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Blasting Near Old Foundations and Strengthening of Foundation Walls for the Headquarters of the Ministry for Foreign Affairs of Finland

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Abstract Designed by architect C. L. Engel (1778 – 1840), the Naval Barracks facility was originally built in the 1820´s for the Russian Navy and also served as a shipyard. The building of national heritage is a prime example of neo-classical architecture in Helsinki. Strengthening and underpinning work for this structure was realised from 1985 to 1988. It was a part of the larger renovation project, where the building was made suitable for the Ministry for Foreign Affairs of Finland. The purpose of underpinning was to realise a new basement in its eastern part as well as to lower the basement floor level in other sectors. The ground engineering duties covered geotechnical and structural designs of temporary and permanent structures from the basement up to the ground floor.

Keywords: Blasting, shoring, strengthening, underpinning

Introduction

From the 18th century, the area of the Naval Barracks was a Swedish military base. As Finland became an autonomous Grand Duchy of Russia at the, beginning of the 19th century, Helsinki was proclaimed capital in 1812. The town was then completely rebuilt and the area of the Naval Barracks assigned for the construction of Russian military buildings. In March 1816, German-born architect C. L. Engel was appointed architect in charge of the city's building committee. After three months of planning, his layout was approved by the Tsar. At the outset, building conditions were difficult because of the winter weather as well as the proximity of the sea. Outer dimensions of the sailor barracks were to be 93 m x 13.4 m x 16 m in height, with 3 floors above basement level (Photograph 1). Later, two wings were added, and the building complex was mostly complete by 1838. Two artillery warehouses from the time of the Swedish rule remained bordering the court at the eastern and western sides (Sinisalo 1980, Kråkström 1988). When Finland gained its independence in 1917, the area was taken over by the Finnish Navy for use as a military harbour. In 1972 the state council decide to place the Ministry for Foreign Affairs in the Naval Barracks, using all the existing structures and eventually demanding the creation of additional basement space (Favorin and Ristolainen 1993). (Photograph 1).

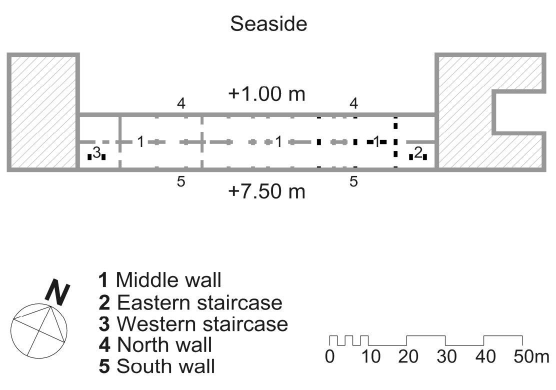


Figure 1: Basement layout and surrounding levels

Photograph 1: Ministry for Foreign Affairs Finland, north elevation (seaside)

Strengthening and Underpinning Work

The massive brick walls of the building were erected over large stone works which themselves sit on stone foundations over moraine or rock. To protect them, these walls were shored during excavation, rock blasting, underpinning, as well as during reconstruction operations. The ground engineering duties consisted in geotechnical and structural designs of temporary and permanent structures which were implemented for foundation work as well as for concrete structures from the basement up to the ground floor. They included drilled steel piles, pre-stressed rock- and soil anchors, the bolting of stone walls, concrete arches, etc. Tasks consisted in risk analysis for blasting and vertical loads of work equipment against shored structures. Removed moraine, blasted and loose rock was mucked out level by level with heights ranging from 1 to 1.5 m. Throughout the blasting process it had to be verified that the just poured concrete foundations lying on rock and moraine had a minimal strength of 5.0 MN/m² (50 kp/cm²). Blasting could be done before setting time of the concrete and in certain circumstances before its limit penetration resistance. Vertical particle velocity was monitored in the eastern and western stair columns. The allowable velocity was 15 mm/s and the horizontal accident load from the work machines was estimated at 5 kN. Duties also included design of the monitoring system and shoring. The level of the earth on the seaside (the north side) was approx. +1.00 and +7.5 on the south side (Fig. 1). Before the underpinning work the level of the western basement of the building was +3.6 and the ground floor level +8.45. (Avellan and Nissinen 2007).

