ENGINEERING FEATURES OF NO-DIG REPAIR OF OUTDOOR UTILITIES

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Abstract

Technological characteristics of the use of innovation methods for the no-dig repair of city infrastructure utilities, as well as prospects of the allocation of foreign technologies in Russia are considered in the work. The comparative analysis of technical and economic parameters of the pipeline section open-laying method with similar parameters of the most common no-dig repair technologies of gravity-flow discharge manifolds is reported with a specific example.

The authors made conclusions on the need to carry out additional further research on both the development of new domestic polymer materials and manufacture of the assembly equipment, and the improvement of the regulatory system for the development of new standard technological documentation for the wide introduction of promising technologies of no-dig repair of outdoor utilities in the construction practice.

Keywords

No-dig technologies, utilities, pipeline repair, renovation, recovery, discharge manifold.

Introduction

As the modern construction practice shows, the most competitive in terms of basic technical and economic parameters under conditions of dense urban development are technologies of no-dig repair and recovery of outdoor utilities and other underground facilities (Avdeeva et al., 2014; Verstov et al., 2008; Khramenkov et al., 2008).

No-dig technologies of recovery of outdoor utilities essentially represent overhaul of existing pipelines, since works are performed, as a rule, from existing wells (Kobelev, 2010), therefore, they do not need carrying out designing and surveying works, or additional expenditures for the construction site preparation, as well as design expertise and other approvals and financial investments, which are needed in new construction. The structure of costs for new construction and recovery of utilities with the use of no-dig technologies is shown in the diagram (Figure 1).

Subject, tasks and methods

In recent years, requirements to the quality of materials, which are applied in outdoor utilities of the municipal infrastructure, have been constantly increasing both in case of conventional open laying of pipelines and in case of no-dig methods of their renovation. The use of polymeric pipes and innovation technologies significantly facilitates and accelerates both the process of new utilities construction and repair of existing pipelines from conventional materials (Prodous, 2004).

At the present time, many large cities in Russia experience successful implementation of the program of reconstruction of existing water supply and sewerage utilities, which provides for fulfillment of works for renovation of outdoor utilities with the trenchless method in order to maintain the urban landscape and avoid traffic obstructions (Ministry of Construction of Russia, 2016; Orlov, 2012).

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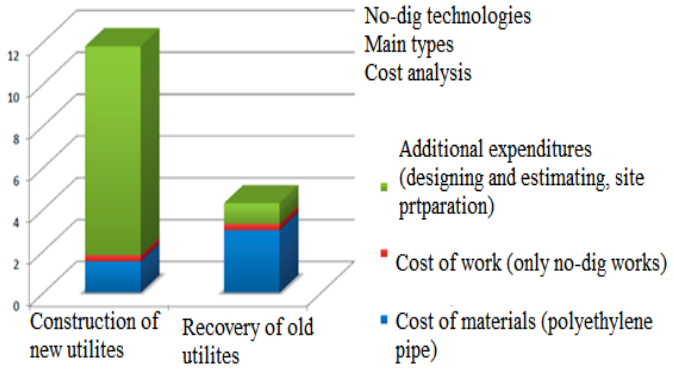

Figure 1. Cost structure of construction of new utilities and recovery of old utilities with the use of no-dig technologies

Besides, the use of no-dig technologies for renovation of urban underground utilities reduces the electric energy consumption by the power pumping equipment by 25–40% on the average, and, due to the use of pipes made of innovative polymer materials, it preserves and in some cases even increases the throughput of recovered pipelines (Verstov et al., 2008).

