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STUDY ON HORIZONTAL DISPLACEMENT OF RESTRAINED EXCAVATION WALLS BY CANTILEVER RETAINING WALL

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ABSTRACT

In general, excavation means to loosen and take out materials leaving space above or below ground. Sometimes in civil engineering term earthwork is used which include backfilling with new or original materials to voids, spreading and leveling over an area. Nowadays, the variety of methods has been used to stabilize the excavation and retaining structures. But all of them are not systematically, and require to the precise study. Some of these methods are only used in special projects and small projects are not economically justified. One of the common methods to stabilize the walls with a variety of conditions is retaining walls, that in this study, numerical modeling to study the movements of the walls has been investigated.

KEYWORDS: Excavation, retaining wall, movements, numerical analysis.

INTRODUCTION

Deep excavations are often located very close to existing buildings in urban areas. As a result, they usually cause uncomfortable movements, which can influence safety of the adjacent buildings. Movements of the retaining wall and ground induced by deep excavations have been studied by many researches, for example Peck (1969), Clough and O'Rourke (1990), Ou et al. (1993), Hsieh and Ou (1998), Hsieh et al. (2003), Ou (2006), Kung et al. (2009), Hsiung (2009), Lim et al. (2010), Likitlersuang et al. (2013) and Khoiri and Ou (2013). However, these researches mainly analyzed excavations in clays rather than excavations in sands.

More than several types of in-situ walls are used to support excavations. The criteria for the selection of type of wall are size of excavation, ground conditions, groundwater level, vertical and horizontal displacements of adjacent ground and limitations of various structures, availability of construction, cost, speed of work and others. One of the main decisions is the water-tightness of wall. The following types of in-situ walls will be summarized below;

1. Braced walls, soldier pile and lagging walls
2. Sheet-piling or sheet pile walls
3. Pile walls (contiguous, secant)
4. Diaphragm walls or slurry trench walls
5. Prefabricated diaphragm walls
6. Reinforced concrete (cast-in-situ or prefabricated) retaining walls
7. Soil nail walls
8. Cofferdams
9. Caissons
10. Jet-grout and deep mixed walls

11. Top-down construction
12. Partial excavation or island method

RETAINING WALLS-EXCAVATION IN STAGES

Due to the development of materials and enhancement in technical understanding of geotechnical engineering, different types of soil retention systems have evolved over the last three to four decades. These systems may be classified into two groups, externally stabilizes walls and internally stabilized walls. The examples of first category are gravity walls, reinforced concrete cantilever according to figure 1 and reinforced concrete counterfort walls. These walls are essentially characterized by the concept that the lateral earth pressures due to self-weight of the retained fill and accompanied surcharge loads are carried by the structural wall. This necessitates a large volume of concrete and steel to be used in such walls. The construction sequence of these walls involves casting of base and stem followed by backfilling with specified material. This requires considerable amount of time as concrete has to be adequately cured and sufficient time spacing has to be allowed for concrete of previous lift to gain strength before the next lift is cast.

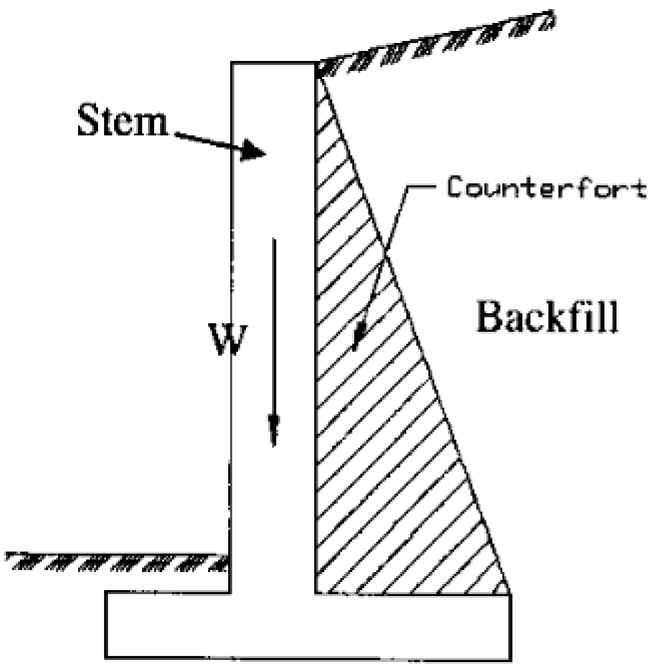


figure1-Diagram of a counterfort wall

GEOMETRY OF THE MODEL AND MATERIAL PROPERTIES

The length and height of model respectively are 55 m and 26 m that is shown in Figure 2. Desired model consists of three layers of soil with different characteristics that their properties are shown in Table 1. The retaining wall material properties listed in Table 2.

