The background image shows a massive concrete dam structure built into a steep, layered rock cliff. A large, dark, circular tunnel entrance is visible on the left side of the dam. The rock face shows distinct horizontal and diagonal geological strata. At the bottom of the image, there is a body of dark green water.

Tunnel Construction
and
Tunneling Methods
Tunnel Boring Machine
TBM

by

Dr. Azealdeen Salih Al-Jawadi

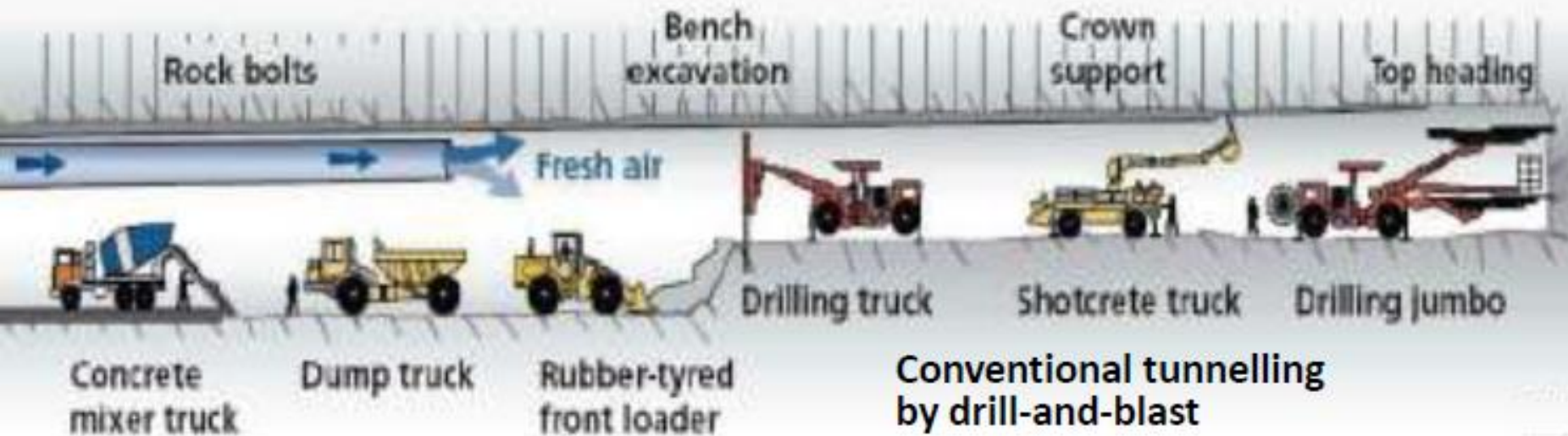
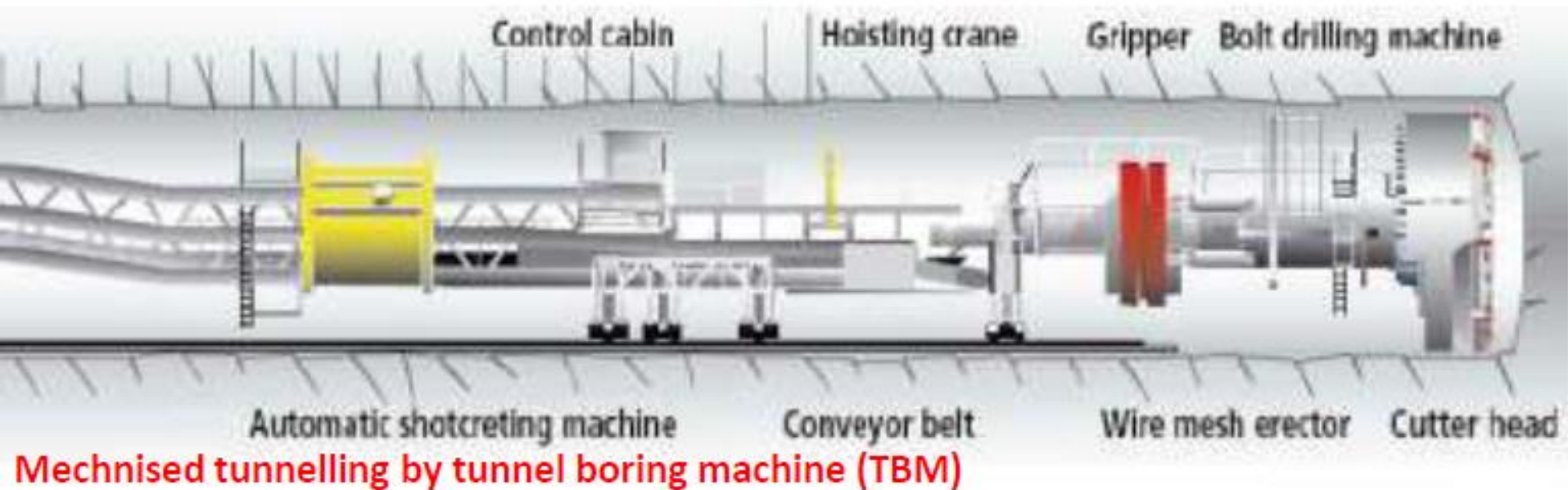
Conventional and TBM Tunneling