From the structural point of view, the building had three load bearing walls and two sectors: the northern wall on the sea side, the middle "kernwall" and the southern wall on the earth side. Because of the presence of surface rock beneath its eastern part, the three story building only had a basement in its western sector. Both sectors, east and west, where divided by a perpendicular heavy stone wall which had to be demolished during the underpinning work. For this reason, loads of the first floor where taken temporarily, partly by steel tension ties up to the old steel beams of the second floor, and partly on drilled steel piles (Fig. 2). The permanent support realised as a concrete arch similar to the existing ones nearby (Photograph 4), also acts to retain the earth pressures at rest. It was also taken into account during the construction stages that the weight of substructure would decrease temporarily because of the demolishing of old ceilings.

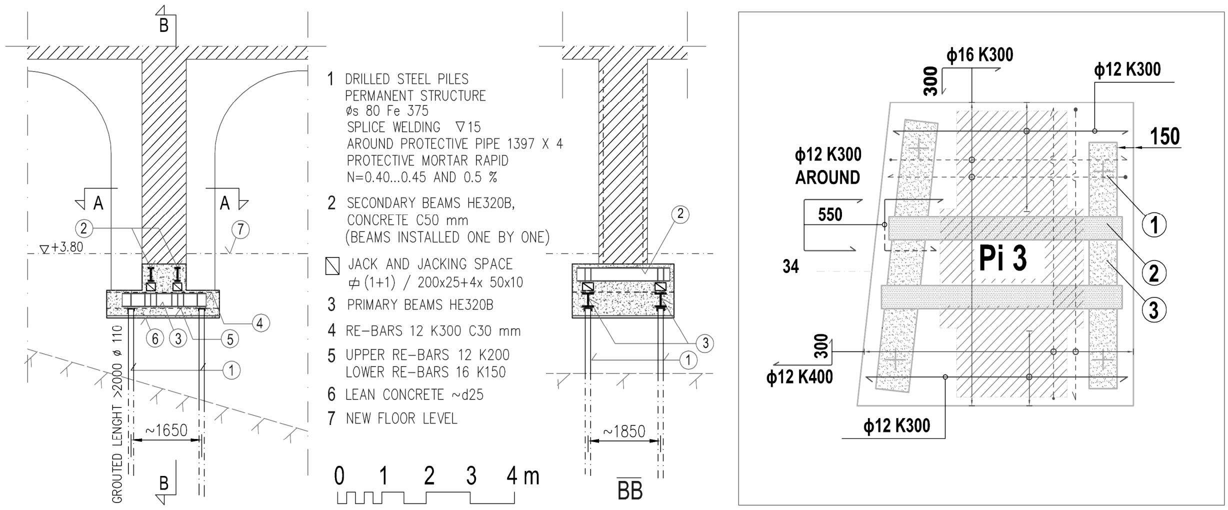


Figure 2: Perpendicular wall. Drilled steel piles. Steel beams and jacking system. Footing detail

Middle Wall

Once digging and rock blasting around and under the old brick columns was realised, new concrete ones were poured underneath them. The loads of the middle wall were initially taken on temporary structures and later transferred to the newly realised concrete column extensions. The sequence of

work proceeded as follows: First, because of the presence of stratified rock and the blasting work, steel piles were drilled and cement grouted in the bedrock on both sides on the existing wall. Piles were designed separately as point bearing and as in-rock grouted piles. Steel beams were installed through the brick wall and loads taken by jacking the piles underneath them. The jacking operation itself was controlled by levelling in order to find the right jacking forces. During the digging work, the drilled steel piles were braced by welding rolled steel angles to them, effectively making them vertical trusses (Fig. 3).

Rock blasting with explosives proceeded around these trusses with a minimum safe distance from piles to smooth blasted face of 0.5 m. For work closer to the steel piles and underneath the brick columns / brick wall, only old hand methods such as loosening rock by using wedge and hammer in close spaced holes were normally accepted. In some cases the loosening of rock could be done by hydraulic wedge machine (Photograph 2). Formwork and reinforcement were realised inside the temporary steel structures and subsequently the new column extensions poured. In one sector of the middle wall, to establish a new floor level, foundations on moraine had to be realised. As mentioned previously, the loads were taken temporarily on steel piles. In this case the sides of the brick columns were prestressed by tension bars to prevent structural collapse during underpinning work. The steel piles were drilled with Odex equipment, with a casting tube of 139.7 x 5 and a core diameter of 80. Empty space between the tube and core was grouted using a cement mix w/c=0.45 and additives.

