



THE ART AND SCIENCE OF MICROPILES



Foundations Solutions for the World Youth Day 2023 Main Stage Cover

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16th International Workshop on Micropiles | **2025** | Valencia, Spain

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Introduction

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Introduction

- Expo 98 aerial view, with Beirolas urban solid waste landfill at North side



- ❑ For the WYD 2023 main event, papal mass with about 1.000.000 people attending, a stage was built at Parque Tejo, Lisbon, the only place available with the requested size



- ❑ However, a geotechnical challenge arose, as at the selected location was coincident with the Beirolas urban solid waste landfill, resting over heterogeneous fills and alluvium materials



- ❑ In this scenario and considering the actions acting at the stage, part of the stage and its cover had to be founded using a deep foundations solutions, sealed at the Miocene bed rock

Introduction

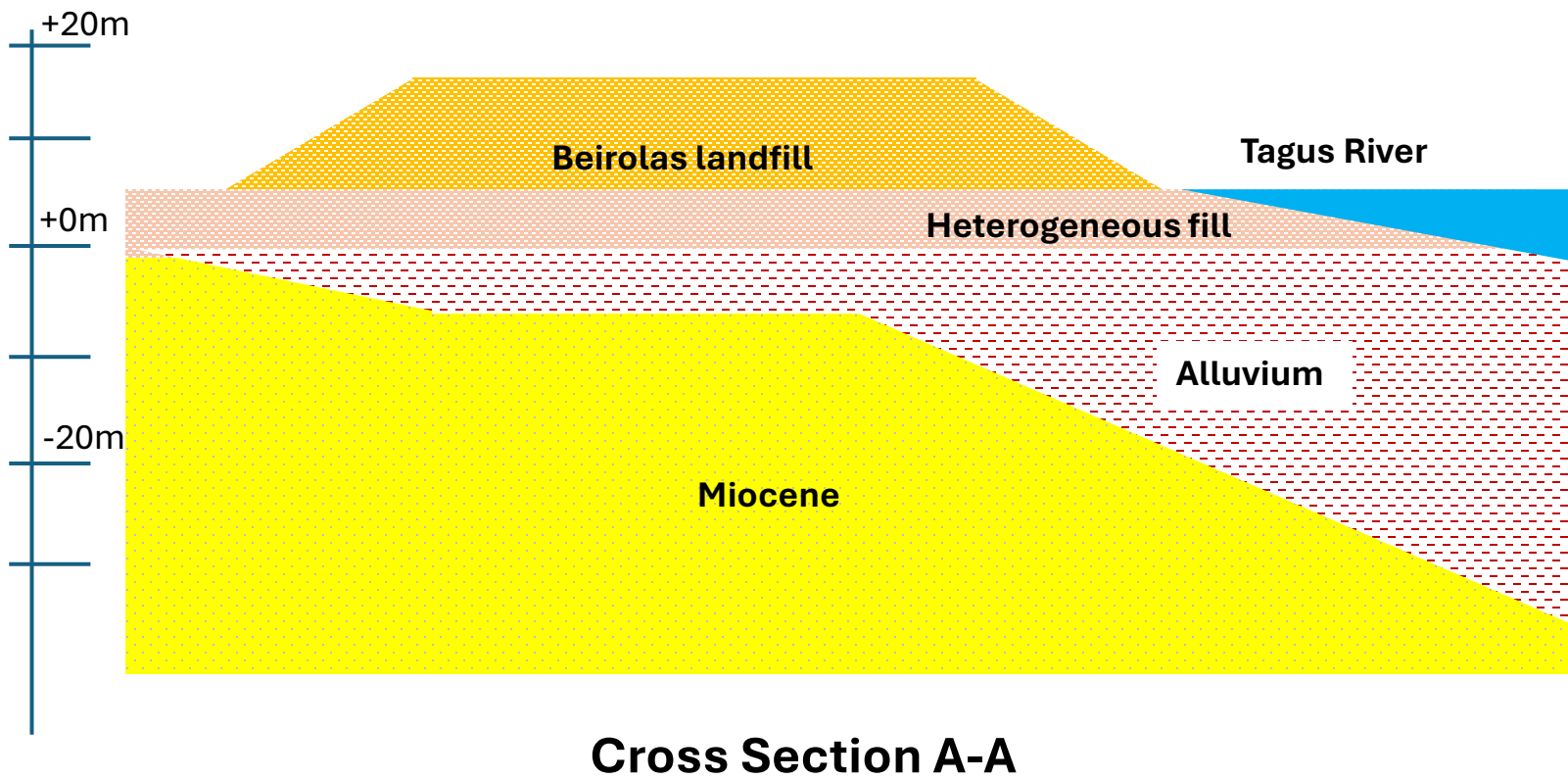
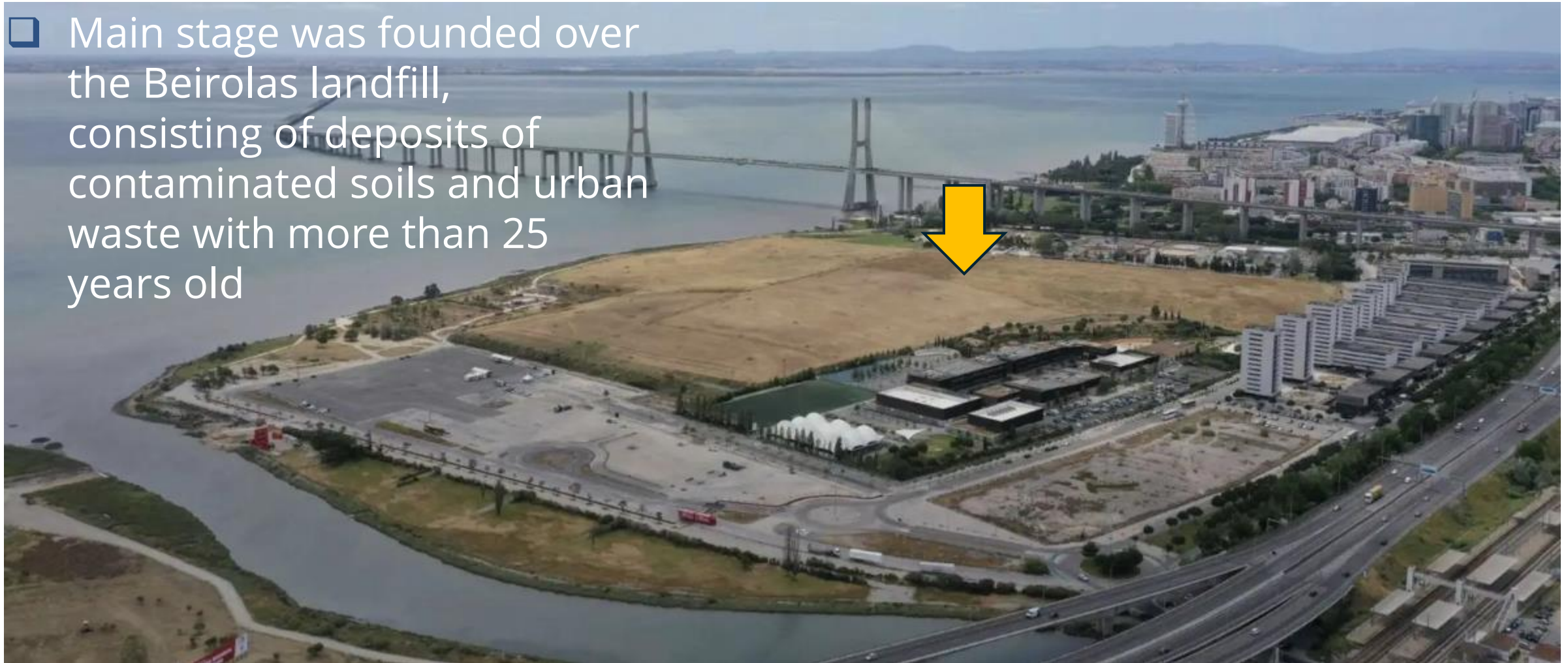


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Geotechnical Restraints

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Geotechnical Restraints

- ❑ Main stage was founded over the Beirolas landfill, consisting of deposits of contaminated soils and urban waste with more than 25 years old
- ❑ At the riverbank direction, the alluvium materials thickness increases, correspondent to the Tagus River basin, very compressible silty muddy soils



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Environmental and Political Restraints

- ❑ To establish the foundation solutions for the main stage cover, it was considered that extracting the waste landfill materials was not advisable



Geomembrane
covering the waste
landfill materials

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- ❑ Due to this restraint, conventional big diameter bored piles solutions were not considered



- ❑ The possibility for future dismantling of those structures was also taken into consideration due to political reasons, so whenever possible, solutions were adapted to this objective

