the ground, which compensated the external water and ground pressure; this material got into the shield interior, which had normal pressure, via the Archimedean spiral. This spiral ensured the pressure compensation. Due to the chosen solution, the establishment of a workplace in caisson form was not necessary. The selected Herrenknecht shields were capable to adapt to both ground type without any substantial retooling.

The shield method of construction created in a single step the structural system of tunnels, the reinforced concrete tubbing structure. By injecting out continuously the rear space, it could be achieved, that substantial subsidence on the surface of the shield section was not generated. The reinforced concrete tubbing itself and, at the connection, the neoprene strips compressed by the power for pushing forward of the shield ensured the insulation against water.

The maintenance of the shields was managed below the station, and also there was carried out the replacement of the teeth and disks of the milling wheels. The approximately 106 meters long equipment went through the station of "his own two feet," as it used its own hydraulic system.

In several exceptional sections of the line, unique construction method had to be applied, for example the line turning structure connecting to the Szent Gellért tér station; the section connecting to the Bocskai út station, this allows the ventilation also, and at the end turning structure of Őrmező which was located over the place where the shield had been started.

The exact track of the railway (horizontal and vertical line alignment), prioritizing the aspect of the most favourable management of transport, has been developed in compliance with the applicable regulations.

Technical characteristics

The design speed is 80km/h; restrictions resulting from track alignment do not hinder this. The largest ascent is 34.5 ‰, the minimum curve radius is 400 m. The superstructure along the line has CWR construction. Static axle load on the line: 180 kN. Track systems: traffic and junction tracks head-hardened 54 E1, canting of the rail is 1:20. In general, the third rail for power supply has been placed on the left of the travel direction of the track.

The current line management and monitoring of all activities is carried out in the control centres. The organization consists of:

- Line traffic management and monitoring (KFM)
- Passenger traffic management and monitoring (KUD)
- Energy supply management and monitoring (EDI)
- Management and monitoring of the equipment necessary for the traffic management (MÜDI).

Accessibility

In the passenger traffic areas 93 pieces escalators had been installed, which are suitable for public transport (so called heavy-duty); at the underground exit of Őrmező, seven more are available for the passengers.

In order to ensure the accessible transport and according to the regulations, 34 pieces elevators had been installed, which can be used by everyone. The elevator cabs are for 13 or 18 persons; their nominal speed is 1m/s.

During the construction, more attenuations were carried out, which are suitable for improving the "liveability" of the surrounding.

Stations and architecture

The architectural firm, PALATIUM Studio (led by Zoltán Erő) had a primary role in defining the architectural tasks and the design background; however, the architects worked out a common architectural language together. Similar gestures of handling spaces, functions and materials inform the world of the stations, and at the same time, each station became unique, based on the artistic intentions of the designer. Thus the new line with its ten stations can be regarded as a building of ten wings, where each wing has its own atmosphere, while they clearly belong together.

The designers aimed to provide attractiveness for public transportation through the quality of the design of a series of new public spaces in Budapest. This aim has met the expectations of the Client from the first moment. People visiting and using the line in the first months have given positive feedback about their new spatial experiences that define the architectural character.

The ten stations of the new line are the results of architectural experiments with space, structure and light. During the design process architects made a strong effort to find optimal solutions among the requirements of construction technologies, transport technologies and the creature of artistic architectural spaces. Predicted by the cut and cover construction technology for the stations, the underground boxes of the stations bordered by diaphragm walls provided enormous spaces, in which only the structural elements, the large horizontal supports in the form of beams, slabs, or pressed rings are visible with their rough, characteristic shape. Fair-faced concrete is used widely for the primary structures, while those elements, close to travellers are in a finer human scale. To use the possibilities of the large open spaces to an extreme, there are smaller or larger openings for the natural light from the surface, ensuring that stations enjoy an atmosphere of free, airy spaces. It is not only natural light that can specially define architectural spaces, but artificial lighting of the station areas has also a series of innovative and specific solutions. A high level and a high temperature of general illumination provides clear and clean feeling for the spaces, while the use of additional coloured lights result in special effects giving unique character for the stations. Although only partially visible from the passenger areas, the structures of large ventilation and smoke exhaust systems were decisive during the spatial design, and, for safety reasons, fire protection became one of the most important issues. It is generally considered that the stations have added new public spaces for the city of Budapest with new aesthetics and high architectural quality of the large infrastructure, they provide attractiveness and high quality architectural environment for public transport.

More than a year have passed since the underground Line 4 of Budapest was handed over to the public. The 10 stations of the new line are the results of architectural experiments with space, structure, light and that of a cooperation of five architectural offices and engineers. We do hope that the result meets the interest of the international community of professionals.

Although the architects used a common architectural language on the whole line, the stations are individual, due to the different physical circumstances and the creativity of the diverse personalities. We can look at the complex as a building of ten wings. Predicted by the cut and cover construction technology for the stations, the underground boxes of the stations provided enormous spaces where only the structural elements, the large horizontal supports are visible with their rough, characteristic shape. Fair-faced concrete is used widely for the primary structures, while those elements, close to travellers are in a finer human scale.

During the design process architects made a strong effort to find optimal solutions among the requirements of construction technologies, transport technologies and the creature of artistic architectural spaces. Main construction technologies have been cut-and-cover boxes bordered by diaphragm walls, divided into two or more levels by the horizontal supports in the form of beams, slabs, or pressed rings. To use the possibilities of the large open spaces to an extreme, there are smaller or larger openings for the natural light from the surface, ensuring that stations enjoy an atmosphere of free, airy spaces.

Nevertheless, it is functionality that basically defined architectural solutions. Considerations on passenger flow from and towards station exits and the most important transfer points on the surface were definitive for the general layout of stations. Even more, certain stations were redesigned for achieving better solutions. The western terminal station, Kelenföld vasútállomás became one of the most important intermodal exchange point of the capital city providing direct access among interurban and commuter trains, interurban and local buses and the Metro Line 4. Due to the construction of the underground station, the railway station could be rearranged and renewed as well. This place can be an important development area also for future urban projects.

At other important junctions, such as Móricz Zsigmond körtér and Kálvin tér, the renewal of the public urban spaces on the surfaces could bring new elements for the pedestrian network. On that way, together with other urban programs, the construction of Line 4 could serve as an essential element of urban renewal of the inner city areas, too. Kálvin tér and Fővám tér became new entrance gates of the historic core of Pest.

Kálvin tér is a junction between Line 3 and Line 4, using a connection tunnel prepared for that purpose in the late 1970's. Similarly, there are some preparations to provide connections at the same place for the station of a future underground Line 5.

Although only partially visible from the stations' passenger areas, the structures of large ventilation and smoke exhaust systems were decisive during the spatial design. It is not surprising, that for safety reasons, fire protection became one of the most important issues of underground architectural work. Each station has three independent exhaust systems and widely used built-in water mist fire extinguishing systems. The very strict regulations of fire protection were present already at each choice of building materials.

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