The Advantages of DTBM Tunneling

DTBM applies new technologies which have been developed for the first time in the world. It is superior to a conventional hard rock TBM in performance and mechanical design. Moreover, a DTBM is designed to deal effectively and promptly with the issues occurred under problematic ground conditions which are hard to deal with for conventional TBMs. It is expected that DTBMs will be utilized worldwide and effect a tremendous change in mountain tunneling once they are put into practical use.

❒Productivity Improvement

☆ High Speed and Mechanized Tunneling

➢In favorable ground conditions, DTBMs are assumed to be capable of excavating more than 500 meters per a month, which is five times as fast as the NATM that requires cyclic process.

➢In favorable ground conditions, DTBMs are expected to reduce a number of workers required during construction by 50% compared with the NATM.

➢ Introducing industrial robots for mechanization and automation allows reductions in the number of skilled construction workers.

➢The wear and tear of DTBM disc cutters are lower than those of TBM disc cutters, which will lead to reduce operating costs including cutter replacement cost.

➢Rail transport as a means of conveyance of materials saves more internal space of a tunnel than truck transport since rail transport requires less passing places.

Staff assignment for ϕ 6 m sengment lining

General	Management		
	Construction management		2 foremen
DTBM Excavation	Central operation/ control room		
	DTBM operation and data control		4 operators
	0.1㎥ Backhoe operation		2 operator
	Facilities maintenance		4 operators
Primary lining	Primary lining		
	Segment assembly robot	Installation and operation	6 operators
	Assist tunnel lining	Segments transportation	
	Supplementary work		4 operators
Outside tunnel	Loading and Supplementary work		4 operators
	Blacksmith		4 operators
	Total		30 operators

Workforce required for construction of 5km tunnel

DTBM: 30 operators/day ×22days/month ×15months = 9,900 operators

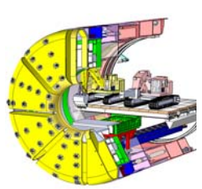
NATM: 20 operators/day ×22days/month ×52months = 22,880 operators

☆ Countermeasures against Problematic Ground Conditions

➢With a primary segmental tunnel lining, grippers can push against not the surrounding ground but the segments previously installed to react the machine's forward thrust. Therefore the DTBM excavation is available for tunneling in almost all types of ground without various auxiliary measures.

➢In problematic ground conditions the NATM adopts subdivided excavation, forepoling and reinforcement of tunnel face, which is both costly and time consuming. DTBMs on the other hand, allow auxiliary methods to be easily carried out from inside the machine, which leads to cost savings.

➢As most of the work and operation can be done inside of the steal machine, tunnel constructions using DTBMs are much safer than those using the NATM during which operators are exposed to unstable tunnel face while working.



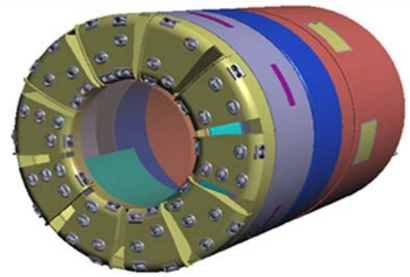
Advanced Construction Technology Center
DTBM Study Team
2-15-6, Otsuka, Bunkyo-ku, Tokyo 112-0012, Japan
TEL: 03-3942-3993 URL: http://www.actec.or.jp/

Advanced Tunnel Construction Method

Donut-shaped Tunnel Boring Machine

❒ Introduction

Donut-shaped tunnel boring machine (DTBM) is an advanced tunnel boring machine (TBM) for hard rock excavation, the cutter head of which has a donut hole in its center to provide the ability to deal with difficult geological conditions. Under such conditions DTBMs are capable of the rapid excavation, and the monthly average/maximum advance rates can be approximately 500 meters and 1000 meters respectively. The concept of DTBM has never been seen before. It is patented in Japan, U.S.A., China and Indonesia and applied for a patent in Germany, Vietnam, India and Brazil.



