Trenchless Technologies for the Construction of Water and Waste Water Infrastructure

May 2011

German Water Partnership

Preface

In the face of limited surface space, ways to construct new water and wastewater infrastructure can only lead underground. This particularly applies to the megacities of the world where water supply is often inadequate and waste water disposal deficient. Besides densly built-up space heavy traffic is the main factor demanding solutions as „invisible" as possible for the construction of supply and disposal conduits.

These invisible methods are no magic. On the contrary, they are exact technology. During the last 30 years numerous techniques for trenchless construction have been developed in Germany and today it would be hard to find a case where there exists no proper solution to. This applies not only to construction of underground conduits but also to their maintenance and rehabilitation. There are only two manholes necessary for trenchless installation of pipes – one start pit and one launch pit and depending on the length of the tunnel few intermediate pits – that may disturb life at the surface during construction. Not more!

German engineers, machine and pipe manufacturers have developed, constructed and continuously optimized technologies and machines for trenchless installation. An ingenious technology proving increasingly superior to conventional construction methods – economically as well as ecologically.

Using intelligent technology and concentrated know-how „Made in Germany" trenchless technologies present absolutely convincing advantages approved worldwide.

Economic Solutions to Construction of Infrastructural Systems

Trenchless – environmentally compatible – convincing

Nine billion people will populate the earth by the middle of the century, two thirds of them presumably in the conurbations. Today Mexico City, Rio de Janeiro, Chicago, New York, Seoul, Moscow and Mumbai are are the biggest cities in the world. In the south and in the east more aspiring business centers are growing: Shanghai, Jakarta, New Delhi, St. Petersburg and Cairo to name only some of them. All of them are already facing the big challenge to secure the supply of their inhabitants.

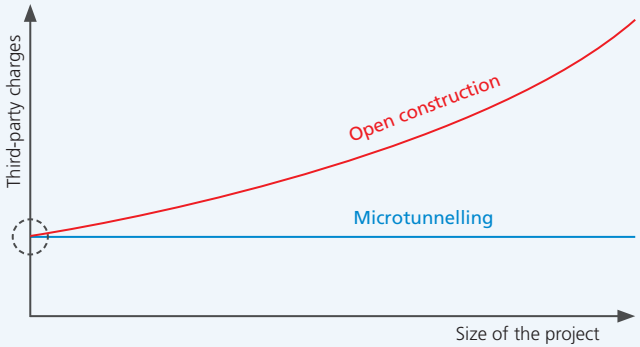
Urbanization as a challenge

Fundamental needs of all mankind are the supply with fresh water and the disposal of waste water. In the world's mega-cities that have only inadequate water supply and even less sewerage these problems can only be solved in an environmentally friendly way by using trenchless technologies. Otherwise traffic obstructions would lead to a collapse of the catastrophic traffic conditions.

The rules of the growing infrastucture are quite simple: waste water disposal follows water supply. Unfortunately both do not take place parallelly. Due to the limited space on the surface routes for new infrastructure can only be planned underground.

This is why tunnel and pipeline system conquer more and more cities and regions worldwide to prepare for future challenges. But not only new systems provide the solution, old systems have to be rehabilitated and rennovated. Thus the modernization of hundred thousands of kilometers of pipeline systems worldwide is inevitable – in a way as economic and safe as possible and if possible with trenchless technologies to minimize disturbances.

Third-party charges for open and trenchless construction



Construct trenchless below, live undisturbed above

While underground a tunnel is drilled, life on the surface has to continue without disturbance. Traffic jams, obstructions and deviations cause economic losses. Therefore trenchless technologies present an ideal alternative: apart from launch and retrieval pit – and dependent on the length of the tunnel of one or more intermediate pits – life on the surface along the tunnel route stays more or less undisturbed. Traffic routes will be spared traffic jams, shops will be spared sales drops and cities will be spared disturbing construction sites; noise and dirt will be largely avoided, CO_2 emissions will be minimized by reduced employment of construction machines and vehicles.

Sustainability

Trenchless construction of water and waste water infrastructure holds many advantages for future operation and pays off due to significantly improved reliability, especially long lifespan of the plants and a significantly reduced amount of mistakes during installation. All in all trenchless technologies meet the ideal of sustainability.

