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Open Method of Restoration of the Sewage Collector Using Corrosion-Resistant Self-Sealing Concrete

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ABSTRACT

The work analyzes the condition of drainage collectors and establishes that the most significant destruction affects the arch part itself. An overview of foreign technologies for the repair and restoration of sewer collectors has been conducted. Technologies for restoring the arch part of the collector using reinforced fiberglass-reinforced concrete with the use of pneumatic and inventory formwork have been proposed. Selected concrete compositions have been provided. Technological sequences for restoring the destroyed collector have been presented.

Keywords: sewage collector, self-compacting concrete, corrosion.

Introduction.

Conducted studies [1-3] show that in the process of wastewater transportation, the vaulted part of the collectors is destroyed, while the trough part, which is usually constantly filled with wastewater, remains intact (Fig. 1).The use of the surviving tray part makes it possible to restore the collector with minimal material and labor costs. At the same time, the tray part can be seen as the main support structure, for leaning on it and connecting the new structure of the crypt with it.

Fig. 1. Destroyed vaulted part of the reservoir.

One of the options for repairing and restoring the collector is to create a new vaulted part using composite reinforced self-compacting corrosion-resistant concrete. The use of pneumatic and metal inventory formwork is effective in this case. The main condition is to provide a gap for filling the space between the formwork with self-compacting corrosion-resistant concrete.

Materials and methods. Several options for creating a new vaulted part by the open method were considered in [1, 2, 4]. For many years, the tent method has been used in Hungary. When using this method, the vaulted part of the collector is subject to replacement [1, 4, 5]. In Kharkiv, the technology of installing a tubular reinforced polyethylene anchor structure in the preserved tray part, manufactured in the factory, with its subsequent concreting using specially designed formwork with concrete mixture was introduced [4, 5]. Currently, the replacement of destroyed collectors constructed of reinforced concrete pipes with polyethylene and fiberglass pipes is widely used.

Works [6, 7] consider options for repairing and restoring sewer collectors using clinker bricks.

For the first time in domestic practice, solutions were developed to carry out repair and restoration work on collectors by constructing a vaulted part using reinforced self-compacting corrosion-resistant concrete and (Fig. 2).

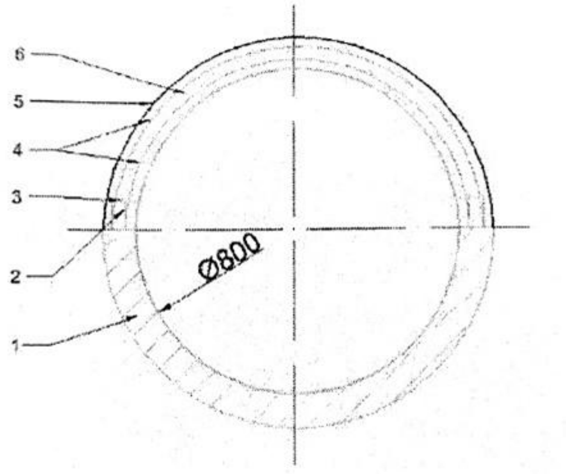

Fig. 2. Scheme of collector repair and restoration using self-compacting corrosion-resistant concrete: 1 - existing tray part; 2 – existing reinforcing rods; 3 - pneumatic formwork; 4 - composite reinforcement; 5 - inventory formwork; 6 - self-compacting corrosion-resistant concrete.

Research results. In the laboratory of the University, experimental studies were carried out to restore the vaulted part of the sewer collector with an internal diameter of 800 mm and a length of 1000 mm. 1000 mm. To conduct the experiment, pre-prepared elements of the surviving tray part were delivered to the laboratory.

It should be noted that after the creation of a new crypt of the rehabilitated reservoir, a high concentration of carbon dioxide, ammonia, and hydrogen sulfide may occur in the surface part of the reservoir, which is several times higher than the normative maximum permissible concentration.

Therefore, the problem of increasing the durability of concrete and reinforced concrete structures in wastewater networks is urgent.

At the same time, the main way to increase the corrosion resistance and durability of concrete for drainage systems is to increase their density and reduce water permeability.

Ways to increase the durability of concrete can be different. one of the most effective ways is the use of special mineral chemical additives at the stage of preparation of concrete mixtures.

Mineral finely ground additives contribute to the compaction of concrete at the meso level, filling the space between binder particles and fine aggregate. Chemically active additives contribute to the synthesis of crystal hydrate compounds with calcium hydroxide and the aluminate phase of Portland cement, which are additional to cement stone.

An important element of the study is also the selection of the composition of the self-compacting corrosion-resistant concrete mix. The selection of the composition of concrete from self-compacting mixtures (with a standard cone spread from 55 to 85 cm) is carried out according to the same principles that underlie the method of concrete selection, taking into account the features associated with the mandatory use of additives and additional requirements for the quality of the components of the mixtures.