However, as the analysis of the existing regulatory base shows (Gosstroy of the USSR, 1987; GESNr 2001-66, 2008; Ministry of Construction of Russia, 2016), there is standard technological documentation for only some no-dig pipeline repair technologies. In the existing regulatory base, as a rule, there is no description of technological processes, data on the latest materials, necessary assembly equipment, which are actually used by contractors in the introduction of new methods of no-dig repair of outdoor utilities. In order to cut significant costs and time, which are needed for the development, agreement and approval of technological documentation for innovative methods of no-dig pipeline repair, contractors, with the consent of the customer, are forced to apply construction design documents, which, in most cases, only partly correspond to the specific no-dig technology used by the contractor at the site. The existing practice of drafting and agreeing calculations for a separate section of urban network under restoration is a very expensive procedure and has a lot of aspects which influence on the estimated cost of repairs. The lack of standard technological documentation and proper quality control of works performed by the contractor, as a rule, entails the non-compliance with the no-dig repair technology, which negatively affects the obtained results of pipeline recovery and often leads to increase of initial cost estimates for fulfillment of works.

Results of the study

The present article, using the example of comparison of carrying out works according to the open-laying technology applied to a section of urban DN 200 mm gravity-flow sewage manifold with a length of 100 running meters in accordance with Collection E9 of the Unified Norms and Prices (ENiR) (Gosstroy of the USSR, 1987), and the no-dig repair technology applied to an old pipeline in accordance with the State Estimate Norms for elements of construction and repair works GESNr 2001-66 (revision of 2008) (GESNr 2001-66, 2008), gives a brief description of technological processes and composition of works performed, machinery and equipment used, as well as results of the analysis of technical and economic parameters for compared technologies.

The technology of open laying of DN/OD 200/225 mm polypropylene corrugated double-layer inserted-joint pipe includes fulfillment of the following works:

- designing, agreeing and examination of the project;
- stopping of the road traffic, organization and agreeing of a scheme of a work site bypass route;
- removal of the road covering with disposal of concrete aggregates;
- mechanized soil development, trenching with wall fixing of frameworks, manual stripping of the bottom;
- disassembly of the existing manifold;
- arrangement of a sand base for pipes with layer-by-layer compacting;
- laying of new polypropylene inserted-joint pipelines;
- filling of pit holes, backfilling of the soil with layer-by-layer compacting in a trench;
- recovery of the road surface and improvement of adjacent territories along the entire pipeline route.

Machines and equipment used upon **open laying of DN/OD 200/225 mm polypropylene corrugated double-layer inserted-joint pipe**: a single bucket back-acting excavator, a bulldozer, an asphalt layer cutter, dump trucks, a truck crane, a diesel generator, an air compressor, a pneumatic rammer, an asphalt-spreader, an asphalt compactor, electric and hand tools.

Special features of work fulfillment: a long period of preparatory and installation works at each section of pipeline laying.

The technology of pulling a new SDR 17 DN 225 mm polyethylene 100 pressure pipe without destroying the existing pipeline includes such works as:

- designing, agreeing and examination of the repair project with the arrangement of excavation pits;
- stopping of the road traffic, organization and agreeing of a scheme of a work site bypass route for each section;
- removal of sections of the road covering with disposal of concrete aggregates;
- carrying out a set of earthworks for arrangement of excavation pits and dismantling of wells;
- backfilling of excavation pits with layer-by-layer compaction;
- recovery of the road surface in the excavation areas and improvement of the adjacent territory.

Machines and equipment used when **pulling a new SDR 17 DN 225 mm polyethylene 100 pressure pipe without destroying the existing pipeline**: equipment for mechanical cleaning and hydrodynamic flushing of a pipeline, TV inspection equipment, a hydraulic automatic winch or pneumatic tool for retraction of welded strings of polyethylene pipes, a welding machine for butt welding

of polyethylene pipes, a single-bucket excavator, a truck crane, sheet piles, a dump truck, a diesel generator, an air compressor, pneumatic rammers, an asphalt-spreader, an asphalt compactor, electric and hand tools.

Special features of work fulfillment:

- a set of earthworks for arrangement of excavation pits and dismantling of wells at each assembly area shalle be carried out;
- a powerful winch is needed to pull a heavy string welded from measured sections of a pressure pipe;
- works on assembly of new inspection wells shall be carried out;
- recovery of the road surface in the excavation areas and improvement of the adjacent territory.

