

The Royal Castle in Warsaw, Poland

Abstracts: Single auger deep soil mixing and a pre-stressed soil anchors were successfully used to construct deep retaining wall inside Royal Castle courtyard in the heart of Warsaw.

Project

The Royal Castle Modernisation Project assumed construction of an underground double-floor machine chamber 10 m below the courtyard of 18th century palace, named Palace under the Metal Roof. Construction of the chamber was highly restricted by the historic structures presented in the subsoil, which resulted in the excavation's complex layout.

Soil conditions

Palace is founded at the Warsaw Slope built of 2 to 8 m thick uncontrolled deposits underlain by fine sands and Pliocene clay. Groundwater level was measured at depth of 2 to 6 m below ground level with the hydraulic gradient to the Vistula River running at the toe of the slope.

Static analyses

Due to the complex nature of the issue, static calculations were conducted with the FEM, using the PLAXIS 2D software. Series of variant calculations were run using the simple Mohr-Coulomb (M-C) and the advanced isotropic hardening model (H-S).

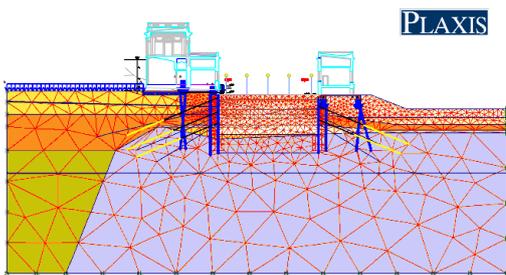
Design solution

A temporary retaining wall was built as a row of DSM columns each 70 cm in diameter and spaced on 55 cm. A steel beam was installed in every second column to provide the required wall strength. The steel beams were embedded to a depth of 4.5 m below the excavation base. Non-reinforced columns were ended 1.0 m below base. The maximum column length was 14.50 m. The wall was anchored with a system of two and three rows of the pre-stressed anchors each 18 m long. Locally, in order to avoid drilling through the historic structures, steel strut and tie rod support systems were used.

The measurements demonstrated that the excavation support system succeeded in protecting adjacent buildings. Lateral displacement of palace's wall did not exceed 4 mm and was two times lower than the estimated by H-S model calculations.



Construction site



Excavation FEM model



Excavation layout



Excavation complete

Keller Polska Sp. z o.o.

ul. Poznańska 172 • 05-850 Ożarów Mazowiecki
tel. (022) 733 82 70 • fax (022) 733 82 80
e-mail: Keller-Polska@keller.com.pl

Gdynia • Kraków • Poznań • Wrocław

www.keller.com.pl