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Research Article

Pressurize Cavity Between Building Structures at The Facility of Sewage System in Kyiv

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Keywords

Junction,
Water leakage, Pressurizing,
Polyurethane material SPT® Resins,
Injection.

Abstract

The article examines the possibility of sealing cavities between buildings structures of the sewage network using polymer material SPT® Resins. The need to pressurize junctions, in particular at sewer network facilities, is a widespread problem that requires a quality solution. The authors conducted a laboratory experiment, based on the results of which sealing of connections was performed on a real object with a further inspection of the state of the sealed connection. Based on the results of the work, conclusions made about the effectiveness of the technology of sealing cavities between building structures using polymer material SPT® Resins.

1. Introduction

During reconstruction chambers, KK7, KK8, KK1a of jumper between Livoberezhniy collector and sewerage station «Poznyaki» on Kollectorna 1 in Darnitsky district of Kyiv, cavities were found at the junctions of fiberglass pipes to an outer reinforced concrete structure of the chambers (fiberglass pipe was mounted in a reinforced concrete pipe during last reconstruction of sewage system) (Figure 1). There was an intense water leak through the detected cavity into a construction.

Groundwater supply is carried out mainly due to a hydraulic communication with the water of nearby lakes, infiltration of precipitation, and due to loosening of water from the water supply system.

Figure 1. Junction of fiberglass pipes to the outer reinforced concrete structures of the chamber

Leaky connections between building structures is a problem that needs to be solved. Such a problem is widely encountered in sewage network facilities. It leads to the gradual destruction of building structures, therefore, the search for a possible solution to the problem is quite an important task.

2. Analysis of information sources

Before developing recommendations for pressurizing damaged junctions of fiberglass pipes to outer reinforced concrete structures of the chambers, we analyzed the results of experimental studies and similar operations that were performed previously. We could give water resistance and water impermeability properties to cavities by compaction of the soil mass adjacent to the tunnel using of cementation, clay, silicate or other methods such as injections of special mortars for outer jacket, sealing joints and holes with quick-hardening materials or pneumatic concrete [1]. The modern building market suggests a wide choice of materials and technologies of applying damp-course during the construction of buildings or structures, but recovery solutions of a joints between prefabricated elements are recommended by regulations or scientific and technic literature are absent. Current solutions of junction recovery are designed for sealing panel and industrial building constructions [2], expansion joints of the water-resistance cladding of canals and bodies of water [3], and cracks repairing [4]. Technologies which we could use for pressurizing previously mentioned constructions are too labor intensive, time-consuming and they are also conducted with damaging construction [5], this is unacceptable for the current occasion. Despite this, the authors of the current article carried out a few experiments of sealing voids using polyurethane material SPT® Resins [6, 7]. The technological solutions of works in real conditions of construction were worked out, based on the results of previously mentioned research.

3. Results of the research

Primarily inspection of damaged junctions of fiberglass to the outer reinforced concrete structures of the chamber was carried out. As a result of inspection was established that during manifold sanitation fiberglass pipe was mounted with a gap (from 2 to 10 cm) to the current reinforced concrete structure. Due to a project, space between fiberglass and reinforced concrete pipe must be filled with grout. The cavities were detected between both structures, especially in the upper part (Figure 2). That cavities were along the entire length of the fiberglass pipe. Edges of pipe junctions to the structure of the chambers were walled up with a brick on cement mortar, thickness was 120 mm.

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Figure 2. Photo of cavities in the upper part of the manifold above the fiberglass pipe

Visual inspection was carried out by video recording of cavities in the upper part above the fiberglass pipe with a remote mini-camera. Throughfall holes were detected in the outer reinforced concrete pipe at a distance of 1,5-2 m from the ends behind which placed cavities that filled with water.

Summarizing results of the structures inspection was determinated that water accumulates in the cavities behind reinforced concrete pipe and then due to holes in the pipe goes to the gap between fiberglass pipe and outer reinforced concrete pipe, then flow outside through holes in brickwork.

A researchable object was carried out trial pressurizing a single junction in chamber KK-8(Figure 3).