Table 1- the properties of soils

	Peat	CL	SM	SM 2
(KN/m^3)γ	**16**	**18**	**19**	**18**
E (KN/m^2)	**5000**	**30000**	**50000**	**90000**
(°)φ	**15**	**9**	**35**	**9**
C (KN/m^2)	**5**	**50**	**15**	**50**

Table 2- the properties of retaining wall

parameters	Material model	)KN/m²(E	W (Kg/m²)	ν
Concrete	Linear Elastic	2.5e7	2400	0.3

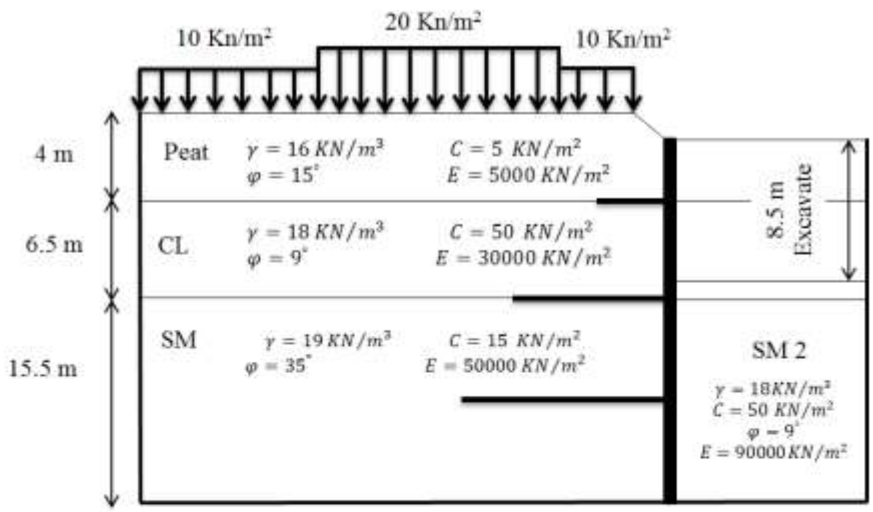
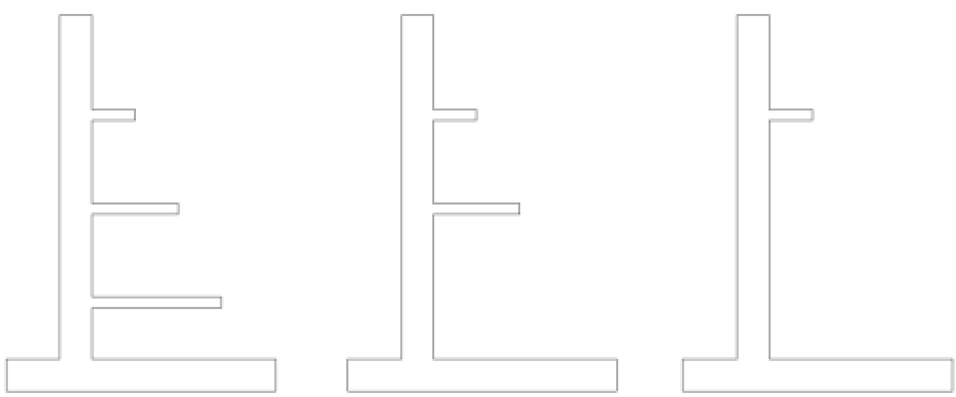


Figure2- Geometry of the model

In the following figures, the geometry of the walls that were used in this study are shown. The height of Retaining wall is 13 m, which was built in three different models with Shelves in altitude 3, 5 and 7 meters. The length of these Shelves is different and in this study, the effect of the Shelves will be discussed on horizontal deformation in the wall.