All over the world underground infrastructure projects use German know-how, German technologies are employed to install modern supply and disposal tunnels. To solve the up-coming challenges also in future with local partners trenchless technologies present convincing advantages:

Advantages of trenchless technologies

- expenses and dates are much easier to calculate and kept with trenchless technologies
- surface life stays mainly undisturbed
- minimal noise pollution, minimal vibrations
- small stress for streets and traffic
- existing conduits can be bypassed
- careful handling of nature and structures
- up to 95 percent lesser load for landfills due to minimal excavations
- also possible in extremely densly built-up areas
- construction work is largely independent on weather conditions
- safe work conditions during construction
- less energy consumption, more than 50 percent saving
- groundwater table needs not be dropped
- low dependency of construction cost on depth
- minimization of CO_2 emissions

Trenchless Technologies – Made in Germany

During the last decades trenchless technologies in Germany have been pushed significantly with the result that today there are technical solutions to almost every problem. This took place in close collaboration of contractors, planners, suppliers, machine constructors and construction companies.

Today microtunnelling technologies developed in Germany are leading worldwide; the same applies to technical regulations and standards which are referred to in many countries as a basis for planning and constructing infrastructural projects. The main emphasis of designing networks for water and waste water infrastructure made with trenchless technologies should always be put on construction quality and operational quality as well as safety for all persons affected (occupational safety).

The currently valid bodies of rules for design construction and operation, e.g.

- **DWA-Arbeitsblatt A 125 (English and German)**
  „Pipe Jacking and Related Techniques" by Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V.

or

- **DWA-Arbeitsblatt A 161 (English and German)**
  „Structural Calculation of Driven Pipes" by Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V.

point the way and are applied worldwide. These technical rules by far exceed the familiar European standard EN 12889 and other international standards.

Besides there are a number of rules specific to various raw materials as well as work instructions relating to soil exploration. In the following the main representatives of steerable trenchless technologies available for maximum construction quality as mentioned in **DWA-Arbeitsblatt A 125** are described.

Trenchless Technologies

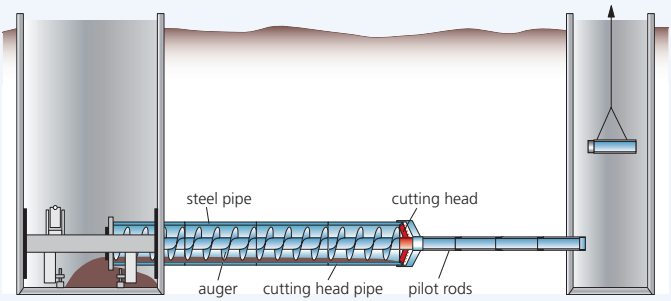
- guided auger boring
- microtunnelling
- horizontal directional drilling (HDD)

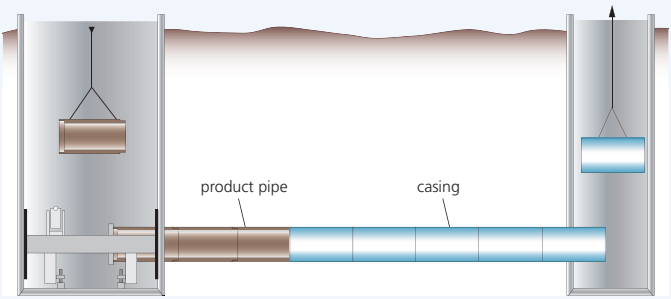
Technologies for Trenchless Construction

Guided auger boring

These borings are generally made from a launch to a reception pit. If there are longer borings to be carried out or if the drilling precision has to be higher the borings are carried out as guided auger borings. First a pilot pipe is jacked through the soil to the reception pit. Direction and slope are monitored continuously during the jacking. After completing the steered boring there are diveres process alternatives for the expansion drilling, depending on the diameter. The common last step of all processes is the jacking of the product pipes.