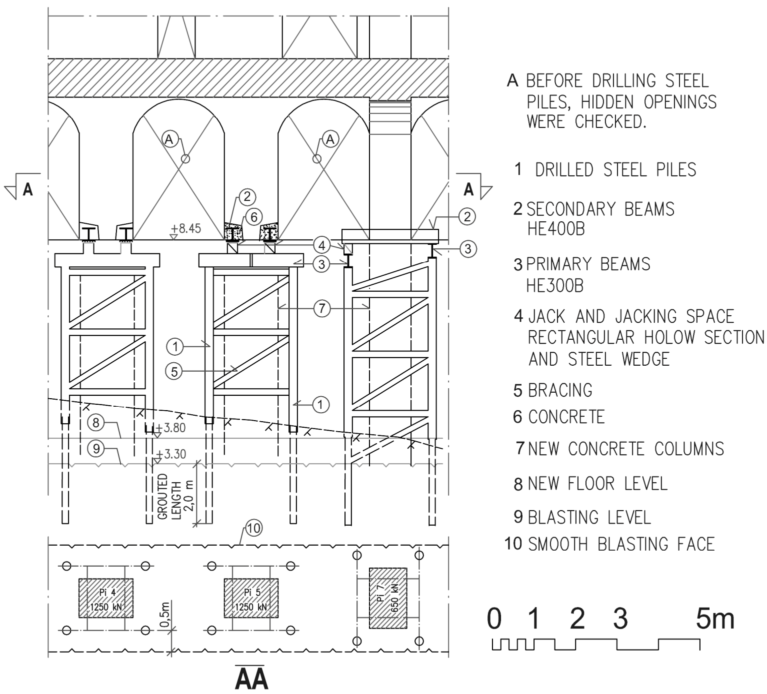


Figure 3: Middle wall, Drilled steel piles, Steel beams and jacking system, Bracing

Photograph 2: Middle wall, Drilled steel piles, Smooth blasted face

Eastern and Western Staircase Columns

As in the case of the middle wall, the loads from the brick-made staircase columns were temporarily supported by drilled steel piles. Each irregularly shaped brick column needed first to be covered in a concrete mantel. Subsequently, in order to get enough friction force between the concrete and the column, the mantel was stressed against it by tension bars. To be sure that pretension on the concrete plate was properly set against the column the mantel was divided into four sections with Styrofoam joints in between them (Fig. 4, Photograph 3). Similar structural “independent” pre-stressed panel technique was also used later on (Avellan and Maanas 2001).

For both staircases, new concrete columns were poured underneath the existing brick ones, in accordance to the original dimensions. Furthermore, to avoid blasting damages, the entire column loads were taken by vertical steel dowels between concrete and rock (Fig. 5). The blasting and loosening of rock was made as mentioned previously for the middle wall.

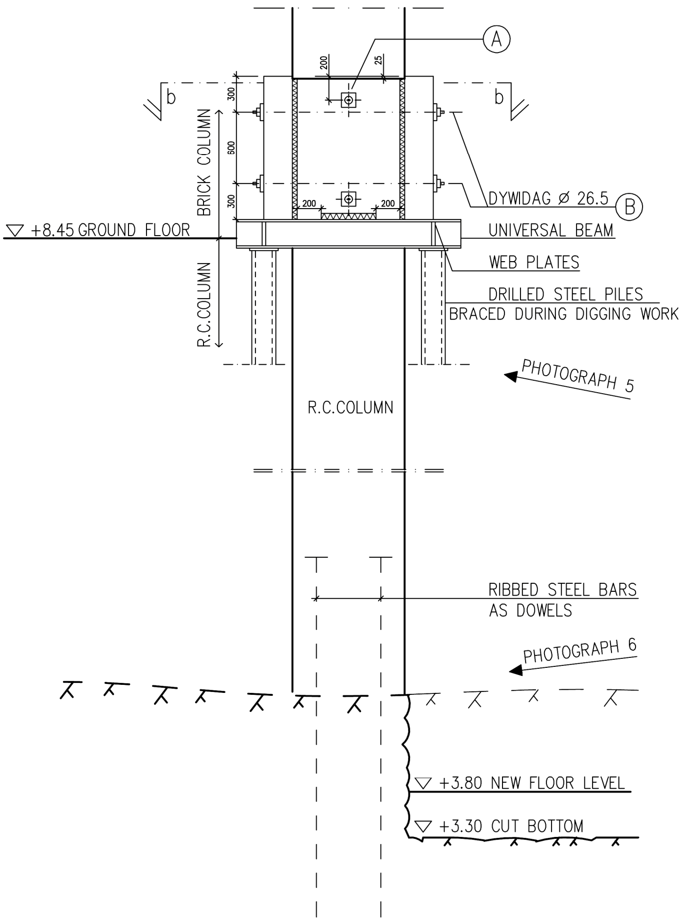


Figure 5:Eastern stair column, Pretensioned concrete mantel, Vertical steel dowels

