CONSTRUCTION OF LARGE DIAMETER CULVERTS FOR PRECIPITATION WATER GRAVITATIONAL SEWAGE SYSTEMS

By Dr. Miroslaw Chlosta and Pawel Kasperek

Trenchless processes of building underground engineering constructions may necessitate locating a pipeline on unstable soil. Usually, this problem is solved by designers, but it may be encountered as a result of unforeseen circumstances. These are: lack of geological survey (for the whole project), lack of geological survey where loose soil is present, no permission of the surface owner (road, railway, pavement, precious natural resources) under which the installation is constructed. Additional complications are caused by tender processes which force cost minimization and flat–rate settlement of tasks. Company's image and reputation are also of great importance in this context.

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The problem of unstable soil becomes significant during the construction of large diameter installations with outer diameter over 800 mm for gravitational sewage systems for transporting precipitation or foul water to water courses. The elevation of the local course influences routing the constructed pipeline and its decrease. The constructions built under roads or railways demand the highest degree of diligence, because maintaining their stability is crucial for people's safety. If the technological requirements presented below are kept, the sewer deformation will also be avoided, and, in consequence, leaks in counter–slopes, or silt accumulation.

The construction of culverts in loosely compacted earth eliminates the use of some trenchless methods. Methods which generate vibrations (use of impact hammers and similar) are inapplicable, because they will cause uncontrolled soil settlement under and over the installed pipe. Another un–recommended method is horizontal directional drilling (HDD), because it is impossible to control the stability of a drilled tunnel. Uncertain results are obtained also by auger–drilling

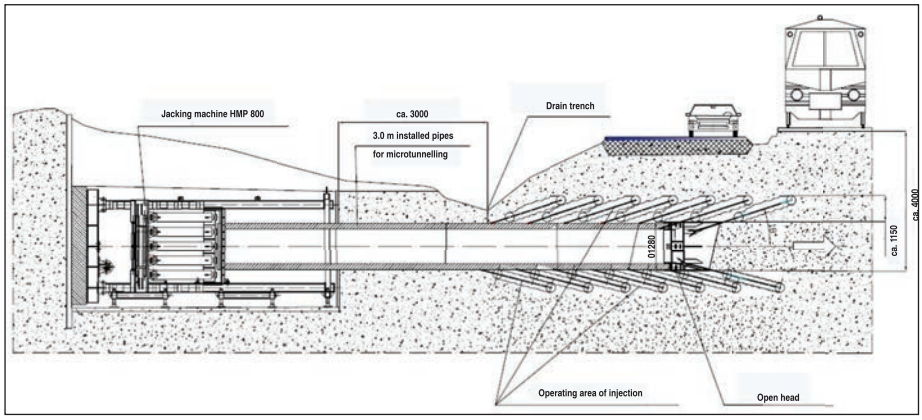


Figure 1: Jacking Under a Traffic Object with Use of Soil Stabilization Technology by Injection and Penetration of Multi–Component Glues.

THE ONLY METHOD WHICH GUARANTEES APPROPRIATE RESULTS IN CONSTRUCTION OF CULVERTS IN LOOSELY COMPACTED EARTH IS STATIC PIPE JACKING WITH FRONT SOIL STABILIZATION.

methods with tele–optic tracking and micro–tunneling with closed head.

The only method which guarantees appropriate results is static pipe jacking with front soil stabilization.

- Synthetic products – multi–component adhesives – are used for stabilization, e.g.: CarboPur – component A (white container) and CarboPur WF – component B (black container), or the second kit:
- Ekopur HW component A – yellow color on the container, hydraulic cables are marked with this color
- Pur B – component B – marked with red color.

