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Solution of excavation and peripheral earth retaining walls near sensitive structures – O'Living Development, Lisbon

Solutions d'excavation et murs de soutènement périphériques à proximité des structures sensibles – Développement O'Living, Lisbonne

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ABSTRACT: This paper refers to the excavation and retaining wall solutions for a residential development located in Lisbon, where part of the basement structure is located 4m above the Lisbon Metro (ML) tunnel crest. The constraints related to the execution of peripheral earth retaining walls are discussed, using the technology of Munich Walls, Berlin Walls, and Mixed Walls, duly adapted to the existing constraints. Finally, the results of the Monitoring and Survey Plan are pointed out, confirming its importance as risk management tool in a work of high geotechnical complexity and located very close to very sensitive structures, as it was ML tunnel.

RÉSUMÉ: Cet article fait référence aux solutions d'excavation et de mur de soutènement pour un développement résidentiel situé à Lisbonne, où une partie de la structure du sous-sol est située à 4 m au-dessus de la crête du tunnel du métro de Lisbonne (ML). Les contraintes liées à l'exécution des murs de soutènement périphériques sont discutées, en utilisant la technologie des murs de Munich, des murs de Berlin et des murs mixtes, dûment adaptée aux contraintes existantes. Enfin, les résultats du plan de surveillance et d'arpentage sont soulignés, confirmant son importance en tant qu'outil de gestion des risques dans un ouvrage de grande complexité géotechnique et situé très près d'ouvrages très sensibles, comme il s'agissait d'un tunnel ML.

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

1 INTRODUCTION

This paper describes the excavation and peripheral retaining walls solutions, designed and executed in a residential development, in Lisbon, whose excavation bottom level was about 4m from the vault of the Lisbon Metro (ML) tunnel, corresponding to the section of the Red Line, located between the stations of Moscavide and Encarnação, executed using NATM technology. The work studied includes two buildings (Plot 1 and Plot 2), with Plot 1 consisting of 8 upper floors and 2 underground basements and Plot 2 consisting of 8 upper floors and 3 buried basements. Figure 1 shows an aerial view of the location of the site.

This article aims to address in more detail the solutions of Mixed Berlin (peripheric wall where the upper side is as munich walls (concrete) and lower side is as Berlin walls (timber lagging), with soldiers piles connecting both type of wall), and Suspended Munich walls (supported by adjacent peripheric walls), conditioned by the proximity of sensitive structures, such as the ML gallery.

Figure 1. Site Plan and ML path.

There was a need to resort to studies of non-conventional solutions considering the regulations and standards of the ML, which does not allow the execution of structural and foundation elements within 3m of the ML.

2 CONSTRAINTS

Given the location of the ML tunnel, about 4m below the entire North peripheral retaining wall of Plot 1, it was not possible to execute the traditional Munich Walls (as Figure 2). Likewise, in Plot 2, in an extension of about 20m, it was not possible to execute piles or micropiles, due to the need to respect the precautionary distance of 3m to the ML tunnel.

According to ML documents (Metropolitano de Lisboa 2010a), in addition to the need to respect the precautionary distance of 3m, during the excavation and peripheral containment works, the following criteria of maximum deformation were also imposed, to be proven by the instrumentation:

- The structure of the ML tunnel could not suffer displacements greater than 7 mm vertically and/or horizontally;
- On the ML rails, it was not possible to verify a variation of relative displacement, between sections of 8m distance, greater than 3mm.

These rules are applied to any excavation that takes place within 25m of the ML tunnel, which was the case (Metropolitano de Lisboa 2010b).

3 CONCEPTUAL SOLUTIONS

3.1 PLOT 1

The conceptual solution for Plot 1 North area was with the execution of a Mixed Berlin Wall (Figure 2 and 3). In this solution, a Munich wall was executed in the top area of the retaining wall and a Berlin wall was executed in the bottom area, because the space between the mixed berlin walls and the definitive wall of the building was to be fille (as Figure 3).