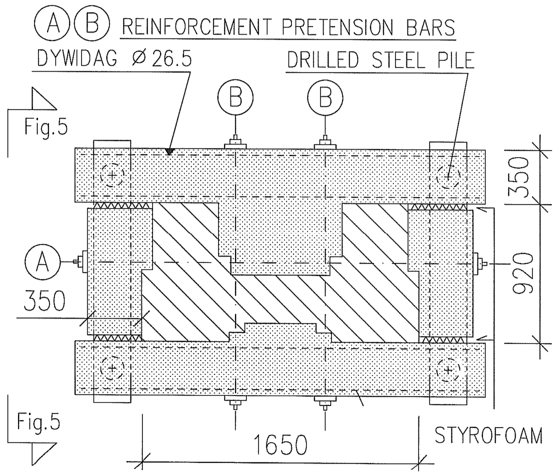
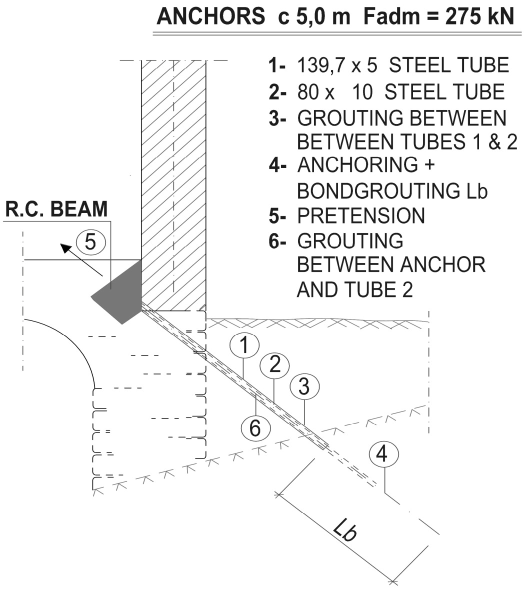


Figure 4:Eastern stair column, Pretensioned concrete mantel, Drilled steel piles

Photograph 3:Eastern stair column, Old brick column, Pretensioned concrete plates Temporary steel supports

South Exterior Wall, Western Part of the Building

Near the southern wall, a pipe channel was built to the level + 2.5 m. The old wall was not strong enough to retain the earth pressure at rest. To solve this problem some of the earth adjacent to the wall was substituted with Leca-aggregate, hence the pressure minimized. Additionally, the wall was supported by using pre-stressed permanent rock and earth anchors (Fig. 6). These anchors were designed to take compressive as well as tensile forces.



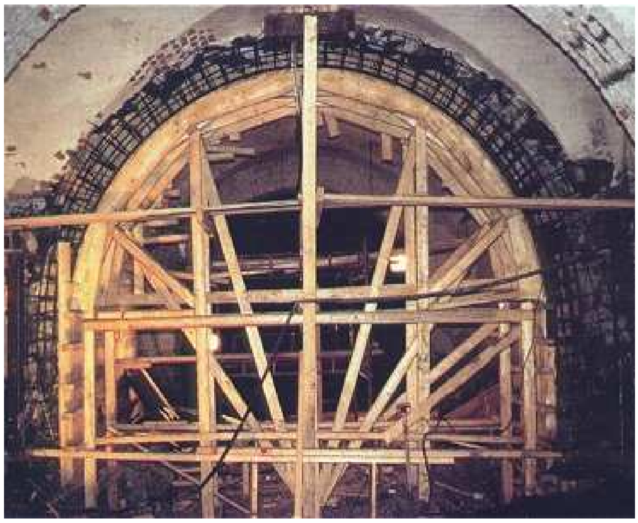


Figure 6: South wall. Rock and earth anchors *Photograph 4: Reinforcement of concrete arch*

Footings of the south exterior wall were underpinned as follows: the old stone foundation, lying on moraine, was grouted slightly before digging under the stone foundation. Underpinning pits were dug down to the rock. Also vertical and inclined dowels (ribbed steel bars) were installed before casting concrete in the pits. In some places, where the old stone foundation had to be cut in order to get more room inside, the foundation was first covered with shotcrete and then injected. Finally rock blasting was done, and explosives could be used as near as 0.5 m from the wall. The last step consisted in using small amounts of explosives in one out of two holes drilled in line, 15 cm apart.

