

Post-Olympics in Rio: Review of major changes allowed by the Tunnelling Industry

The Olympic Games in the “Cidade Maravilhosa” may have come to an end, but even after the effervescence of such an event, it is now obvious that Rio has risen as a vibrant global metropolis. It is time for Tunnelling Industry to review and highlight projects that were part of the Olympics success. If this worldwide competition was a particular moment for athletes to shine, it was also a momentous occasion for the Tunnelling Industry to introduce major projects undertaken in the city. Indeed, as the organizer of these Olympic Games like previous cities: London, Sochi or Beijing, Rio had to prepare and make some improvements; numerous projects were launched in order to facilitate mobility and access to the different venues.

Overall endowed with strong industry assets, Brazil’s economic development is committed to strengthen competitiveness and enhance a massive development of transport infrastructures. Moreover, in the last decades, cities around the world have been awakened to the new paradigm of sustainable development, where the new frontier is the occupation of vacant and underground spaces. The Tunnelling Industry is a key actor to meet this challenge.

Behind the curtains, Rio shapes its future, Tunnelling Industry is continuously acting to cope with urban issues raised every day. For the Olympic Games in Rio, that translates into 4 major projects:

- **The Metro Line 4:**

A technical challenge...

The construction of Metro Line 4 in Rio de Janeiro (Brazil), used cutting edge domestic and international technology to cross densely populated neighborhoods while minimizing the impact on local infrastructure and residents. That shows that hybrid Earth Pressure Balanced tunneling in pure sands is possible and comparable to state-of-the-art slurry shield tunnelling in granular soils.

The shield-driven tunnel of Metro Rio Line 4 has an approximate length of 5.2 km. The excavation was performed using a Hybrid Earth Pressure Balanced shield with an excavation diameter of 11.51 m and crossed complex geology that includes a long stretch of pure sand bounded by two stretches of hard, highly abrasive rock. Considerable reduction in materials, for conditioning consumables for example, and energy of power consumption are achieved with Hybrid EPB technology, comparing to a slurry shield requests, since it represents a considerable reduction in the consumption of bentonite and no separation treatment plant is required.



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The application of EPB shield concept has allowed to minimize the area needed for jobsite equipment and the accurate face support pressure and controlled reduced settlement measures, as demanded in high density urban areas, has been possible in pure sands under the groundwater table, compared to slurry shield.

Around 340 companies and more than 200 specialists and consultants were involved. Throughout the project, worksites underwent external auditing and the project received ISO 9001 quality management certification.

...for a fantastic social & economic transformation

Since construction started in 2010, around 30 thousand direct and indirect jobs have been created, generating R\$ 3 billion in salaries paid to employees from 23 of Brazil's 26 states and the Federal District. Around R\$ 3 billion was paid in federal, state and municipal taxes (31% of project costs) and will be invested in benefits for the general public.

The Metro Line 4 was inaugurated the 30th of July, a few days before the opening ceremony of the Olympic Games, enabling to transport 300,000 persons a day. Five stations and 16km of track now connect Ipanema to Barra da Tijuca and the Olympic Park.

According to the *Getulio Vargas Foundation* (FGV), implementation of Line 4 will increase city productivity and represent savings of R\$ 883 million a year, reducing travel time between Barra and South Zone neighborhoods by at least one hour by reducing the amount of traffic on the road.

- ***The Porto Maravilha project: where past and future meet***

Built in the seventeenth century, the historic harbour of Rio de Janeiro is a unique place. Famous for its strategic location and commercial development, it had once a worldwide scope. Although a huge cultural and traditional background; the historic and strategic value of the region faded as centuries went by and even more since the building of an elevated highway was launched. It blocked the famous view along the shoreline and worsened the urban and environmental deterioration.

The Porto Maravilha project was aimed to revitalize the Rio de Janeiro harbour area facing the Guanabara Bay and the Pão de Açúcar. The project developed remodeling of 55km of streets, demolition of the 5.5km long perimetral viaduct, construction of 4 tunnels with 7,915m total length, and related drainage, sewage, drinking water supply, electrical energy, and media networks.

A series of technical challenges had to be faced especially excavating underground roads beneath or very close to historical buildings - many of them built on shallow foundations, others on wooden piles, excavating through rock mass, but also in deposited marine sediment or early twentieth century hydraulic landfills, where several drainage, sewage, as well as electrical ancient and recent utilities had to be reallocated.

The project aims to bring new conditions for work, housing, transportation, culture and leisure market in order to increase the current population of 28 thousand residents to 100 thousand in 2020.



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- **The duplications of the Joá and Pepino Tunnels: alleviating traffic in Rio**

Joá and Pepino Tunnels were constructed in the 1960's contributing significantly for the expansion of the city. Their duplications will relief traffic congestion improving the quality of life in the southern part of the city. Sprayed concrete was used for final lining, a solution promoted by ITA Working Group 12 and so much used in Brazil.

- **Underground Works for flood control at Grande Tijuca and Maracanã**

Large scale integrated underground works are still underway for flood control in the neighborhood of the Maracanã legendary stadium. Three reservoirs with 120 thousand cubic meter capacity (Praça da Bandeira, Praça Niteroi and Varnhagen) were constructed to retain flood peaks. In addition, the longest storm water drainage tunnel in the country was constructed to divert the Joana River to the Guanabara Bay. The total length is 3.4 km. The tunnel goes underneath railways and the Magueira neighborhood with very low overburden. Careful drill-and-blast method was also used for the hard rock section under residential area.

The word of Tarcisio B. Celestino, President of ITA:



"Due to the beautiful hills all over Rio de Janeiro, the urban development of the city was always based on underground works. Perhaps the very first infrastructure work constructed under a public-private partnership in the country was a toll road with a tunnel between Laranjeiras and Rio Comprido districts. The tunnel was constructed in 1887 and refurbished in 1952. Many tunnels were constructed during the 1960s when the city celebrated 400 years.

Many other tunnels were also constructed for the 2016 Olympic Games. Among those, I would highlight the Metro Line 4 and the Porto Maravilha. At Line 4, many technical developments were required to overcome difficult and variable geotechnical conditions underneath a very densely occupied area. Porto Maravilha will continue bringing high-quality urban development for many years. Urban elevated highways became fashionable throughout the world during the 1970. Many of them have already been substituted by tunnels in other cities, but the arrangements with the real estate market were probably unique in Rio. Furthermore, the construction of a spectacular museum designed by the famous architect Santiago Calatrava in the area and the return of the breath-taking view of the Guanabara Bay and the Pão de Açúcar have already attracted investment to the once degraded area. Investment will continue in the coming years. All of that was made possible because of the construction of a set of tunnels.

I am sure the example will be copied in other cities around the world."

About the International Tunnelling and Underground Space Association:

The International Tunnelling and Underground Space Association (ITA) is a non-profit and non-governmental international organization, which promotes the use of underground space for a solution to sustainable development. Founded in 1974 and operating out of Lausanne, Switzerland, ITA currently associates 73 Member Nations, 300 affiliated members, 17 Prime Sponsors and 60 supporters, as well as individual members.

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