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Structural Restraints

- Wind actions, combined with the low weight of the stage cover structure



- Deep foundations solution had to accommodate horizontal and vertical tension loads



- Some micropiles had to be driven inclined and sealed at the Miocene bedrock

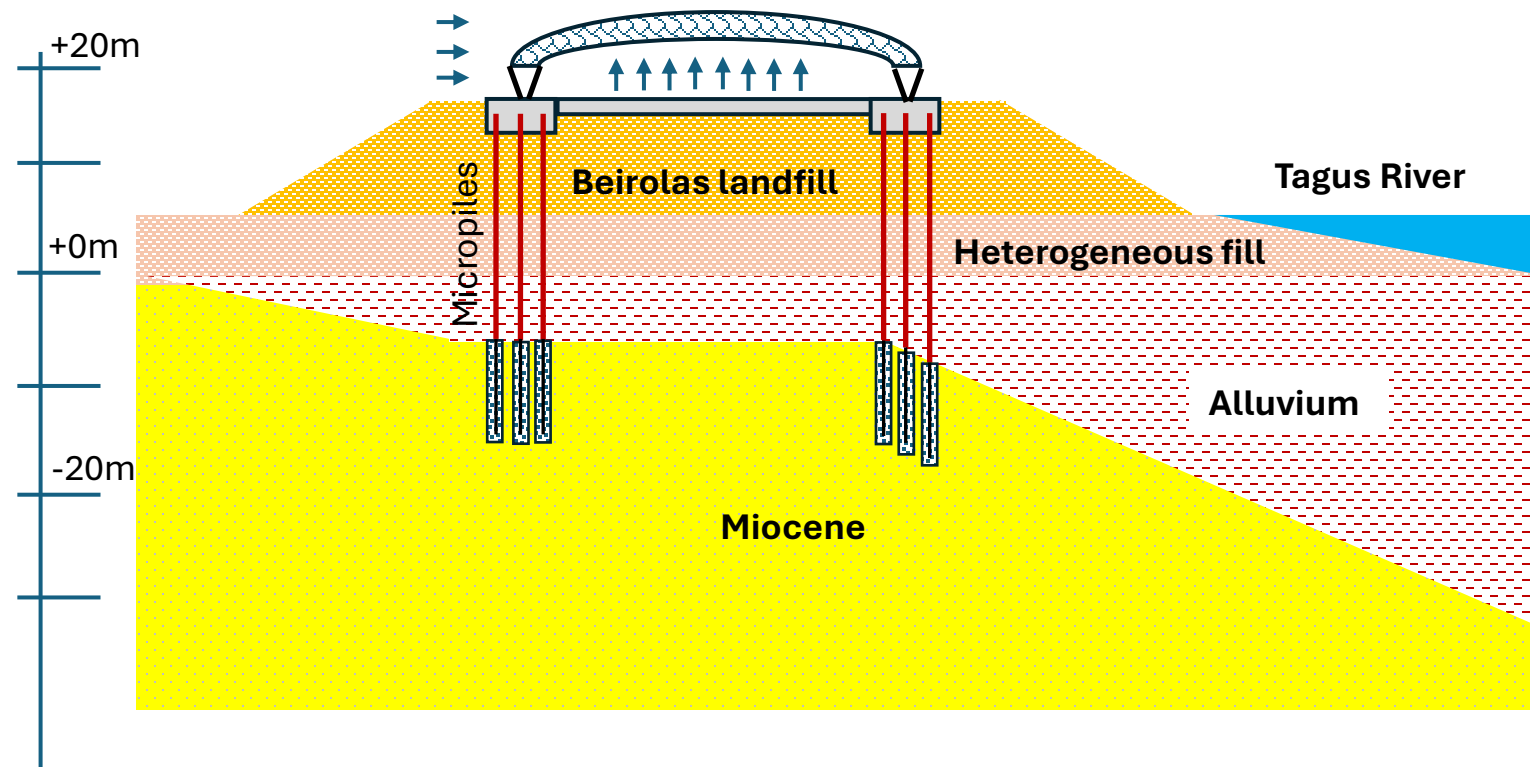


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Schedule Restraints

- An important restraint was the construction schedule, as the main stage works had to be finished before the WYD 2023, in August 2023, and the main works have started just 6 months before



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- ❑ An important restraint was the construction schedule, as the main stage works had to be finished before the WYD 2023, in August 2023, and the main works have started just 6 months before
- ❑ Adoption of versatile and high-rate solutions was mandatory!

