International Journal of Scientific Engineering and Science
Volume 9, Issue 1, pp. 92-94, 2025. ISSN (Online): 2456-7361

Repair of Sewer Collectors with Polymer Concrete

Vykhrystiuk Igor
Kyiv National University of Construction and Architecture
(Povitroflotskyi prospect, 31, Kyiv, 03680, Ukraine;
vykhrystiukigor91@gmail.com

***Abstract*— *The article discusses constructive and technological solutions for the repair and restoration of sewer collectors by the open method using polymer concrete. It is proposed to perform these works using pneumatic and inventory formwork. Two compositions of polymer concrete, their physical and mechanical properties, and technological features of their use are presented. The scheme of reinforcement of the vaulted part of the collector, which was destroyed as a result of gas corrosion, is determined. The sequence of repair and restoration works using polymer concrete is considered.*

***Keywords*— *Sewer collector, repair, restoration, pneumatic formwork, polymer concrete, work technol.*

I. Introduction

According to studies /1, 2, 3/, during the process of wastewater transportation, the vaulted part of the collectors is destroyed, while the tray part, which is usually constantly filled with wastewater, remains intact. Using the surviving tray part makes it possible to restore the collector with minimal material and labor costs. In this case, the tray part can be considered as the main supporting structure, for resting on it and connecting the new vault structure to it. One of the options for repairing and restoring the collector is to create a new vaulted part using polymer concrete reinforced with composite reinforcement. Effective in this case is the use of pneumatic formwork laid in the surviving tray and installation of inventory metal formwork on top of it. At the same time, space should be provided on top of the inventory formwork to fill the space between the self-sealing polymer concrete formwork.

Between 1960 and 1980, about 60% of sewerage networks were built in Ukraine, most of which are shallow (the bottom of the pipelines does not exceed 8 meters) with a diameter of 600-1000 mm. However, since there is still no effective mechanism for monitoring the technical condition of sewer collectors, preventive and repair and restoration work is usually carried out in the event of emergencies. As a result, for example, in Kharkiv and the region, more than 70% of sewer pipelines are beyond the limit of depreciation and require repair work [1-4].

The analysis of numerous studies shows that the vaulted part of the collector structure is primarily damaged due to the high concentration of hydrogen sulfide in the “above-water” space. While the tray part of the pipelines remains intact due to its constant contact with wastewater. It follows that it is advisable to consider the possibility of repairing and restoring sewer collectors using and incorporating the existing tray part into the operation. This will ensure long-term uninterrupted operation of engineering networks and provide reasonable cost-effective solutions for the work.

Works [2, 5] consider several options for creating a new vaulted part by the open method. The tent method introduced in Hungary has been known for many years. When using this method, the roof part of the collector is subject to replacement [2]. In Kharkiv, the technology of installing a factory-made tubular reinforced polyethylene anchor structure in the preserved tray part with its subsequent concreting using specially designed formwork with concrete mixture was introduced [2, 5]. Currently, the replacement of destroyed collectors constructed of reinforced concrete pipes with polyethylene and fiberglass pipes is widely used.

Paper [6] considers options for repairing and restoring sewer collectors using clinker bricks. To use clinker bricks, research was conducted to select bricks from the variety of bricks available in the construction markets of Ukraine. The corrosion resistance of the brick was determined experimentally in the university laboratory and by keeping it for a long time in a biocamera (a sewer shaft in a deep tunnel in which the concentration of hydrogen sulfide was several times higher than the regulatory maximum permissible concentration). The choice of a solution that could withstand gas corrosion was made experimentally. Brickwork was performed using pneumatic formwork [6]. For the first time in domestic practice, it was decided to carry out repair and restoration work on collectors by constructing a vaulted part using reinforced polymer concrete (Fig. 1) [7, 8].

