The Expertise of Geo-Base, Foundations, and Deep Foundations: Regional Features of Accounting and Assessment of Deformations During Operation

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Abstract. The article publishes the results of the examination of the foundations and pile foundation of a multi-storey building during operation. In the examination of the geological base, foundations and deep foundations, significantly reliable research results are precisely with the use of the development of ground pits and modern devices for destructive and non-destructive control.

1. Introduction

Since 2015 to 2019 the Department of Expertise carried out comprehensive studies of the operated residential 5-storey brick building, including the expertise of the geological base, foundations, and foundations [1,3-5].

At the surveyed object, 7 pits were developed in the most characteristic problem areas. The pits were developed in places of deformation and cracks in walls and foundations, to study the soil base, strength characteristics of the foundation and to determine its bearing capacity. On the right side of the main facade of the building along the perimeter of the loggias and end walls, 6 pits with a depth of up to 1.8 m have been developed. The dimensions of the pits section are 800x800 mm. (Figure 1)

One hole was developed using an excavator along axes 1-3 on the left side, 7500mm long, and 3000mm wide in characteristic cracks between the A1 and A3 axes.

It was revealed that the grillage under the load-bearing walls of the building is a strip-type concrete foundation with a thickness of 500-550mm and has a second step with a step from 2000mm to 36000mm in the form of columns spaced apart from each other, which are made with a width of 400mm to 600mm. The columns are located on both sides of the tape (Figure 3, 4, 5, 6). As a result of pitting, it was found that in the places of formation of cracks in the grillage, the columns in the underground part have cracks and "come off" from the main grillage, do not bear the load from the building, but only the load from their own weight, transferring it to the pile.
Figure 1. Fragment of the graphical part of the grillage plan with hundreds of cracks in the grillage and the location of 6 pits (marked in red).
**Figure 2.** Fragment of the grillage in the developed pits along the A axes (1-3).

**Figure 3.** Columns in the lower part of the grillage in the A2 and A3 axes.
Figure 4. Concrete post with a pile, separate from the main foundation of the building.

It was also found that in the places where the posts are mated, a pile with a section of 350x350, located under the lower base of the grillage, is adjacent almost close to the left. The length of the piles under the pillars was determined using spectral-time analysis. Installed as a result of destructive testing - the grillage is not reinforced.

2. Methods
Spectral-time analysis in determining the grade of piles. Non-destructive express control of the continuity of concrete and reinforced concrete structures allows you to determine the length and defects in the pile only based on the analysis of the reflectogram. To expand the capabilities of this method, the resulting reflectogram is processed using the Fourier transform. Using the obtained signal spectrum, we obtain additional information both on the length of the pile and on the depth of the location of defects. The classical Fourier transform deals with the signal spectrum taken over the entire range of existence of the variable. The use of a sliding windowed Fourier transform (spectral-time analysis) allows you to obtain, investigate, and plot dynamic spectra in the form of spectrograms and analyze their behavior in time. The spectrogram is plotted in three coordinates - frequency, time, and amplitude. In this case, the amplitude is set by the color or shade of the color of each rectangle of the spectrogram. Knowing the speed of propagation of sound in concrete, you can convert the vibration frequency into depth.

Studies to determine the grade of the pile in the developed soil pits and in the basement of the building were carried out using the PDS-MG 4 device.

To determine the speed of sound in the pile, you can use an ultrasonic device UKS-MG4 with the installation of 2 sensors at a distance of at least 1 m (the more, the more accurate the readings will be), however, the value of the speed of sound is scientifically calculated and ranges from 3800 - 4200
m/sec. The amplitude of the reflected bottom signal in the pile depends to a large extent on the properties and composition of the soil, as well as on the amount of adhesion of the lateral surface of the pile to the ground. Amplitude bursts between the beginning of the signal and its bottom reflection mean the presence of defects in the pile or any other discontinuities in the body of the pile. In cases where the adhesion of the pile to the ground is weak, the signal from the source of wave propagation in the pile (it is an elastic impact hammer) will be weakly damped, and vice versa. According to the signal graph and spectrum through the software package, where data is processed from the device, it is possible to determine the depth of pile driving, as well as to detect discontinuities in the pile body, determine the degree of adhesion of the pile to the ground. During the month of June 2019, a number of experiments were carried out on piles in the excavated pits of the surveyed building.

After processing this information from the device on a computer, the length of the pile is also determined on the signal graph after the hammer blow (Foto 3, Figure 3).

Time-frequency analysis allows with high accuracy and in the shortest possible time to determine the continuity of the structure material and analyze the state of an underground structure at a considerable depth without the need to drill near its special well (pits) and take measures to keep its walls, which increases the labor intensity and cost of work, and also violates the continuity of the structure with the ground.

![Figure 5. Test preparation.](image)

Weak attenuation of the amplitude of wave oscillations when this signal is reflected from the end of the pile indicates a weak adhesion of the pile to the ground in its upper part.
3. Results
In the tests, the length was determined for 6 piles located along the A1, A2, A12 axes both from the outside in the pits, and from the inside from the basement.

For each pile, 10 measurements were made according to the research methodology. However, if the pile is in the grillage, as in our case, it is embedded in columns, then the acoustic signal propagates not only along with the pile but also into the grillage elements. As a result, the signal arriving at the sensor will have a complex structure and it is very difficult to isolate the bottom signal from it. Therefore, if the pile is in the grillage, then the grillage around the pile must be removed to obtain the most accurate result. However, the use of jackhammers at this facility leads to additional vibrations, and as a result of shaking structures and to their collapse. In view of this, when receiving 60 plots of the "bottom signal", the averaged three indicators of the pile length were determined - 3000mm, 4000mm, and 5000mm, i.e. the minimum pile length is 3 meters and the maximum is 5 meters. All piles have a cross-section of 350x350mm. Measurements of the physical and mechanical properties of soils to a depth of up to 2 meters from the lower base of the pillars in the pits showed that under the lower end of the grillage at a depth of 2.5-3 meters, fine uniform water-saturated sand of medium density lies, and under the lower sole of the grillage lies at a depth 2.5-3 meters semi-hard loam with sand interlayers. sand is a "roofing" rigid base for piles; the use of short piles with a length of 3m, 4m, or 5m is indirectly confirmed.

In the examination of the geological base, foundations and foundations, significantly reliable research results are precisely with the use of the development of ground pits and modern devices for destructive and non-destructive control [2-15].

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