Today, Tunnel Boring Machines (TBM) excavate rock mass in a form of rotating and crushing by applying huge pressure on the face with large thrust forces while rotating and chipping with a number of disc cutters mounted on the machine face (cutter head).

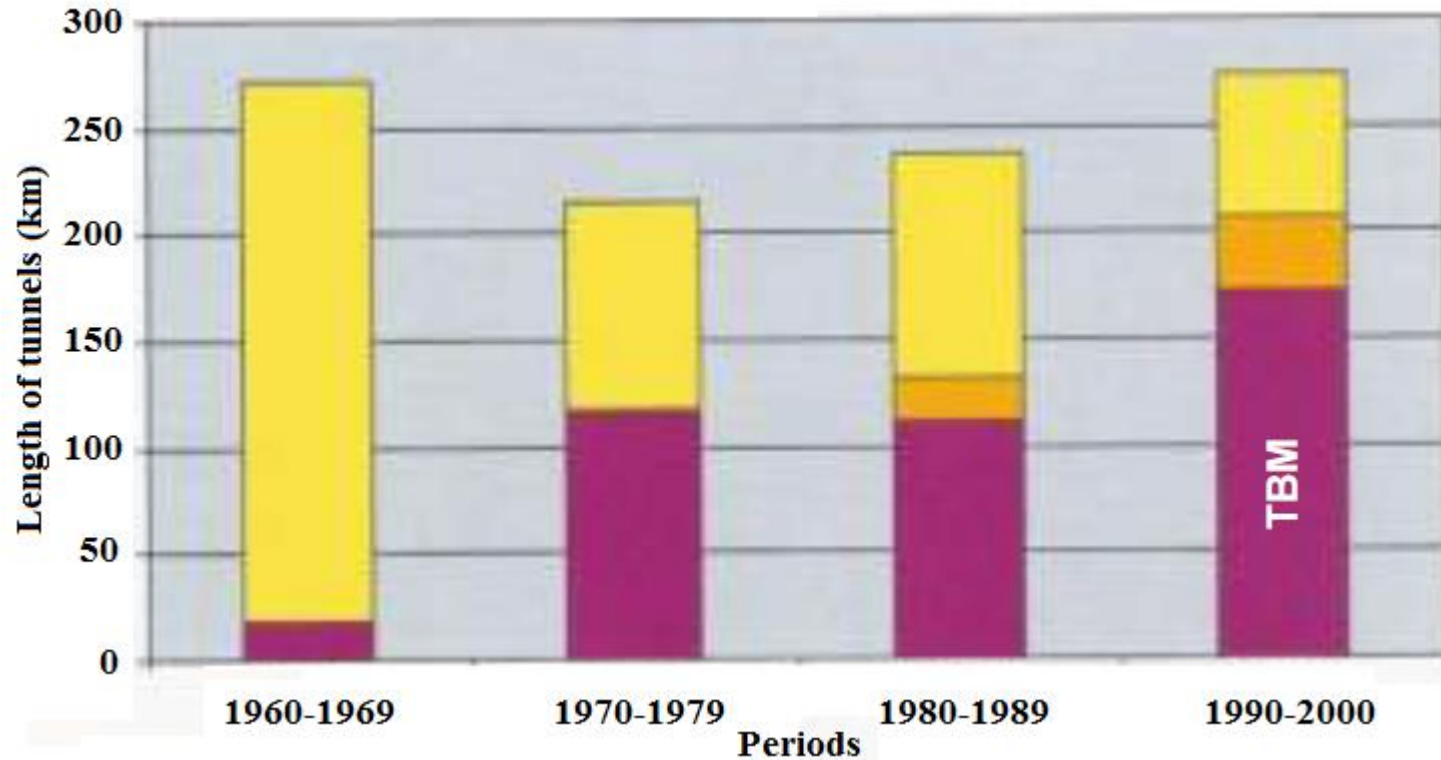
Tunnel Boring Machines (TBMs) nowadays are full-face, rotational (with cutter heads) excavation machines that can be generally classified into two general categories: Gripper and Segment.