❒ Characteristics of Tunneling Construction using DTBM

The most critical problem of the conventional hard rock TBM is that under unfavorable geological conditions TBM excavation cannot offer its advantages of cost saving and higher advance rates. DTBM has a cutter head with a donut hole to improve its performance so as to reduce construction risks that a TBM has in complex geological conditions.

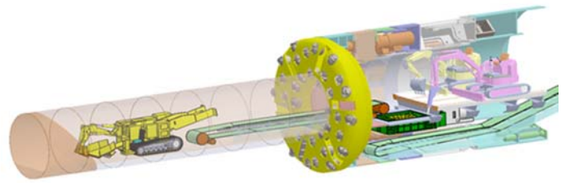
➢Constantly observing tunnel face directly through the opening in the center portion of the cutter head, countermeasures can be taken without any delay.

➢Exploration drilling can be conducted through the opening to take core samples 100-150 meters ahead of the tunnel face for prediction of groundwater flows, and dewatering can be done via a drill hole.

➢During excavation in fracture zone, gravels can be removed via the opening.

➢In case mudflow occurs at a tunnel face, consolidation operations can be done from inside the machine through the opening.

➢Where weak and sensitive zone lies ahead, construction method can be switched to NATM utilizing the opening as a path.



Construction method switched to NATM

❒Mechanical Characteristics of DTBM

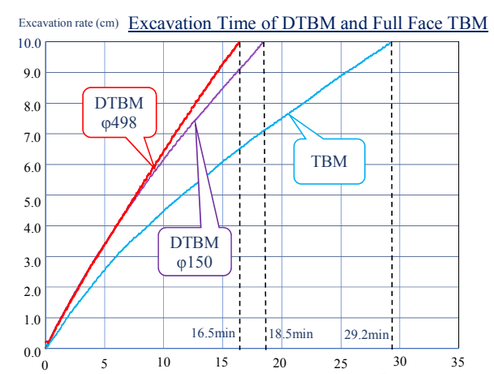
The boring experiments on mortar specimens (55N/mm^2) show that DTBM excavation is approximately 40% more efficient than TBM excavation (Fig.3.). It is expected that the high cutting efficiency of DTBM will be a significant advantage of DTBM excavation once it is put into practical use for tunneling in hard rock.

➢ DTBM excavation is faster than TBM excavation in case the operating torque and thrust forces of the DTBM and the TBM are at the same levels.

➢ The levels of the operating thrust and reaction forces can be lowered, which is advantageous in soft ground excavation.

➢ The 40% excavation efficiency shown by the experiment result indicates low wear and tear of the disc cutters, which leads to huge cost savings on replacing the cutters.

