

## The most important economic and



Microtunnelling takes place beneath existing service lines. The safeguarding or diversion of these is either minimal or unnecessary and road surfaces aren't damaged.

Ability to construct sewers without problems and in a cost-effective manner near buildings or historic areas since settlement of the soil is avoided and expensive trench sheeting is not required.



The amount of soil to be excavated, transported and dumped is restricted to the volume of the sewer line. There are important cost advantages in contaminated soils, in water catchment areas, in soils with a high water table and weak soils.

## ecological advantages of microtunnelling

Since the greater part of the work of laying a sewer takes place underground and as the space required at ground level is small, life and commerce can go on virtually undisturbed. Noise, dirt and smell are minimised.

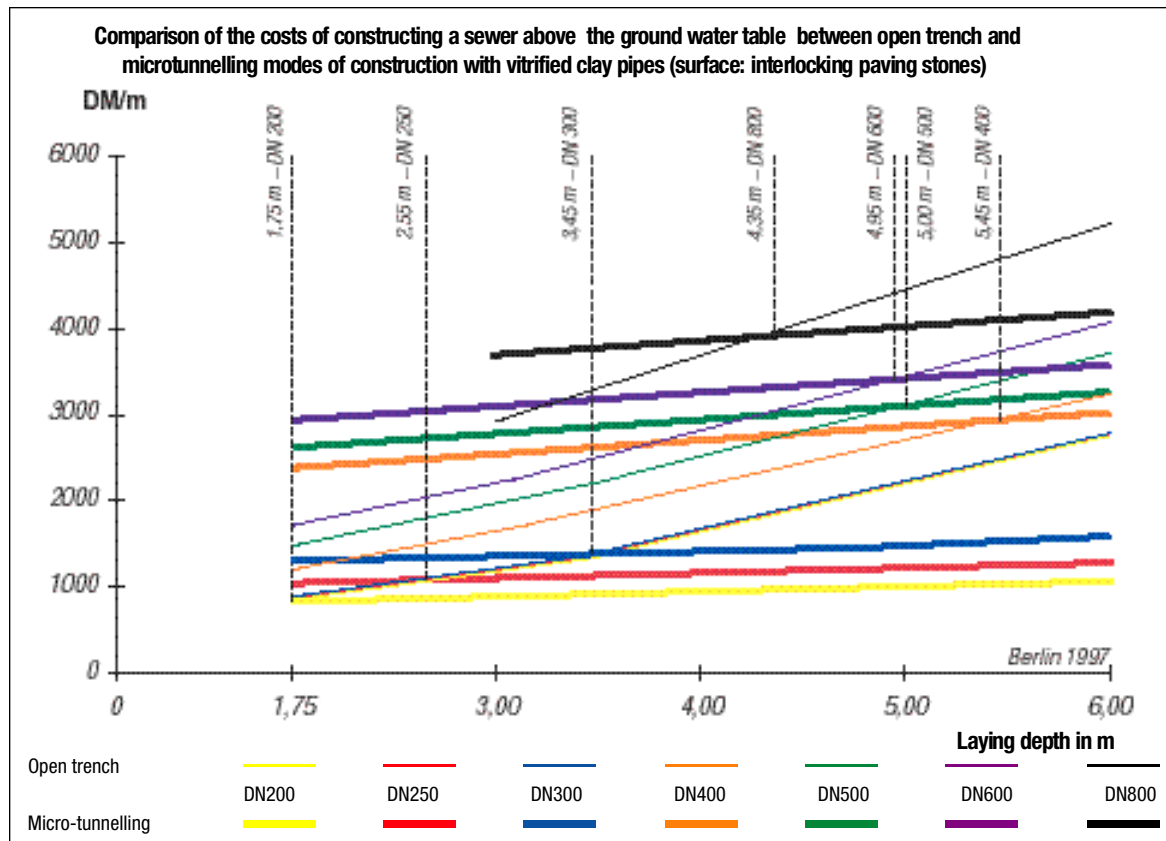


As a rule traffic can continue to flow when microtunnelling is being employed since the site facilities in the region of the start shaft can be kept compact and target and intermediate shafts can be covered after construction.