Three general types of TBMs suitable for rock tunneling include Open Gripper/Main Beam, Closed Gripper /Shield, and Closed Segment Shield.

Conventional and TBM Tunneling



Tunneling and Use of TBM in Switzerland

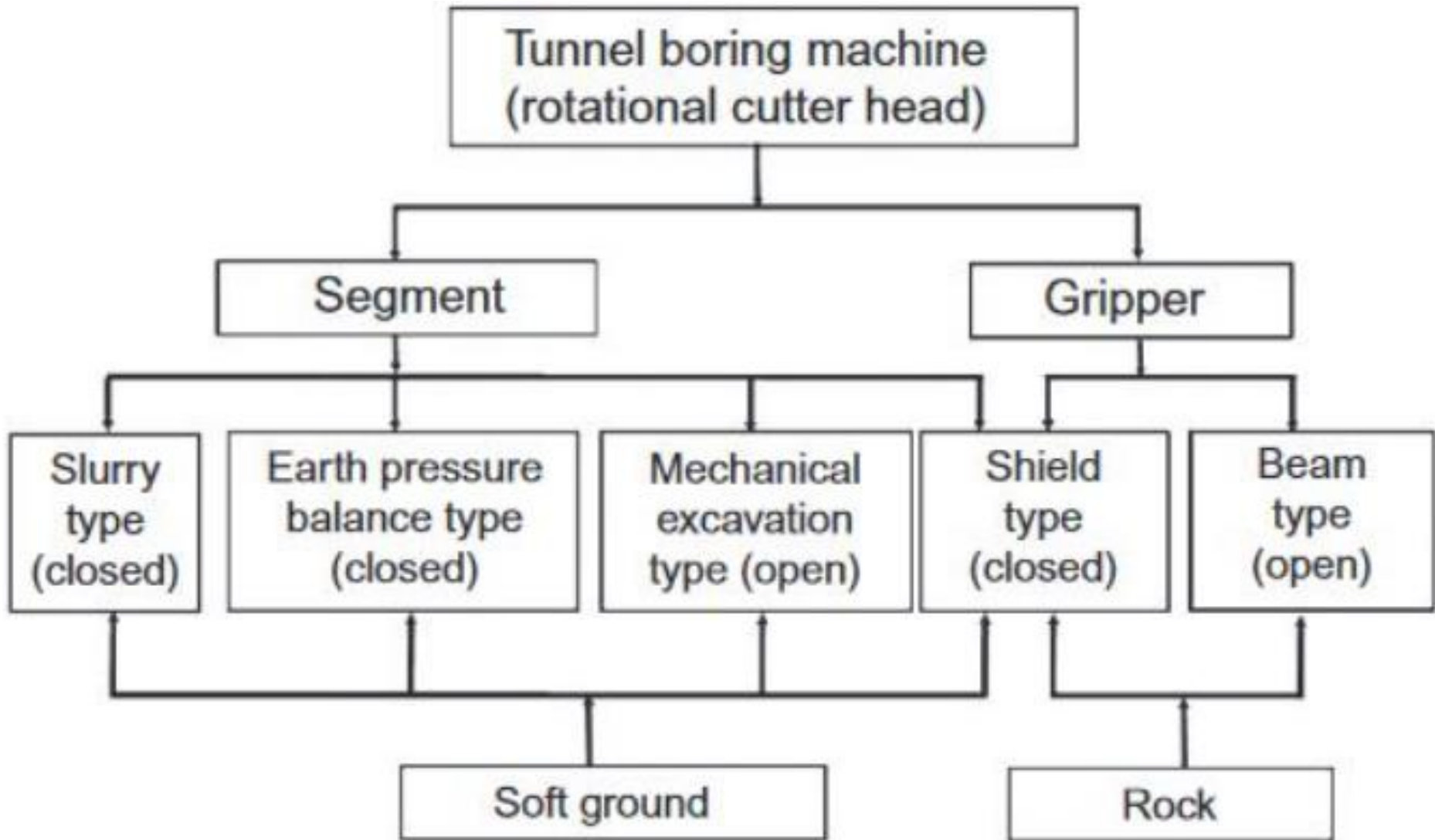


Singapore is the most intensive user of TBM for tunnel construction.