Model 1 **Model 2** **Model 3**

Figure 3- the model of Shelves

NUMERICAL MODELING

The finite element program Plaxis v8 was used to develop a numerical model of a reference problem to study on Retaining wall. For modeling the retaining wall, the plate element is used. Using finite element, PLAXIS can model heterogeneous soil types, complex stratigraphic and slip surface geometry, and variable pore-water pressure conditions using a large selection of soil models. Also the retaining wall has been modeled in two states with and without heels that is shown in Figure 4 and 5. In the models, the lengths of shelves are considered to be variable. In the first model the length of shelves 3, 4, 5 and 6 m are considered.

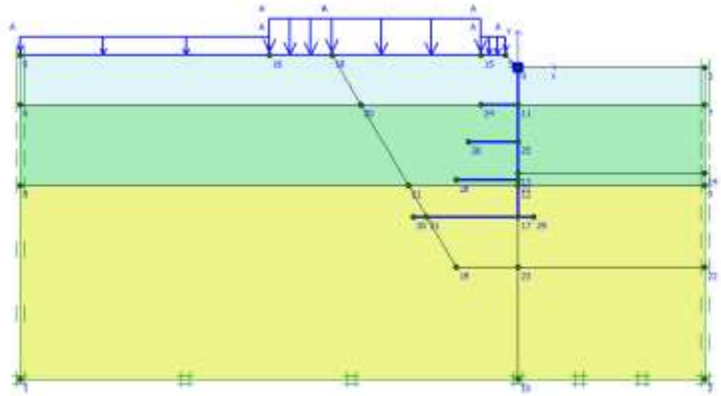


Figure 4 - Modeling retaining wall with heel in PLAXIS software

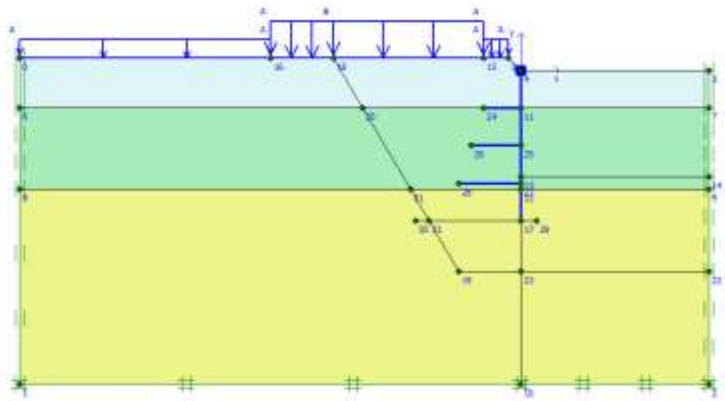


Figure 5 - Modeling retaining wall without heel in PLAXIS software

ANALYSIS OF THE RESULTS

By examining the results obtained from the analysis of the excavation, which is performed in the vicinity of retaining wall, the implementation of shelves and the heel can significantly reduce the movements of excavation walls. This displacement has reduced with increasing the length and number of shelves.

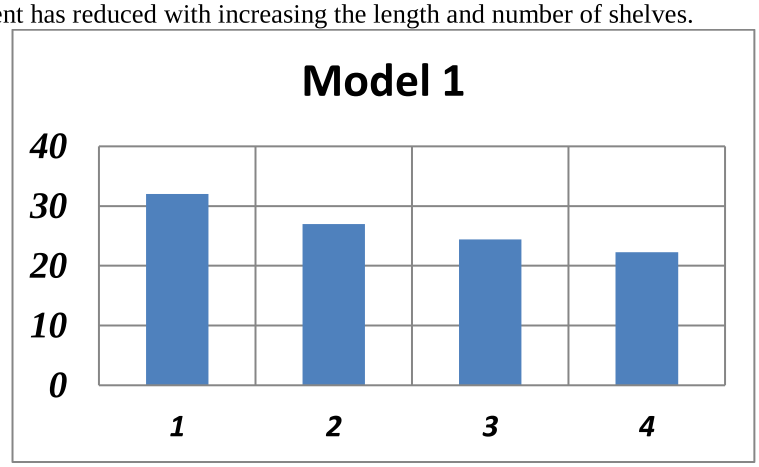


Figure 6 - The results of modeling retaining wall without heel

As seen in Figure 6, with increasing the length of shelf for the first model, the amount of wall deformation decreases by about 30 percent. The results of the modeling for all three models are shown in Figure 7.