Microtunnelling will not harm existing vegetation. Roots in the line of the sewer are only cut away in the region of the cross-section of the cutter head. In addition measures to lower the level of the ground water are not needed provided suitable construction techniques are employed.



## Economic efficiency



The large number of sewers that have been commissioned and constructed in Berlin permit definite statements to be made on the relative costs of the open trench and trenchless or microtunnelling modes of construction. The tender prices for the years 1997 and 1998 were taken as the basis for the preparation of the above example, which represents just one of a large number.

With every sewer construction project, the relevant economic factors should be considered at the planning stage for both the open trench and trenchless modes of construction. Not least to be considered here are all the factors of influence likely to increase costs with in particular the open trench mode of construction. These include the possible requirement to divert existing lines in advance, the traffic light systems needed and the length of the construction period.

If the costs appear approximately the same, the market should be challenged to submit alternative bills of quantities so that the most

economic method of construction can be seen and selected. Decisions to execute a project by combinations of open trench and trenchless modes of construction often result from such economic comparisons.

The three most important parameters determining the economic efficiency of micro-tunnelling are:

- Soil and ground water conditions - favourable conditions permit lower estimates
- Manhole to manhole lengths - long manhole to manhole lengths give savings in the cost intensive setup times
- Overall quantity of microtunnelling to be carried out - the costs of setting up and later dismantling the site are spread over the total project

The depth at which the sewer is to be laid is not of decisive importance with micro-tunnelling since it affects the price per metre merely through the costs for the start, target and inspection shafts.

## Economic efficiency

### Rules and standards for microtunnelling

Careful preparation in terms of planning and formulating invitation for tender documents form an important initial stage if a micro-tunnelling project is to be realised successfully. At the same time such careful preparatory work permits the companies tendering to cost their work optimally. In DIN 18319 "Micro-tunnelling", which is a component of VOB part C, the following points are laid down amongst others:

- Details of the site by the client
- Billing units
- Recent grading of soil and rock in terms of their suitability for microtunnelling
- Requirements for the mode of execution, e.g. applicable procedure in the case of variances from the agreed reference axis or in the case of obstacles arising
- Billing

ATV (Technical Waste Water Association) working sheet A 125 "Microtunnelling" is based on DIN 18319 but goes significantly further in its statements.

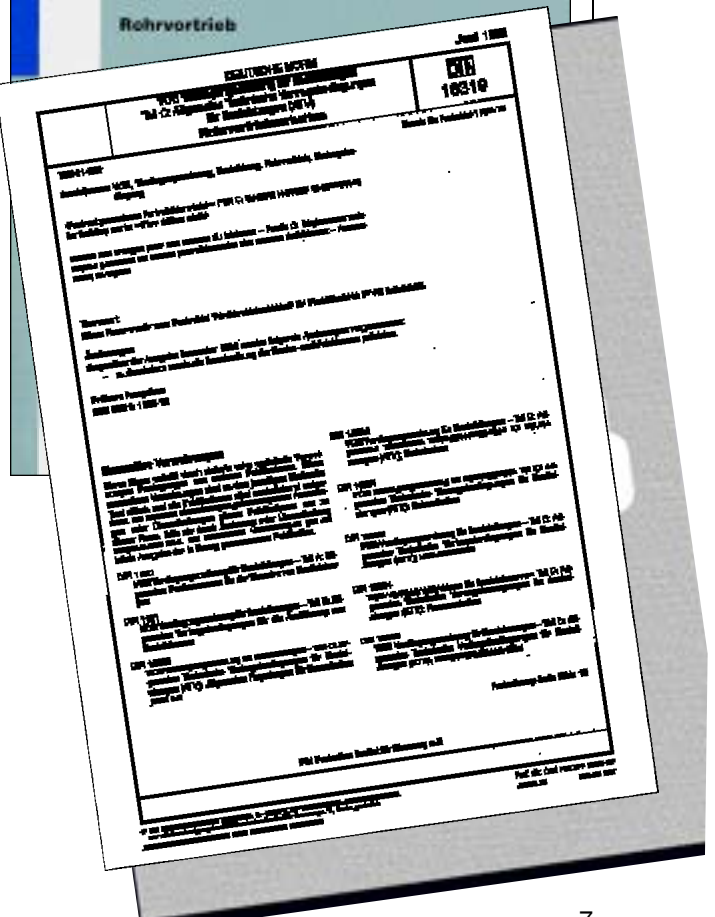
In addition to describing unmanned and manned microtunnelling systems, it lays down requirements in terms of:

