600 mm internal diameter culvert below the Nežárka river

A trenchless, controlled horizontal bore was performed for the first time ever in the Czech Republic to install a cast-iron pipe with 600 mm internal diameter below the river.

Ivan Demjan, TALPA-RPF s.r.o (GmbH).

Petr Krejčí, DUKTUS litinové systémy s.r.o (GmbH).

Investor: Jihočeský vodárenský svaz – JVS (South Bohemian Water Board)

Contractor/author: Hochtief CZ a.s. (AG)

Supplier of trenchless technology: Talpa RPF s.r.o (GmbH)

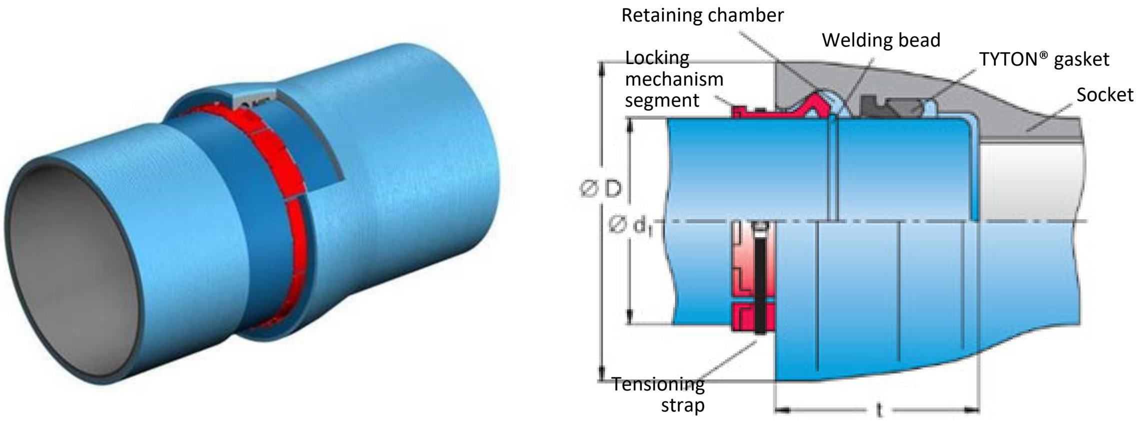
Project engineer: Sweco Hydroprojekt a.s. (AG)

Pipe material supplier: Duktus litinové systémy s.r.o (Duktus Gusseisensysteme GmbH).

The Chotýčany–Zlíchov water supply line, which is managed by the South Bohemian Water Board, is one of the most important main lines for the local water sector. This line crosses the Nežárka river near Veselí nad Lužnicí as an overland line with a steel bridge. However, the floods of 2002, when the river's water level almost reached as high as the bottom of the bridge, highlighted the weaknesses of this solution. In light of the anticipated service life of the bridge, its cost of maintenance and susceptibility to water line vandalism, a decision was taken to relocate this main water line and install it below the river very close to the location of the current bridge.

The project for crossing the Nežárka river employed a culvert, which was installed using trenchless technology with horizontal drilling and pulling in a ductile cast iron pipe measuring 71 meters in length with an internal diameter of 600 mm. The entire length of the boreholes, including guide bore, is 113 meters. The curved culvert employed is in line with the technical capabilities of the pipe material, whose socket pipe connection facilitates up to 2° of angular deflection of the two connected pipes and serves as an articulated joint. When using this trenchless technology, alongside the angular deflection it is also important for the ductile cast-iron pipes to transfer the high tensile forces that occur during pipe feed by the drilling rig. Tensile forces of up to 152.5 tonnes are permitted for the 600 mm nominal dimension used. The external diameter of the pipe is 742 mm due to the socket. At the same time, the secured lock connection with welding and cast iron segments can withstand an operating pressure of 32 bar. This data makes it clear that the water pipe should not only be assessed on the basis of operating pressure, but rather that the assessment should be so comprehensive that its quality and durability matches the entire water supply system.

In the context of trenchless technology, it is necessary to use a pipeline with special external mechanical strength and strong corrosion protection. The manufacturers of ductile cast-iron pipes therefore developed a pipeline with an external shell made of OCM/CMC cement mortar that is reinforced with plastic webbing. The concrete barrier on the surface of the pipeline prevents mechanical damage and tensions that can occur when using trenchless technology. The sockets of all connections are protected by a rubber or thermoshrink sleeve and a sheet metal collar, which increases protection of the socket and, at the same time, prevents the rubber sleeve from being stripped. The pipe was pulled in using a special traction head matched to the socket shape that employs a secured lock connection with welding and cast iron segments.



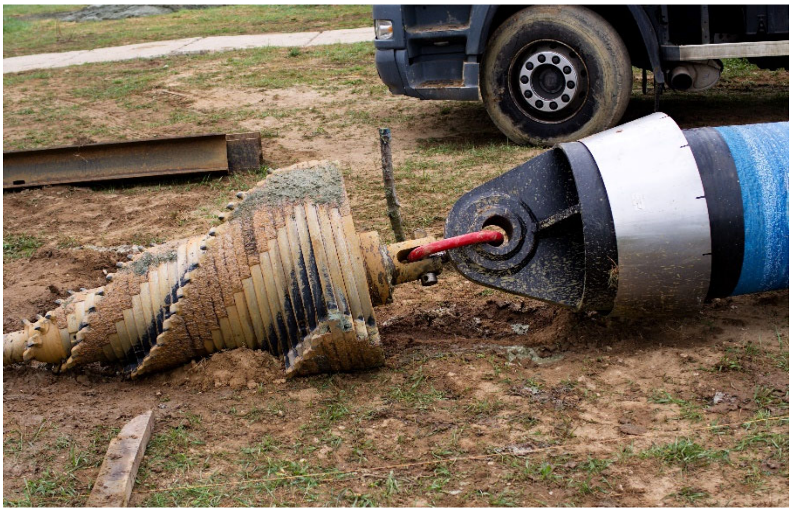
Design of the locking connection with 600 mm diameter welding

