The "TISB" and the "TMG" Concepts. Application on a Proposal for the Railway Tunnel through the Gibraltar Strait

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Summary

The paper presents two innovative and cost-effective concepts for the construction of tunnels using TBMs ("tunnel boring machines"): the "TISB" concept, to be used when the referred tunnels are executed in soft soils (e.g., alluviums), in seismic areas, and the "TMG" concept, which allows for the use of a single tunnel that provides the capabilities usually obtained with three parallel tunnels. The paper also presents an alternative proposal for the railway tunnel through the Gibraltar Strait, in which these concepts are applied.

Keywords: Tunnels, Railway, TBM, Earthquakes, Soft soils, Multi-gallery, Gibraltar Strait.

1. Introduction

When executing a tunnel with a TBM, the machine excavates the soil and places precast segments, which are linked together, in order to form its circular wall, reducing costs and time.

In the case of soft soils (mud, etc), the execution of tunnels with a TBM is unreliable because, in the tunnel thus formed, the connections between the precast elements are weak, hence the strength of the tunnel is low, so there is the risk of sinking, or collapsing, particularly during an earthquake.

Also, in the case of long railway tunnels (typically, tunnels spanning more than 1000 meters), instead of having a single tunnel, it is convenient to build two separated tunnels, one for each sense of traffic, in a way that, inside the tunnel, the air will circulate in a unique sense, the sense of the traffic. However, the trains have no possibility to change the lines, if needed. Sometimes, there is also the need to build a third tunnel (service tunnel), for local access and the evacuation of persons, in the case of an accident or of fire inside the tunnel.

2. The "TISB" concept

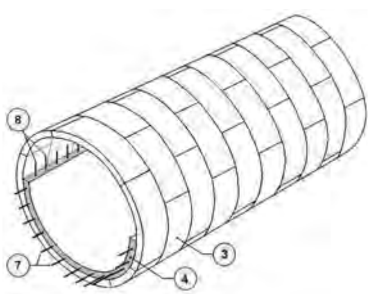

Fig 1: The "TISB" concept: Detailed perspective of the tunnel

The "TISB" ("Tunnel of Improved Structural Behaviour") concept constitutes an innovative solution for the construction of tunnels of the roadway and of the railway types, executed with TBM, when the referred tunnels are executed in weak soil (e.g., mud), allowing for the tunnel be provided with the necessary strength and ductility. The "TISB" concept is illustrated in Figure 1.

The tunnel is constituted by two tubes in concrete; an exterior tube (3), which is built by the TBM in the weak soil, and an interior tube (4), which is executed later on, inside the exterior tube. The exterior tube (3) is formed by precast elements, which are mounted by the TBM. The interior tube (4) is cast inside the exterior tube (3), with the help of a supplementary interior formwork. Inside the thickness of the interior tube (4) longitudinal and

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transversal reinforcements (7) (8) are placed in order to provide the tunnel with the necessary strength and ductility to resist the vertical and the horizontal actions that may act on the tunnel.

3. The "TMG" concept

The "TMG" ("Tunnel Multi Gallery") concept constitutes an innovative solution for the construction of railway tunnels with two lines, made with TBM, allowing for completely independent, but interconnected, senses of traffic, and the installation of devices for easy local access and the evacuation of persons, in the case of an accident or of fire inside the tunnel. The "TMG" concept is illustrated in Figure 2.

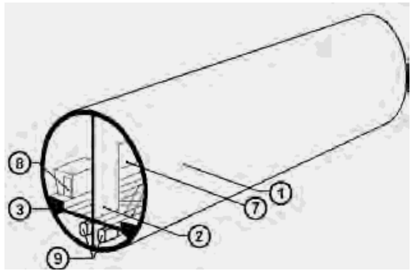

Fig.2: The "TMG" concept: Perspective of the tunnel

The TBM excavates the soil and places precast segments, which will form the exterior wall of the tunnel (1). Inside the tunnel, a wall is executed (2), disposed at the middle of the tunnel and at all its high, and a slab (3), placed a bit over the bottom of the tunnel and at all its width, in order to form two independent railway galleries, disposed side by side (4) (5), one for each line, and a service gallery with two cellules.

In the vertical wall (2) large openings are arranged (7), provided with fire walls, regularly spaced along the length of the tunnel, in order to allow the trains to pass from one line to another. In the slab (3) openings are also arranged, protected with fire devices (8), on both sides and regularly spaced, in order to allow for the passage of persons to the service gallery, in the case of an accident or of fire inside the tunnel. Inside the two cellules of the service gallery, vehicles of shuttle type (9) are installed, in order to provide local access and the evacuation of persons, in the case of an accident or of fire inside the tunnel.

4. Alternative proposal for the Gibraltar Strait tunnel

The planned railway tunnel through the Gibraltar Strait will link Punta Palomas, 10 km West of Tarifa, in the South of Spain, to Cape Malabata, near Tanger, in the North of Marocco. It will be 39 km long, of which 28 km under the sea. The tunnel goes very deep, till 400m, since the water depth is 300m. In the middle of the strait, the tunnel crosses two paleo-channels, of weaker characteristics (Figure 3).

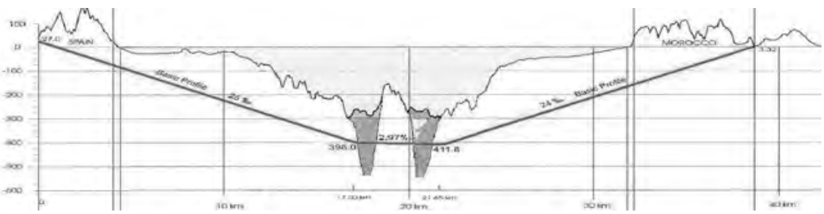

Fig. 3: Basic lay-out of the Gibraltar Strait tunnel

Based on the "TMG" concept, instead of having three tubes, as planned, the tunnel will be a single tube tunnel, with an interior diameter of 11.5m. It will be divided by the central wall and the slab in four galleries, two railway galleries on the upper floor, and a service gallery with two cellules on the lower floor (Figure 2). The section of each railway gallery is equivalent to one of a single tube of 7.5m diameter.

Based on the "TISB" concept, the two zones of the tunnel where it crosses the paleo-channels, the tube made by the "TBM" will be enhanced with an interior tube, cast in- situ, provided with longitudinal and transversal reinforcements (Figure 1), dully confined, in order to provide the tunnel with the adequate ductility under earthquakes.