› FURTHER INFORMATION: www.bohrtec.de





Microtunnelling

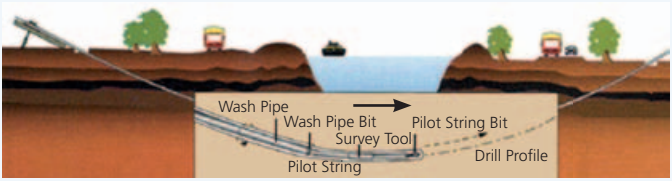
Pipes are jacked from a launch pit to a reception pit by means of a hydraulic jacking station in the launch pit. At the front end of the pipes a driving machine is placed to excavate the soil. The distance between launch pit and reception pit can be up to 2000 m or even more depending on nominal diameter, geology, pipe material and number of interjack stations. After the hydraulic cylinders of the jacking machine achieved their target position they are pulled back and the next jacking pipe is lowered into the launch pit. This process is repeated until the reception pit is reached by the pipe string. Here the driving machine is recovered and ready to be prepared for the next operation.

› FURTHER INFORMATION: www.herrenknecht.de

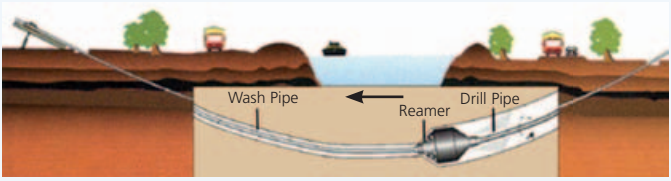
Horizontal Directional Drilling (HDD)

Horizontal directional drilling consists of three steps: the first step is a pilot drilling from the starting point in direction of the target point, the second step is the expansion of the drilling hole and in the third step the pipe is pulled in. HDD technologies are only suitable for piplines with high tensile strength. The constructed pipelines may be for water and wastewater, oil or gas.

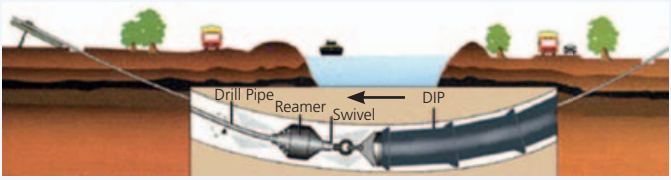
› FURTHER INFORMATION: www.herrenknecht.de



Pilot Hole

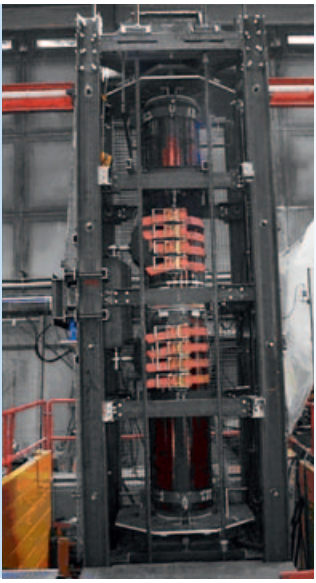


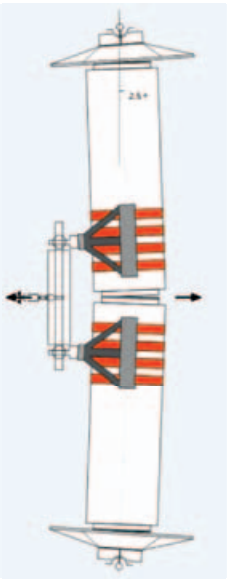
Pre-Reaming



Pull-Back

Research and Results





Test stand for jacking pipes and joint interpasses

There is a permanent collaboration between universities, machine and pipe manufacturers as well as construction companies to advance technologies for pressure transfer between the components. There are also similar cooperations in order to develop automated control systems for steering and thus qualitiy improvement of microtunnelling. In this area universities, machine and pipe manufacturers as well as cities and municipalities work side by side financially supported by the Federal Republic of Germany. As one result of this collaboration the company Bohrtec was founded as a spin-off of the Rheinisch-Westfälische Technische Hochschule (RWTH) Aachen. All new machines and process technologies are tested by means of the existing testing equipment under almost real-life conditions.

Last but not least the further development of longitudinally force-locked plug-in sleeves is being pushed forward supported by various universities.

Experiences and References

Steinzeug-Keramo Group

The German clay pipe industry with their products has been part of microtunnelling in Germany since 1984 and adjusted pipes, connections and pressure transfer technology to pipe jacking together with clients and contractors. Today they look back on thousands of meters of trenchlessly constructed sewers.

