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

Sécurité géotechnique d’ouvrages du génie civil sous influence anthropogène intense et exploitation à long terme

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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. It 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.

RÉSUMÉ : L’article décrit l’expérience de plus 30 ans d’assistance scientifique et technique, en conception, construction et restauration d’infrastructures de distribution d’eau et d’évacuation des eaux usées à Saint-Pétersbourg, Sotchi, etc. L’article détaille les défauts typiques des stations de pompage de grandes dimensions et des tunnels profonds, exploités sur le long terme et amenés à des niveaux de risque et de danger au cours de leur exploitation. On donne les résultats des calculs géotechniques et de conception, en simulant le fonctionnement des tunnels profonds, compte tenu des facteurs de risque induits par les défauts apparus aux étapes de la construction et de l’exploitation, ainsi que des influences extérieures, y compris les influences dynamiques. Le rapport présente l’analyse comparative des expériences théoriques et pratiques, et fournit les mesures à mettre en œuvre pour la sécurité géotechnique des ouvrages de génie civil exploités à long terme.

KEYWORDS: 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 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.

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

<table>
<thead>
<tr>
<th>City</th>
<th>Sewerage networks length, km</th>
<th>Tunnel collectors length, km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moscow</td>
<td>8354</td>
<td>550</td>
</tr>
<tr>
<td>St. Petersburg</td>
<td>8245</td>
<td>290</td>
</tr>
<tr>
<td>Volgograd</td>
<td>1054</td>
<td>52</td>
</tr>
</tbody>
</table>

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 m$^3$ 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 m$^3$ 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.