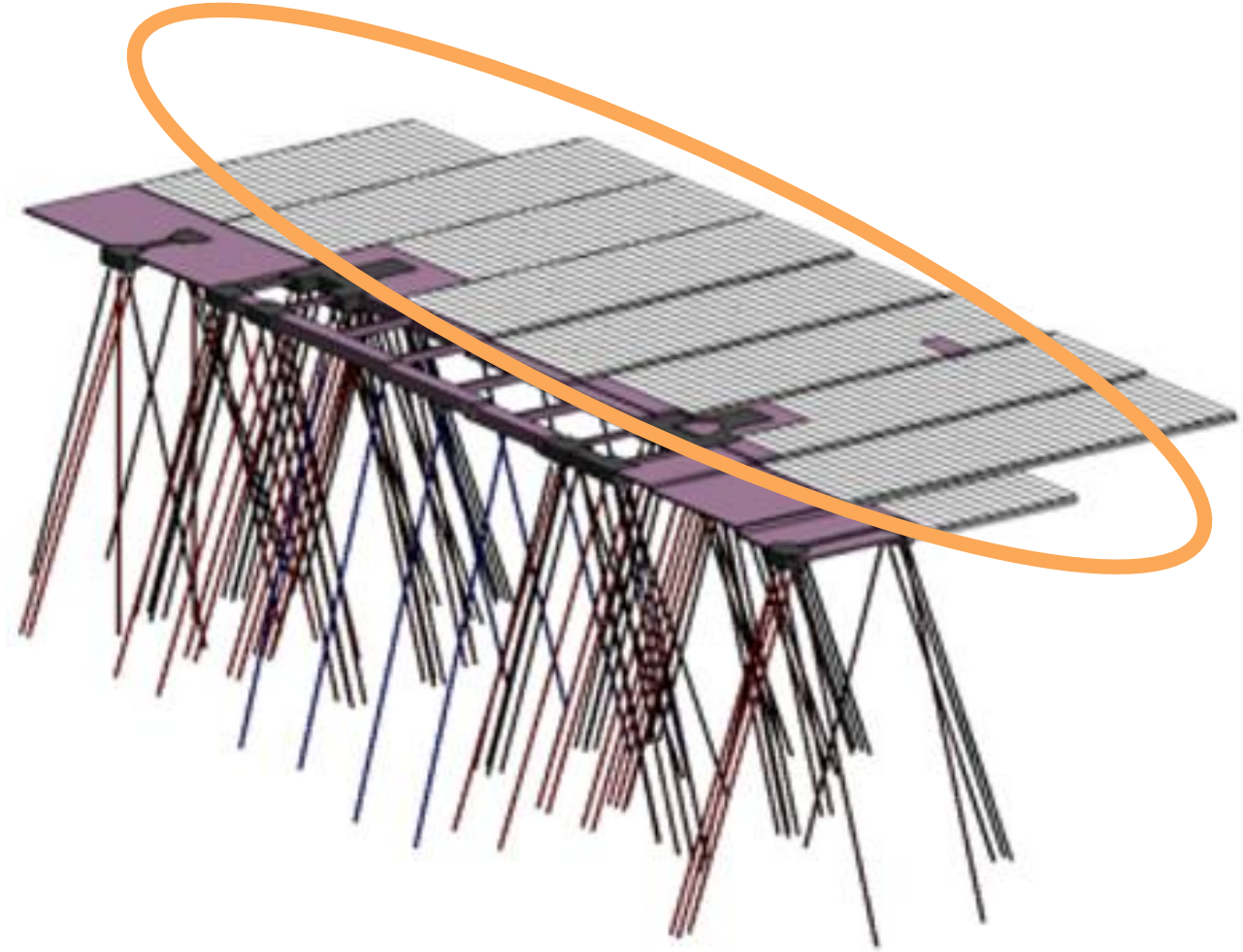


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Foundations Solutions: Stage Current Area Preloading + Shallow Solution

- ❑ Raft solution with hollow-core precast slabs simply supported on also precast peripheral beams with an L-shaped or rectangular section, depending on the existing ground level difference, special at the landfill west slope
- ❑ This solution was applied after 2 months of a temporary preloading, using an embankment, to decrease the void index at the landfill



