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DEFORMATIONS OF THE RETAINING STRUCTURES UPON DEEP EXCAVATIONS IN MOSCOW

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ABSTRACT

Foundation trenches for the buildings having underground floors and vehicular traffic tunnels are excavated in Moscow in congested urban housing environment. A retaining structure is a “slurry wall” made of cast-in-place reinforced concrete), and “soil-mixed-wall”. Retaining structures of trenches are fastened with the help of anchors, metal tie-beams, struts or floor structures. During the monitoring performed at major Moscow construction sites with deep trenches the (NIIOSP) named after Gersevanov created a database on retaining structures deformations.

1. INTRODUCTION

1.1 Relevance of the problem

Foundation trenches for the buildings having underground floors and for vehicular traffic tunnels are excavated in Moscow in congested urban housing environment. This implies the necessity to minimize the impact made by the construction of retaining structures and foundation trenches on the existing buildings, especially historical monuments. Therefore, creation of a database on retaining structures deformations during foundation trench excavation is critical for Moscow.

2. INFORMATION ABOUT SITES

2.1 Vehicular traffic tunnel for one-way traffic in Lefortovo district

Open-type construction of a vehicular traffic tunnel is being performed by the company Cosmos. The retaining structures of the tunnel’s foundation trench are made of soil-cement piles made by Jet-Grouting method. Soilmex equipment utilization for soil-cement piles construction makes it possible to apply two ground treatment methods: Jet-1 (one-component method) and Jet-2 (two-component method). The retaining structure of the foundation trench was constructed according to Jet-2 technology. The company Cosmos provided NIIOSP with a pilot section of the tunnel for full-scale experiments. The foundation trench was 11.5 m deep, 20.7 m wide and 65.0 m long (figure 1). The retaining structure of the foundation trench was a wall made of two rows of soil-cement piles with metal pipes. The retaining structures were spaced by two rows of metal-pipe struts. The foundation trench was excavated in two tiers: up to –5.7 m depth and then, after the construction of the first row of struts, up to –11.5 m depth with further construction of the second row of struts.

Figure 1. Foundation trench of Lefortovo tunnel.

2.2 14-storied residential building with two underground floors

A 14-storied residential building with two underground floors is being erected in Kapranov lane. Two existing buildings adjoin the constructed building on both sides. The foundation trench is 8.8 m deep, from 19 to 21 m wide and 27.5 m long (figure 2). The retaining structure of the foundation trench is a 0.7 m wide reinforced-concrete “slurry wall”. The spacing system consisting of metal pipes and struts is located at 2.7-3.0 m depth. The foundation trench was excavated in three stages: the first stage – from the mark 141.62-140.64 to the mark 138.70; the second stage – from the mark 138.70 to the mark 134.70 with spacing system construction; the third stage – from the mark 134.70 to the mark 129.87.

Figure 2. Foundation trench in Kapranov lane, Moscow.

3. GEOTECHNICAL MONITORING OF RETAINING STRUCTURES OF FOUNDATION TRENCHES

Inclinometric measurement of the deformations of the metal pipes relating to the retaining structure of the vehicular traffic tunnel and of the plastic pipes installed in the "slurry wall" in Kapranov lane was performed and the retaining structures convergence was measured with the help of a light range finder. Deformations were measured before foundation trench excavation, during the excavation process and after spacing structure installation. Preliminary geotechnical calculation was made according to PLAXIS 7.2 program, Mohr-Coulomb model.

4. ANALYSIS

Numerical modeling results comparison with monitoring results showed that measured displacements of the retaining structure turned to be less than the calculated values by 22…96% (figure 3).

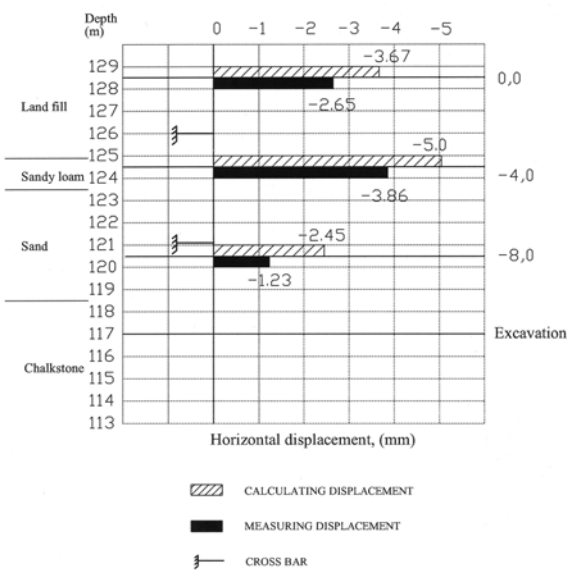


Figure 3. Horizontal displacements of Lefortovo tunnel retaining structure made of soil-cement elements in sandy soil (2002).