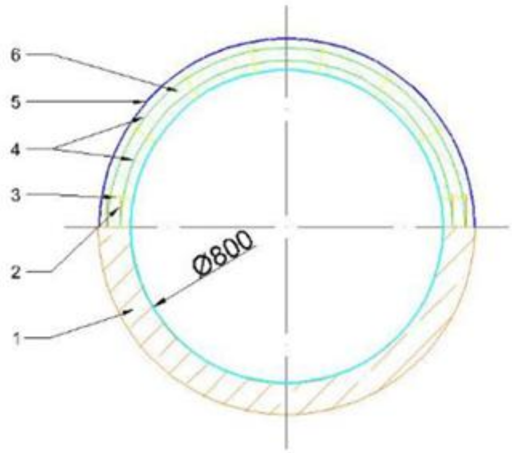

Fig. 1. Scheme of collector repair and restoration using polymer concrete
1 - existing tray part; 2 - existing reinforcing rods; 3 - pneumatic formwork; 4 - composite reinforcement, 5 - inventory formwork; 6 - polymer concrete

Due to their high wear resistance and resistance to aggressive environments, polymer concretes are successfully used in the lining, restoration and repair of sewage network piping systems [9]. Polymer concretes based on furan and epoxy resins work well in systems of concrete and reinforced concrete pipelines of sewage networks, which are most resistant to biologically aggressive water environments of wastewater, aggressive effects of sulfuric acid aggression and gas corrosion under conditions of high concentrations of sulfur dioxide, carbon dioxide and ammonia [10-12]. For the experiment, two compositions of polymer concrete based on furan and epoxy resins, hardeners, mineral fillers, and aggregates were considered.

The polymeric binder for furan polymer concrete is furan resin of the "SQG" series, which is used in the technological processes of manufacturing cold-hardening mineral-resin mixtures and cured with acid catalysts. For hardening, the acid catalyst of the GS series was chosen, which has a low viscosity and ensures the formation of a homogeneous mixture of liquid and solid components of the composition. The aggregates are quartz sand (fraction 0.5-2 mm) and crushed stone (three fractions from 5 to 40 mm), and the filler is andesite flour. The thickness of the polymer concrete layer is 100-200 mm. When laying furan polymer concrete, the ambient temperature should not be lower than 10-150C. In 30-40 minutes after laying, the temperature of the mixture rises by 25-400C and rapid hardening occurs (in 2-3 hours). Subsequently, polymer concrete gains strength. The average compressive strength of furan polymer concrete after 90 days of curing is 45-55 MPa, the maximum is up to 100 MPa.

The basis of epoxy polymer concrete is ED-20 epoxy resin, which is hardened with an aliphatic amine curing agent, PEPA. The filler and aggregates are similar to the composition based on furan resin. Epoxy polymer concrete reaches its solid state in about 30-60 minutes. The physical and mechanical properties of epoxy hardened polymer concrete are as follows: density 2200-2400 kg/m'; compressive strength 90-110 MPa; tensile strength 9-11 MPa; linear shrinkage during hardening 0.05-0.08%; water absorption in 24 hours 0.01%; Martens heat resistance 1200C.

As in the case of clinker bricks, the use of pneumatic formwork was proposed for the work and the use of polymer concrete. If in the previous case it was sufficient to create a new crypt, when using polymer concrete, it became necessary to develop an auxiliary side inventory formwork. This formwork is mounted on both sides of the pneumatic formwork in such a way that a closed circular profile of the new vaulted part is created during concreting.

To conduct research, a fragment of the tray part of the collector with an internal diameter of 800 mm and a length of 1000 mm was delivered to the laboratory of the Department of Reinforced Concrete and Stone Structures. In this case, it serves as a supporting structure for the creation of a new crypt on its basis. During the preliminary calculations of the bearing capacity of the new vault, a reinforcement scheme using composite fiberglass reinforcement was determined (Fig. 2).

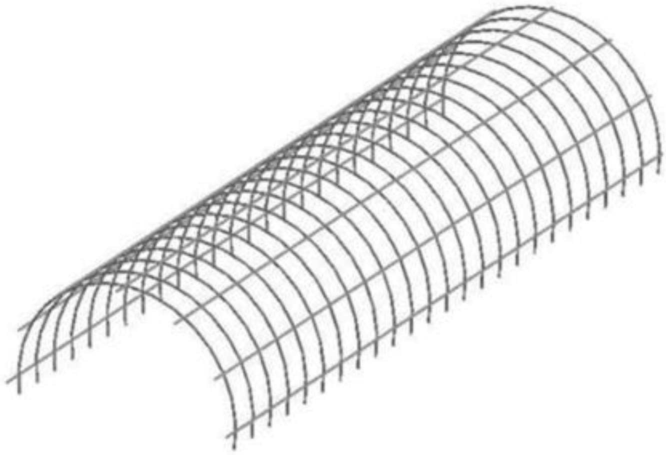

Fig.2. Scheme of reinforcement of the vaulted part of the collector with composite reinforcement:
vault diameter 800 mm; length 1000 mm; transverse reinforcement d=8 mm; - pitch - 60 mm; longitudinal reinforcement d=8 mm; - 7 pcs.