Foundations Solutions: Stage Current Area Preloading + Shallow Solution



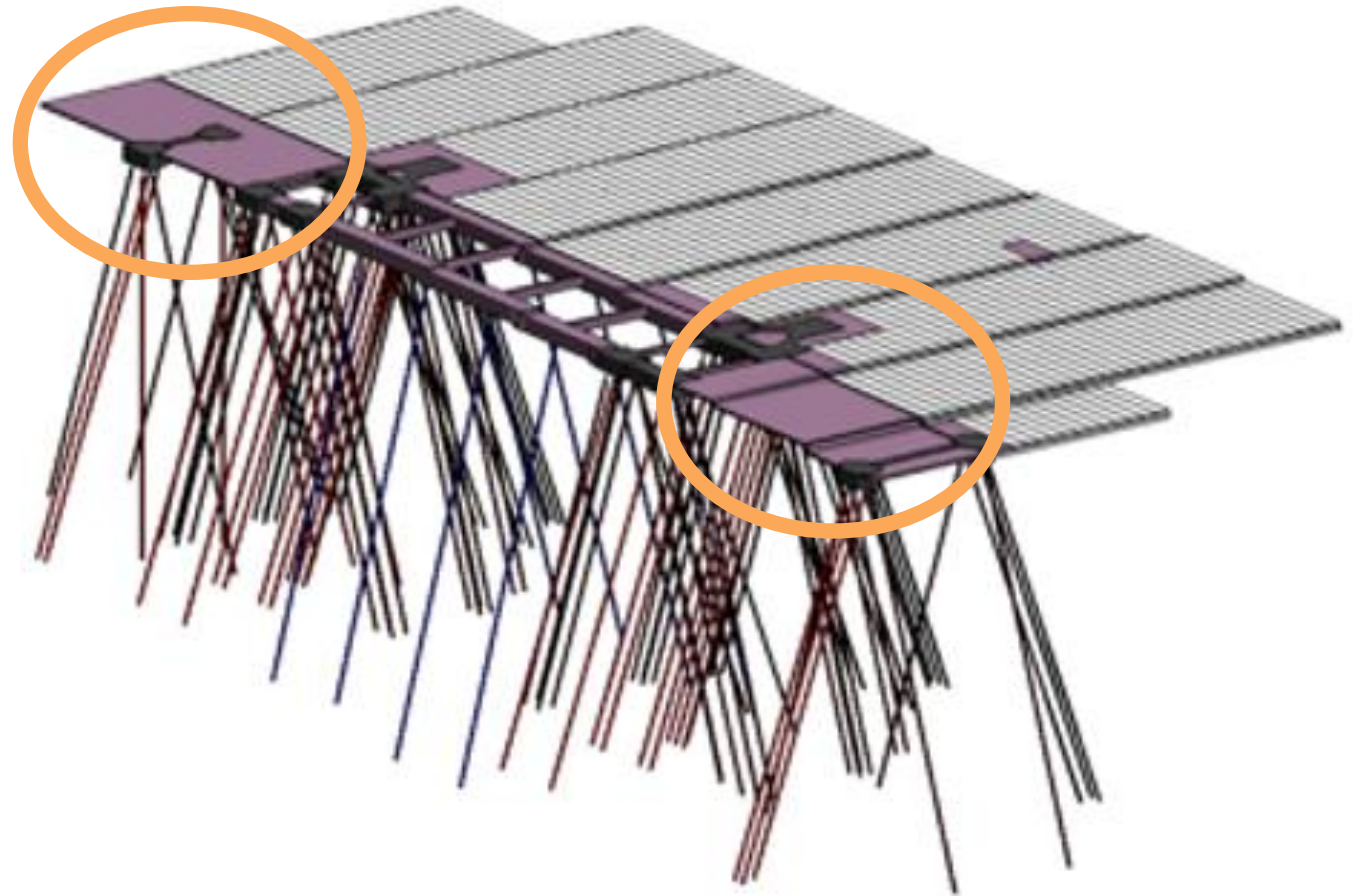
Foundations Solutions: Stage Current Area Preloading + Shallow Solution

