Machines, Equipments and Systems for Tunnel Construction
High pressure concrete pumps for extreme heights and distances

Putzmeister has gone beyond the bounds of possibility time and time again by using more powerful concrete pumps and intelligent placing systems for tunnel construction. In 1994, during the construction of a hydro-power station in Northern Italy it was thus possible to achieve the world record in covering a height of 532 m with just one pump. The effective concrete pressure at that time was 18.5 MPa (2683 psi).

At a construction site in Le Refrain, France, Putzmeister achieved the world record in long-distance concrete conveying of 2015 m with the BSA 14000 HP-D. In many such cases, pumping is the quickest and most economical solution compared to the alternative methods of concrete placing using track vehicles, pneumatic conveying, step-by-step pumping over short distances, and/or combined means of transport which Putzmeister also offers where appropriate.

What matters is that the solution offered is the right one for the customer. This is ensured by our highly qualified engineers who base their recommendations on the know-how gained through their wide practical experience.

Our pump and system technology can be applied to the most different operations up to 220 m$^3$ and 40 MPa (5801 psi).

Here are some examples:

- Smaller high pressure pumps for conveying fine slurries and materials with a grain size up to 32 mm. The compact pump is equipped with a S-transfer tube and is predominantly used for pumping shotcrete and mortar.
- Pumps with ball valve technology are used for mortar with a grain size of 8 mm. Pressures of up to 13 MPa (1885 psi) are obtained here, making it possible to pump mortar over large distances.
- Supplementary components such as mixers and silos for the suction side of a plant.
- High pressure delivery lines with check valves for the delivery side of a plant.

With delivery rates of over 100 m$^3$/h (depending on the core pump fitted), concreting work can be carried out up to a height of 24 m. The maximum vertical reach is nearly 20 m. The 360° rotation of the Twistip allows any concreting position.

Putzmeister concrete pumps even master extremely stiff concrete.
Tunnel formwork distributor TSV for different tunnel cross-sections

This rail-mounted hydraulically-driven placing system is recommended for continuous backfilling along tunnel formwork.

Depending on the model flexible scissors pipes make it possible to move 12 m forwards without having to open the pipeline. The distributor is locked in the working position by hydraulically actuated clamps. Every formwork connection piece can now be reached at the exact position by the telescopic placing arm as it is moved axially. Concreting is carried out from bottom to top.

When the pre-set maximum pressure is reached, the distributor lifts up automatically and prevents damage which could be caused by over-pressure. This is essential for the long-distance conveying of concrete from above ground.

Specially compact plant variants are available for working in extremely low heights in combination with portal formwork.

The overpressure automatic device of the tunnel formwork distributor

Compact tunnel concrete distributor TSV 2-4 for mounting on a wagon

Portal formwork with mobile tunnel formwork distributor

World record in long-distance concrete conveying (1997): 2015 m

TSV in 30 m long 4.5 m diameter tunnel formwork. It is hydraulically propelled and length compensation of the delivery line is carried out with the scissors' pipe.

The TSV 3-6 formwork distributor can be adapted infinitely variably to tunnel diameters of 3 – 6 m. The scissors pipe allows concreting progress of 12 m without the TSV having to be moved.
Clean and safe conveying of large amounts of muck by using pumps

The way Putzmeister has mastered the conveying technology for high density solids and the experience it has gained from more than 100 tunnel construction projects, make the company the right partner for complete solutions when conveying muck out of tunnels.

In addition to the extensive consultancy offered, machines such as the drive units, crushing and sorting plants, conveying belts, screens, mixing troughs, high performance pumps, silos above ground, etc. are all within the scope of supply.

The following examples are representative of the range of technical possibilities:

Eurotunnel from France to England
Here approximately 8 million cubic meters of muck mix were conveyed over a distance of 2000 m and over a height of almost 200 m.

Storebelt Tunnel Project (Denmark)
- Maintaining earth and water pressure up to 0.8 MPa (116 psi) to prevent the inflow of ground water
- Dumping of muck under atmospheric pressure
- Transporting the rock mixed with ground water from the rear side of the muck conveying augers into the muck trucks

Seewage tunnels in Japan
Water drains and sewers can be built by pipe jacking in regions of the earth with soft ground and rock, such as for example, in Japan. This requires:
- Muck-removal in narrow sewers, and/or tunnel cross-sections
- Simple adapting of the transport engineering to the alternating conditions in-situ, such as, for example, different shaft depths

Road tunnel with large cross-section in Japan
Over 30 Putzmeister decompression excavation pumps have been supplied to Japan in the last few years. The reason for this is the high level of efficiency for conveying the excavated material, as well as maximum safety for the structure and tunnel personnel.