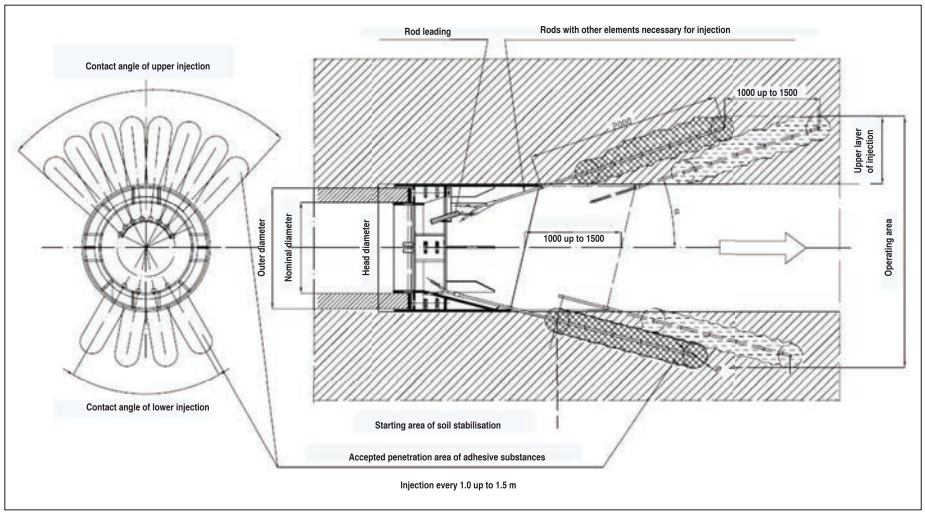


Figure 2: Spacing of Holes and Operating Area of Adhesive Substances on Soil.

When the two components are mixed, they undergo a chemical reaction and form an adhesive substance with penetrating and adhesive properties. The injection technology of soil stabilization is performed by injecting a mixture of an adhesive substance into soil. A portable piston pump is used for this method with a pneumatic drive, HA 1P type. Nominal operating pressure of the pump: 0.5 Mpa. ☞ **www.ksk–dev.com**

Technology of Culvert Construction

Stage 1: Preparation of Spaces for Injecting Glue

The open control head is inserted from a shutter starting chamber equipped with support block. Next, 2 m rods (diameter ½" or ¾") with holes with 4 mm in diameter are driven into the soil. The rod construction is shown in Figure 1.

To improve correct insertion of the rods into the soil, a guide is used, which is mounted in the open control head (bolted onto ribs). The rod guide consists of a half–rim with 8 welded tubes at the angle of 18°. The tube's inner diameter is 50 mm, length 320 mm.

The rods are inserted to the guide tubes. The rods are covered by special caps which work with the tip of a jack hammer and they are driven into the soil (0.6 m deep) with the hammer. The process is continued until the cap reaches the guide tube given in Figure 3. After all 8 rods are inserted, the guide is dismantled.

Extenders (tubes, 500 mm long) are wound up on the inserted rods, and then the rods are driven again until their tips leave the opening of the open control head.

A felt line soaked with injection substance is wound over ca. 300 mm at the end of 2 m rods. When this end section is driven into the soil, the line slides down and rests on the joint flange and seals the gap between the soil and the inserted rod.

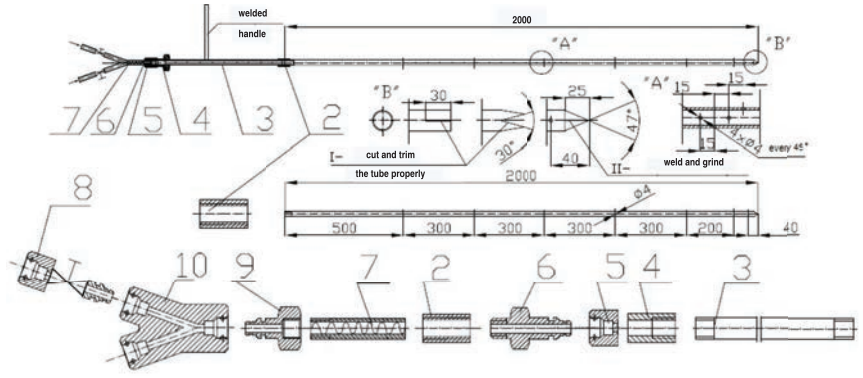
Stage 2: Connection of Injection Assembly and Injection

After the rods have been inserted and the cap has been dismounted, a kit for glue injection is screwed down on the extender (joined by a steel coupling). The kit consists of a 300 mm long tube, in which a plastic mixer is located, and endings for connecting two tubes which carry adhesive components. The elements comprising the complete installation are presented on Figure 1.

