

A NEW SOLUTION FOR REPAIRING OF A DEEP FAILURE HOLE - A CASE OF STUDY

MỘT PHƯƠNG PHÁP MỚI ĐỂ CỨU CHỮA SỰ CỐ HỒ ĐÀO SÂU –
MỘT TRƯỜNG HỢP THỰC TẾ

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Abstract: This case of study happened in Hue City, where a deep hole was required for a pumping station. The soil at that location is very soft. As the temporary shoring method for the excavation was sheet piles walls and braced beams were not enough, the failure was occurred during the excavation work, showed by the displacement and inclination of the sheet piles walls and deformation of braced beam.

To solve the situation, based on the ideal of shear key principle, sheet piles and root piles panels installed perpendicular to hole's wall to increase the shear strength of the surrounding soil.

The work was completed successfully with the assistance of an intensive monitoring program. Through this paper, the authors want to share with the colleagues an experience for excavation work in practice.

Keywords: deep failure hole; shear key panel; sheet piles panel; root piles panel; monitoring.

Tóm tắt: Trường hợp thực tế này xảy ra ở thành phố Huế, nơi cần thi công một hố đào sâu để xây dựng trạm bơm. Đất ở khu vực thi công công trình là rất yếu. Hệ chống đỡ tạm là tường cừ thép và hệ dầm văng chống cho công việc đào là không đủ nên sự cố đã xảy ra trong quá trình đào. Dấu hiệu được thể hiện thông qua sự dịch chuyển, nghiêng lớn của tường cừ thép và sự biến dạng của hệ văng chống.

Để giải quyết vấn đề, nguyên lý “khóa cắt” gia cường đã được đưa ra thông qua các kết cấu tấm tạo thành bằng cừ thép và cọc rễ cây được bố trí vuông góc với thành hố đào để tăng khả năng chống cắt của nền đất xung quanh hố đào mà không can thiệp đến kết cấu chống đỡ bên trong.

Quá trình thi công hố đào đã được thực hiện thuận lợi với sự hỗ trợ của một chương trình quan trắc với tần suất cao. Thông qua bài viết này, các tác giả muốn cùng các đồng nghiệp chia sẻ một kinh nghiệm thực tế cho lĩnh vực thi công hố đào trong nền đất yếu.

Từ khóa: hố đào trượt sâu; tấm chống cắt; tấm chống cắt bằng cừ thép; tấm chống cắt bằng cọc rễ cây; quan trắc.

1. Introduction

This is referring to the design of the reinforced support system for the excavation work of pumping station No 8, at Hue city of Vietnam.

The initial shoring system for excavation, is sheet piles and braced beams (see in the figure 1). The lengths of sheet piles are varied depended on the excavation depth, with 16 m long at location where the depth of excavation is 11 m, and 12 m long for the rest. Two level of bracing are designed.

When the excavated depth reached about 6.5 m from the ground surface the sheet piles are moved (see in the figure 2).

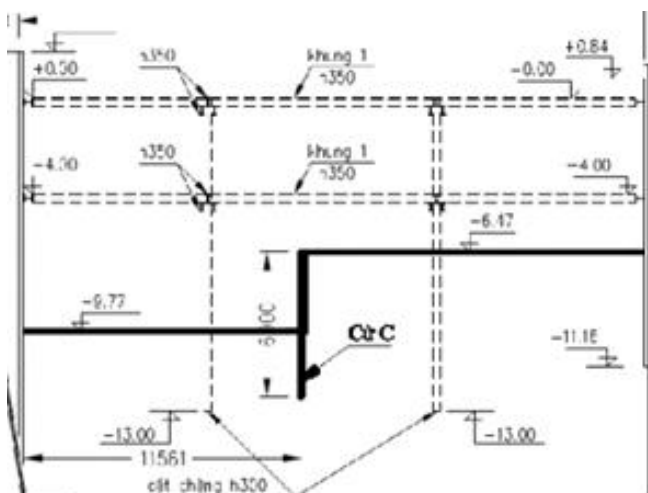


Fig. 1 Original design

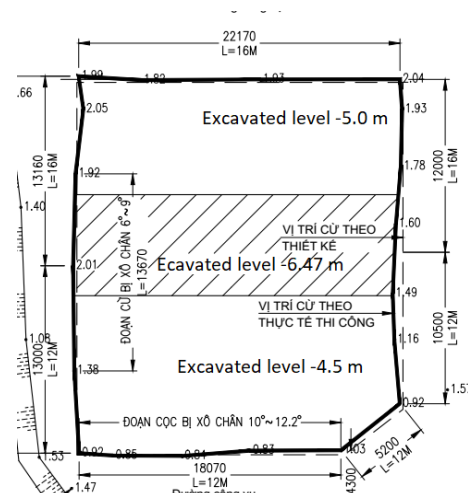


Fig. 2 Original design and Excavated depth at failure

2. Site condition

2.1 Construction area

The excavation is located at the corner of the To Huu street and the Phat Lat river. One other side is Nguyen Lo Trach street and the last is a resident house. The dimension of excavation is 22 x 27 m of

the total area for the project is about 800 m².