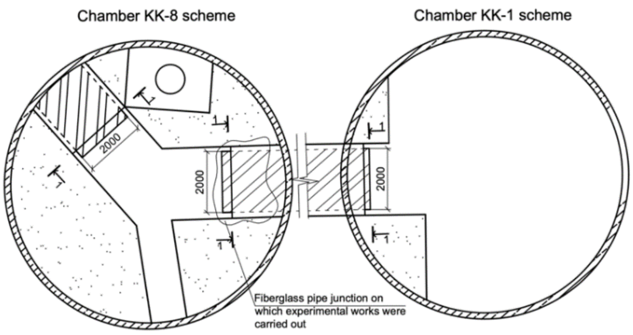

Figure 3. Scheme of the chambers KK-8 and KK-1 with trial pressurized junction

According to the detected defects of the junction and given of experience of implemention similar projects, was developed an experimental research program of junction pressurizing single junction in chamber KK-8. As per the program provided next point:

- *Visual inspection of damaged zones;*
- *Designing constructive-technological schemes of junctions pressurizing;*
- *Preparation works;*
- *Junction pressurizing;*
- *Humid state monitoring of junction.*

It should be noted that planning of pressurizing joints of the chamber was performed according to the result previously executed experimental studies. The research was performed in a specially equipped laboratory in conditions close to real using polyurethane material SPT® Resins. Studies of the efficient and feasibility of four technological solutions of a joint sealing between concrete pipe segments were stipulated using polyurethane material SPT® Resins.

Studies of the first technological solution stipulated mounting on the first joint expanded rim. To provide better sealing between the rim and concrete structures, gaps on both sides were sealed with polyurethane foam.

Studies of the second technological solution stipulated mounting on the first joint expanded rim. To provide better sealing between the rim and concrete structures, gaps on both sides were sealed with rubber hollow sealant.

Studies of the third technological solution stipulated mounting on the first joint expanded rim. To provide better sealing between the rim and concrete structures, gaps on both sides were sealed with polyurethane sealant.

Studies of the fourth technological solution stipulated filling the joint between concrete segments of pipe by splattering polyurethane material SPT® Resins on the surface of the conjunction with the applicator.

The joints were pressurized between the concrete segment of pipe which is common uses for sewerage collectors. The specs of the pipe are:

- ✓ length – 2500 mm (was cut for 5 equal parts);
- ✓ inner diameter – 800 mm;
- ✓ outer diameter – 1000 mm.

The spreading rim is a steel rim, created form steel strip 40 mm wide and 2 mm thick with spreading machinery. In each of the rims were drilled 3 bores for installing injectors.

The special stand was designed and created for conducting experimental research. It was assembled from beams and decking of formwork. The bore 1000 mm in diameter was cut at one of the webs of the stand. Through this bore the concrete pipe was mounted. The general view of the stand is displayed in Figure 4.

The concrete pipe consisted of 5 segments that mounted one after another, one segment went outside through the bore. Between each segment was a gap 20 mm wide (for joint imitation). The pipe was wrapped with film and covered by sand. A layer of sand was 300 mm.

Figure 4. General view of experimental stand

As mentioned earlier, experimental studies are divided by technological solutions into four types. When performing the first three technological solutions, expandable rims were used, and the study of the fourth took place without the installation of the rim (Figure 5).

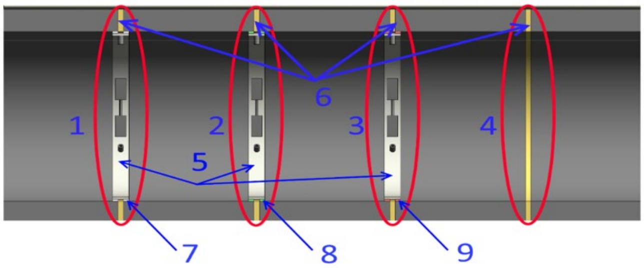

Figure 5. Cross-section of pipe with different technological solutions of pressurizing joints: 1, 2, 3, 4 – joints with different types of pressurizing;
5 – spreading rim; 6 – polyurethane material SPT® Resins; 7 – polyurethane foam;
8 – rubber hollow sealant; 9 – polyurethane sealant.