Sewer construction is a basic measure of establising or rehabilitating technical infrastructure. The scope of applications for and experiences of constructing pipelines made of vitrified clay pipes is related directly:

- urban or industrial wastewater
- sewers in up to 15 m depth under and above the groundwater table
- pipe jacking of 50, 100, 150 and 200 m, depending on the jacking method
- adaptable methods for curved jacking

Vitrified clay jacking pipes are used for sewage construction worldwide. The material is especially suitable for this purpose. The pipes are adjusted to the common outer diameters of the driving machines and have been advanced continuously based on long-term experience and permanent dialogue with jacking companies, machine manufacturers and clients.

Special improvements were achieved by increasing the specific longitudinal pressure resistance to 100 N/mm^2, broadening the walls to 10 cm, computer-aided measuring of the pipes before and during construction, further developing of pressure transfer

materials and pre-stressing the pipes to increase robustness, the latter of which has been patented. Vitrified clay components are robust and suitable for construction site conditions. They resist jacking forces of up to 600 t (6000 kN) and put back jacking distances of up to 250 m and more. With additional machinery equipment the pipes are also suitable for curved jacking.

There are references for pipe jacking with vitrified clay pipes under motorways, airports and rivers. Vitrified clay jacking pipes have been installed successfully in groundwater, in different soils as well as in hard rock.

› FURTHER INFORMATION: www.steinzeug-keramo.com

Bohrtec GmbH

For 25 years Bohrtec GmbH has been developing technologies for trenchless construction. The company always focusses on easy-to-use and economical machines. Skilled personnel is able to operate the machine after short instruction by the Bohrtec team. Besides easy maintenance the solid construction of the machines has to be pointed out. Since more than ten years Bohrtec GmbH is represented woldwide by its partner company, Herrenknecht AG.

Meanwhile Bohrtec drilling machines are used successfully on all five continents. More than 300 machines and systems have been sold and more than 400,000 m have been constructed trenchlessly with them. Numerous special projects like pipe arches, drainage or rebuildings of foundations have been completed successfully supported by Bohrtec engineers.

Due to continuous stimulation triggered by practical application new process technologies are developed together with partners and led to market maturity in collaboration with Technical University of Aachen.

Herrenknecht AG

Herrenknecht AG is technology and market leader in the field of tunnelling. As the only company worldwide Herrenknecht supplies up-to-date tunnel boring machines for all kinds of soil and in all diameters – from 0.10 m up to 19 m. The product range comprises custom-made machinery for traffic tunnelling and utility tunnelling.

Furthermore Herrenknecht offers an efficient, quick and secure solution for all trenchless construction projects: Horizontal Directional Drilling. This trenchless technology makes it possible to cross under obstacles like rivers, mountains, streets and residential areas as well as difficult ground or even nature reserves. Besides, trenchlessly constructed pipelines are protected better against environmental influences.

Under the group's roof there works a team of innovative specialists that offers integrated solutions around tunnelling with specialized equipment and service packages: separation plants, conveyor plants, navigational systems, rolling stock systems as well as segment formwork up to turn-key segment factories. The services also comprise technical services, design and supervision of jacking projects or staff solutions for temporary expansion of construction crews.

Herrenknecht AG develops innovative technical solutions to sink vertical manholes in great depth or successfully drive sloping tunnels. Additionally the company produces cutting-edge deep drill plants to drill up to 6000 m deep and plants for developing geothermal resources close to the surface.

Duktus Group

The development of trenchless technologies is inseparable from ductile cast iron pipes, their joints and coatings. Starting with the first trenchless installations during the 1970s a rapid development began. Further new processes entered the market ever increasing diameters and lengths were demanded. Duktus, too, has been supplying ductile iron water and waste water pipelines for trenchless installation for over 30 years now.

When installed trenchlessly, ductile cast iron pipes normally are being pulled in. For this purpose there are pipes with restrained socket joints locked together by means of the interaction between a preliminary chamber and the welding bead at the spigot. The BLS/VRS-T joint by Duktus is common standard with regard to a maximum of flexibility within the joint (deflection) and in connection with quick and easy mounting. Furthermore this joint is resistant to high tractions.

To protect the ductile cast iron pipes from mechanical influences during pulling Duktus coats pipes for trenchless technologies with cement mortar coating acc. to DIN EN 15542.

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