Performance of deep excavation in overconsolidated clay: Case History – Japan Center, Frankfurt, Germany

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1 INTRODUCTION

During the course of its development into a European center of finance, the Rhein-Main metropolis Frankfurt has developed a skyline unique in Europe with regard to its prominent high-rise buildings.

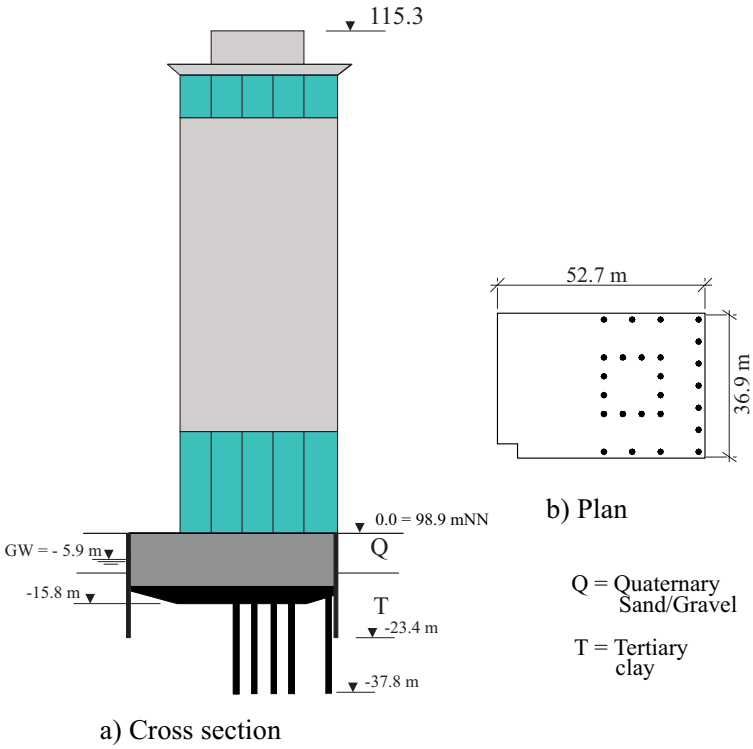

Figure 1: General layout of the high rise building Japan-Center and its foundation

A deep excavation pit of about 16 m was required to build the basements and underground car parks of the Japan building. The main tower of the building complex has an area of about 37 x 37 m and it is planed eccentric to the basement area (Fig. 1). The foundation of both the main tower and the side basements could be constructed without settlement joints applying a piled raft foundation. The piles were placed eccentrically below the tower to minimize the building tilting to acceptable limits.

2 GEOTECHNICAL CONDITION

In the town center the subground consists of quaternary sand and gravel down to about 5 to 7 m followed mainly by the so-called Frankfurter Clay which developed 2 to 10 million years ago as a result of the sedimentation in the tertiary sea in the Mainz basin. This clay includes limestone banks, lignite coal lenses and layers of calcareous sand. The groundwater level is mostly just above the clay surface and circulates in the fissured limestone banks and sand

lenses resulting in different confined aquifer pressures. The clay is geologically overconsolidated through older, already eroded sediments and volcanic rock from the Vogelsberg volcanoes. As a result of this development, the subsoil is highly horizontally stressed. This influences the deformation and the failure behavior of this overconsolidated clay. The main geotechnical parameters of different soil layers are summarized in Table 1.

3 PIT EXCAVATION SUPPORT SYSTEM

Due to the above mentioned subground conditions and due the presence of underground contamination in some areas, lowering of the groundwater table must be prevented as far as possible to minimize the risk of excessive settlements of neighboring buildings and to avoid environmental impacts. Under the subsoil conditions of Frankfurt this is achievable effectively by applying impermeable walls round the pit excavations and connecting the lower end of them to the clay layer beneath the water leading quaternary layer.