Before the injection of the polyurethane material SPT® Resins into gaps, plastic injectors were installed [7] and the polyurethane material SPT® Resins was heated to the temperature of +60 ᵒC.

For the first three experiments, the injection of material into the joints between the concrete rings began with the connection to the injector of the applicator, to which the SPT® material and compressed air are fed through rubber hoses [6]. By pressing the hook of the applicator, the injected material under pressure passed into the plastic injector and then into the joint cavity.

Firstly, the lower spots were injected, then the upper ones.

Through each injector were injected 1.91 kg of the polyurethane material SPT® Resins.

Fourth joint was filled by splattering the polyurethane material SPT® Resins into conjunction with the applicator.

It should be noted that the polyurethane material began to react (expand) and gain strength, approximately 5 seconds from the moment of its injection.

The next day after the experiment, the sand was removed from the experimental stand to the level of the bottom of the pipe, the spreading rims were removed and a visual inspection of the joints was performed (picture 5).

As a result, it was found that technological solutions for sealing the joints of concrete segments of pipe using spreading rims have proven themselves well. The fourth technological solution was unsuccessful, as evidenced by the presence of a large number of cavities in the joint.

It should be noted that in most cases the liquid polyurethane material stopped at the boundary with the polyethylene film, which was wrapped around the pipe. The fragments of joints filled as a result of the experiment make it possible to state that the liquid polyurethane material, which was fed into the joints between the concrete rings of the collector, increased several times (approximately 2.2 times) as a result of thermal reaction and gained high strength.

Subsequently, the pipe was cut in the middle of the joints, the results were analyzed and photofixation was performed (Figure 6).

a *b*

Figure 6. General view of joints after cutting: a – joint pressurized by the first technology; b - joint pressurized by the third technology

Visual inspection of the joints between the concrete segment of the pipe after cutting allows us to say that the joints pressurized by the first, second, and third technology were filled by 95-96% (Table 1), and the joint of the fourth type has a large void and inhomogeneity.

Table 1. The results of research on the sealing of joints between the concrete segment of pipe

№ technology	Temperature of supplying material °C	Volume of joint, cm³	Filling of the joint, %	Purpose of filling of the joint, %
1			99	
2	+60	56,54	96	95-100
3			96	
4			56	

Considering the values given in Table 1 constructed a diagram that is displayed in Figure 7, which shows the effectiveness of technologies for sealing joints between a concrete segment of the pipe.

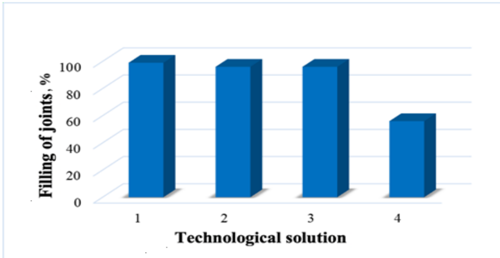

Figure 7. Filling of joints depending on sealing technology

The process of work performed on the construction site is as follows:

1) The results of the visual inspection are given previously;

2) Designing constructive-technological schemes of junctions pressurizing; (Figure 8).

The design solutions provide for the sealing of connections by injection polyurethane material SPT® inside detected cavities around fiberglass pipe. This material expands after injection in doing so displaces water and silt. According to the project, polyurethane material has to be injected through 5 holes in brickwork (Figure 9). In every single hole insert two tubes (14 mm), one of them to a depth 2.5 m, the other to the depth 1.0 m. Overall length of every single tube has to be 3.0 m or longer.

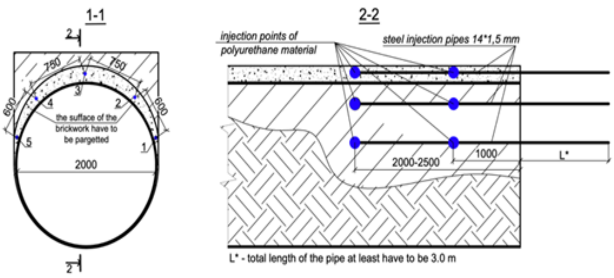

Figure 8. The scheme of placement of injection points of polyurethane material into the cavities

The technological solution provides restoration of damaged zones of masonry and plastering areas where water may flow and polyurethane material may go outside of the structure. Provided next sequence operate material injection:

- at the first stage material injection into points 1 and 5 to a depth 2.5 m;
- at the second stage material injection into points 2 and 4 to a depth 2.5 m;
- at the third stage material injection into point 3 to a depth 2.5 m;

at the second stage material injection into points 1, 5, 2, 4 and 3 to a depth 1 m.