Tunnel Boring Machine Types

There are several types of TBMs. The best TBM for a project is based on the geological conditions of the site and the project's features. The general classification of the different types of TBM's for both hard rock and soft ground are presented below:

Classification of TBM



Basic Functions of TBM

1. Excavating the Ground
2. Supporting the Ground
3. Mucking the Excavated Materials



ADVANTAGES

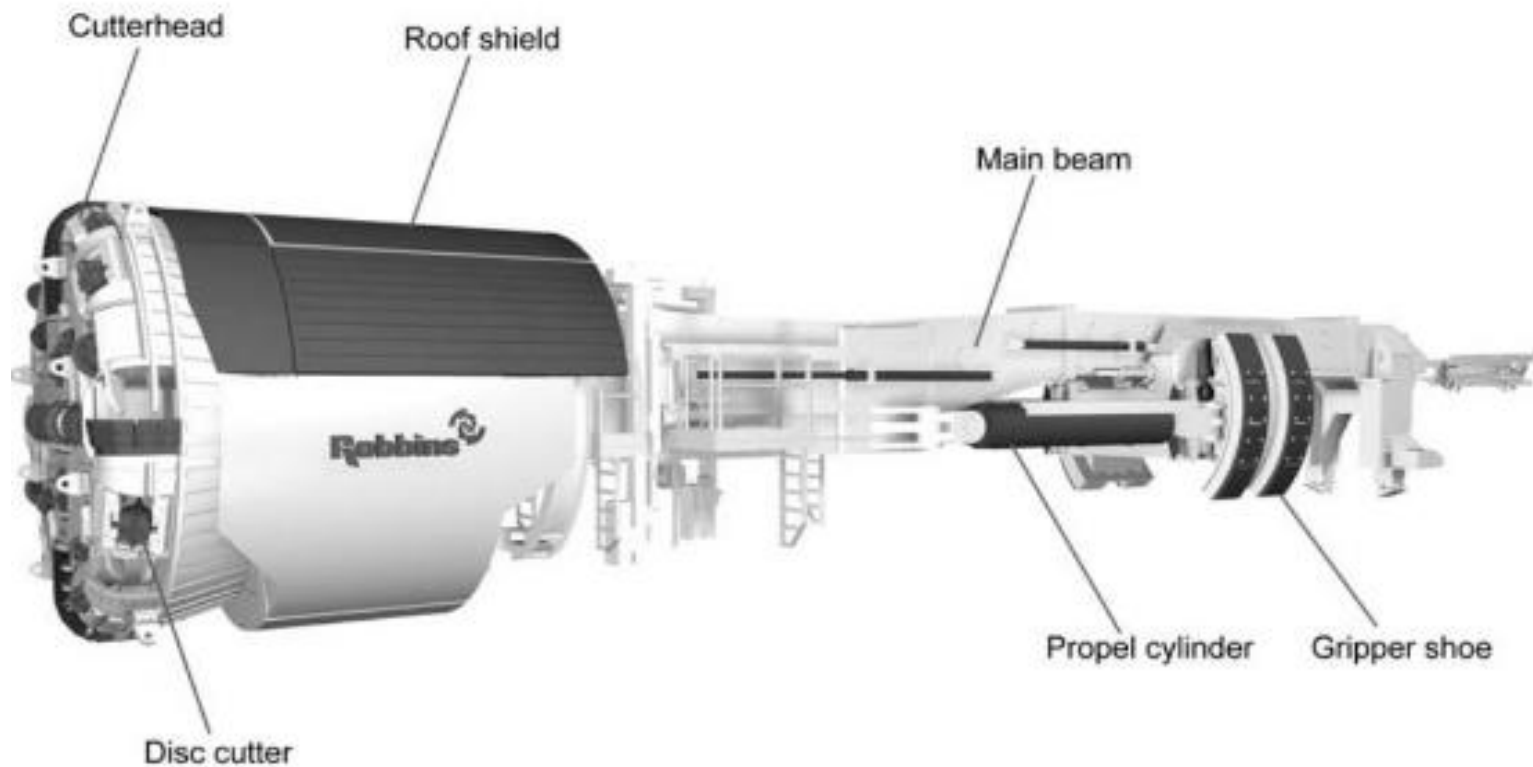
- Enhanced health and safety conditions for the workers.
- Industrialization of the tunneling process, with ensuing reductions in cost and construction times.
- Possibility of crossing complex geological and hydrogeological conditions safely and economically.
- Good quality of the finished product (surrounding ground less altered, precast segment lining).