- Construction and mechanical devices
- Jacking pipes, jacking pipe connections and shafts
- Preparatory planning
- Execution by the contractor

Further themes are:

- Microtunnelling under the lines of German Railways
- Microtunnelling under federal main roads and motorways
- Microtunnelling under federal canals.

The ATV working sheet as an important set of rules for planning and executing projects is now serving as the foundation for a European set of rules for microtunnelling.



## The trenchless mode of construction



At the present time two remote steered methods for the construction of underground sewers are in use. These two methods are described below in accordance with ATV working sheet A 125 - microtunnelling:

### **Shield pipe jacking (slurry system)**

Jacking of casing or media pipes with simultaneous full cross-section removal of the soil from the working face, counter balanced by mechanical and hydraulic loads. Surveying is carried out with a laser beam. Changes in direction are executed with the aid of a cutter head able to be swivelled hydraulically. Removal of the soil is carried out continuously, as a rule by hydraulic means. The drive for the cutter head is located in the jacking shield. In general this method is used for pipes of external diameters up to 1850 mm and manhole to manhole lengths of up to 250 m in earth and rock with and without ground water, the particular manhole to manhole length possible

depending on the nominal size of the pipes.

The cutting wheel to be used on the cutter head is selected on the basis of the composition of earth. Use of the correct tools selected in accordance with the consistency of the soil and the size of the stones enables the rate of microtunnelling to be optimised. Cutter heads for rock can be used from DN 500. The expert reports on the soil, which are essential for microtunnelling, can be prepared in accordance with DIN 18319, VOB part C. A reprint "Opportunities and limits for microtunnelling taking into account the excavating tools" can be obtained from KERAMO-STEINZEUG .

## The trenchless mode of construction



### **Thrust boring pipe jacking (Auger system)**

Jacking of casing or media pipes with simultaneous removal of the soil at the working face by a cutter head. Surveying is carried out with a laser beam. Changes in direction are executed with the aid of a cutter head able to be swivelled hydraulically.

Removal of the soil is carried out continuously with the aid of auger flights. Cutter head and auger flights are driven as a rule from the start shaft or pit. The area of application of this method covers in general pipes of external diameters up to 1300 mm and manhole to manhole lengths of up to 100 m. In the case of cohesive soils of firm consistency, excavating and conveying of the soil can be facilitated through the feeding of water at the working face.

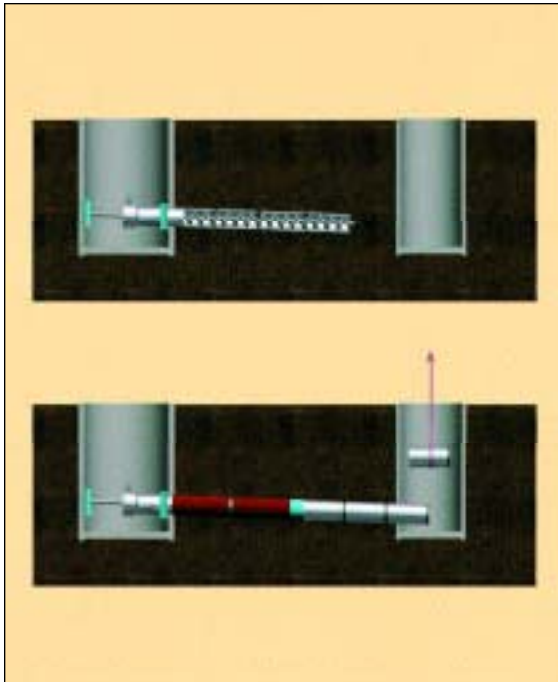
In water bearing soils, additional measures, e.g. the use of compressed air, are necessary.

