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Geotechnical protection of engineering infrastructure objects in large cities under intense anthropogenic impact and long term operation

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Abstract

This article describes more than 30-year experience of scientific and technical support, design, construction and reconstruction of water supply and sewage facilities in St. Petersburg, Sochi, etc. Describes the specific defects of long-term operation of large-size pumping stations and deep-laid tunnels that cause risks and dangers of their use. It gives the results of geotechnical and design calculations, modeling of underground and tunnel constructions taking into account risk factors determined by defects that occur during construction and operation, and also taking into account external influences, including dynamic ones. The report gives a comparative analysis of calculated and industrial experiments, provides activity and implementation experience of geotechnical support of long-term operation of engineering infrastructure .

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Keywords: safety, : monitoring, geotechnical analysis, objects of water disposal, deeply lying constructions, tunnels, geoecological safety.

1. General information about the objects of deep engineering infrastructure in large cities

With long-term operation and intensive development of engineering infrastructure of megalopolises increase the

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requirements to the ecology and efficient usage of land resources. During engineering development of underground spaces of such a megalopolis, design of integrated measures for protection of town-planning environment against negative anthropogenic impact is of special actuality. Thereupon there must be introduced special safety requirements for the sewage and water treatment facilities.

Sewage (transportation) of waste waters is done through the city sewerage system and tunnel collectors. In the general drainage system these facilities account for up to 60% in large cities and up to 70% in difficult hydrogeological conditions by construction volumes and costs.

Sewerage system objects data for the most typical Russian cities with the population over 1 million people is given in table 1.

Table 1. Length of sewerage networks and tunnel collectors in large cities of Russian Federation.

City	Sewerage networks length, km	Tunnel collectors length, km
Moscow	8354	550
St. Petersburg	8245	290
Volgograd	1054	52
Yekaterinburg	1220	230
Novosibirsk	1150	145
Samara	1200	215
Ufa	900	180

By now around 88% of all sewage collectors are made of ferroconcrete, around 7% - of metal (steel, cast iron), around 3% - of bricks, plastic, ceramics. Tunnel sewage collectors diameter is from 1.2 to 5.6 m, they are buried from 3 to 60 m underground. For example, in St. Petersburg all sewage network is divided into three basins that serve three main pumping plants up to 70 m deep and up to 66 m in diameter, with productivity of 1.5 mln m3 of sewage per day. For such conditions the main constructive solution for the tunnels are the ferroconcrete tubings with inner ferroconcrete jackets.

Transportation volumes of waste waters in some sections of the tunnels reach 20 m3 per sec, and in case of decrease of their operational reliability or failure will inevitably lead to a technospheric catastrophe.

“Lengiproinzhproekt” institute together with the St. Petersburg State Transportation University has been providing scientific and engineering maintenance, design, construction and rehabilitation of St. Petersburg sewerage system objects for more than 30 years: more than 70 pumping plants, including those with depth of 45 m, 59 m and 71 m, and with diameters of 47 m, 59 m and 66 m; more than 15 km of tunnel sewage collectors with diameters of 1.85, 2.5 and 3.4 m and with depth of 16 m, 24 and 37 m.

Table 2 shows the most typical defects of long-term operated pumping plants and deep tunnels.

Analysis of the materials of the investigations shows that at the moment 60% of gravity sewage tunnels and 80% of pressure sewage tunnels require repairs and sanitation. Instrumental probing (with geological radar) shows that 70-75% of inner surface of pumping plants wells and sewage tunnels have continuity violation and cracks which require strengthening of construct and renewal of waterproof shell.

Table 2. The list of defects typical for the long-term operated (more than 30-45 years) deep pumping plants and tunnel collectors.

Location of the defect	Description and photo of the defect		
Sunk wells walls	Up to -25÷30m marks.	-30 to -40÷45m marks.	More than -45m marks.
	On some sections of sunk well walls there’s leakage through knots. In the knots area there’s leakage of concrete corrosion. Defects are of repetitive nature.	On the surface of the wall there’re marks of intense leakage through the cracks. Defects are of mass nature. In the knots area there’s leakage of concrete corrosion.	On the surface of the wall there’re marks of intense leakage through the cracks. In the knots area there’s leakage of concrete corrosion. Defects are of mass nature.