The technology of pulling a new SDR 17 DN 225 mm polyethylene 100 pipe with destruction of the existing pipeline with the help of a pneumatic drift hammer consists of the following technological processes:

- designing, agreeing and examination of the project;
- partial stopping of the road traffic, organization and agreeing of a scheme of a work site bypass route;
- removal of sections of the road covering with disposal of concrete aggregates;
- carrying out a set of earthworks for arrangement of excavation pits and dismantling of wells;
- preparation of a string of polyethylene pipes with welding of joints;
- installation of a winch on the metal shield base with subsequent dismantling;
- installation and dismantling of an anchor device, a rimer and a valve;
- assembly of a pneumatic hose, its pulling into the polyethylene pipe with subsequent dismantling;
- dragging of the string of polyethylene pipes with the help of the winch;
- closing of string ends;
- backfilling of excavation pits with layer-by-layer compaction;
- arrangement of inspection wells;
- recovery of the road surface in the excavation areas and improvement of the adjacent territory.

Machines and equipment used for pulling a new SDR 17 DN 225 mm polyethylene 100 pipe with destruction of the existing pipeline with the help of a pneumatic drift hammer: a special truck, a powerful pneumatic press machine, a hydraulic automatic winch with an adjustable head advance speed and effort, a welding machine for butt welding of polyethylene pipes, a compressor with a pressure of not less than 0.6 MPa for driving the pneumatic press machine, a device for control of pipeline bends of the repair section, a diesel generator, an excavator, a truck crane, sheet piles, a dump truck for soil removal, a diesel generator, jackhammers, pneumatic rammers, an asphalt-spreader, an asphalt compactor, electric and hand tools.

Special features of work fulfillment:

- a long and very noisy process of old pipeline destruction with possible significant displacement of soils.
- curved sections of the route cannot be used for driving;
- significant hindrances for the street traffic;
- high energy consumption, possible pollution of the environment.

The technology of sewage manifold recovery with the INSITUFORM method (sleeve of DN 200 mm) includes the following works:

- bypass of the route with opening of well covers;
- pumping and outflowing of waste waters through a temporary pipe;
- flushing of a pipe at siltation of not more than 30 % with the water suction and driving off a silt;
- inspection of the network state with a TV control device;
- breakdown of prominent parts of pipe connections in a well;
- technological process of sanitation with a heated DN 200 mm sleeve;
- pumping out of technological waters from wells;
- cutting out of a sleeve tail and chutes in wells with removal of wastes;
- TV inspection of the sleeve inner surface;
- sealing of joints of pipes and chutes in reinforced concrete wells.

The following equipment is used during these works: equipment for hydrodynamic washing and cleaning of pipelines, equipment for TV-inspection of pipes, a heat- and UV radiation generator, a conductor casing, a take-up catch for sleeve dragging out, a heat-resistant hose, a buffer, a rubber stopper, a mechanical or electric winch for pulling of the sleeve, a mobile process system for sleeve polymerization, a robot-cutter for making holes in the wall of a polymer pipe, electric and hand tools.

Special features of work fulfillment:

- a set of expensive special equipment is required;
- the technological process of preparation, installation and warm-up of the sleeve for its polymerization is very complex, long and continuous;
- the material of the sleeve, sewn from polyester fiber or fiberglass, is pre-impregnated with epoxy resins and delivered to the site in a sealed package;
- the sleeve is very sensitive to the ambient temperature, the impregnated material has a limited period of use, having harmful chemical effect on humans at the direct contact;
- not environmentally friendly and not subject to disposal.

Since the formation of a new pipe is carried out under the ground, it is very difficult to control the work quality until its completion. It is almost impossible to pull out a pipe in the installation process.

