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Restoration of the Military Club Building in Sofia, By Micro Pile Injections

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RESTORATION OF THE MILITARY CLUB BUILDING IN SOFIA, BY MICRO PILE INJECTIONS

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ABSTRACT

The building of the Military Club is one of the most beautiful architectural monuments within the Bulgarian capital of Sofia. Construction of the club in a New Renaissance style and was initiated in 1895 according to the draft of Antonin Kolar, the famous Czech architect. It was completed in 1907 by Nikola Lazarov, a no less famous Bulgarian architect. Thereafter, a long series of cultural events, important for Bulgarian history were held on in Sofia Military Club.

The building is a brick structure with three floors and a basement. Foundations are made out of massive stone blocks on the clay. The building is located in the heel of a slight slope, near the highest point of the city at the intersection of Boulevard "Tsar Liberator" and "Georgy Rakovsky" Street.

During the period between 2006 and 2008, a tunnel for Sofia subway route was built diagonally under the intersection of the two streets at depth of about 20m. A deep shaft control between tunnel and ground, surrounded by diaphragm walls was constructed about 10 m aside, in front of the building. Ground is multi-layered, including sand aquifer above in silt and plastic clay. During the construction of diaphragm walls of the trench, a drain effect quickly formed a very steep curve depression between the building and the shaft.

The rapid decline and great amplitudes of the groundwater level resulted in adverse settlement of the foundation under the front facade and arches on the facade of the building are cracking, fissures are dissolving, and a real danger for the stability of the structure occurred.

After the examinations, a micro injection with micro piles is performed along the contour of the building facade. The achievements of technology helped to achieve a high pressure injection into the solution and foundation to be slightly lifted, and cracks in the arches and columns to close.

INTRODUCTION

The Central Military Club is one of the cultural icons of Sofia. It has hosted many events such as concerts, exhibitions, meetings, theater performances, and other ceremonies (Fig.1). The construction of the club began in 1895 on land purchased for 180,000 golden Bulgarian leva. Conceived and built in Neorenesans style upon the project Antonin Kolar, Czech architect, the building was completed by the Bulgarian architect Nikola Lazarov in 1907. It became a model of the post-liberation architectural style of Bulgaria (Fig.2).

Fig.1

The building consists of two wings situated on three floors and three monumental towers whose walls are completely decorated: elegant terraces, elegant colonnades, windows with triangular pediments and rich palette of Renaissance neoclassical architectural elements (Fig.3). The interior spaces are divided by the standards of Europe's conventional military clubs from the XIX-century. Its halls are decorated with fine Italian silk, art panels, coverings marble and bronze sculptures and elegant ceiling ornaments.

The building has a great concert hall, which can accommodate up to 450 spectators. It has also a remarkable acoustics and richly decorated with beautifully painted plaster casts of various architectural elements.

Fig.2

II. DESCRIPTION OF THE GROUND STRUCTURE

The building is a brick structure with three floors and a basement. The three towers have additional fourth floor. Foundations are of massive stone blocks laid on clay. Military Club is located at the intersection of Boulevard "Tsar Liberator" and "Gerogi Rakovski" Street., in the heel of a slope, not far away from the highest geographical point of the city center. It is believed, that this place has a fault, formed more than two million years ago, and with abated movements nowadays.

Bulgaria is in the middle of the Balkan Peninsula and the region of Sofia is in danger by noticeably high seismic hazard.

Fig 3

The ground itself is multilayered; including sand aquifer and above them, there is plastic silt and clay. High levels of underground water - about 1.5 m beneath the floor of the building and almost at the foundation level were found under the Military Club. In the area, the underground water is usually at a depth of 5.5 m to 6 m. The above suggests that the high water level is probably due to damage of the antiquated sewage and water supply.

It is reported, that slight subsidences have been noticed under the foundations even 25-30 years ago due to deteriorating of soil texture, but they have now grown to unacceptable proportions.
Brick stone stripes of the foundations are at a depth of 0,8 m to 1,2 m; they are wide 60 cm to 80 cm. Verical scaffolding is brickwork. Floor structure of the building is made out of wooden beams.

