THE BREAKTHROUGH FOR TUNNEL BORING MACHINES

Anyone reading this article will have regularly enjoyed the benefits of modern tunneling technology – whether by driving on highways, crossing mountains or passing below rivers with the train, by taking the metro on the way to work, drinking fresh water from the faucet or simply flushing the toilet. All these everyday activities and many more would be impossible without tunnels.

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PHOTO: SIKA AG, HERRENKNECHT AG

Herrenknecht Gripper TBM for the Gotthard Base Tunnel, Gripper TBM, Ø 8,830 mm.

Many of these tunnels are likely to have been excavated by tunnel boring machines (TBMs). These high-tech machines are used as an alternative to “drilling and blasting” through rock or “conventional mechanical excavation” in soft ground.

In recent years, with the rapid growth of underground construction, especially in megacities, TBM excavation has gained increasing importance.

With advance speeds of 40 – 60 mm/min, TBMs may seem slow. Yet, given that excavation proceeds 24 hours a day, 365 days a year, regardless of weather or ground conditions, TBMs far outperform alternative excavation technologies. Tunnels several kilometers long can be easily driven within a matter of months. Moreover, TBM excavation causes next to no disruption, with the buildings, roads and landscape above the tunnel remaining unaffected during the construction period.

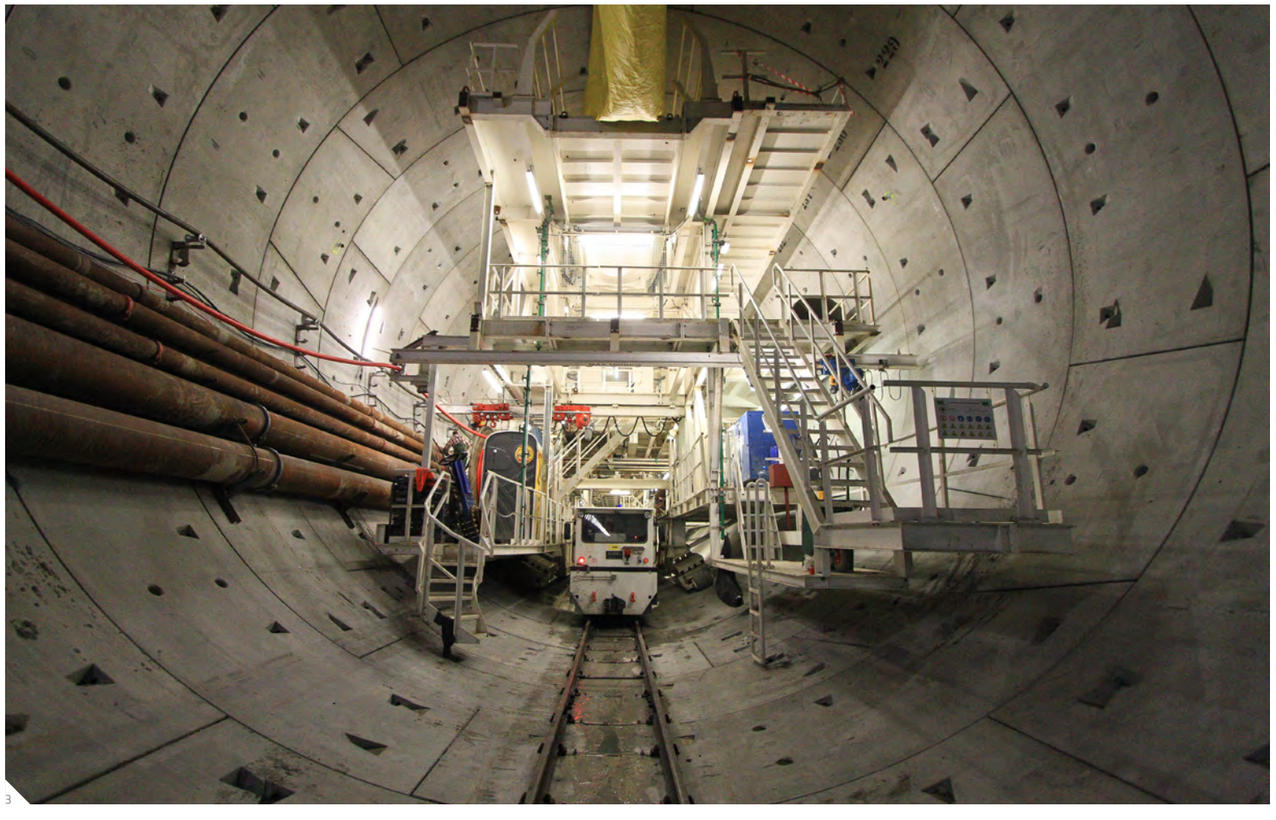
The TBM’s cutting wheel with its cutting tools, the main drive – equivalent to the motor – and the shield are custom-designed in line with the geological conditions and characteristics of the tunnel drive so as to meet the highest demands. The back-up is also specially configured to carry the required electrical and hydraulic installations along with the logistics-related equipment needed to build the finished tunnel.

The design and diameter of the cutting wheel are geared to the geology and intended use of the tunnel. The diameter of tunnels carrying water or electrical cables, for example, may range between a few centimeters and up to 4 or 5 meters. The diameter of tunnels for metros, trains or roads is normally around 9 to 12 meters, though may be anything up to 17 meters, as for a recently built tunnel in Hong Kong.

Not only the cutting wheel, the shield of

1-2 Sika TBM products during filling

3 Supply train entering the entry of the TBM



4 Supply train on its way to the TBM, carrying the backfill grout and Sika Foam TBM products

5 Inside the control center of the TBM

> the TBM is also adapted in line with the conditions of excavation. This explains the wide range of TBM features, which include hard rock shields, grippers, earth pressure balance (EPB) with screw conveyor and slurry shields with steel pipes for material extraction.

The back-up is the name given to the steel structure on boogies or rails behind the shield. It houses pumps, tanks, cranes, containers, transformers, cabinets, ventilators and all the equipment needed to keep the huge factory working. Depending on the tunnel length, it may even accommodate a lunchroom, restroom, nursery or rescue chamber. While standard back-ups are around 80 – 100m long, they are sometimes bigger than four football fields – as for the gripper machines used to excavate the Gotthard Tunnel in Switzerland, which last year became the world's longest rail tunnel.

For decades, Sika has successfully delivered concrete and waterproofing solutions for numerous tunnels worldwide. A lesser-known fact is that Sika also provides a wide range of products designed specifically for use with the various types of TBM. These include foams and polymers for conditioning the tunnel face to be excavated by soft-ground TBMs as well as sealants (similar to greases) for use at the back of all shielded TBMs.

The injection of foams, polymers and other additives into the tunnel face can significantly modify the characteristics, e.g. plasticity, texture and permeability, of the soft ground in order to facilitate and speed up the progress of the drive. Selection of the best type and quantity of ground-conditioning product depends on the specific geological conditions and equipment available in the TBM.

Sika sealants were specially developed with a hydrocarbon-free, vegetable-oil-

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> based formulation so as to resist water and ground pressure while avoiding any residual spoil contamination. Tail sealants are injected between the back of the shield and the lining segments to prevent water, soil and the backfilling grout from entering the TBM.

Now, after many decades of development, TBMs tackle much bigger challenges. And, without the resulting tunnel structures, we would no doubt have to plan our time quite differently. <

For more information on TBM technologies and products, please visit:
http://www.sika.com

https://www.youtube.com

Launch shaft for the Eurasia Tunnel on the Asian side of the Bosporus, Istanbul, Mixshield, Ø 13,660 mm.