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Doctor of Technical Sciences

Kari AVELLAN / LECTIO PRAECURSORIA

The doctoral thesis presented here concerns the strengthening of the foundations of historical buildings using drilled spiral piles and measuring in the bounded space via the example of St. John's Church, Tartu.

The understanding of the meaning of architectural constructions in the environment and the protection of ancient buildings in our country is very young. Even in the '60s and '70s of the last century, many buildings of cultural-historical significance were destroyed. Their value and protection were increased greatly as a result of the activity of UNESCO. The United Nations Educational Scientific and Cultural Organisation (UNESCO) was founded in 1945 as an international organisation and declared many objects and buildings to be part of the world heritage; the ancient church at Kerimäki in Finland ranks among them.

Slide 1. Even in the era of the Soviet Union, St. John's Church, situated in Tartu, Estonia, was a scheduled monument because of its cultural significance on the European level.

Slides 2 &, 3. There were about 2000 terracotta sculptures in the Middle Ages and nearly 1000 of them have survived until today. Tillemann Bredenbachi wrote in a book published in 1558 that this church was built *"on a high artistic level and with major inputs".* These words also reflect the appreciation of the architectural mastery of the Middle Ages. The Orthodox Church built by people from Novgorod in 1100 was located on the site of this modern church. The construction works of the modern church were started somewhere around 1350 after the conquest of the territory of Tartu in the Middle Ages during the Crusades and the coming of workmen and merchants from Central Europe.

Slides 4 &, 5. During its long historical lifetime St. John's Church has been destroyed and burnt many times during numerous wars and battles. The most severe trial was in World War II, when the constructions of the roof were totally destroyed. The industrialisation of the territory of Tartu after the war led to a lowering of the ground water level that influenced the process of the destruction of the wooden foundations of the building.

Repair works on strengthening the upper circle by means of temporary needles were started in Soviet times. After Estonia's declaration of independence a fund for the support of the restoration of the church was established (the Jaani Kiriku Fund). The main goal was to remain as close as possible to the original medieval form of the building. The main financial support for the reconstruction of the church was provided by the Estonian state and town of Tartu and also by the Pohjois-Elben church and the town of Lüneburg.

A tender called "Keys to the hands" was organised for the repair works involved in the strengthening of the foundations of St. John's Church . The winners of the tender were the Estonian company AS Stinger and the consulting firm KAREG Oy from Finland, which was responsible for the training in the teamwork method used for the strengthening of the foundations, the planning of the construction and geotechnical works, and the monitoring and technical supervision of the realised works.

1. What does " strengthening the foundations" mean?

"Strengthening the foundations" means the strengthening of the subsoil under the foundations of the building, for example by filling it with liquid cement in large amounts and under pressure (the injection method).

The concept of "strengthening the foundations" may also mean the use of piles installed near the foundations or poles installed under the foundations. In this case the load from the building located above or the weight of the construction also falls on the piles.

2. Types of piles used in the restoration of at the St. John's Church

The repair works involved in the strengthening of the foundations of St. John's Church began with the tower in 1993-1994. Other parts of the church were strengthened in 1994-1996. The repair works involved in the strengthening of the church were performed with the use of piles of two types: ordinary steel compression piles and drilled spiral piles specially designed for this study by the author of the thesis.

Slide 6. The author of the thesis designed a practical and uncomplicated technology for the installation of the spiral piles for these construction works. It is possible to transfer the parts of the device manually. The piles are installed into the firm ground located under the foundations but do not reach the hard rock.

3. Ancient foundations

The church stands upon thick stonework, under which the foundations made of wood are located in two layers in a lattice. The layers above the stonework were processed with special putty and seems under the layers were filled with sand.

The foundations located under the tower were made from wooden logs in four layers in the form of a lattice. A layer of loose soil 6 m thick lay under these and after that there was a layer of solid loamy soil.

4. Strengthening of the foundations of the tower

The foundations of the tower were strengthened by means of the installation of the piles. This procedure was performed using a gradual step-by-step method of dismantling the stonework together with a simultaneous procedure of installing piles in the demolished parts and filling them with concrete in the form of plates. The weight of the tower, which stands upon four columns, is 5 500 tons. A special

“floating” foundation in the form of a plate was made for each column and was strengthened by the piles.

Slide 7. It is very important to measure the characteristics of deflection and weight during the strengthening of the foundations. These parameters were measured continuously during the work. A total of 138 piles were installed under the foundations of the tower.

Slide 8. According to the principles of the Anastylosis method, the authenticity of the construction was preserved. In some places the old stonework was partly opened. This fact enables archaeologists and engineers to study the work done.

5. Strengthening of the foundations of the walls

Slide 9. The stages of the strengthening of the foundations of the 10 m high walls without a roof on line A are shown in Slide 9. The columns on line B, which were totally destroyed during the war, and the arcuated constructions were built anew. Spiral piles were used for the strengthening.

6. Monitoring measures

Slide 10. The weight of the tower and the deflections of its upper part were measured continuously during the work. The direction of the deflections was measured at every stage of the installation procedure of the piles. The directions of the deflections of the upper part of the tower are shown in Slide 10.

7. The activities of the restored church

Slide 11. The restoration works on the facilities in the church interior were completed in 2005. A church service is shown in Slide 11. On the left-hand side it is possible to see part of the newly-built wall on line B and on the right-hand side part of the wall on line C, which is original and restored.

The church building, which is designed for different types of activities, is nowadays used as the training church for the Theological Faculty of Tartu University and as the operating church for the congregation St. John's Church's in the town of Tartu; the author of the thesis is a member thereof.