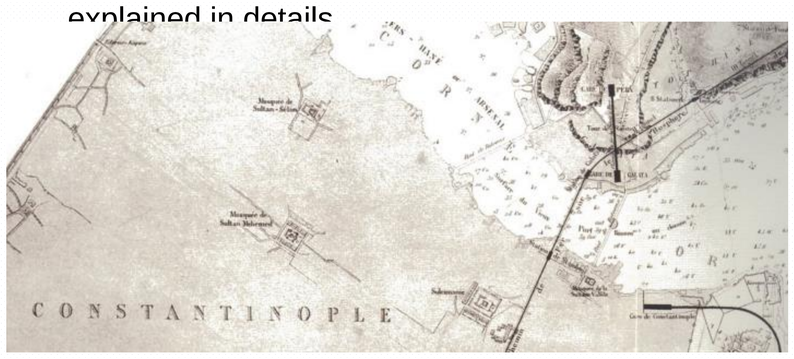
Early Application of Underground Funicular 'Tunnel' in Istanbul

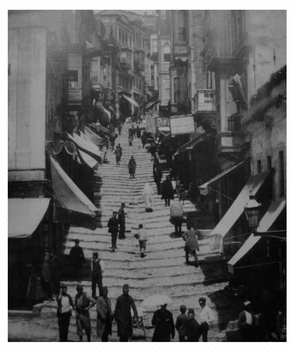
Eren Kayaoğlu Adem Candaş
Y. Ziya Kocabal C. Erdem İmrak

Istanbul Technical University
Mechanical Engineering Faculty

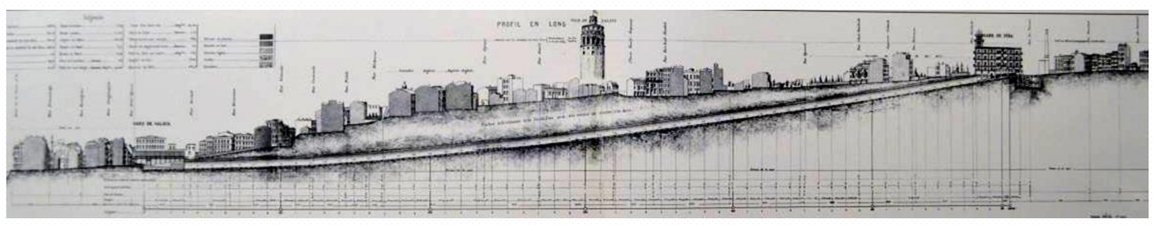
Abstract

Tünel (means tunnel in English) is a short underground funicular with two stations, connecting the quarters of Karaköy (Galata) and Beyoğlu (Pera) and located at the northern shore of the Golden Horn in Istanbul. Tünel is the second-oldest subterranean urban rail line in the world, after the London Underground. It was originally conceived by Eugène-Henri Gavand in 1867 and opened for service on January 17, 1875. In this study, Tünel and its history and working principle are expressed and the crucial components and mechanisms are explained in details.

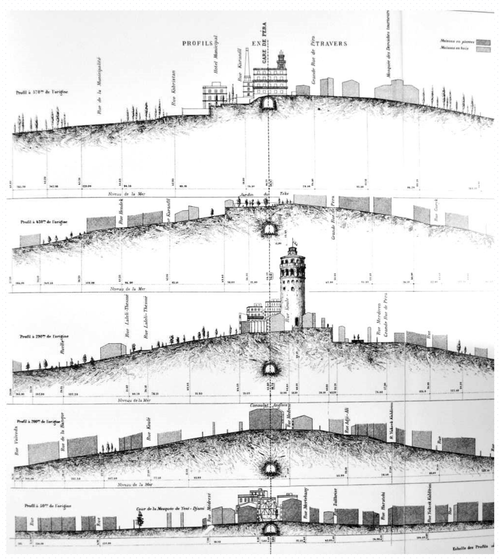




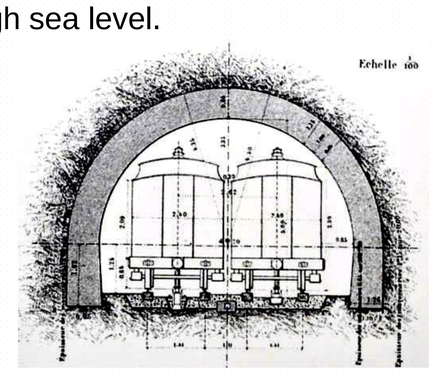
French engineer Eugène-Henri Gavand came to Istanbul as a tourist in 1867 and released that the people are climbing the slope of Yüksekkaldırım (above). A railway project between Galata, the banking center, and Beyoğlu, the center of social life, might be great and profitable. After long negotiations, his project was accepted by Sultan Abdulaziz and he took the privilege of construction the first subway of İstanbul. So, Tünel was constructed by hundreds and opened with a magnificent ceremony. Now, it is one of the historic and symbolic attraction points of the city.