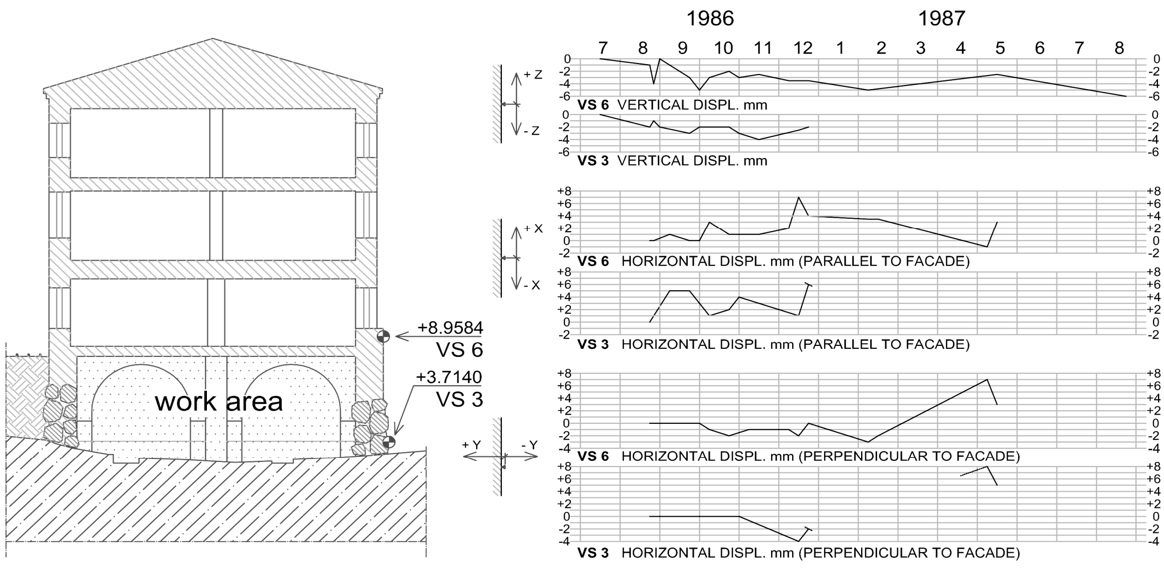


Figure 7: Measurements of facade movements during work (2 points at one of three exterior sectors)

Structural and Facade Movements

Throughout the work, horizontal displacements of the middle wall were small because the loads were taken temporarily by steel piles, which were grouted in rock and the loads of beams jacked against deflection. Possible dangerous situations were avoided by monitoring points at regular intervals, during the whole period of work (Fig. 7). A very slight inclination of the southern wall towards the sea was registered and the displacements measured locally at 2 mm (at level +3.99) and 4 mm (level

+8.5). The reason for this displacement was thought to be a strike from the "Bobcat", or the result of blasting or both. As a precautionary measure more bracing was done.

Conclusion

Many other underpinning and strengthening works of lesser importance were also realised throughout the building, although the above mentioned were by far the most important and challenging ones for this project. Also of consideration was the fact that during the whole period of digging and blasting, construction work was also being done at the upper levels of the building. Because the building is of national heritage, designed by architect C. L. Engel, enough time was allocated to implement good design solutions. Finally credit should be given to the contractor who was responsible for this demanding project, one of a few Finnish companies with good experience and workmanship in this field.

References

[1] Avellan, K, and Maanas, M (2001). "St John`s Church, Tartu, Estonia. Strengthening of the foundations," in *Geotechnical Engineering for Soil Mechanics, Proc, International Conference Istanbul*, 27-31 August 2001, 1687-1690.
[2] Avellan, K, and Nissinen, M (2007). "Strengthening and underpinning the foundations of the main building of the Ministry of Foreign Affairs of Finland", in *XIV European Conference on Soil Mechanics and Geotechnical Engineering,* 24th-27th September 2007, 1119-1124.
[3] Favorin, M, and Ristolainen, K (1993). "*The Naval Barracks = Merikasarmi."* Sulkava, Finland: Finnreklama Oy.
[4] Kråkström, E (1988). "Katajanokka Merikasarmi. Naval Barracks. Ministry of Foreign Affairs of Finland." Unpublished.
[5] Sinisalo, J (1980). "Katajanokan kasarmin suunnittelu ja rakentaminen." Unpublished.