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Deep and complex excavation in an urban environment in Miraflores, Oeiras

Excavation profondes et complexes en milieu urbain à Miraflores, Oeiras

R. Justiniano*, A. Pinto

JETsj Geotecnia, Lisbon, Portugal

**rjustiniano@jetsj.com*

ABSTRACT: This paper addresses the design and building solutions for the peripheral earth retaining structures, required for the construction of a development, which is a building complex of two building each 14 storeys high. The excavation footprint has approximately 6000 m2 with the deepest excavation depth of 9 m. The majority of the excavation intersected on heterogenous landfills, resting on top of Lisbon's Vulcanic Complex. The site is located in Miraflores, near Monsanto Forest Park. Surrounding the site there are public roads and other building constructions taking place. To minimize settlements around the excavation a secant pile wall was built, and braced either by a concrete strip slab or temporary ground anchors, the north elevation has an open filed, which was used to create a slope, to access to the final excavation level allowing an easy way to remove the soil.

RÉSUMÉ: Cet article traite des solutions de conception et de construction pour les structures périphériques de soutènement en terre, nécessaires à la construction d'un lotissement, qui est un complexe immobilier de deux bâtiments de 14 étages chacun. L'empreinte d'excavation est d'environ 6000 m2 avec une profondeur d'excavation maximale de 9 m. La majorité des fouilles ont été recoupées sur des décharges hétérogènes, reposant sur le complexe vulcanique de Lisbonne. Le site est situé à Miraflores, près du parc forestier de Monsanto, autour du site, il y a des routes publiques et d'autres constructions en cours. Pour minimiser les tassements autour de l'excavation, un mur de pieux sécants a été construit et contreventé soit par une dalle de béton ou des ancrages au sol temporaires, l'élévation nord a un dépôt ouvert, qui a été utilisé pour créer une pente, pour accéder au niveau d'excavation final permettant un moyen facile d'enlever le sol.

Keywords: Munich walls; Berlin walls; mixed walls; deep excavations.

1 INTRODUCTION

This paper addresses the peripheral earth retaining walls solution for the construction of a private condominium with two buildings of 14 storeys high on a plot with over 6000m^2, and three levels below ground, with a maximum excavation over 9 m.

The main constraints of earthwork were the tight deadline to execute the excavation work, the geological and geotechnical environment, and the proximity to nearby constructions. Figure 1 presents the locations of the constructions site.

Figure 1. Site Plan plus ML path.

This article aims to address in more detail the solutions of peripheric retaining walls taking account than in west side is not possible to execute provisory anchors and that 60 000 m3 needed to be excavated in less than 6 months.

2 MAIN CONSTRAINTS

From the site geological and geotechnical investigation, it was possible to confirm that the site was located on the Lisbon's Vulcanic Complex, covered by a heterogeneous landfill deposit layer. In Figure 2 is presented the geological chart of Portugal, 34-D Lisbon.

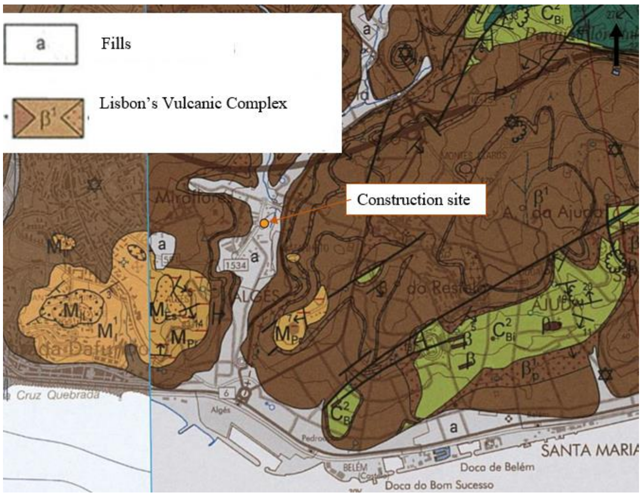

Figure 2. Geological Chart of Portugal.

The laboratory testing on the basalt rock mass shows a high modulus of elasticity and compressive resistance, in line with historical results in excavations in the area.

The existence of two PT (Transformation Post) constraints the solution, as electric cables with median tension were active in the area with no possible deactivation.

At last, the main constraint was the time schedule for the execution of the peripheric retaining walls and the excavation, in less than 6 months.