III. HISTORY OF THE ACCIDENT

During the period between the years 2006 and 2008, a tunnel, deep around 20m was built below the diagonal intersection of two streets due to the construction of Sofia subway. Approximately 10 m in front of the building, a deep ventilation shaft, surrounded by a groove wall, was erected between the tunnel and the terrain. During construction of groove walls, the drainage excavation effect quickly formed a very steep depression curve between the building and the shaft. Relatively weak multilayer ground is a precondition for the rapid decrease of the ground water (Fig.4), accompanied

by uneven subsidences. This rapid decline and the large amplitude of the groundwater level resulted in unfavorable settlement of foundation under the front facade of the building at "Tsar Liberator" Blvd. Arches on the facade of the building are cracking, other cracks are opened and dissolved; and a real threat for the stability of the construction is occurring. Most probably, the imbalance of the ground when the excavator was digging for groove walls of about 20 m deep, the same has created conditions for formation of the active earth pressure wedge, and so it has resulted in subsidence of the land and building. After the construction of the subway, a vent was done, where the subsidence of the ground next to the building was measured and it accounted to about 5 mm. And although the subsidence is relatively little, the damages to the building rose quickly.

The biggest are the cracks in the southwest and the northeast tower (Fig.5), which are the most haviest parts of the building and are the closest to the shaft and the tunnel. The cracks have different widths - from barely visible to 20-21 mm each. Expanding cracks occur mainly at the sites of the two towers – the southern one and northern one. After analyses of the direction and how to open the cracks of the towers, it was found that the largest active subsidence of the soil is not positioned immediately next under the foundations of the building, but at some distance from it - close to the subway shaft. There are no cracks at the Northwest Tower, although the line of the fault goes beneath.

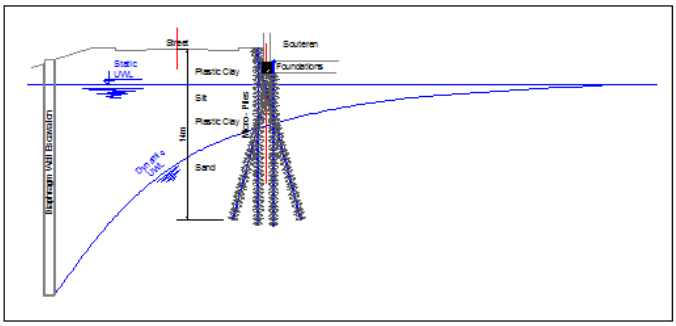

Fig. 4

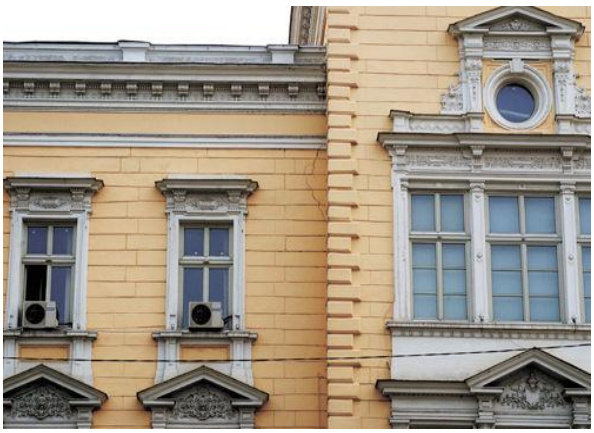

Fig.5

Strengthening of the building is preceded by several expert studies about the structure and the foundation itself.

IV. STRENGTHENING OF THE FOUNDATION AND GROUND WORKS

Two projects are designed to strengthen the building. The first project is to reinforce the ground, and the second is to strengthen the masonry crown.

After a research, two injections were performed – the one was with tilted micro piles at the sloping contour of the building facade, and the second with vertical micro piles in the fields beneath the basement floor. Thus, a powerful block of reinforced earth was created almost beneath the entire building where cracks were available. The technology achievements made it possible to do a high pressure injection solution and raise slightly, so the cracks in the arches and columns to close (Fig.6).

The injected micro piles are at basic distances of 120 cm and 100 cm from each other. The average length of the piles is 10 m, 12 m and 13 m. Injection occurred at intervals of 50 cm. Consumption of dry cement is 75 kg per interval, or 150 kg per meter (Fig.4).