Raft solution with hollow-core precast slabs

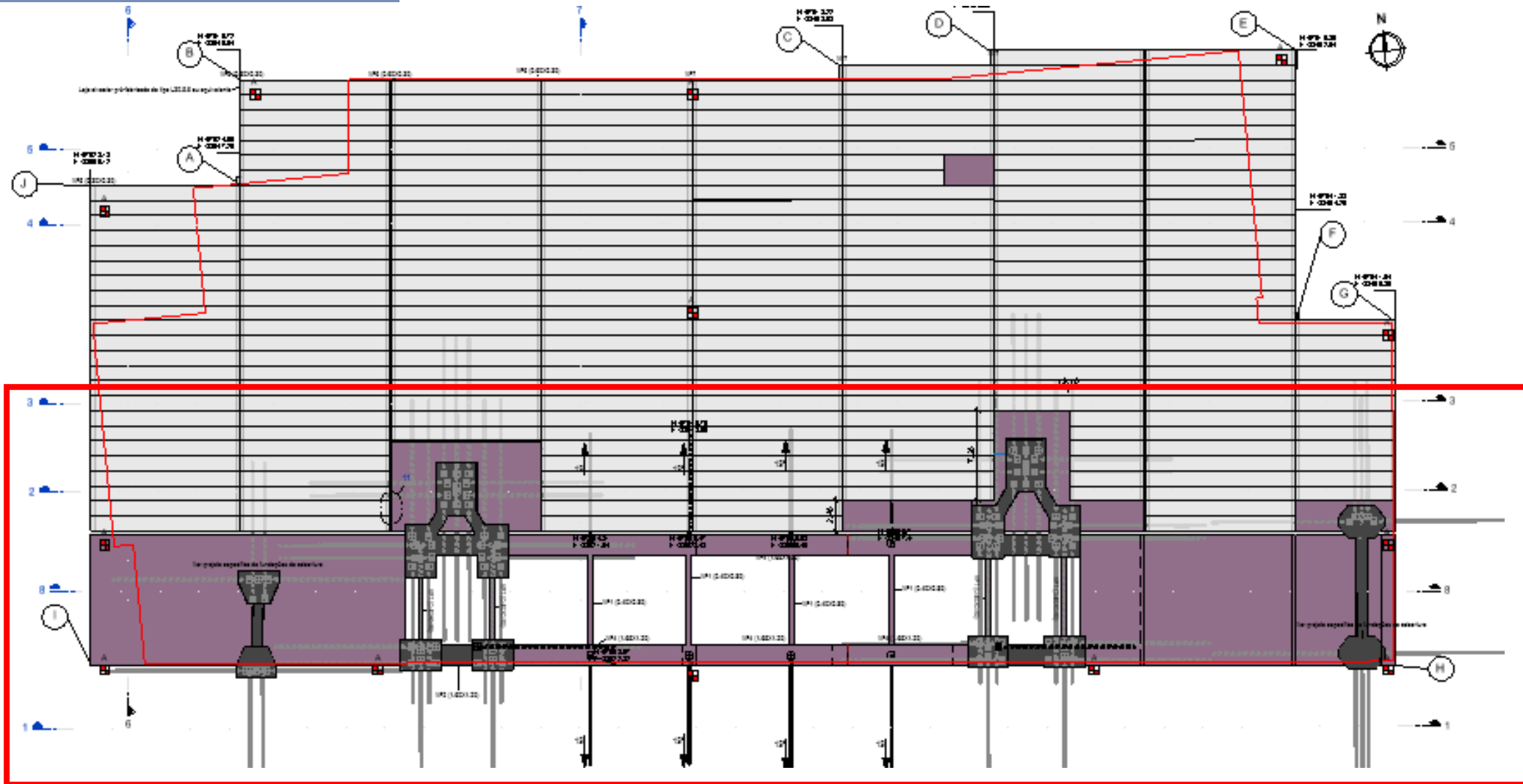


Foundations Solutions: Stage Rear Alignment End Areas - Preloading + Shallow Solution

- ❑ In-situ concrete raft slab with a thickness of 25cm
- ❑ This solution was also applied after 2 months of a temporary preloading, using an embankment, to the decrease the landfill void index