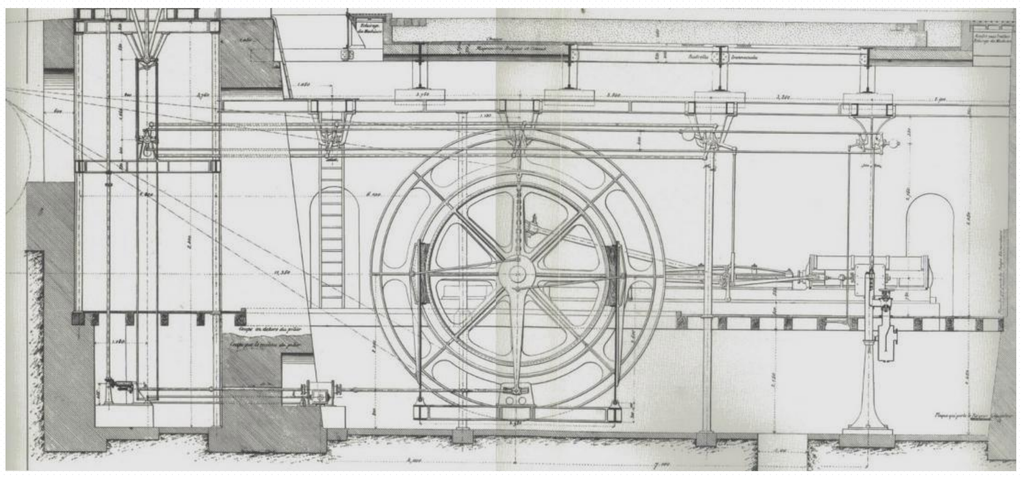
There is a light ramp at Karaköy side. The reason for this is, cars to gain sufficient speed in order to overcome the next ramp. This image serves as a parabolic railway line. There is a 10-20 mm/m slope at Karaköy side. This slope increases and reaches to 149 mm/m. It remains constant until Tünel exit for 90 meters. Then, with a slight decrease in slope, it reaches to Beyoğlu Station with 139 mm/m. The railway is 1.15 meter above sea level at Karaköy Station. The railway is 62.70 meter above sea level at Beyoğlu Station. The length of Tünel is 550.80 m, width is 6.70 m and the height is 4.90 m. The length of the railway inside is 626 m. It was first built as double track railway.



Galata Tower's location with respect to the tunnel can be seen in this figure. On the other hand the upper sectional view represents the Beyoğlu Station, the lower sectional views represent sections of the tunnel descending through sea level.



Each train consists of two cars. A dual brake system was installed on each car. They are driven by a fixed steam engine until 1968, located on Beyoğlu Station.



The driving gear of Tünel was powered by two steam engines of 150 HP each (Figure 8). Tünel was closed in 1968 for electrification and renewal works and the new system of Tünel was reopened in 1971.

The Steam Tünel (1875-1968)	The Electric Tünel (1971-2014)
Cars operate on the same track by coming and going constantly without changing lines.	Except the meeting point in the middle of the line, the rail was transformed into one line (Figure 8)
Because the passengers use the same entry and exit points, only one side doors of the cars are opened.	The passengers enter to the cars from right side in Karaköy and leave from the left side in Istiklal St. (Beyoğlu).
Each train consists of two wooden cars (Figure 9). Second class carriage trips are made on the front car, and there is a platform for carrying belongings, animals and carts in this car. Rear car is reserved only for passengers. Second class seats are made of wood, first class seats have cushions.	There are two metal cars. These cars moving in opposite direction. No class separation. 
It is operated by steam engine.	It is operated by electric engine.

Technical Characteristics of Tünel	
Length of tunnel: 574 m	Number of cars: 2
Track length: 626 m	Car weight: 22 tons (empty 34 tons (full)
Elevation between stations: 51 m	Car length: 16 m
Average track incline: 10%	Normal waiting time 3.5 mins
Maximum load: 170 P/car	Traveling time: 1.5 mins
Handling capacity: 3,500 P/h	Maximum speed: 8.33 m/s (22 km/h)
Daily handling capacity: 15,000 P	Minimum operating speed: 1.5 m/s
Annual handling capacity: 1,000,000 P	Driving sheave diameter: 3.5 m
Main engine: 350 HP	Hauling rope diameter: 30 mm
Stand-by diesel engine: 250 HP	Tension weight: 33 tons

Today Tünel is operating between Karaköy and Beyoğlu. After the renovation between 1968-1971 it became very modern and vibrations and noises caused by iron wheels are not experienced anymore.

Tünel is not only the world's second subway but also it is the first of the modern funiculars. It is hoped that in the near future a variety of new transport systems as an outgrowth of the funiculars will be developed and become widespread for short-range transport.

Acknowledgement

This document is supported by Machinery Promotion Group.

References

1- Acar, F., Engin, V., Kargı, H. (2013). *The World's Second Subway in the Memory of Tünel's 138th Anniversary*, *Tünel Tanıtım Broşürü İETT*, İstanbul.

2- Engin, V. (2000). *Tünel, Simurg Publ.*, İstanbul.

3- Engin, V. (2011). *İstanbul Tüneli, Tunnel de Constantinople, Yeditepe Publ.*, İstanbul. (Gavand 1876 - In Turkish)

4- Gavand, E.H. (1876). *Chemin de fer Metropolitan de Constaninople au Chemin de fer Souterrain de Galata Pera dit Tunnel de Constantinople*, Paris.

5- Imrak, C.E., Özkırım, M. (2002). *Funicular Systems and Early Application in İstanbul, Elevator Technology 12, Proc. of ELEVCON'2002*, pp.151-160.