RISKS

- Lack of flexibility: Once the technique has been chosen it is practically impossible to change it throughout the construction of the tunnel.
- Therefore, a correct analysis of different parameters is needed for the choice of the correct mechanized tunneling technique

Gripper Tunnel Boring Machine

A gripper TBM is suitable for driving in hard rock conditions when there is no need for final lining. The rock supports (rock anchors, wire mesh, shotcrete, and or steel arches) can be installed directly behind the cutter head shield and enable controlled relief of stress and deformations. The existence of mobile partial shields enables gripper TBMs to be flexible even in high-pressure rock. This is useful when excavating in expanding rock to prevent the machine from squeezing.



Gripper TBM

ADVANTAGES

- **Rapid excavation rate in hard rocks.**
- **Capable to excavate hard rocks of UCS up to 300 MPa.**
- **For tunnels of diameter up to 14 m (largest 14.4 m, 2008).**
- **Flexible rock support measures according to ground conditions.**

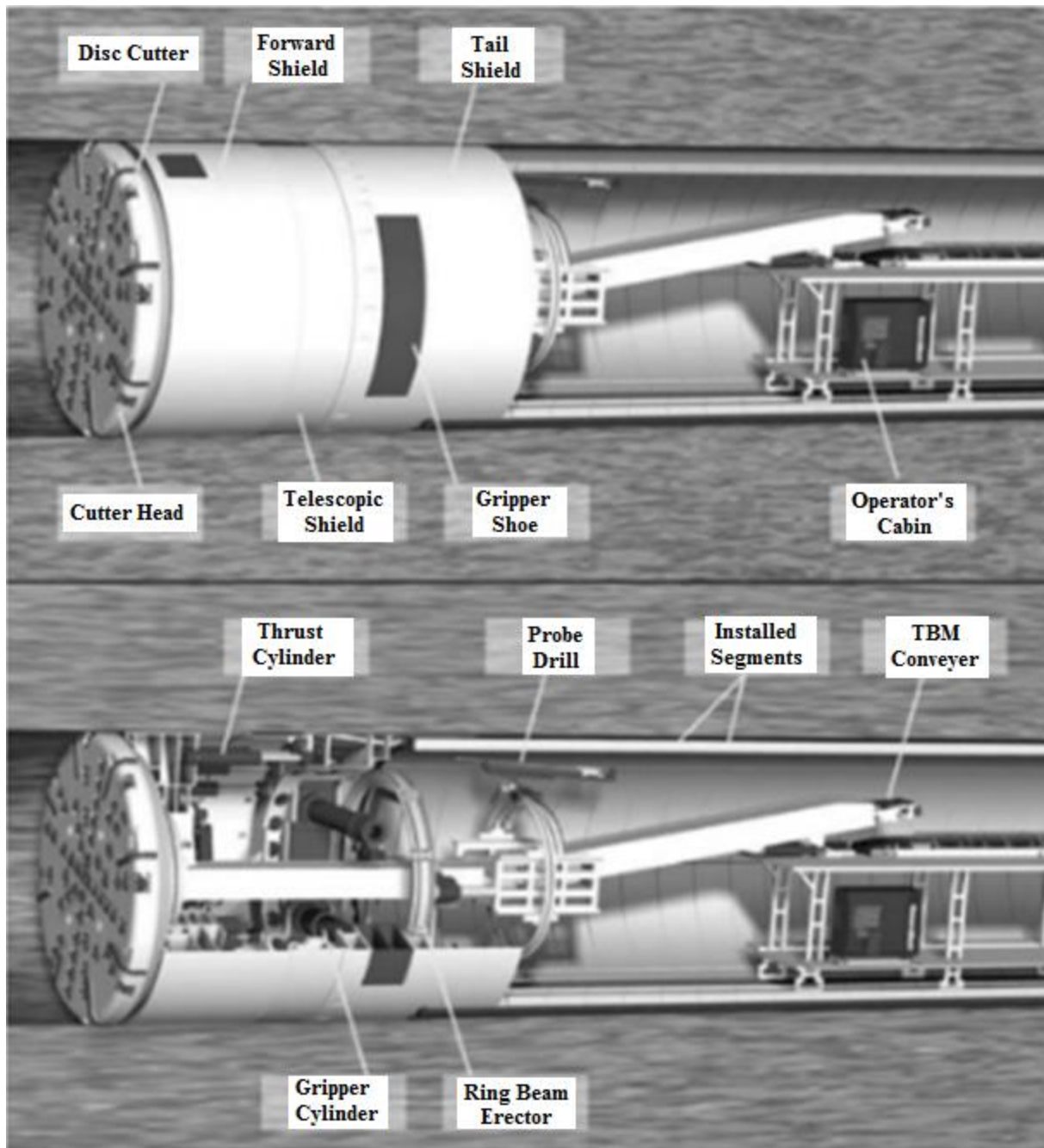
LIMITATIONS

- **No protection or support is given to the rock while excavating.**
- **Limited to stable ground.**
- **Gripper may have difficulty in poor rock masses with low strength.**
- **Dedusting is needed.**

Double-Shield Tunnel Boring Machine

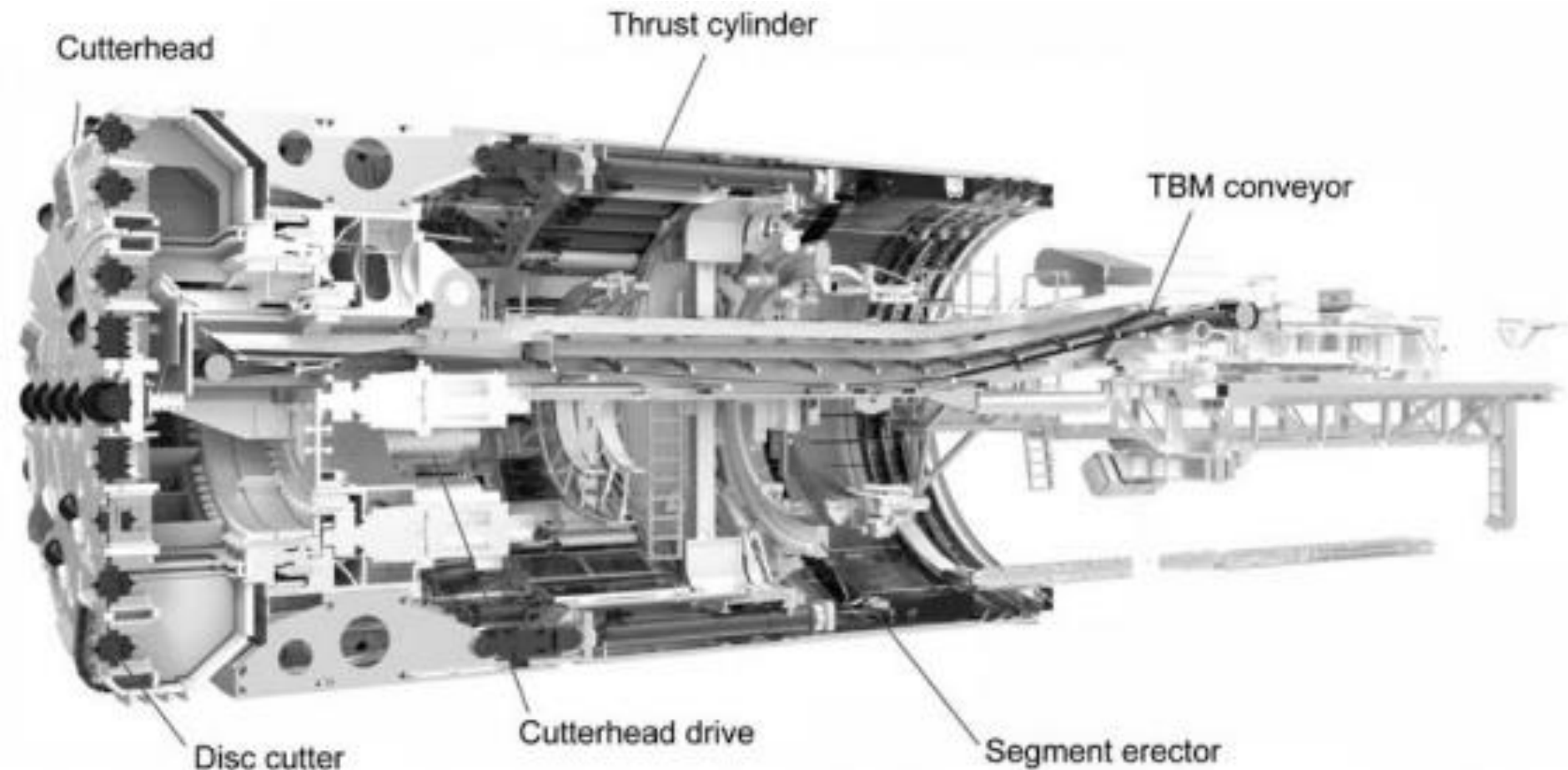
A double-shield TBM is generally considered to be the fastest machine for hard rock tunnels under favorable geological conditions with the installation of the segment lining. It is possible to drive 100 m in 1 day. This type of TBM consists of a rotating cutter head and double shields, a telescoping shield (an inner shield that slides within the larger outer shield), and a gripper shield together with a shield tail.

