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THE EXPERIENCE OF REINFORCEMENT OF EXISTING BUILDINGS DURING CONSTRUCTION IN CONDITIONS OF COMPACT URBAN PLANNING.

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ABSTRACT

Two-level underground part of 12-storeyed dwelling building was constructed in the historical center of Moscow in 2000.
The strengthening of foundations was carried out by pressing in of tubular and concrete piles or by placing of bore and injection piles, depending on the results of mathematical modeling. Geotechnical monitoring of the adjacent buildings was carried out in the process of strengthening and new construction. The results of monitoring confirmed the correct way of the chosen solutions: the settlements did not exceed the ultimate permissible values.

The construction of 13-storey dwelling house including two-level underground parking was performed in conditions of compact urban planning of Moscow historical center.

In constructive sense the building under construction is presented by frame of pylons and continuous plates of partitions made of monolithic reinforced concrete. House footing is executed as monolithic reinforced concrete slab of 1.0 m thickness. Assumed load on foundation soil was 300 kPa, predictable average settlement of building under construction was 37 mm.

Trench of 5.8m depth was made for arrangement of underground part of building. Sheet-pile enclosure of trench was performed with the help of screwing pipes of 325 mm in diameter and 12 m length with a pitch equaled to 0.5m. Anchor system of pipes by 535mm diameter was performed in two levels.

Geologic and lithologic structure of area is presented by the following engineering and geological elements (top-down):

1 – fill-up soil with debris, by capacity to 3.8m;

2 – alluvial sands from fine to coarse, hard, by capacity to 4.0 m, φ = 30-32°, C=2 kPa, E =25 MPa

3 – drift clays of soft and hard wet constituency, by capacity up to 3.9 m, φ = 10-12°, C = 22-26 kPa, E = 10 MPa

4 – cretaceous sands coarse and gravelly hard, by capacity up to10 m, φ = 35°, C= 0 kPa, E = 30 kPa.

Unfavorable physical and geological processes and effects in soils during investigation for construction of building were not found. Subsoil waters are exposed at the depth of 6.0 m from the surface of the ground.

The circumstance that complicated the construction was the following: three existing houses (Fig. 1) located practically right against building object fell into zone of influence of building under construction. The complex of works including a number of stages was fulfilled to provide safe operation of these houses both during the process of construction and after setting new building into operation.

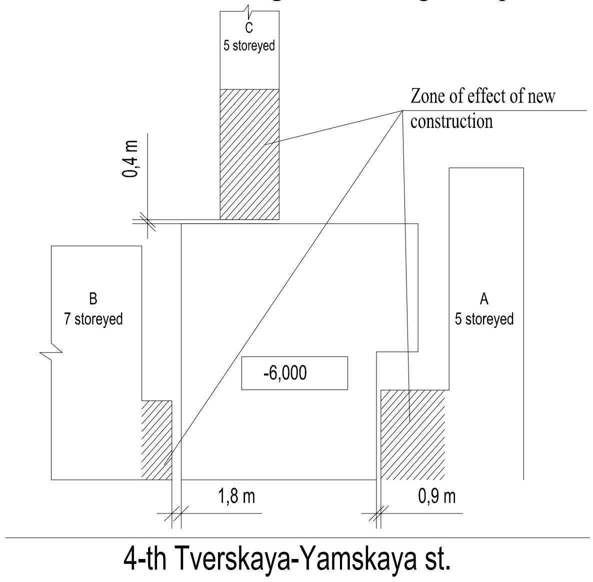

Fig. 1. Diagram of disposition of buildings.

It was established at first stage of works that areas of houses A, B, C shaded on the drawing 1 fell into direct zone of infection of construction. The following characteristics of these houses were found with the help of investigation.

A – 5-storey building of administrative destination with basement at the grade 3.50 from the ground surface. In constructive sense it has exterior and interior supporting walls of brick and wooden floors at metal and wooden beams. Footings are contentious of rough limestone on the base of whitewash. The depth of foundation from basement floor ~ 1.40 m, the width of bottom – 1.20 m. Distance from wall of house to edge of trench is 0,9 m;

B – 7-storey residential construction with basement at the grade – 3.00 m, including exterior and interior supporting walls of brick and wooden floors. Footings are contentious of brick and rough limestone on the base of whitewash with depth of foundation ~ 3,4 m, base of foundation depth is 1.70 m. Distance from wall of house to edge of trench is 1.8 m.