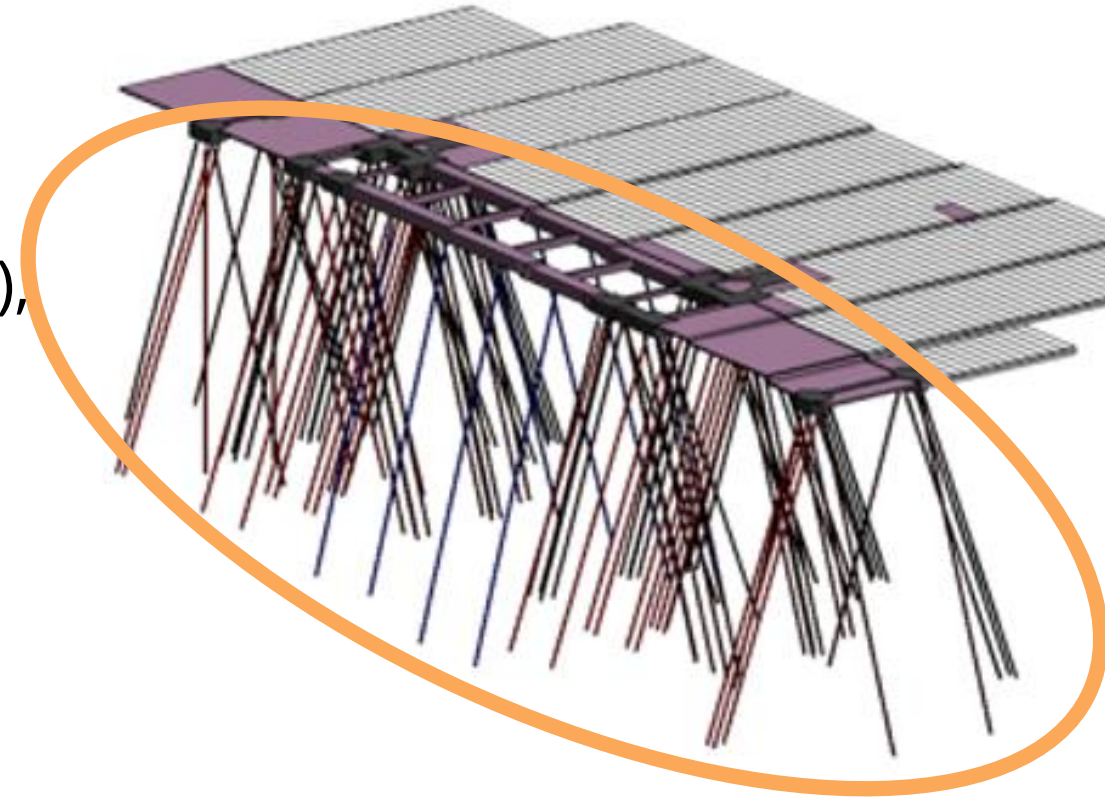


Foundations Solutions: Cover and Rear Stage Central Area – Micropiles Solution



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- ❑ Vertical and inclined driven (dry method) ductile iron micropiles with a section of 170x7.5mm filled with micro-concrete and reinforced with a self-drilling inner bar RR64x38,5mm / H1200-64 (tension micropiles), assuring the sealing length at the Miocene layer



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- ❑ During the driven operations, the first (lower) tube was filled with micro-concrete, to avoid clogging and facilitate redrilling