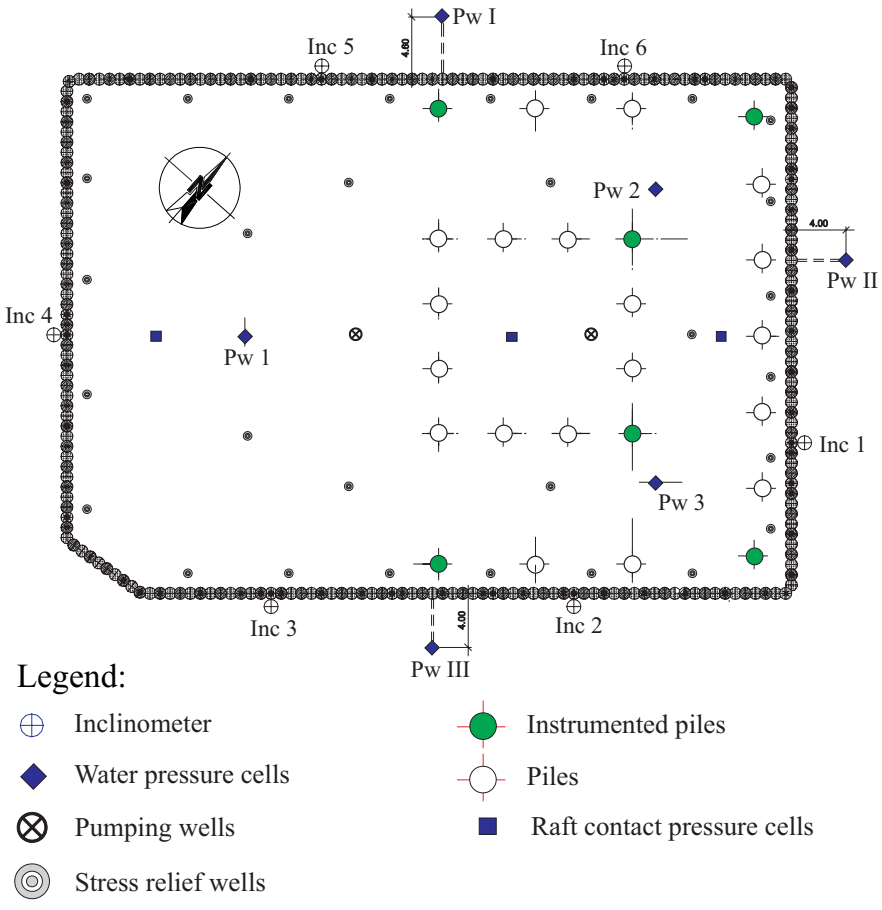

Figure 2: Plan with measuring devices

The unique feature of the retaining structure used to support the pit excavation of the Japan Center project was the use of relief wells in conjunction with staggered pile lengths (Figs. 2,3) to minimize the water pressure on the retaining structure in order to achieve an economical design that fulfills the serviceability and the environmental requirements. The relief wells must be distributed over the pit area to prevent bottom heave due to upward directed hydraulic gradients. The retaining walls consisted of secant bored piles with a diameter of 0.9 m. Plain concrete piles were first constructed 1.5 m apart with the pile tips just beneath the final excavation depth. Reinforced concrete piles were then constructed between the plain piles with 0.15 m overlapping to guarantee the water tightness. The reinforced piles had an embedded length of about 8 m below the final excavation depth (Fig. 2).

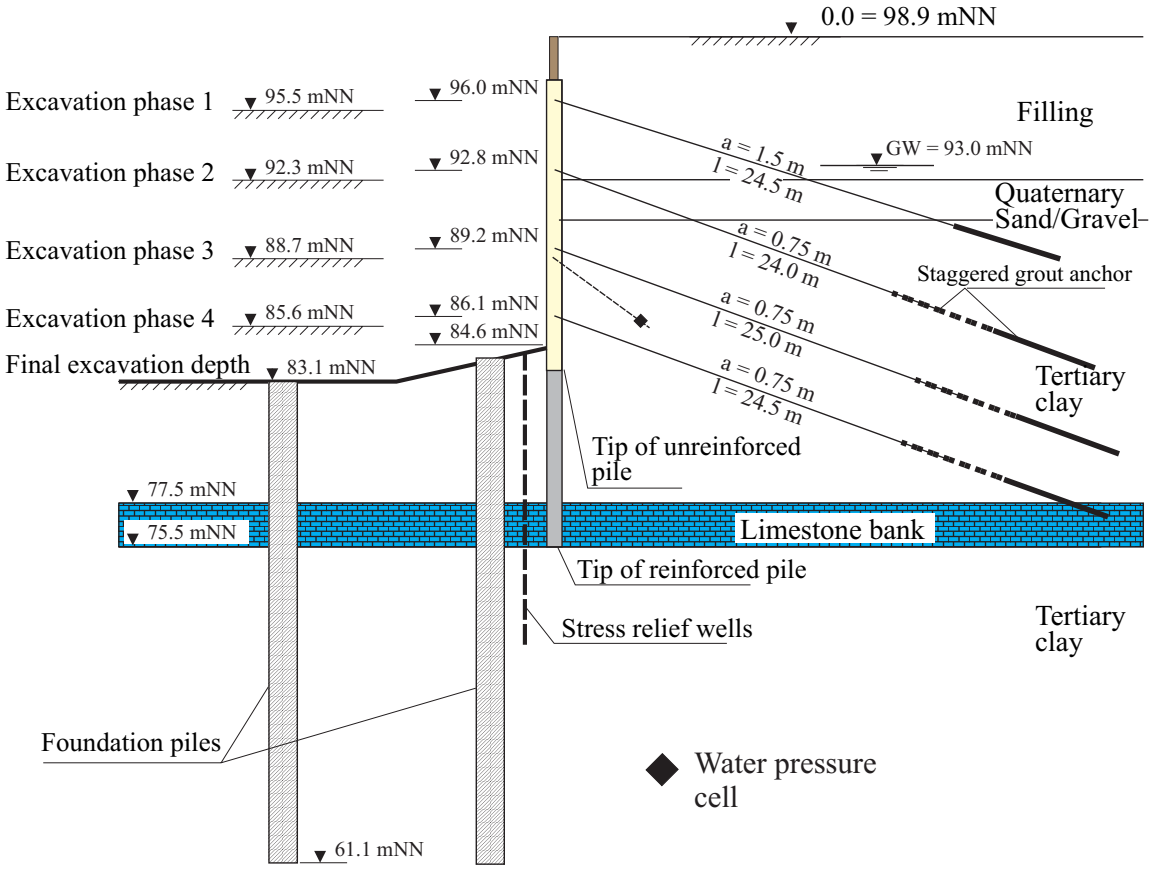

Figure 3: Layout and dimensions of the pit excavation