Excavation Time of DTBM and Full Face TBM

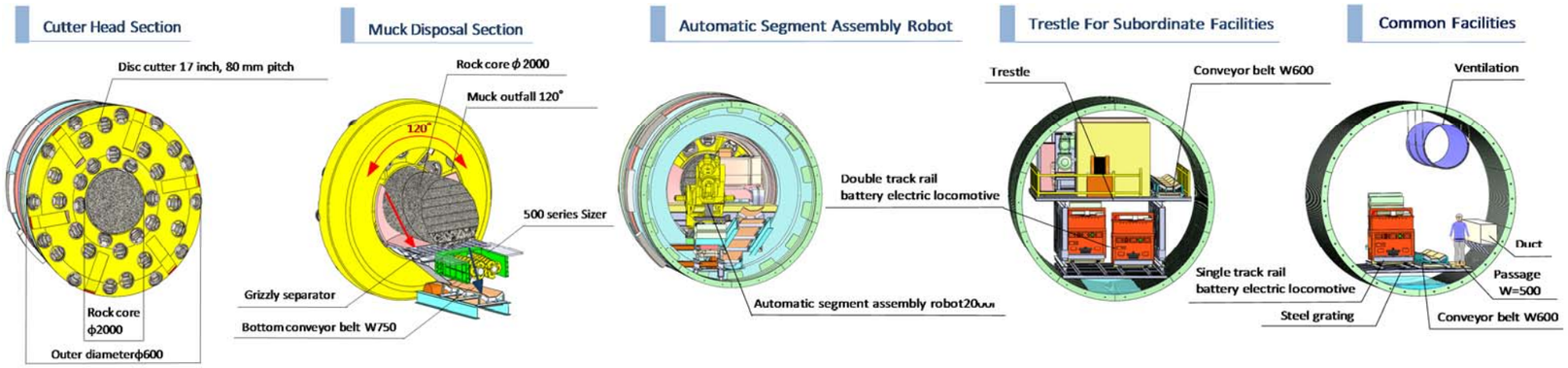


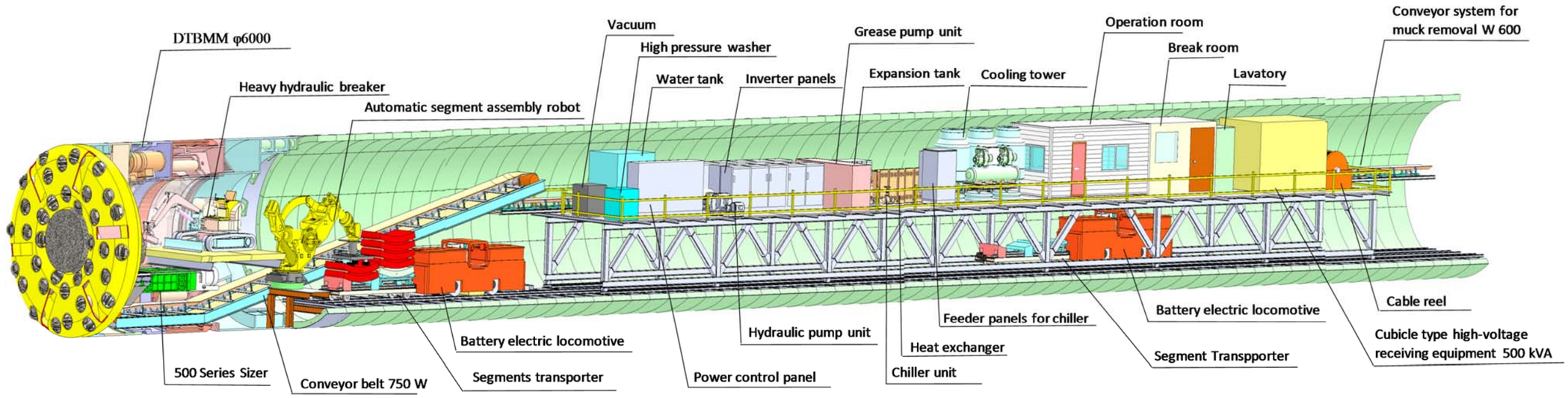
(Each of DTBMs and a TBM provides 70kN of thrust force in total)

TBM without Limitations under Complex Geological Conditions

DTBM Construction System

Precast Segmental Concrete Lining for Tunnel Lining





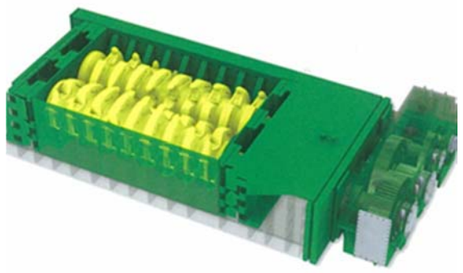
❒ Excavation mechanism of DTBM

1. Thrust and rolling forces of cutter head cause the tunnel face to clip away except the center part of the face.
   Muck caused by excavation spontaneously falls out of the 120 degree angle opened area.
2. The remained rock core comes out through the cutter head to be fractured into pieces smaller than 20 cm by Twin Shaft Mineral Sizer.
3. Conveyor system installed at the bottom brings muck out of the tunnel.

Ratio of a donut hole to a cutter head shall be set based on the geological conditions in which the machine is used, to make sure that construction machines are able to pass through the hole and that a rock core fragmentation must not be a critical operation in a whole process of excavation.

Twin Shaft Mineral Sizer created by MMD, even though has never been used in Japan, has been widely used in the world. For instance, it was used in granite area in the Alps. The Sizer is the most suitable to be installed in a DTBM since it is compact and efficient.

Muck Removal Flow



Twin Shaft Mineral Sizer

Sizer at work