3) Preparation operations

The next processes include; drilling holes, installing injection pipes to a project depth (Figure 5); mounting plastics injectors into injection pipes; restoration of damaged zones of masonry and plastering areas where water may flow out and polyurethane material may go outside of the structure; preparing operation station.

4) Junction pressurizing

Junction pressurizing was carried out by filling cavities with polyurethane material SPT®.Before injection polyurethane material SPT® was heated approximately to +50°C.

Figure 9. Mounting injection pipes and restoring damaged areas

Material injection started with connection of the injectors to an injection gun which polyurethane material SPT® and compressed air are fed through rubber pipes. After pushing the gun trigger polyurethane material is mixed with air and comes through the injector and injection pipe to cavities and filled them.

Figure 10. Injection process of polyurethane material SPT®

5) Humid state monitoring of junction. After 30 min when the material had completely polymerized was carried out photographing and video recording of the surface state of the pressurized junction. There was no water leakage.

The second inspection was carried out in 10 days after the previous one. There also was no water leakage (Figure 11).

Figure 11. State of junction in 10 days after pressurizing

The same constructive and technological solution could be recommended, because the carried out experimental research and overall sequence of actions have proved its effectiveness.

4. Summary

It is known from the practice of inspections of sewerage systems that frequent defects are the flow of water into the building due to damage to the collector structures (cracks, holes and, often, adjacency of structures). Elimination of leaks is a necessary measure for further operation of the buildings. Experimental studies have shown that the use of polyurethane materials SPT® injected into the body of the structure, allows to full seal the joints by increasing the volume of repair material and its complete filling in cavities, holes, etc. This eliminates the flow of water. The developed technology was tested in real conditions at one of the junctions between the segments of the pipe. Thus, this technology could be recommended to use for pressurizing cavities between structures in similar conditions. Recommendation is made on the basis of conducted research and further inspection of the pressurized junction.

Declaration of Conflict of Interests

The authors declare that there is no conflict of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1.] Sewerage. External networks and structures. Basic design provisions. Correction: DBN B.2.5-75: 2013. - [Effective from 2014-01-01]. - Kyiv: Ministry of Regional Development of Ukraine, 2013. - 219 p. - (National standard of Ukraine)

[2.] Butyl regenerate sealing material. Technical conditions: DSTU B B.2.7-78-98 - [Effective from 1999-01-01]. - Kyiv: State Construction Committee of Ukraine, 1999. - 31 p. - (National standard of Ukraine)

[3.] A method of complex sealing of interpanel joints and joints of prefabricated concrete facings of reclamation canals / SS Marchenko, PS Popov, DP Arkov, OG Semenenko. // Scientific and agronomic journal, "Federal Research Center for Agroecology, Land Reclamation and Protective Forestry". - 2018. - P. 38–41.

[4.] Testing and assessment of epoxy injection crack repair for residential concrete stem walls and slabs-on-grade - Earthquake Engineering Richmond: NAHB Research Center, Inc. Upper Marlboro, 2002. - 32 p.

[5.] Experience of work on waterproofing of underground structures / VM Dianov, AV Savich, KS Pashin, SA Grafkin. // St. Petersburg: Notes of the Mining Institute. - 2012. - P. 145–150.

[6.] Technology of sealing joints between prefabricated reinforced concrete rings with polyurethane materials SPT® Resins according to the results of experimental studies //OS Molodid, IV Reznichenko / Construction production. - Kyiv: State Enterprise "Research Institute of Construction Production". - 2020. - № 69. - P. 47 - 53.

[7.] Experimental studies of the technology of sealing joints with polyurethane materials SPT® RESINS // OS Molodid, IV Reznichenko / Construction production. - Kyiv: State Enterprise "Research Institute of Construction Production". - 2019. - № 65. - P. 54 - 59.

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