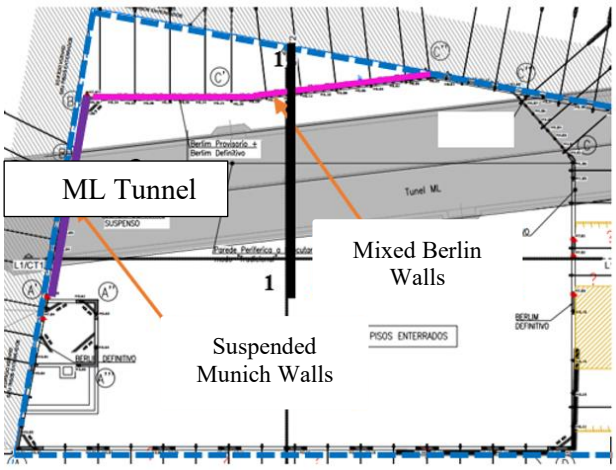


Figure 2. Plot 1 – Conceptual solution.

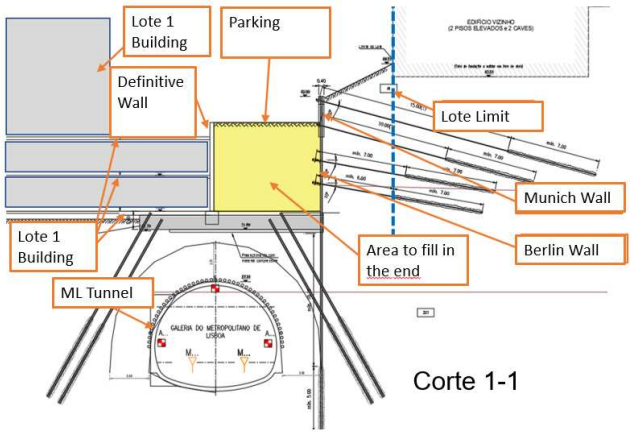


Figure 3. Plot 1 – section 1.

3.2 PLOT 2

The conceptual solution for Plot 2 North area was with the execution of a Suspended Munich Wall (Figures 4 and 5). In this solution, the micropiles in the suspended Munich wall are in tension, to transmit the vertical load from the wall to the top beam (with 2m height). Due to the suspended load, reinforcement of the micropiles in the end of Munich wall is required, to hold all vertical load from the suspended Munich wall.

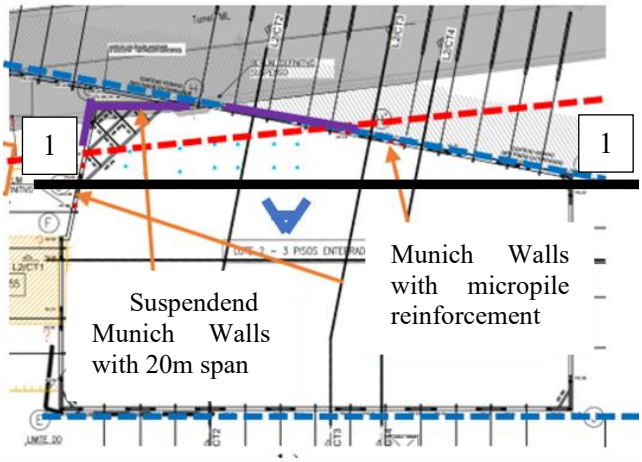


Figure 4. Plot 2 – Conceptual solution.

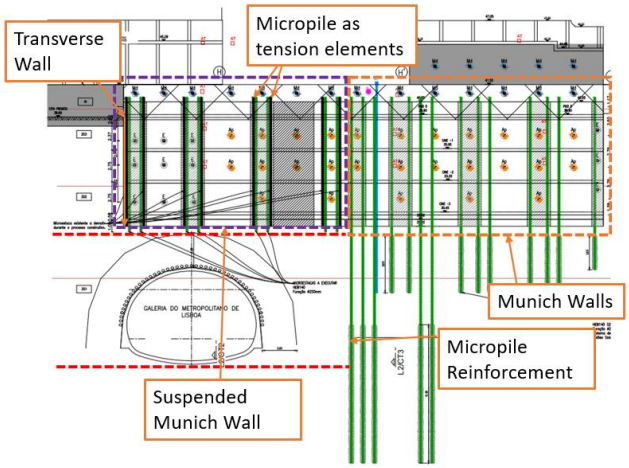


Figure 5. Plot 2 – section 1.