C – 5-storey residential construction without basement with exterior and interior supporting walls of brick with wooden floors, contentious footings of brick on the base of mortar with depth of foundation 3,20 m, base of foundation depth – 0,8m. Distance from wall of house to edge of trench is 0.40 m.

Technical state of surrounding buildings was estimated as satisfactory before construction.

During the second stage beacons were placed on the cracks existing in building structures to measure crack opening, and marks for measuring of foundation settlement were put on walls. Two cycles of observation for definition of dynamics of deformation processes was performed before start of construction.

During the third stage the estimation of new construction on surrounding building up was performed with the help of method of mathematic modeling of ground deflected mode change. The improved Kulon-Mor elasto-plastic model was used as geotechnical model of bottom soil. The results of calculations, conducted in NIIOSP, with the use of program complex «Plaxis» permitted to:

- Precise the zones of infections of new construction on adjacent buildings A,B.C;
- Estimate the size of additional house settlement in result of construction;
- Recommend optimal decision on shoring of foundation of these houses. The calculations showed that the values of additional deformation of foundation will be the following without arrangements on shoring of foundation of houses:
- for house A maximum settlement $S_{max} =$ 50мм - relative difference of settlements is 0,002;
- for house B maximum settlement $S_{max} =$ 30мм - relative difference of settlements is 0,0025;
- for house C maximum settlement $S_{max} =$ 32 мм – relative difference of settlements is 0.0021.

It should be noted that actually bedding deformations could be even bigger since calculations didn’t take into account technological influence on the foundation during the arrangement of sheet-pile enclosure of trench.

According to existing in Moscow standards similar additional bedding deformations are inadmissible even for houses A, B, C, which are in satisfactory state. Thus at forth stage the following technical solutions on shoring of foundation were worked out:

- shoring of section of houses A and B by indenter tube-concrete piles, by length of 9 and 10 m;
- shoring of section of house C by boring and injection sloping piles by length of 8 m.

According to data of mathematic modeling the efforts which should have been perceived by piles were the following: for house A-5560 kH, house B-6650 kH, house C- 4530 kH that consisted maximum 70% of existing loads.

At the same time the predicted values of bedding deformations of buildings decreased to values:

- house A, S_{max} = 12mm, relative expense of settlements = 0,0005;
- house B, S_{max} = 16 mm, relative expense of settlements = 0,001;
- house C, S_{max} = 14 mm, relative expense of settlements = 0,001.

These values of additional deformations provided with normal conditions of operation of existing houses during construction of new building.

At fifth stage the shoring of foundation was performed. The indentation of piles was made from two sides of shoring walls including load transfer to them through monolithic grillage of beam type installed in embrasures. The calculated values of assumed load on piles were 65-79 tons accordingly. Piles of 219mm diameter plunged into the depth of 10-15m.

Boring and injection piles of 160mm diameter, 8mm length, were performed from exterior side of building C before works on shoring of trench and then were combined into monolithic reinforced concrete wide range with incut in existing walls and seal in house footing. The calculated assumed load on piles did not exceed 25 tons.

The works on excavation of trial trench of building under construction and installation of sheet piling started at the same time as shoring of A and B house footing.

In the process of works on monitoring (6 stage) the local inconsistency between engineering and geological conditions and data of investigation got on the stage of design works was detected. On the area of house A the interred crease of one of old channels of Moscow River was exposed.

Changeability of soil conditions on the area of house A showed in increased settlement of indenter piles and decreased values of their bearing capacity against designed values. At the same time the tendency to stabilization of settlements of piles was not observed.

The settlements were stabilized only when additional piles were made taking into account the transmission of load from building on pile work not 70%, as was stipulated by the project but 100%.

On houses B and C the values of settlements did not exceed the calculated ones (B-17mm, C-14mm).

Conclusion:

The analyzed in the present article example of reinforcement of houses that fall into zone of infection of new construction in conditions of compact planning, shows the necessity of obligatory fulfillment of monitoring and scientific maintenance of construction as well as efficiency of alternative approach application (indenter and boring and injection piles) during the working out and realization of technical decisions. Worked out by employees of NIIOSP solutions permitted the following:

- to decrease the cost and terms of works in result of application of boring and injection piles for less responsible house C without reducing reliability;
- to increase the reliability of reinforcement due to application of indenter piles with guaranteed bearing capacity on houses A and B, where it was necessary to provide operational safety of buildings with greater level of responsibility.