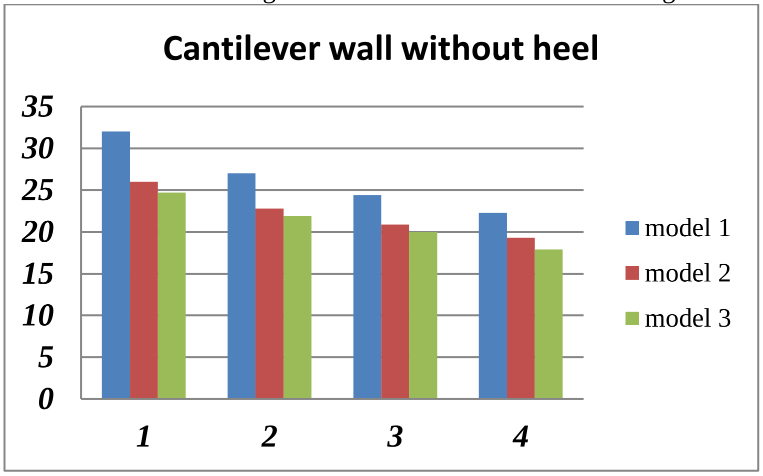


Figure 7 - The results of modeling retaining wall without heel

Also, as seen in Figure 7, with increasing the number of shelf, the amount of wall deformation decreases by about 23 percent. So it can be concluded, that by increasing the length and number of shelves, the movements of the excavation walls is reduced. But effects of the shelves length in reducing is more from change in the number of shelves.

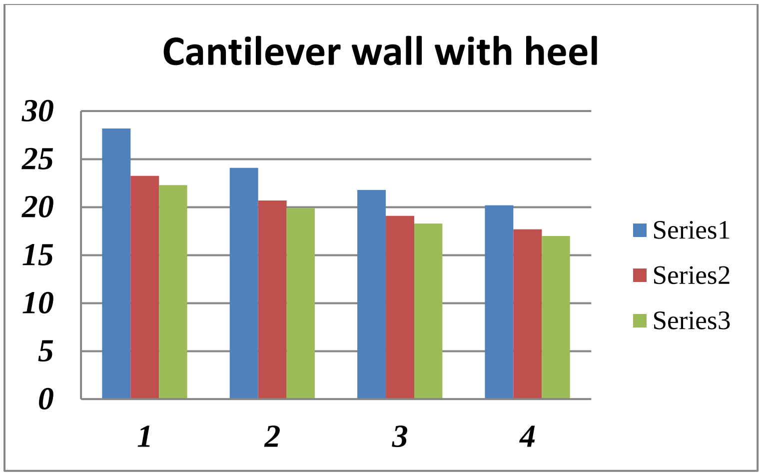


Figure 8 - The results of modeling retaining wall with heel

Adding the heel at the foot of the wall is effective in reducing displacement of retaining wall and horizontal movements of excavation walls reduced up to about 10 percent.
However, it must be said, based on the results of the modeling, implementation of shelves and the heel, do not influence on the vertical movements in excavation wall.

CONCLUSION

The shape of excavation surface varies in the patterns as a linear or a curve as the limit of the construction machinery in the excavation engineering. The position of the sliding surface back the earth retaining wall has relations to the excavation shape. The sliding surface might come into being in the old fill, recent fill or on the interface of the two fills. The parameters such as internal friction angle or cohesive force in the sliding surface are related to its position and the active earth pressure is related to the excavation shape. Therefore, On the basis of literature survey carried out following concluding remarks are made:

1- By examining the results obtained from the analysis of the excavation, which is performed in the vicinity of retaining wall, the implementation of shelves and the heel can significantly reduce the movements of excavation walls. This displacement has reduced with increasing the length and number of shelves.
2- With increasing the length of shelf for the first model, the amount of wall deformation decreases by about 30 percent.
3- With increasing the number of shelf, the amount of wall deformation decreases by about 23 percent.
4- Adding the heel at the foot of the wall is effective in reducing displacement of retaining wall and horizontal movements of excavation walls reduced up to about 10 percent.

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