4 EXECUTION

4.1 PLOT 1

Figures 6 and 7 show the site at completion of the excavation. Figure 7 shows the beginning of execution of the permanent wall of the building and the space (min 3m) to the Mixed Berlin Wall.

Figure 6. Plot 1 – Mixed Berlin Wall.

Figure 7. Plot 1 – Suspended Munich Walls.

4.2 PLOT 2

Figure 8 show the suspended Munich wall solution at bottom excavation. To reduce vertical load, 3 levels of props were adopted.

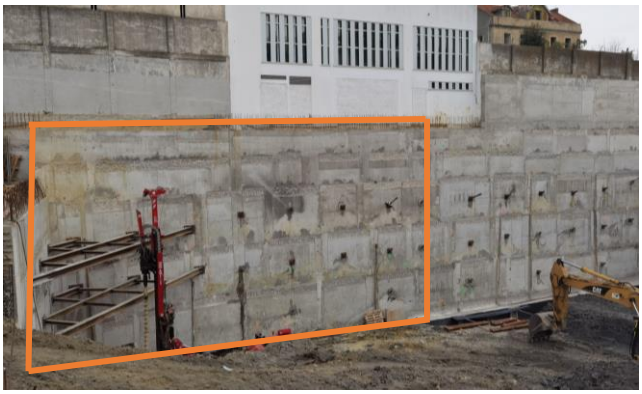


Figure 8. Plot 2 – Suspended Munich Walls.

5 MONITORING AND SURVEY PLAN

The instrumentation adopted in situ, consisted of a wide range of devices, as the following:

- Topographic targets in the peripheral retaining structures, placed during their execution;
- Topographic targets in the surrounding structures, 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 ground;
- Load cells, used to evaluate loads on temporary anchors;

Topographic targets and topographic marks installed inside the ML gallery to control the relative (convergences) and absolute deformations of the vault and rails, respectively. Figures 9 to 13 show the results.

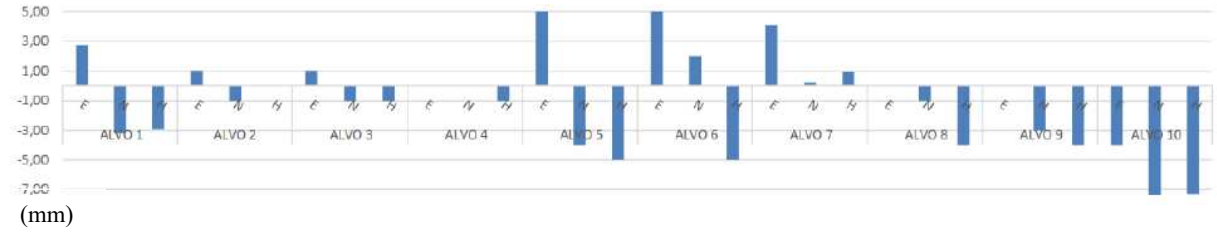


Figure 9. Surrounding Structures settlements (mm).