2.2 Soil condition

At the construction area three boreholes were carried out. The soft soil is extended down 18 m deep. The main parameters down to 18 m deep is shown in table 1.

Table 1. Soil parameters

Parameter	Unit	Layer 1	Layer 2	Layer 3	Layer 4
Thickness	m	0.2	4.2	13.9	
Wet dens.	kN/m ³		18.7	1.71	
Dry dens.	kN/m ³		14.15	11.69	
Cohesion	kN/m ²		13.0	5.0	
Fric. (φ)	Degree		9°53'	4°30'	13°36'
E _{def.} modulus	kN/m ²		8330	1760	
SPT	Blows/30 cm		2	1	3
GWL	1.5 m from ground level				

3. About solution

The main factor in this design is the limitation of the remained area around the excavation. As the remained area is too small, then the idea of the solution is to create enough strength for the soil around the excavation.

3.1 Calculation principle

Excavation is a type of slope, the analysis of the failure of a slope is based on a slip surface where the shear generated by the slope parameters and other actions is higher than the shear strength of the soil material.

To ease the construction work, this design proposed the idea of only strengthening the ground around the excavation without interfering with the existing internal shoring system. The concept of "shear key panel" is applied (see the figure 3) to strengthen the excavation wall. Two types of panel structures are used for "shear key panel", including:

- The panel of sheet piles;
- The panel of R.C root piles [1].

The "shear key panels", its will extend across the slip surface embedded in the better layer and

increase the stiffness of the excavation wall and to form a composite retaining wall around the excavation.

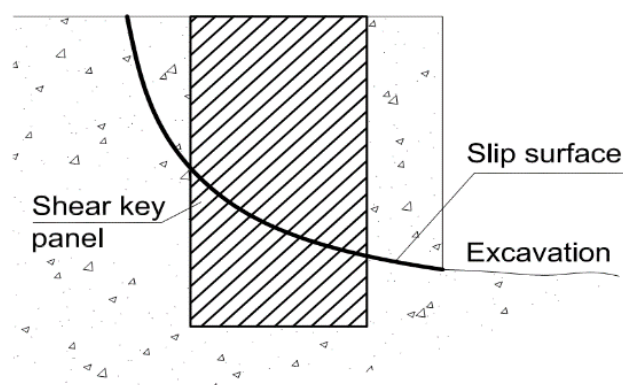


Fig. 3. The "Shear key panel" concept for slope stability

3.2 Assumptions for "shear key" panel

As mentioned above, there two types of shear keys in this design, including (see in the figure 4):

- From sheet piles (available at site Larssen IV);
- From root pile (RC pile 130 mm in diameter and one steel bar 16 mm). The piles are joined by pile cap.

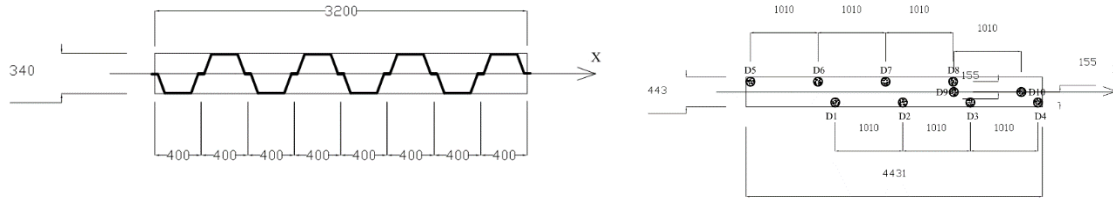


Fig. 4 Panel structures by sheet piles and root piles

The parameters of panel for the calculation are Cross area (A), Moment of inertia (I). The determination of A and I is based on assumption that the panel is working as homogeneous structure formed by several members (sheet pile, single pile), then":

$$A_x = \sum A_{xi}$$

$$I_x = \sum I_{xi} + \sum x_i^2 A_{xi}$$

In which A_{xi}/I_{xi} is the area/Moment of inertia of member number i in axis X ; x_i is the coordinate of the member number i related to the center of the system.

The calculation of panel distribution is carried out

with the help of several softwares as 2D Plaxis [2] and GeoSlope [3].

Calculation model including:

- The original braced system (is kept as the original, shall be repaired during the 4re-excavation);
- Installed piles at the bottom of excavation;
- The soil in the wall of excavation with shear key has new parameters as equivalent parameters of original soil and the shear key material;
- The depth of shear key panel is 18 m.

A result of calculation is shown in figure 5.

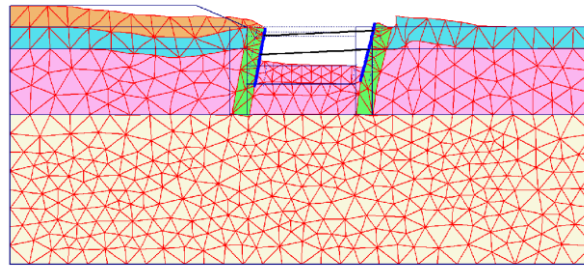


Fig. 5 A calculation result by Plaxis

4. Final solution

The final solution is shown in the figure 6 and 7.