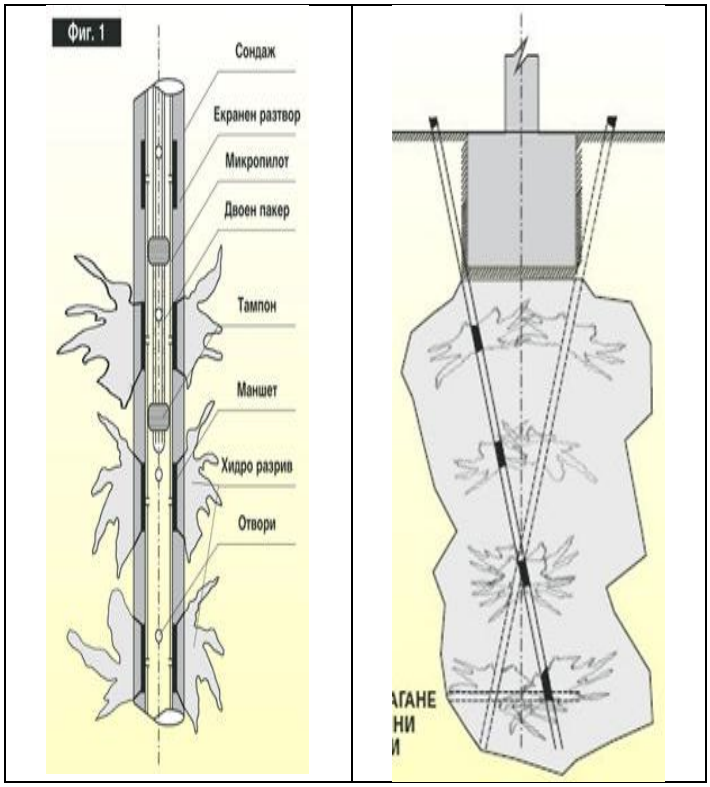

Fig. 6

There are three zones, where the micro piles were positioned. They are in the direction of both streets and in the basement of the building. First, the injection was performed from side of

the Northern Tower, and then from the side of the two towers and advancing towards the middle of the building at the same time. Together with injections on the outer side of the building, tilted micro piles inside the walls of the towers were performed too.

Fig. 7

The above injection grout contains cement, bentonite and water. 150-l solution of grout required 115 kg of cement.

Construction works were carried out under continuous instrumental monitoring. Electric sensors followed the moving of cracks. The subsidence of the building along its whole perimeter, as well as at the level of ground water, was measured continuously during injections.

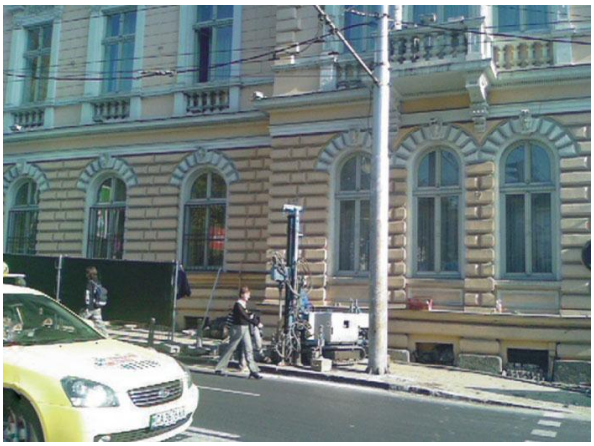

Fig. 8

The injection took place in two cycles - primary one and a secondary. The secondary injection was performed one day after the primary, and aimed to develop a high pressure, especially at the level just beneath the ground, so that the high pressure of the solution to raise the stone wall and close back the construction cracks (Fig.8). Monitoring showed that cracks have really shrunk in large degree or even closed after completing the injections (Fig 7). Suspension was the downfall of the ground and foundations.

Fig. 9

Fig.10

The next step of the reconstruction works (Fig.9) was the reinforcement of the floor structures with steel anchors in the direction of the bearing walls. In the transverse and longitudinal directions, in total there are 51 anchors, branded MINOVA, at three floor levels of SAS type 500. Strain of the anchors is to a point where the cracks in the brick walls and arches were closed. They have a thickness of 25-23 cm and a length of 600 cm to 3600 cm, according to the length of the individual walls. Once the above was done, an architectural restoration of affected zones, cracks blurring and walls repair were executed as well (Fig.10).

V. FINAL CONCLUSIONS

The micro pile injections and entire strengthening works succeeded in consolidating ground deformations and preventing old masonry of demolishing.

Conducting an instrumental monitoring enabled the process of controlled cracks closure in the building and regulating the pressure in the injected solution.

Masonry anchors into the superstructure of the building improve its bracing and absorb tensile stress.

As a result of restoration, the bearing capacity of the construction of the 110 years old Military Club is significantly greater than the one at the time of its actual erection.

VI. REFERENCES

http://www.geostabil-bg.com/