One of the most important parameters that influences the success of controlled horizontal boreholes is the geological composition of the rock at the operation site. Nature seemingly decided to make the conditions pretty tough here – as the drill had to pass through fluvial sediments on the entry side of the borehole, followed by slightly weathered paragneiss at a depth of around 3 metres, and then granite. On the left river bank, which is 2.5 meters lower than the right bank, there is a 4-metre high mass of deposits from the Nežárka river, comprising loose and deposited sand, below which there is bedrock similar to the right-hand bank of the river. The water table was reached at a depth of approximately 1.2 metres. The planned drilling process was guided from the right bank through rock formations, and the borehole reached the sandy sediment at around the half-way point.

Work started on 13th April, 2018. The DitchWitch AT30 machine (with maximum traction force of 15 tonnes) created a pilot hole with a rotary cutter and then increased the diameter of the borehole to 300 mm using a large diameter drill with rotary cutters. A much larger DW JT60 machine then took over, expanding the borehole to 400 mm, 500 mm, 700 mm and ultimately 950 mm in a step-by-step process that ran between 17th and 23rd April. Kodiak drill bits were used for this widening of the borehole. Their high rotational weight helps the carbide blades cut through even relatively hard rock evenly. The largest drill used to widen the borehole weighs one and half tonnes.

DitchWitch JT 60 machine

To be able to pull though a ductile cast iron pipe with nominal diameter of 600 mm and socket external diameter of 742 mm, calculations indicated that an opening of approximately 950 mm was required. The volume of a borehole with a diameter of 950 mm and length of 71 m is 50 m3. So that the pipe can be pulled through the borehole, earth of this volume needs to be transported to the start and target pits respectively. The borehole then needs to be emptied as far as possible during all follow-up drilling operations. This is the main task of the drilling fluids. These primarily contain bentonite (i.e. ground clay with special properties) and additives, which are added on the basis of the type of earth located beneath to provide better transport properties. At the same time, the "flushing" guarantees the stability of the borehole, which must not be allowed to collapse during the expansion procedures or when pulling in the pipes. Correctly prepared flushing with drilling fluid largely determines the success of the process for pulling pipes into the borehole. However, it is also the most expensive item of the project, which is why the procedure has such a great influence on the profitability of the entire order.



Connecting the expansion head and 600 mm nominal diameter pulling head

When installing the culvert below the Nežárka river, the AMC-2000 unit was used to mix the drilling fluid. It was able to provide up to 20 cubic metres of the mixture in just 10 minutes. This quantity is required, as the DitchWitch JT 60 machine consumes up to 570 litres of this mixture per minute and the drilling work cannot be stopped during the individual operations.

A total volume of 350 m3 of drilling fluid is required during the step-by-step expansion of the borehole to the diameters of 500 mm, 700 mm and 950 mm. This represents a significant logistical problem. The drilling fluid therefore had to be stored away from the construction site at a dumping/storage area. A drilling fluid recycling system is therefore used for such large construction projects. This system is capable of filtering the solid earth and rock particles from the mix transported from the borehole to the dumping areas at the start and end of the borehole, and then reusing the drilling fluid. The filtration quality is important, as ultrafine rock particles and grains of sand would cause wear to the piston pumps and lead to costly damage within just a few hours. In our case, an AMC 500 R was used, which is capable of removing all particles above 50 microns.

The expansion and flushing of the borehole was completed on 23rd April, 2018. Work started the following morning on pulling the 600 mm internal diameter ductile cast iron pipe into the borehole, and was completed that same afternoon. The pipe was preassembled and pulled in as a single piece. A pressure test was performed before pulling in the pipe as a way of ensuring that all connections had been established correctly and were watertight. Guiding the drill between the soft, weathered paragneiss and the much harder granite presented difficulties during the last five metres of the borehole, which led to an extremely difficult final draw-in of this large pipe during the latter stages.

Performance test of the drill head prior to pulling in the pipe – pulling the pipe into the borehole

When successfully resolved, this and other similar realisations represent a solution to what is always a burning issue for the investor. In this case, an important water supply line was laid below the river using a trenchless method, thereby eliminating a critical point in the water system. However, this construction is important for a different reason. While similar ductile cast iron pipes have been laid below rivers overseas in previous years using trenchless technology, this is the first case in the Czech Republic. It is therefore all the more important that an investor was found that was not afraid of preparing the construction site using trenchless technology and that the objective was met, even in these extremely difficult conditions.

Advantages of ductile cast iron/other materials

To conclude, we will summarise the benefits of trenchless laying of ductile cast iron pipe using the horizontal drilling procedure in comparison with classic excavation:

- High operational reliability,
- Greater verified pipe service life (up to 140 years). The service life of other materials used for water supply networks is 50 to 80 years
- Quick installation
- Fast approval and authorisation of the project documentation and investment plan
- High tensile force tolerance of the joint based on the nominal size
- High load-bearing properties for operation,
- An affordable solution from the perspective of the
  - earthworks,
  - Maintenance of the surrounding areas,
- The opportunity for pulling in the pipe in a curve (pipe deflections from 5° to 1.5° depending on the nominal size),
- Environmentally friendly, no restrictions in terms of the domestic comfort of residents in the area.