3 CONCEPTUAL SOLUTIONS

The conceptual solution for the excavation was developed considering time restrictions, space limitation and the type of geotechnical field. The design solution was an overlapped pile wall consisting on 500mm diameter piles spaced 400mm. The primary piles consist of unreinforced piles, which reach the basalt rock mass. As for the secondary piles, which are reinforced, they have an embedment length of 2,5 m on the rock mass underneath the maximum excavation depth, ranging from 7 to 12 m. Figure 3 and 4 show pile wall section.

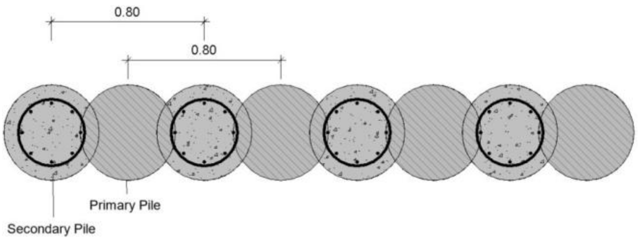

Figure 3. Overlap pile wall.

Figure 4. Overlap pile wall preparation in situ with marks.

The overlapped pile wall was horizontally supported by two types of solution. In South, North and East side, provisory anchor levels were considered with pretension. Figure 5 shows the section solution.

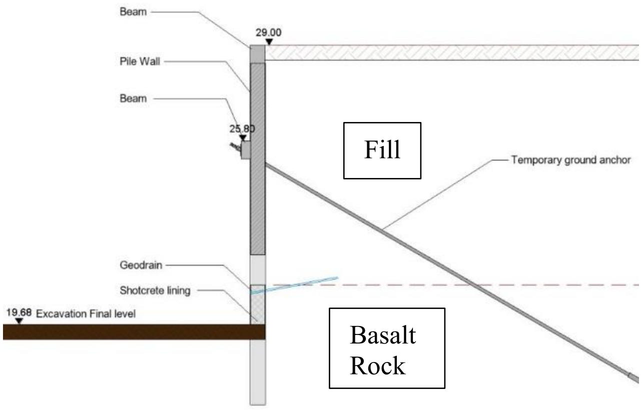

Figure 5. Section solution for North, South and East side.

On the West side, provisory anchors were not possible due to the proximity to adjacent lot excavation.

Due to time restrictions, the solution for horizontal support was slab bed solution. In this solution, the slab is partially executed before the full excavation. The pile wall has enough stiffness to allow 3m excavation with no support, followed by the execution of the slab bed that is fixed in the extremities by the pile wall showed in Figure 5 and or by sub vertical micropile elements, as Figure 6.

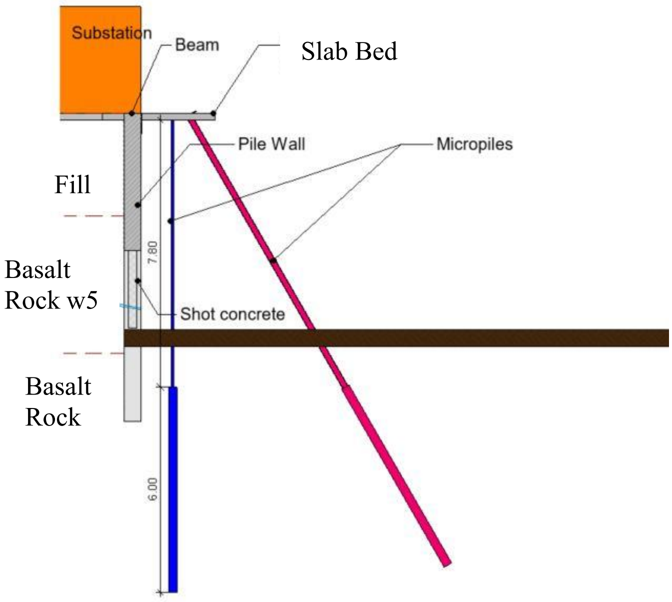

Figure 6. Section solution for West side.

Due to length of the slab bed, vertical support was needed to control the deformation of the slab bed in excavation phase.

Taking in consideration the overall force in the slab bed in excavation phase, additional reinforcement bars were considered, in addition to the reinforcement bars predicted in the stability project. Figure 7 show BIM model for the excavation.

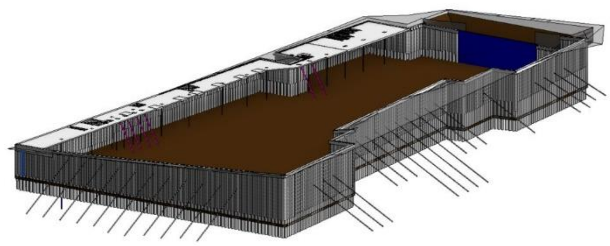

Figure 7. BIM model.