The adhesive components are pumped via hoses to the mixing unit by a two cylinder piston pump. The kit is connected one by one to the earlier inserted tubes – rods. If it is necessary, the soil can be stabilized under and over the installed lining or product pipe. In this case there were eight injections made over the culvert and four under it. The injected substance pours through the holes in the tubes (rods) and penetrates the soil for ca. 125 – 150 mm. The substance bonds the soil, creating a protective layer, called "a root" (because of the shape of the bonded soil shown in Figure 2). The depth of penetration and bonding of the adhesive substance depends on soil properties.

It enables to perform ramming without deformation of ground surface (roads, railways) in places with insufficient compaction. The penetration process of the glue and bonding with the adhesive substance takes ca. 15 minutes, but only after ca. 120 minutes the glue hardens and the bonding is stable.

After this time, tunnel drilling can be continued and culvert pipe can be installed at 1.5 m length. The jacked pipe (concrete, concrete–polymer, composite, steel) should be moistened with a polymer substance, e.g. Argipol (or equivalent). This agent prevents the soil from sticking to the jacked installation and significantly decreases friction factor between the soil and the installed pipe, which influences the required power during jacking. The agent should be sprayed or brushed on the side surface of the pipe directly before it is jacked into the soil. The agent must not dry on the pipe. After 6 linear meters have been jacked (two three–meters pipe sections), the side surface should be moistened with bentonite. It is performed by pumping bentonite washer (prepared earlier) via factory made nozzles and in the case of steel pipe via bored holes into which



Parts are presented in the assembly sequence

1. Rod, ½" pipe, length 2000 mm with Ø 4 holes, 4 holes every 30 mm, shifted by ca. 15 mm in relation to each other every 45° at the circumference (so they are not in one plane).
2. ½" double thread connector - steel.
3. Extender, ½" pipe, double - threaded with G ½' male thread, length 500 mm.
4. ½" steel connector - with one female thread.
5. Stecko 10 female connector (half connector) welded to connector4.
6. Stecko 10 plug - in connector and ½" male thread.
7. Mixing chamber (with replacable plastic spiral mixer), length ca. 250mm.
8. Isolating ball valve with Stecko 10 connections - ZK 10, socket and plug.
9. Stecko 10 plug - in connector and ½" female thread.
10. Special Stecko 10 t-connector.

Note: parts should be screwed or welded together

Figure 3: ½" Rods and Injection Accessories

the nozzles are screwed. The amount of bentonite has to be small (1 liter per nozzle) in order not to disturb the unstable soil structure. This procedure is performed until the obstacle is overcome and the receiving chamber is reached. A good practice is to continue works in a constant manner and to set shifts in such a way that the time of finishing and preparatory works coincides with the bonding time of the adhesive substance.

The activities presented in sections 1.1 and 1.2 are to be repeated every 1.5 m until the whole route which needs stabilization is completed.

Important Things

- In order to perform the works properly, it is very important that the tubes are connected correctly. They are marked with appropriate colors.
- Two–cylinder pump can work properly only in a vertical position.
- Switching the mixing unit between rods during injection has to be performed as fast as possible – up to 30 seconds. Otherwise, the adhesive substance can condense in the mixing chamber and block inlets.

Activities During Finishing the Works

After the works have been finished, the pipe tubes should be switched to drain in order to transport the liquid to containers. The remaining hoses should be dismantled and the liquid should drain gravitationally. The mixing chamber should be flushed with one component. Remove the plastic mixer. A mixer that cannot be flushed (it is contaminated or "glued") should be replaced.

Dismantle the extenders. After the glue has hardened, the extenders can be recovered and used in further injections once the adhesive substance has been burned. The adhesive components cannot be stored in temperature below 0°C.

A good practice is to continue works in a constant manner and to set shifts in such a way that the time of finishing and preparatory works coincide with the bonding time of the adhesive substance.

About the Authors

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Institute of Mechanized Construction and Rock Mining is a research and development body operating in the field of mechanized construction, industrial automation and the construction industry, mechanical engineering and safety, construction equipment and rock mining machinery, waste management and recycling, information science, technical and economic information.

KSK Developments' main areas of operation are design and manufacture of mechatronic devices. For trenchless technologies we manufacture measuring and control devices – such as strain gauge device for logging the axial and radial forces, together with static pressure monitoring acting on a pipeline in the process of Horizontal Directional Drill.

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