

## 15th International scientific conference “Underground Urbanisation as a Prerequisite for Sustainable Development”

## Preservation of urban historic centers

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**Abstract**

The subway construction in St. Petersburg is a very important challenge for the development of the city. The existing stations are dramatically deficient, especially in the city's bedroom suburbs. The end stations are overloaded, and parallel subway lines have to be built to relieve the available ones. The subway in St. Petersburg is mainly a deep-level one, as stable water-free rocks (Proterozoic clays) are at depths of over 40 m. Located higher are unstable aqueous sand-clay Quaternary varieties prone to frost heave, and parent Upper Vendian clays, characterized by fissures and sandstone interbeds of varying thickness. But even at significant bore depths, ground surface movements occur on large areas covering several hectares of the city's territory. The current technology of construction of subway station hubs and inclined escalator tunnels lead to significant deformations of the overlying rock and of buildings and structures erected on it, sometimes resulting in loss of structural strength and full decommissioning of buildings. The rehousing of dangerous buildings and their repair require sizeable funds and time for reconditioning of the buildings. This is especially intolerable for subway construction in the historic center of the city when memorial buildings and samples of architecture are subjected to total destruction. For instance, during the construction of the exit to the Griboyedov Canal from Nevsky Prospekt Station, one half of a historic building was dismantled, and for the construction of the surface concourse of Admiralteiskaya Station, an available house had to be totally pulled down, with a new one having similar facades erected in its place later. Therefore, extremely important is development and implementation of proposals to prevent intolerable deformations of existing buildings and structures in the construction of the subway and other underground facilities in the central districts of St. Petersburg. To solve the problem of ground surface deformation, an integrated approach is needed, comprising low-subsidence sinking techniques with parallel geotechnical monitoring including monitoring of low-depth displacements of the surrounding rocks, both in the vertical and horizontal plane.

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## 1. Background

Let us have a brief look at the background. The first stage of the subway in Leningrad was commissioned in 1955. At that time, there was no such thing as low-subsidence technology. “Allowed” during the construction were subsidence values of several dozens of centimeters, bringing buildings to a dangerous condition, rehousing the buildings, and suspending their operation. For instance, in the erection of Mayakovskaya Station of Subway Line 3, which is a connection to Ploschad Vosstaniya Station of Line 1, in 1964-1967 several residential houses on Pushkinskaya Street and a bath house felt an impact of ground surface deformations from sinking operations. The greatest footing deformations were recorded for the house at No. 4, whose subsidence was 620 mm. The building was also affected in the construction of Ploschad Vosstaniya Station when the subsidence reached 150 mm. The five-storey brick house at 4 Pushkinskaya Street required an overhaul reconditioning by its functional/technical condition. The crack width in the houses Nos. 4 and 6 in the drive’s area reached 70 mm. The use of some parts of Nos. 2 and 4 was stopped.

The zone of influence of sinking, inclined tunneling in particular, covered also two five-storey brick houses in Marata Street (Nos. 2 and 4) and the yard part of the building at 75 Nevsky Prospekt – these are former coach houses later raised to a third-storey height and adapted for use as residential spaces. The maximum subsidence of these buildings reached 736 mm. The houses on Marata Street leaned towards each other, with the longitudinal yard wall of No. 4 squeezed out.

It should be noted that the greatest subsidence was recorded during inclined tunneling, which was protected with an ice wall.

Nevsky Prospekt Station, Line 2 was built in 1961-1963.

In the construction of the station tunnels, the building of the former City Duma erected in 1799-1802 was affected by ground surface deformations the most. Observations using ground and wall reference marks showed that the maximum subsidence was 160 mm. The maximum settlement rate was 1.2 mm/day.

During the construction of the station, cracks up to 5-7 mm wide were recorded in some parts of the brick arches and above the door aperture lintels in the 1st storey of the building.

Later, the house was in the zone of influence of sinking for the construction of the inclined tunnel and underground concourse during the ice wall melting.

As of the end of 1965, the maximum subsidence of the foundation under the building of the former City Duma was 334 mm (Fig. 1). Vertical cracks developed in the house’s transverse walls where they abutted the façade wall. Some window openings in the façade wall of the first storey were bricked up. The building was reinforced with pre-stressed steel ties. The brick arch over a 20-meter span was reinforced with a steel tie bar.

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