As for the "slurry wall" of the residential building located in Kapranov lane, the measured values also turned to be less than the calculated values. Only for two wells the measured values exceeded the calculated values by 31…89% at –6.5 m depth (figure 4). This may be explained by the fact that the calculation program does not take into account the specific nature of the work performed.

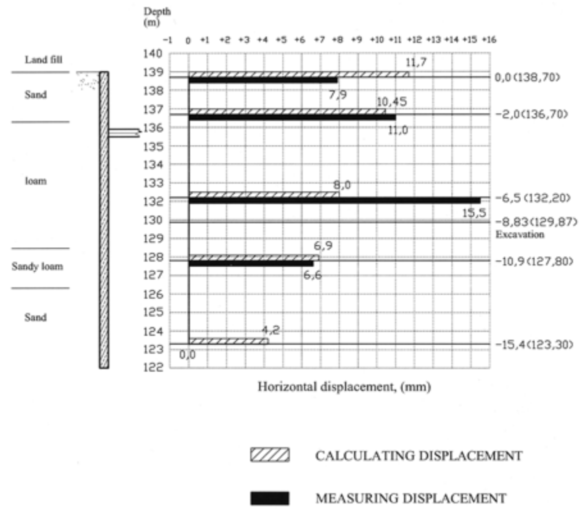
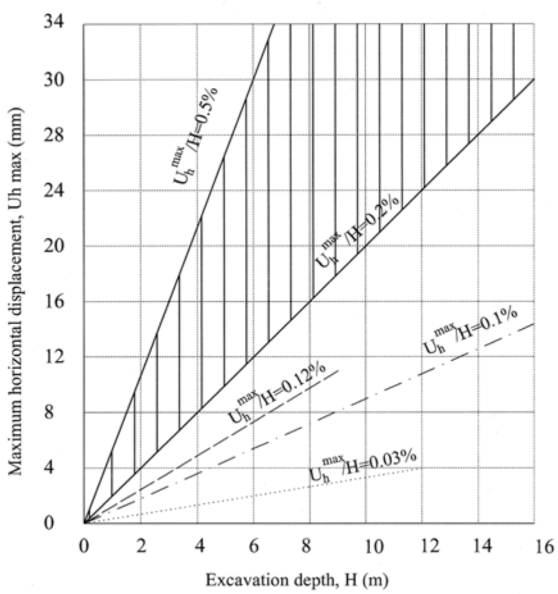


Figure 4. Horizontal displacement of the «slurry wall" at the construction site of the residential building located in Kapranov lane, Moscow, in sandy and loamy soil (2002).

We have compared the obtained results of the deformations of foundation trench retaining structures made of soil-cement elements and of the "slurry wall" at the above-mentioned sites with the generalized results of over 500 experiments performed by Ch. Moormann, H. Moormann (2000) (figure 5).

For a retaining structure made of soil-cement elements the ratio between maximal horizontal displacement U_h^{max} and foundation trench excavation depth H in sand is U_h^{max}/H=0.03%, while according to Ch. Moormann, H. Moormann (2000) U_h^{max}/H=0.1%. This discrepancy is connected with the fact that reinforcing and spacing structures were designed with margins at the pilot section of Lefortovo tunnel. For the "slurry wall" in sandy and loamy soil the ratio between maximal horizontal displacement U_h^{max} and foundation trench excavation depth H in sand is U_h^{max}/H=0.12%, while according to Ch. Moormann, H. Moormann (2000) U_h^{max}/H=0.2…0.5%.



According to Ch. Moormann, H. Moormann (2002) for foundation trench retaining structures: "slurry wall", secant contiguous bored piles, sheet piling made of pipes in hard clay and sand.

For the "slurry wall" at the construction site of the residential building located at 2-6, Kapranov lane, Moscow, in sandy and loamy soil (2002).

According to Ch. Moormann, H. Moormann (2002) for foundation trench retaining structures: soil-cement elements in hard clay and sand.

For soil-cement elements reinforced with pipes at the Lefortovo tunnel construction site in sandy soil (2002).

Figure 5. The impact of foundation trench excavation depth and retaining structure type on the maximal horizontal displacements of retaining structures

5. CONCLUSIONS

1. Deformations of two types of foundation trench retaining structures: soil-cement piles and "slurry wall" have been analyzed. The values of horizontal displacements of retaining structures in soft (sandy and loamy) soil have been obtained. For soil-cement piles the ratio between maximal horizontal displacement of a "slurry wall" and foundation trench excavation depth is Uhmax/H=0.03%, for the "slurry wall" – Uhmax/H=0.12%. These values turned to be less than the values provided by Ch. Moormann, H. Moormann (2000).
2. Measured displacements of foundation trench retaining structures made of soil-cement piles and the "slurry wall" turned to be less than their calculated values by 1.5…3 times on the average.
3. The obtained values of U_h^{max}/H almost matched the results of the research made by Ch. Moormann, H. Moormann (2000) for a "slurry wall" and for soil-cement piles they turned to be by 2-3 times less than the values provided by Ch. Moormann, H. Moormann (2000).

6. REFERENCES

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