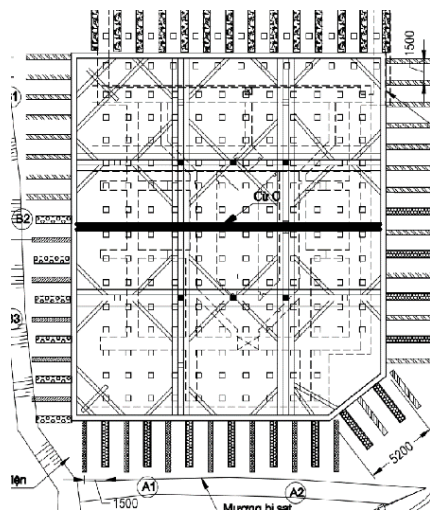


Fig. 6 Distribution of sheet piles and root piles panels around the excavation

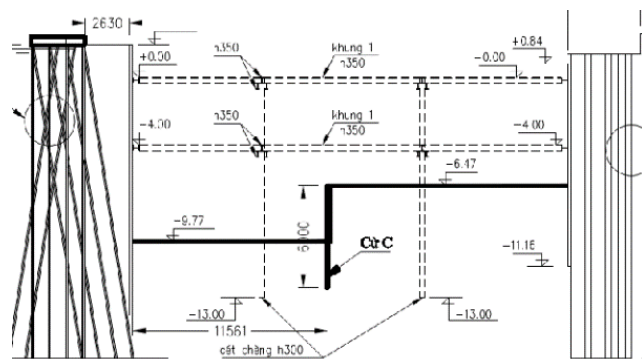


Fig. 7 Cross section of the excavation after the reinforcement

The reinforcement of the soil around the excavation completed about 30 days accorded to the requirement of the Main contractor.

5. Monitoring program

Five (05) inclinometers and two (02) standpipes were

installed for the control of the excavation procedure. The location of monitored points are shown in figure 8.

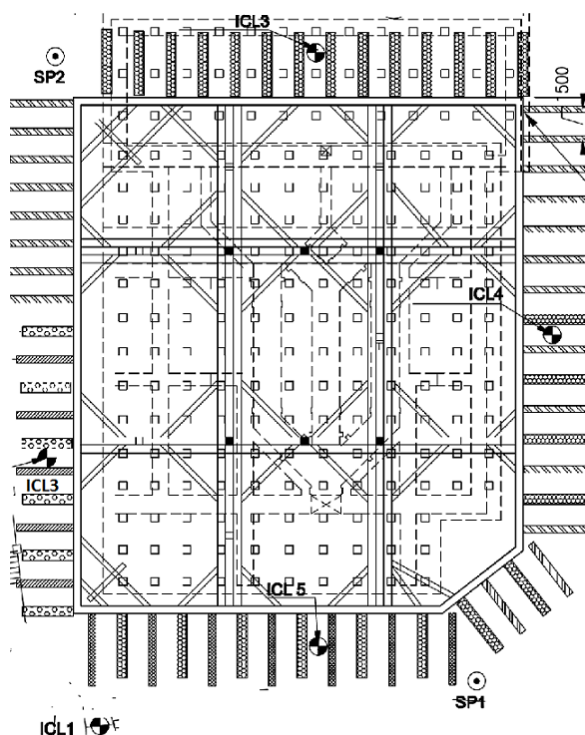


Fig. 8 Monitoring lay out (ICL: Inclinator, SP: Standpipe)

The monitoring frequency was twice a day from 10th March till 28th May 2018 when the bottom slab was completed.

The work completed successfully without any problems.

6. Result of monitoring

The total time of monitoring work is 79 days and the displacements inwards the excavation in five inclinometers.

Side	Horizontal displacement (mm)		
	Surface	Max. value	Max. Predicted
Phat Lat river	20	37/8 m (*)	47.4
To Huu street	60	50/6 m	130
Nguyen Lo Trach Str.	40	40/0 m	94
Resident	40	140/10 m	170
Access road	10	20/10 m	

Note: - 37 is the value of horiz. Displacement in mm; 8 m is the depth of max. displacement.

The ground water level is varied in small range around 1.3 – 1.5 m from ground surface.

7. Conclusion

Result of the solution shows that this reinforcement method is not only suitable for repairing cases, but also for new excavation, in which the space out of the excavation is narrow.

The solution allows to use simple and small equipment for the execution.

The report presented a new alternative for deep excavation. Although the proposed assumptions for the explanation of the solution is not yet convincing. But the monitoring results and reality have proved its effectiveness.

REFERENCES

- [1] Underpinning. S Thorburn, J F Hutchison. Survey University Press Galsgow and London 1985.
- [2] Plaxis 2D version 8.2.
- [3] SLOPE/W 2007.