Design of the foundation of high-rise buildings in a deep excavation

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The project 'Anna van Buerenplein' contains the realisation of a three-level underground parking-garage in the centre of The Hague. The underground parking garage is located close to the Central Station of the Hague and other high-rise buildings. Before the realisation of this parking garage an above-ground three-level parking garage will have to be removed. The dimensions of the new parking garage are ca. 100 x 100 m^2, with an excavation depth of 12 m. In the future, on top of the garage, two high-rise buildings with a maximum length of 140 meter will be build.

The excavation is performed with an open excavation and anchored sheet piles. The groundwater level is about 1 m below ground surface so therefore the excavation will be performed with a 1.1 m thick underwater concrete floor and tension anchors (Gewi bars) to resist uplift during construction stages. The skyscrapers are founded on several different groups of screwed 'Tubex-piles' with variable loads per group. The pile caps are integrated in the 0.6 m thick reinforced concrete floor of the parking garage.

In the article the influence of the skyscraper on the foundation of the parking garage will be discussed. The settlements of the pile groups due to permanent and variable loads of the tower are therefore determined. Because of the integrated foundation system, the settlements causes significant moments in the construction floor and additional forces in the tension anchors (Gewi bars).

The settlements are derived with a combined method of a two-dimensional and three-dimensional finite element analyses (Plaxis). First the settlements of a single pile are derived and compared with the National Code (NEN) for foundation on bearing piles. The next step is to model a pile row in a two dimensional calculation. Then these calculation are compared with the settlements of the three dimensional model, and this model is calibrated with the 2D results. Finally more pile rows and pile groups are modelled in the three dimensional model.

By using advanced calculation techniques is was possible to design an integrated foundation system with state-of-the-art technical solutions. This results in a cost reduction because the additional moments in the concrete floor could be taken by additonal reinforcement, so it is not necessary to apply expensive connections.

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