While boring, gripper shoes radial press against the surrounding rock to hold the machine in place and take some of the load from the thrust cylinders. For the motion of the front shield, the gripper shoes are loosened, before the front shield is pushed forward by thrust cylinders protected by the extension of the telescopic shield. Because regripping is a fast process, double-shield TBMs can almost continuously drill. As for the shield tail, it is used to provide protection for workers while erecting, installing the segment lining, and grouting.



Single-Shield Tunnel Boring Machine

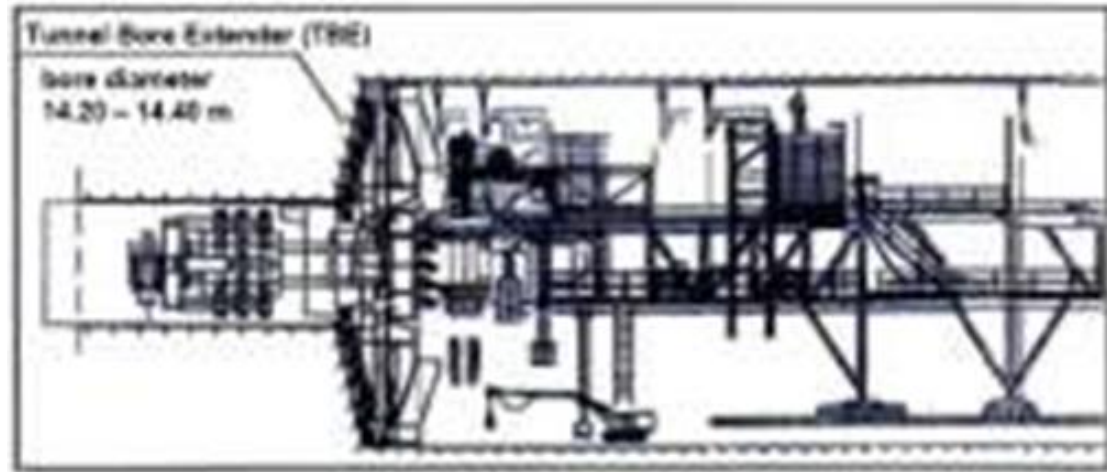
A single-shield TBMs are used in soils that do not bear groundwater and where rock conditions are less favorable than for double-shield, such as in weak fault zones. The shield is usually short so that a small radius of curvature can be achieved.



Tunnel Reaming and Enlarge Machines

Tunnel Bore Extender (TBE) used at Uetliberg Tunnel in Switzerland. The tunnel is enlarged from a 5 m pilot tunnel to 14.4

- TFBMs, this machine is Reaming boring machine that bores the final section from an axial pilot tunnel from which it pulls itself forward by means of a gripper unit.
- With the production of a large diameter no longer needed.



A large concrete dam with a tunnel entrance and a reservoir. The dam is built into a rocky cliffside. The water in the reservoir is a deep green color. The text "Thanks for your attention" is overlaid in yellow on the upper part of the image.

Thanks for your attention