When polymer concrete is used to restore the collector, the following sequence of works is provided [7]: cleaning of the collector from the elements of the destroyed vault part; installation of pneumatic formwork in the preserved tray part; reinforcement of the collector vault, including the connection of new reinforcement with the reinforcement outlets of the preserved tray part; installation of inventory formwork on the sides of the pneumatic formwork; concreting the vault with polymer concrete; dismantling of pneumatic and inventory formwork after the concrete has reached the required strength.

II. Conclusion

The use of the preserved tray part of the corroded sewage collectors makes it possible to create a new vaulted part on their basis using polymer concrete reinforced with composite reinforcement. High efficiency is achieved by using pneumatic and inventory formwork. The developed technology of works with the use of polymer concrete has a 2...3 times lower cost compared to the use of polyethylene or fiberglass pipes for repair and restoration works, the diameter of which is smaller than the diameter of the collector to be restored.

References

[1]. Abramovich I. A. Kanalizaciya goroda Har'kova (1912-1980 gg.) Opyt proektirovaniya i stroi-tel'stva. Har'kov: Osnova, 1997. 220p.
[2]. Goncharenko D. F. Ekspluataciya, remont i vosstanovlenie setej vodootvedeniya: monogra-fiya. Har'kov: Konsum, 2008. 400 p.
[3]. Goncharenko D. F., Alejnikova A. I., Gudilin R. I. Kanalizacionnye tonneli i kollektory - na poroge ekologicheskoj katastrofy. Naukovij visnik budivnictva. 2018. №4 (93). S. 110-115.
[4]. Programma razvitiya KP «Har'kovvodokanal» do 2026 goda. Harkgv, 2012. 115 p.
[5]. Dobryaev A. A. Opyt likvidacii avarij na setyah vodootvedeniya otkrytym sposobom. Naukovij visnik budivnictva. 2004. №26. S. 89-94.
[6]. Gudilin P.I. Remontno-vidnovlyuval'ni roboti na kanalizacijnih merezhah z vikoristannyam vidkri-togo sposobu. Harkiv: UkrDUZT, 2019. No 185. P. 52-61.
[7]. Goncharenko D.F., Starkova O.V., Gudilin P.I., Degtyar Є.G. Zastosuvannya pnevmoopalubki dlya remontu ta vidnovlennya kanalizacijnih truboprovodiv z vikoristannyam klinkernoї cegli ta polimerbetonu. Ukraїns'kij zhurnal budivnictva ta arhitekturi. 2021. №1. P. 26-33.

[8]. Gontscharenko D., Ratschkowskij A., Gudilin R., Degtjar E. Renovierung und Wiederherstellung von Abwasserkanälen flacher Verlegung in offenem Verfahren, Korrespondenz Abwasser, Abfall-2020 (67). Nr. 8. 593-597. www.dwa.de/KA
[9]. Shapovalov B.M. Tekhnologiya polimernyh i po-limersoderzhashchih stroitel'nyh materialov i izde-lij. - Minsk: Belarus. navuka, 2010. - 454 p.
[10]. Erofeev B.T., Fedorcov H.P., Bogatov A.D., Fe-dorcov B.A. Osnovy matematicheskogo modeliro-vaniya biokorrozii polimerbetonov// Fundamen-tal'nye issledovaniya. 2014. №12. P. 701-707.
[11]. Frog D.B., Primin O.G., Ten A.E. Rekonstrukciya truboprovodov s ispol'zovaniem polimerbetonov. Stroitel'stvo i rekonstrukciya. 2019. №3(83). p. 120-128.
[12]. Dongpeng M., Zhongming Liang, Yiping L., Zhenyu J., Zejia L., Lscheng Z. and Liqun T. Mesoscale modeling of epoxy polymer concrete under tension or bending. Composite Structures. 2021. Vol. 256. 113079.