Soil stabilisation with lime-cement columns – A solution for deep sheet pile wall in soft clay

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Lime-cement columns (LC-columns) are widely used for stabilisation of soft soil under embankments in order to reduce settlements. This method can also be used for other purposes than stabilisation of embankments. Deep excavation in soft soil is an example. LC-columns can be used for reducing the active earth pressure if the columns are placed behind the sheet piles, or for increasing the passive earth pressure if the columns are in front of the sheet piles. As a result, the wall bending moments, the wall horizontal displacements and the ground surface settlements will be reduced. Too simplified analytical methods can not answer important design questions, such as how far from the sheet pile wall the clay should be stabilised with LC-columns; at what side, the active side or passive side, the LC-stabilisation is more effective; or how much the anchors should be pre-stressed, etc. A parameter study has been performed with varied thickness of the stabilisation area, the side of stabilisation, as well as the quality of LC-columns.

In this paper the finite element method (FEM) is used to study a deep excavation in soft clay which is a part of the project SL-10, South Link in Stockholm, Sweden. The excavation is assumed to be stabilised with LC-columns at only one side of the sheet pile wall, either the active or the passive side. A parameter study has been performed with varied thickness of stabilisation area, the side of stabilisation, as well as the quality of LC-columns. The calculations are made by PLAXIS.

From this parameter study, several interesting conclusions can be drawn. These can be used in practice as a design guideline for the case where the sheet piles are driven to the bedrock.

1. LC-stabilisation for deep excavation in clay is an effective method for reducing soil movements and bending moments for sheet pile wall excavations in soft clay. In this case case, the maximum sheet pile wall bending moment for the case of soil not stabilised was 677 kNm/m. For the LC-stabilised case the value was only 247 kNm/m.

2. If only one side of the pile wall is stabilised, in this case study LC-stabilisation at the active side is more effective than that stabilisation at the passive side. However, passive stabilisation is also substantial in comparison with the unstabilised wall behaviour.

3. The optimal thickness of the LC-stabilised area in this case study is between 4 and 6 m for stabilisation at the active side, and between 2 and 4 m at the passive side.

4. The “normal” quality of LC-columns, with \( M \)-modulus of 17.5 MPa, is suitable for stabilisation of deep excavation in soft clay.

5. The use of the finite element method FEM, as PLAXIS, makes it possible to design the optimal configuration of stabilisation, anchors and sheet pile wall section.