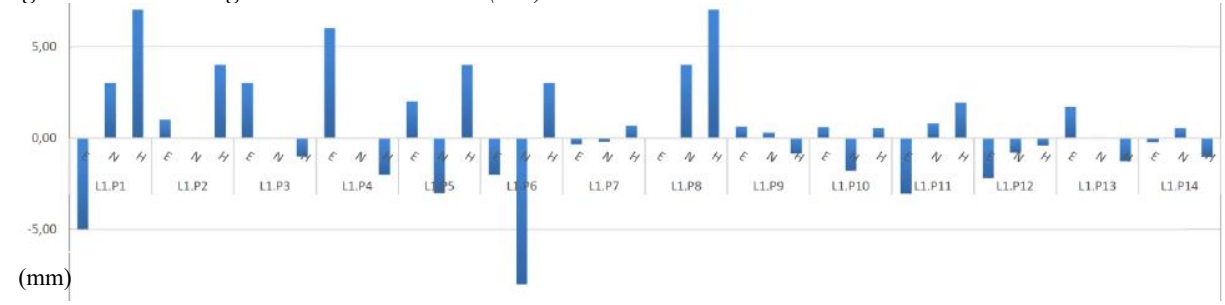
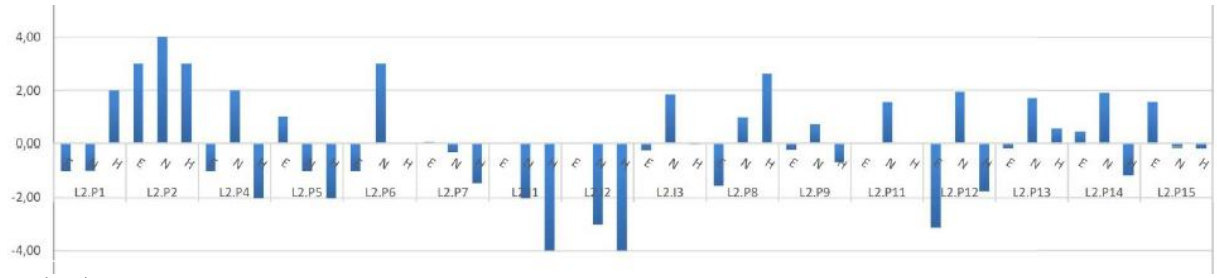
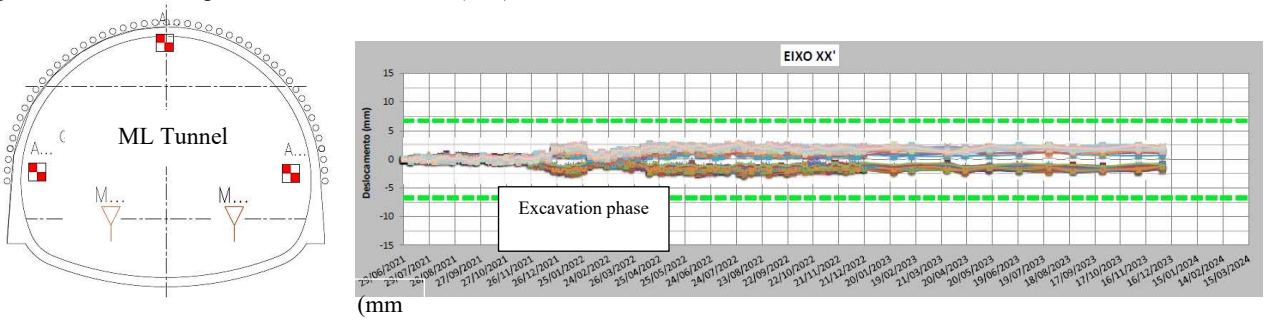


Figure 10. Plot 1 Peripheric wall settlements (mm).



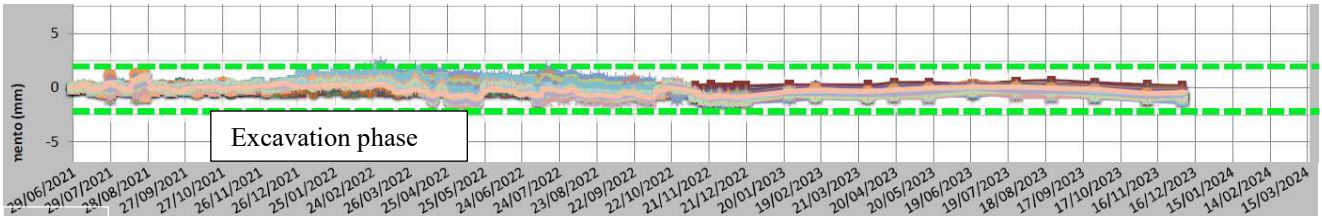
(mm)

Figure 11. Plot 2 Peripheric wall settlements (mm).



(mm

Figure 12 - ML Tunnel – Topographic longitudinal settlements of the vault (mm).



(mm)

Figure 13. ML Tunnel – Rails vertical settlements (mm).

Settlement result of the peripheric retaining wall suggest good correlation with the model considered in the design. Settlement result of surrounding structures were compatible with the profile of those structures. ML tunnel settlement was lower than max acceptable value. Rails settlements were at the max acceptable value (3mm) during excavation phase.

6 CONCLUSIONS

This article highlights the main solutions of peripheric earth retaining walls in a sensitive geotechnical area, due the vicinity of the ML Tunnel. Risk management, soil behaviour with good correlation with design models and assessment of good behavior of the structures were only possible with the execution of a Monitoring and Survey Plan.

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