A container is placed over the jacking pit or immediately adjacent to this. This enables the work to be carried out at the site more or less regardless of the weather even in winter months.

The width of the container is such that in general the site only occupies one traffic lane so that traffic can pass the site with relatively little disturbance on one half of the road or with the aid of traffic control signals.

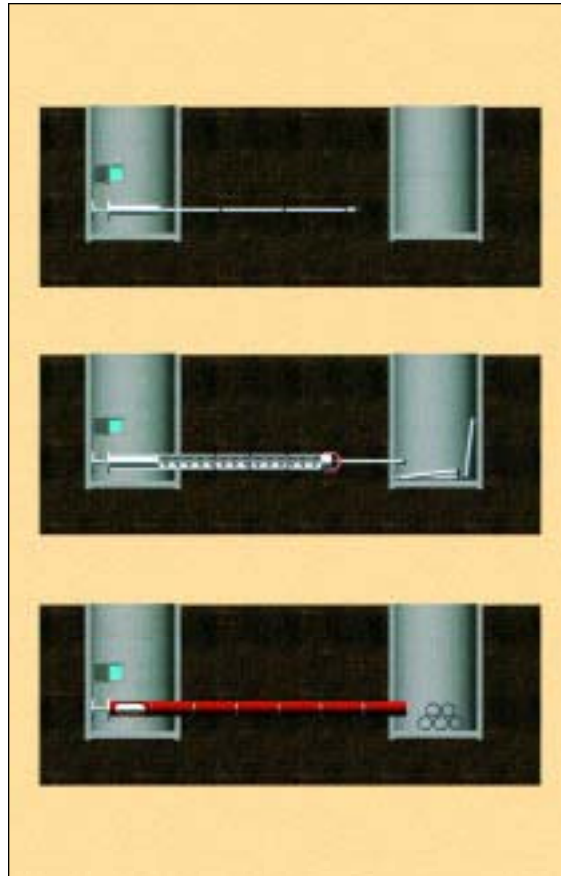
Sewers can also be renewed by the pipe cracking or pipe eating methods with the aid of this method. Further information is available on request.

## House connections



### **Unsteered microtunnelling with the aid of a horizontal thrust boring device**

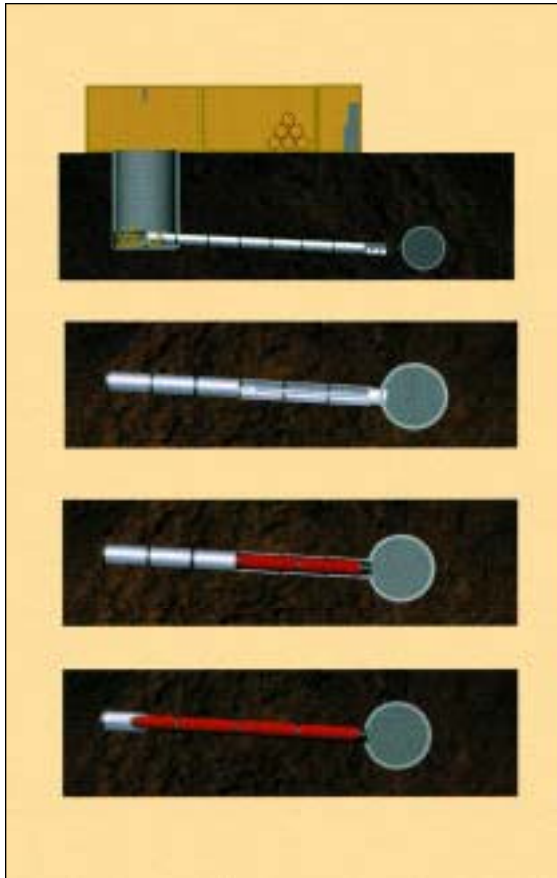
Here steel pipes (lengths between 500 mm and 1000 mm depending on manufacturer), which can be coupled together, are jacked first with the aid of a thrust device. Simultaneously with the jacking, the soil at the working face is excavated and conveyed away mechanically with the aid of auger flights. The drive for the cutter head is located in the start shaft or pit. Microtunnelling can be carried out in soil and rock subject to the use of the appropriate cutter heads. In water-bearing soils, additional measures such as lowering the level of the ground water are necessary. When the first of the recoverable steel pipes, the external diameter of which is the same as that of the vitrified clay jacking pipes, arrives in the target shaft or pit, the first vitrified clay jacking pipe is coupled with the aid of a transition piece to the last steel pipe that has been inserted and is then itself jacked. In this way the steel pipes are pushed out into the target pit and removed.