London Heathrow tunnel
Two Putzmeister single-piston decompression pumps removed 200 m³/h of untreated loamy soil from the shield area supported by compressed air. This prevented the ground from subsiding and the loamy soil was not contaminated by auxiliary fluids, such as bentonite or polymers.

Sewage tunnels in Thailand
With regard to the construction of a new sewage tunnel in Bangkok the muck removal pump technology in a “closed system” is applied on more than 10 construction sites. The muck removal technique offers a great deal of safety for the pipe driving speed and at the same time more simplified logistics for the removal of earth material.

Botlek tunnel in the Netherlands
Two Putzmeister decompression pumps transported 300 m³/h sand with foam and polymers behind the gantry and guaranteed a clean and safety job site.

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Engineering for every kind of mortar injection work

Depending on rock, construction method and time plan, different machines for the injection of mortar are used in tunnel construction. Putzmeister’s programme includes everything from the smallest single machine to fill anchor holes, worm pumps for low pressure work to piston pumps for pressures up to 10 MPa (1450 psi).

In combination with important accessories such as turbo mixers, high pressure valves, high pressure rotor distributors, special delivery lines, auger conveyors, flow meters, pressure gauges, etc. plants can be individually arranged for the most advanced methods.

TRIA, i.e. continuous ring space filling for tubbing, is often used behind the tunnelling machine.

Single-cylinder piston pump
HSP 1030

For the annular gap injection, Putzmeister has developed the HSP 1030 model single-cylinder piston pumps which work independently of each other and have their pressure and suction cycles controlled by seat valves. The HSP 1030 pumps can be additionally equipped with a volume measuring feature to allow the volume of injection mortar to be precisely determined. They are easy to clean and have favourable assembly properties for installation in even narrow tunnel cross-sections, thanks to the rotating pump head. The HSP 1030 can be combined with other pumps for various requirements and numbers of injection points.

Features of the HSP 1030

- Output: up to 7 m³/h
- Delivery pressure: up to 6 MPa (870 psi)
- Intake and delivery valves can be flanged on in a modular fashion
- Delivery piston with double lip for optimum suction
- Easy to clean

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The wet spraying method is becoming more and more popular in tunnel construction.

The specific benefits of the wet-spraying concreting process are demonstrated in tunnelling: less spray mist, little rebound, low energy requirements and comparatively low installation effort.

During the wet-spraying process, the accelerator and compressed air are regulated, combined with the pumping concrete and sprayed. The upper limit for the grain size of the concrete lies at approx. 6 mm. For smaller jobs, the spray nozzle is handled manually; when high outputs are required, machines are used to help manipulation.

There are three types of machines for wet spraying:

- **Attachable machines for existing carriers**, such as shovel loader hydraulic excavators for use with a stationary pump BSA 1002
- **Manipulators and concrete pumps mounted on truck chassis** for flexible use at frequently changing construction sites, type WKF
- **Shotcrete manipulator Sika®-PM 500** for concrete outputs up to 30 m³/h for heights and distances up to 14 m

All machines are equipped with the proven S-transfer tube.

Concrete spraying made simple, secure and convenient with the high performance manipulator Sika®-PM 500

Wet sprayed concrete in tunnel construction with BSA 1002 Multi and Sika®-PM 500
Towards an economical comprehensive plant –
developed with a system

The economic planning and timely execution of large tunnel construction projects requires the optimum combination of a variety of machines with a host of Know-How and Service components. The command of the technology for conveying concrete, mortar and high-density solids, and the precise and comprehensive knowledge of other machines and methods in tunnel construction, are available for projects with the most complicated requirements. They are put into practice leading to functional and economical solutions in co-operation with the customer.

The partners on the Putzmeister side are project engineers who are qualified to co-ordinate the elements (components) and tasks starting from an analysis of the requirements to the conclusion of the project, and who ensure that everything is carried out smoothly. Successful contributions to large projects all over the world are our best references – such as, for example:

- The Eurotunnel from France to England
- The Storebelt tunnel project in Denmark
- Many kilometres of tunnels in Japan
- Tunnel construction for power stations in Riva del Garda, Italy
- Metro construction in Madrid, Barcelona, Bologna, Seville, Gijon and Lisbon
- Sewage tunnels in Shanghai and Bangkok
- Rail and road tunnel in London, Tokyo, Madrid, Leon and San Lorenzo

Innovative machine technology
Multi-purpose accessories
Defined interfaces for PM components to further machine technology
Engineering, know-how gained from many projects on large construction sites and in tunnel construction
Reliable After Sales service
Quick parts service
Plant-specific customer training at works or on site

Co-ordinated acquisition and handling of business

The Putzmeister Group
Concrete Technology PCT · Mortar Technology PMT
Pipe Technology PPT · Water Technology PWT
Industrial Technology PIT · Belt Technology PBT
Underground Technology PUC

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