The design of the peripheric retaining wall was developed with Plaxis 2D models and Autodesk Robot models for the strip slab (figure 8 and 9).

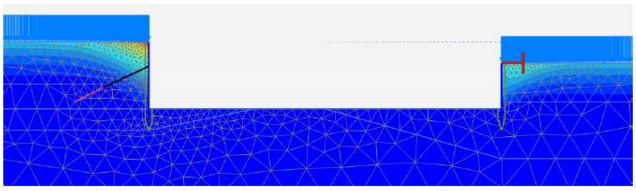

Figure 8. Plaxis 2D model.

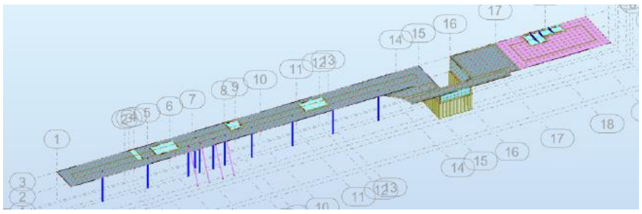

Figure 9. Autodesk Robot Model.

Due to the complexity of the geotechnical field, it was executed a survey and observation plan in situ, to confirm the design criteria and evaluate the behaviour of peripherical retaining wall structure.

4 EXECUTION

The solution of pile wall allows the execution of the peripheric retaining wall with multiple site fronts, with 5 pile machines at the same time.

Intended to support the high intensity work of 5 pile machines, 2 auto concrete mixers were in site to support the piles machines.

Figure 10. East Side with 2 pile machines.

Figures 11, 12, 13 and 14 show the retaining pile wall solution at bottom excavation or during excavation.

Figure 11. West Side solution with slab bed.

Figure 12. East Side solution with provisory anchors.

Figure 13. South Side solution with provisory anchors. (definitive structure already in place).

Figure 14. West Side (Left) and East Side (Right) solution at bottom excavation. (definitive structure already in place).

5 MONITORING AND SURVEY PLAN

The instrumentation adopted in situ consisted of a wide range of devices, of which the following stand out:

- Topographic targets in the peripheral retaining structures, placed during their execution.
- Topographic targets in the surrounding tower cranes, installed before the start of excavation work.
- Piezometers, installed to control the position of the water table.
- Inclinometers, installed to control the evolution of horizontal displacements of the terrain at depth;
- Load cells, used to evaluate loads on temporary anchors;

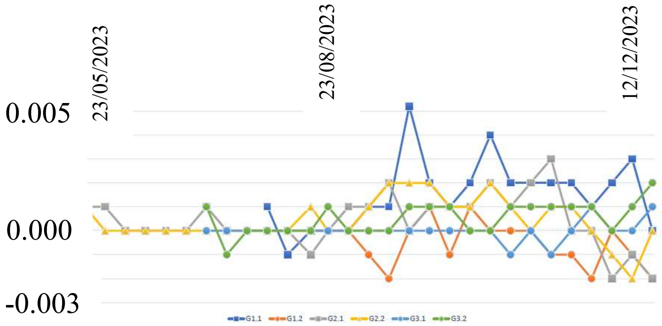

Figure 15. Towers Cranes vertical deformation (m).

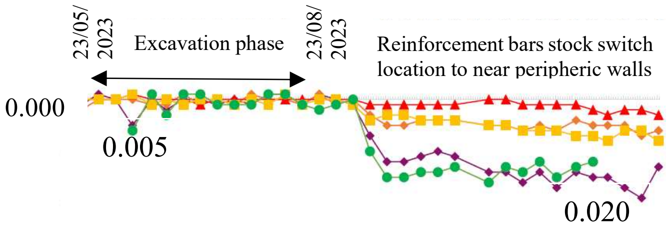

Figure 16. Horizontal deformation pile wall (m).

The survey and observation plan confirmed the design criteria of the project. Nevertheless, during the construction of the structure from the bottom of the excavation, the reinforcement bars stock switch to a very close area near the peripheric retaining wall, which results in a significant horizontal deformation, yet, under accepted values.

6 CONCLUSIONS

This article highlights the mains solutions of peripheric earth retaining walls with time constrains and nearby excavations constrains. Risk management, conceptual confirmation, assessment of good behaviour of the structures were only possible with the execution of a Monitoring and Survey Plan.

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