### **Steered pilot jacking mode**

In contrast to the previously described unsteered method, an additional phase is used here at the beginning in order to obtain a steering function. A line of hollow steel pilot rods, which can be connected together, is first jacked into the ground from the start shaft or pit displacing the soil. The short lengths of the rods enable them to be removed in a shaft of DN 1000. Monitoring that the system axis is being followed is carried out with the aid of a theodolite or laser system. Changes in direction are brought about by turning the pilot rod line from the start shaft. When the tip of the first pilot rod has arrived in the target shaft or target pit, a recoverable steel pipe is connected, with the aid of an adaptor, to the last pilot rod that has been inserted. The succeeding steps are as described for the unsteered process.

## House connections



### Underground construction of a house connection to a main sewer

The connection is achieved here with the aid of a 4 phase system:

1. Steered drilling from a start shaft to a main sewer with the aid of a line of special steel casing pipes.
2. Removal of the auger flights and fitting of a diamond core bit and a line of drilling rods. Trepanning of the main sewer with camera monitoring. Removal of the drilling core.
3. Slip lining of the DN 150 vitrified clay pipe with a special sealing element at the tip of the first pipe. Pressing of the sealing element into the wall of the main sewer with camera monitoring.
4. Withdrawal of the steel casing and filling of the resultant annular void.