In this work, the selection of materials for the creation of acid-resistant self-compacting concrete was performed.

The optimal amount of additives introduced into the concrete mixture (D, kg/m3) is determined according to DSTU.

The total consumption of materials per 1 m3 of concrete is:

- Sulfate-resistant cement of 360-400 kg;

- Washed Bezlyudovsky sand - 760 kg;

- Crushed stone of 1-3 mm fraction - 760 kg;

- Microsilica - 36 kg;

- Quartz flour - 182 kg;

- Super water-reducing additive SikaPlast® -2508 NE UA from l - up to 3 kg - according to the instructions.

The average density of the concrete mix is equal to: 2298 kg/m3.

When using the developed solution, the following sequence of works is envisaged [7]: cleaning of the collector from the elements of the destroyed vaulted part; installation of pneumatic formwork in the preserved tray part; reinforcement of the collector vault, including the connection of new reinforcement with the releases of the reinforcement of the preserved tray part; installation of inventory formwork on the sides of the pneumatic formwork; concreting the vault with self-compacting corrosion-resistant concrete; dismantling the pneumatic inventory formwork after the concrete has reached the required strength. Table 1 shows the data of hydrogen sulfide concentration measurement, which is 500 mg/m3, which exceeds the maximum permissible concentration by 50 times. Table 2 shows the flow chart of the reservoir recovery sequence.

To study the effect of aggressive environment on acid-resistant concrete in the process of concreting the crypt, samples of cubes with an edge length of 10 cm were made and tested for strength at the age of 28 days of normal curing. Individual samples from this batch were placed in a biocompartment for three months. The biocamera was an observation shaft of a deep sewer collector.

Table 1 - Results of measuring the hydrogen sulfide concentration in mine No. 12 of the Kharkiv sewer collector

	Control point	Measurement depth, m	Hydrogen sulfide H2S, mg/m3	Carbon dioxide CO2 % vol.	Combustible gases, methane, CH4 % vol.	Ammonia, NH3 mg/m3	Oxygen, O2, % vol.
№			10	20	2,0	20	18...23
1	No. 12 of the collector	3,0	>500,0	-	-	-	-

Table 3 and Figure 3 show the results of the concrete cubes' compressive strength test before and after being in the biocompartment.

Table 2 - Technological sequence of restoration of the Ø800 mm collector by the open method using corrosion-resistant concrete.

	General view	Technological process	Construction material and equipment
1		Reinforcement of the newly created vaulted part of the reclaimed collector on the basis of the preserved flume part	Fiberglass reinforcement Ø 4.7 mm
2		Installation of pneumatic formwork	Pneumatic formwork with a diameter of 800 mm and a length of 1000 mm
3		Installation of composite clamps to ensure the thickness of the	5 cm diameter composite clamps made of composite

		protective layer	material
4		Preparation for installation of metal inventory formwork	Metal inventory formwork
5		Technological process of installation of metal inventory formwork	Metal inventory formwork of the lot part of the collector, pneumatic formwork, reinforcement elements
6		The final stage of installation of metal inventory formwork before the start of concreting the vault part of the rehabilitated collector	Металева інвента-рна опалубка для бетонування склепу діаметром 800 мм довжиною 1000 мм
7		Concreting of the vault part of the collector to be restored	Corrosion-resistant concrete of class C 16/20
8		Fragment of the restored sewer after dismantling of pneumatic and metal invested formwork	Composite reinforcement Ø 4.7 mm, corrosion-resistant concrete class C 16/20

As can be seen from Table 3, the loss of compressive strength of self-compacting concrete after exposing the samples to the aggressive environment of the sewer mine for three months was 13 %, while the loss of strength of conventional heavy concrete is 60-70 %.

Fig. 3. Compressive strength tests of concrete samples after being in the biocompartment.

Table 3 - Results of the study of the strength of concrete samples after being in the biocompartment.

Name of concrete	Date of manufacture	Date of the test		
Self-compacting concrete: PC 400 - 400 kg; quartz sand - 760 kg; crushed stone 3-10 mm - 182 kg; quartz flour - 182 kg; microsilica - 36 kg; SkaPlast - 2.3 kg.	12.07.21	18.08.21	21.10.21	20.12.21 (after 3 months in the biocamera)
		Compressive strength, Rst, kgf/cm2		
		120	100	87

Conclusions.

The use of the preserved tray part of the corroded canalization collectors makes it possible to create a new vaulted part on their basis using fiberglass reinforced concrete with a corrosion-resistant joint. High efficiency is achieved by using pneumatic and inventory formwork. The developed work technologies have a 2...3 times lower cost compared to the use of polyethylene or fiberglass pipes for repair and restoration work, the diameter of which reduces the capacity of the rehabilitated collector.

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