The technology of no-dig recovery of sewage pipelines with the FLEXOREN method (DN of 200 mm) includes the following works:

- the existing sewage manifold is flushed with a high pressure water jet at silting-up of not more than 30 % and is cleaned with other methods;

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- TV examination of the existing sewage manifold for detection of hidden connections, damages or displacements of pipes;
- pipes and assembly equipment are delivered and stored in the immediate proximity to the assembly site (usually on the sidewalk or the roadside);
- road traffic in the repair area is not stopped,

temporary barriers are installed around wells, not obstructing the traffic or movement of pedestrians;
- a fiberglass line is pushed from the feeding well into the receiving well, a winch pulling cable is then pulled with it;
- a pipe guide with an extension rod is installed in the feeding well and a guiding support is mounted above this well;
- a reversible block and an extension rod are mounted in the receiving well, and the winch is mounted above this well;
- sections of pipes are welded into a string with the help of welding rings with an embedded heating element;
- dragging and detaching of the meter template of a pipe;
- joining of the head to the string with its subsequent detachment;
- dragging the polyethylene pipe string into the existing sewage manifold through the well in the streamline direction with the help of the winch installed above the receiving well;
- filling of the annular space with light cement-sand mortar or foam concrete;
- jointing of inlet and outlet openings of the pipe and the well with cement mortar;
- control TV-inspection of the recovered sewage manifold and check of its tightness.

In order to carry out works according to the technology of no-dig recovery of sewage pipelines with the FLEXOREN method (DN 200 mm), the following machines and equipment are required: equipment for TV-inspection of pipelines, a welding machine for welding polyethylene pipes with couplings with embedded heating elements, a welding frame, pipe retainers, a pullout line, a winch, a guide support above the well, a concrete pump for annular space filling.

Special features of work fulfillment:
- a unique wall design and pipe flexibility for repair of gravity-flow sewage manifolds through wells;
- repair of the sewerage system is carried out without stopping the road traffic;
- operation of the sewage manifold is allowed in the process of its sanation;
- a continuous pipe completely covers the distance between wells;
- a significant increase in the throughput of the existing sewage manifold and a high degree of new pipe self-cleaning;
- does not interfere with the traffic and movement of the inhabitants of adjacent houses;
- a crew of 3 people can repair 200–300 m of pre-prepared sewage manifolds with the internal diameter from 100 up to 300 mm during a shift.

Results and discussion

The data of comparison of different technologies of open laying and no-dig repair of pipelines by costs and labor inputs are given in Table 1.

Table 1. Comparative economic parameters of technologies of open laying and no-dig repair of pipelines

Technology and reference to the regulatory document	Cost of materials, %	Labor inputs, %	Estimated cost, %
Technology of open laying of DN/OD 200/225 mm polypropylene inserted-joint pipe (ENiR E9-2)	51	83	67
Pulling of a new SDR 17 DN 225 mm polyethylene 100 pipe without destruction of the existing pipeline (TERr66-32)	29	36	32
Stretching of a new SDR 17 DN 225 mm polyethylene 100 pipe with destruction of the existing pipeline with a pneumatic drift hammer (TERr66-31)	24	42	33
Sewage manifold recovery with the INSITUFORM method DN=200 mm (TERr 66-41)	100	100	100
No-dig recovery of sewage pipelines with the FLEXOREN method DN 200 mm (TERr 66-40)	28	21	25

As it follows from the analysis of the obtained results, given in Table 1,

the application of innovative technologies of no-dig pipeline repair with the use of high-quality polymer materials is undoubtedly an economically effective long-term investment in the urban infrastructure in comparison with the use of the conventional open laying method. However, not nearly in all Russian cities, even in large ones, infrastructure enterprises can use modern no-dig technologies for laying new pipelines and repairing existing pipeline networks. Unfortunately, innovative no-dig technologies are up to now unavailable for a lot of housing and utilities

enterprises due to the insufficient funding of regional programs of construction and repair of outdoor utilities.

Conclusion

1. Additional researches on both the development of new domestic polymer materials and manufacture of assembly equipment, and the development of cost-effective innovative technologies of no-dig pipeline repair are necessary for the large-scale implementation of no-dig methods of underground utilities recovery in the engineering practice.

2. There is an urgent need to improve the existing regulatory base and develop a new one for creation of standard technological documentation on innovative technologies of no-dig repair of outside utilities.

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