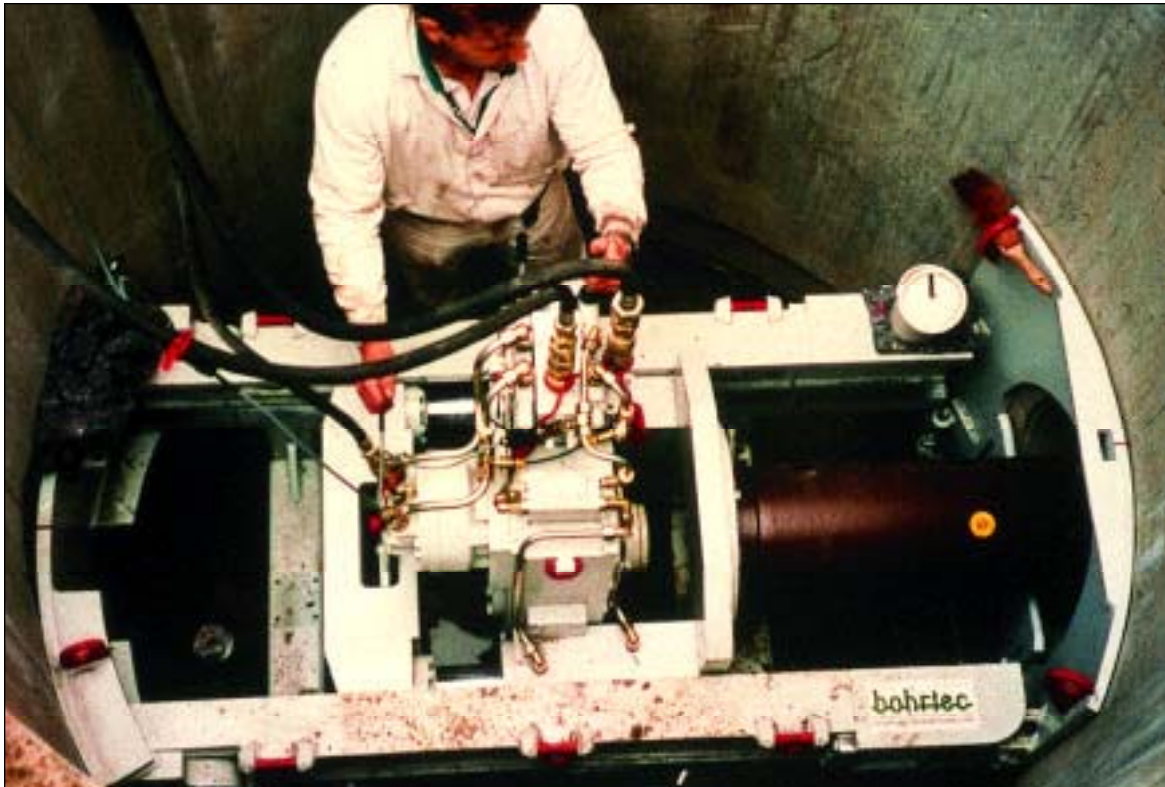


### Underground construction of a house connection from a main sewer

This process is carried out in 2 phases as with the unsteered horizontal thrust boring process. The thrust boring unit is fitted in an existing sewer or tunnel and can be aligned for any inclination up to 90°.

The minimum size for the installation of the jacking unit is a man sized main sewer of at least 1200 mm. The unit is transported through the pipe on a trolley to the previously surveyed connection point. The opening for the jacking process is produced by trepanning. On the completion of work, the annular space remaining between the pipe and the trepanned hole is sealed in a watertight manner with the aid of a specially designed rubber link chain.

## Jacking methods for DN 200 pipes



Fitting of a CreaDig vitrified clay jacking pipe in the third phase of the pilot rod jacking pipe method - manhole to manhole length 56 m.

### Microtunnelling of DN 200 main sewers

The steered method of producing house connections from main sewers by the pilot jacking pipe technique is also used for constructing small DN 200 main sewers underground with manhole to manhole lengths up to 60 m. An overall more robust version of the equipment makes this work possible. The use of this simple technique enables microtunnelling to be offered very competitively so that it gives cost advantages over the open trench method even at shallow depths of laying.

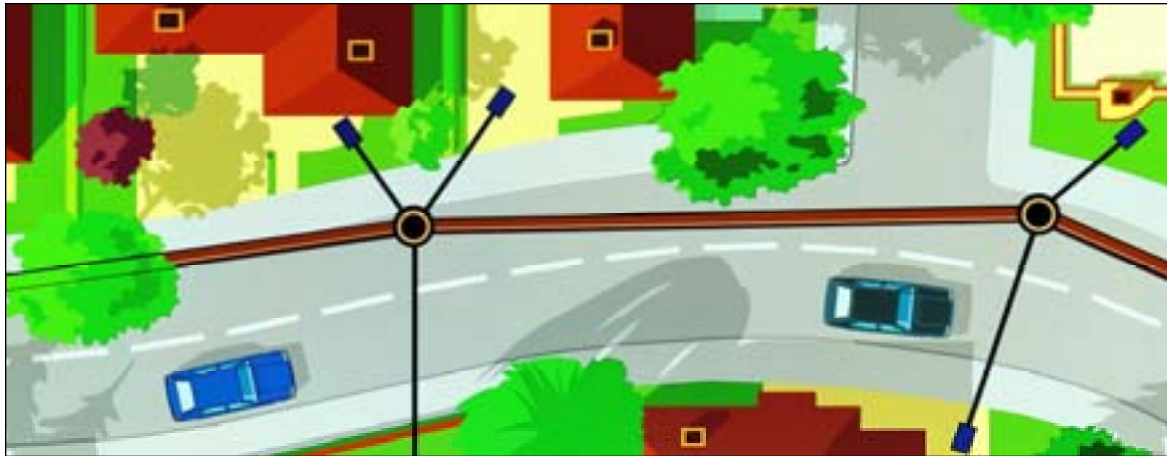
By expanding in stages with the aid of an enlarging cutting head for DN 250, DN 300 and DN 400, microtunnelling of short manhole to manhole lengths can also be carried out in these nominal sizes by this pilot jacking pipe method.

### Crossing under lines of German Railways

KERAMO-STEINZEUG's vitrified clay jacking pipes in nominal diameters of DN 250, DN 300, DN 400, DN 500, DN 600, DN 700 and DN 800 have general approval for crossing under lines of the German Railways. For nominal diameters DN 150, DN 200 and DN 1000 approval has to be obtained for each individual case of application. The foundation for the granting of approval are the test regulations for vitrified clay jacking pipes laid down in DIN EN 295 and RAL RG 534 VT (i.e. fatigue strength under pulsating load).

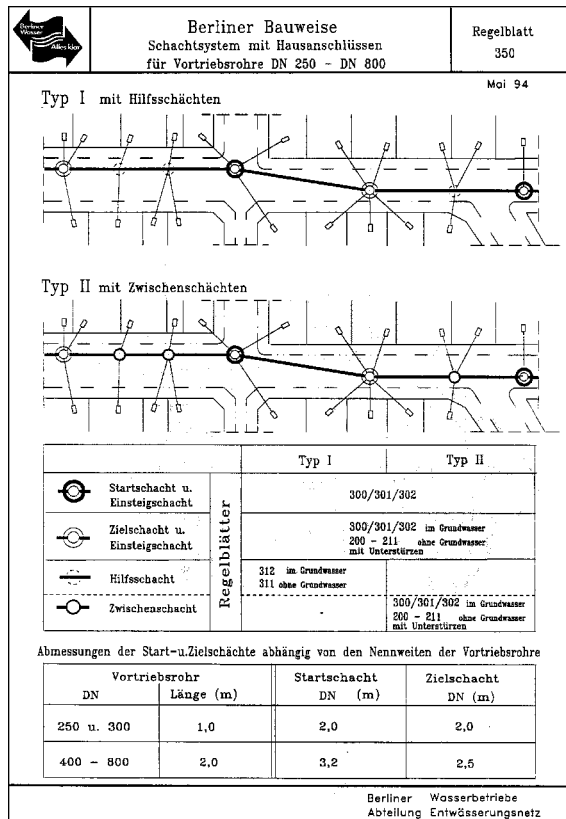
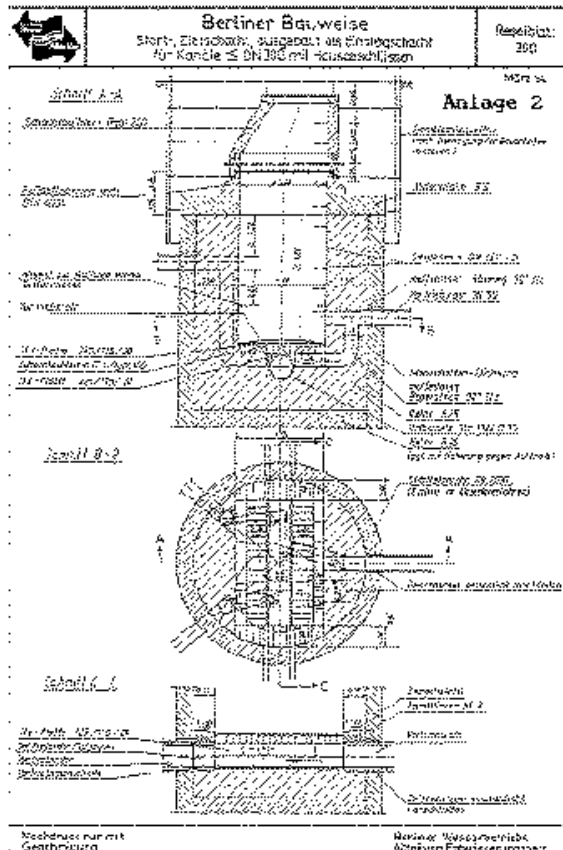


# Berlin mode of construction



## Berlin mode of construction

The Berlin mode of construction is based on the consistent application of steered micro-tunnelling for both main sewers and house connections from cylindrical start and target shafts. The shafts sunk for the micro-tunnelling of the main sewers are also used as the starting points for the driving of the house-connections. The latter are driven to the different properties in star form. On the completion of all microtunnelling work, the start and target



shafts are converted into inspection manholes. In addition to offering economic advantages in terms of construction, the execution of the house connections to the inspection manholes in straight lines offers many operating advantages such as the ease of cleaning and the checking of lines.