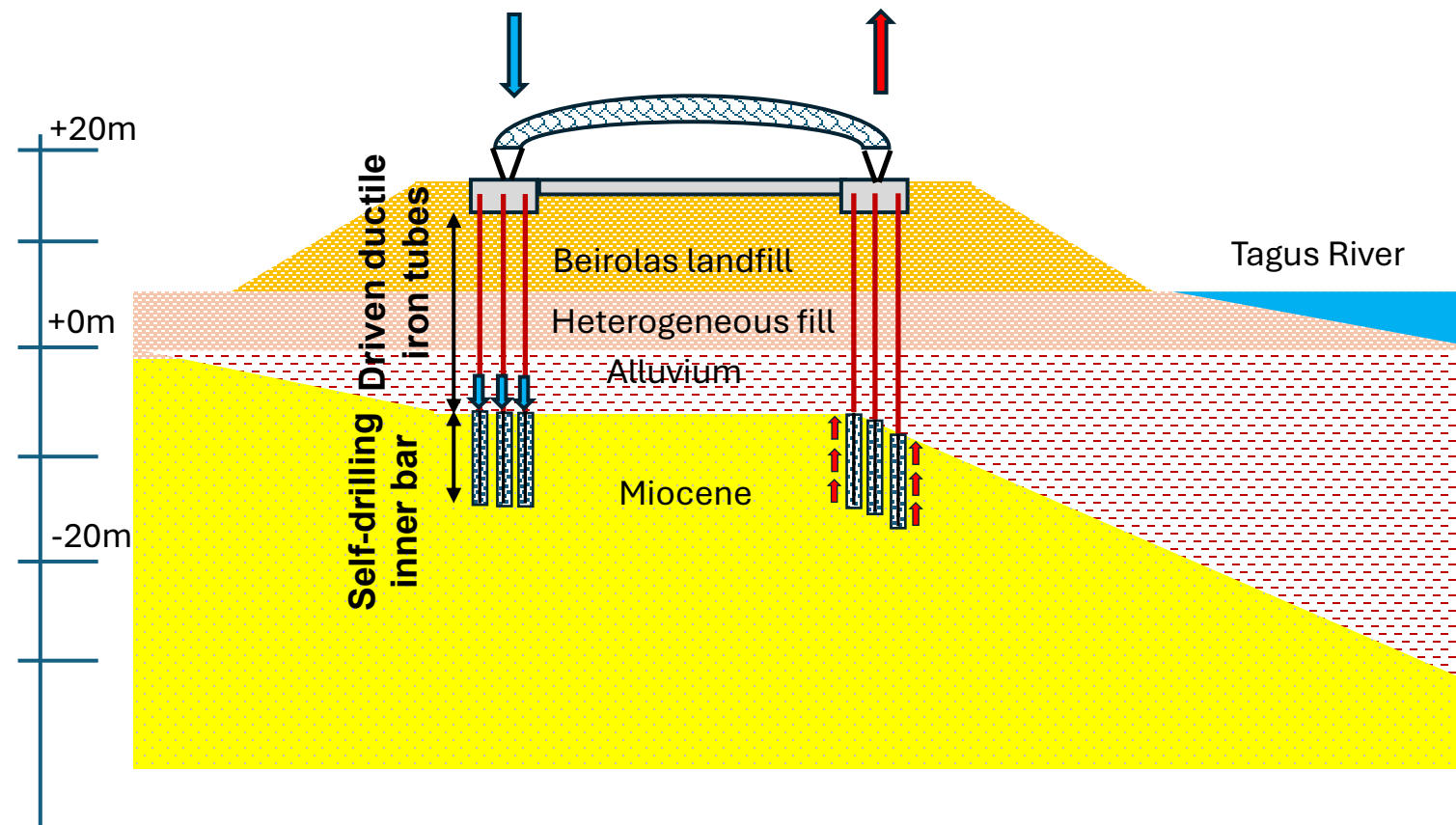
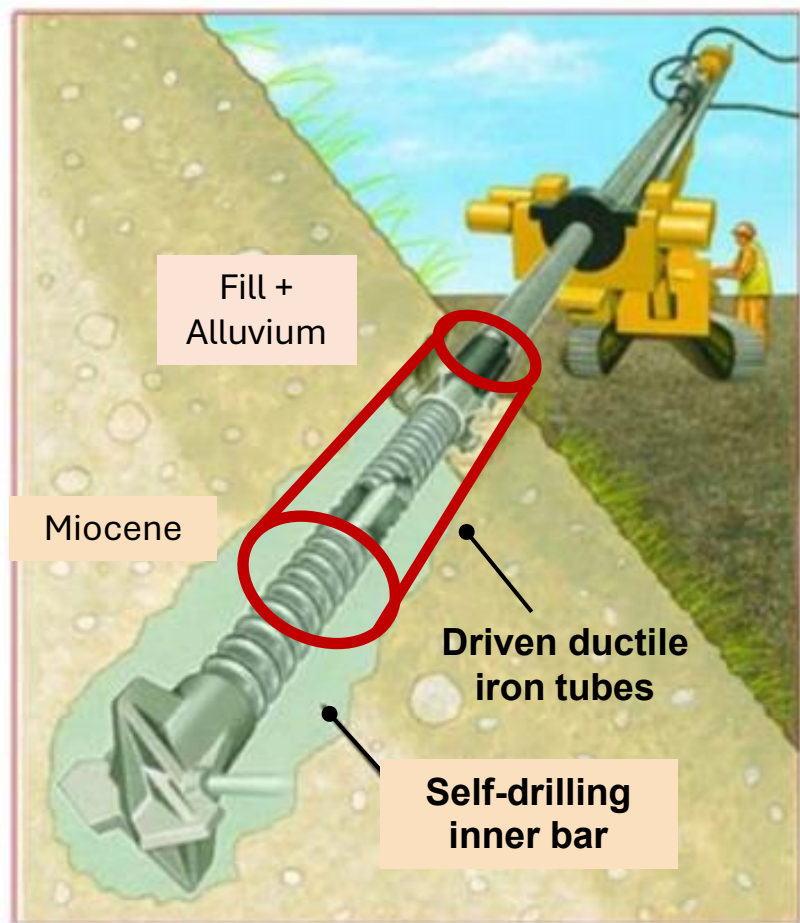


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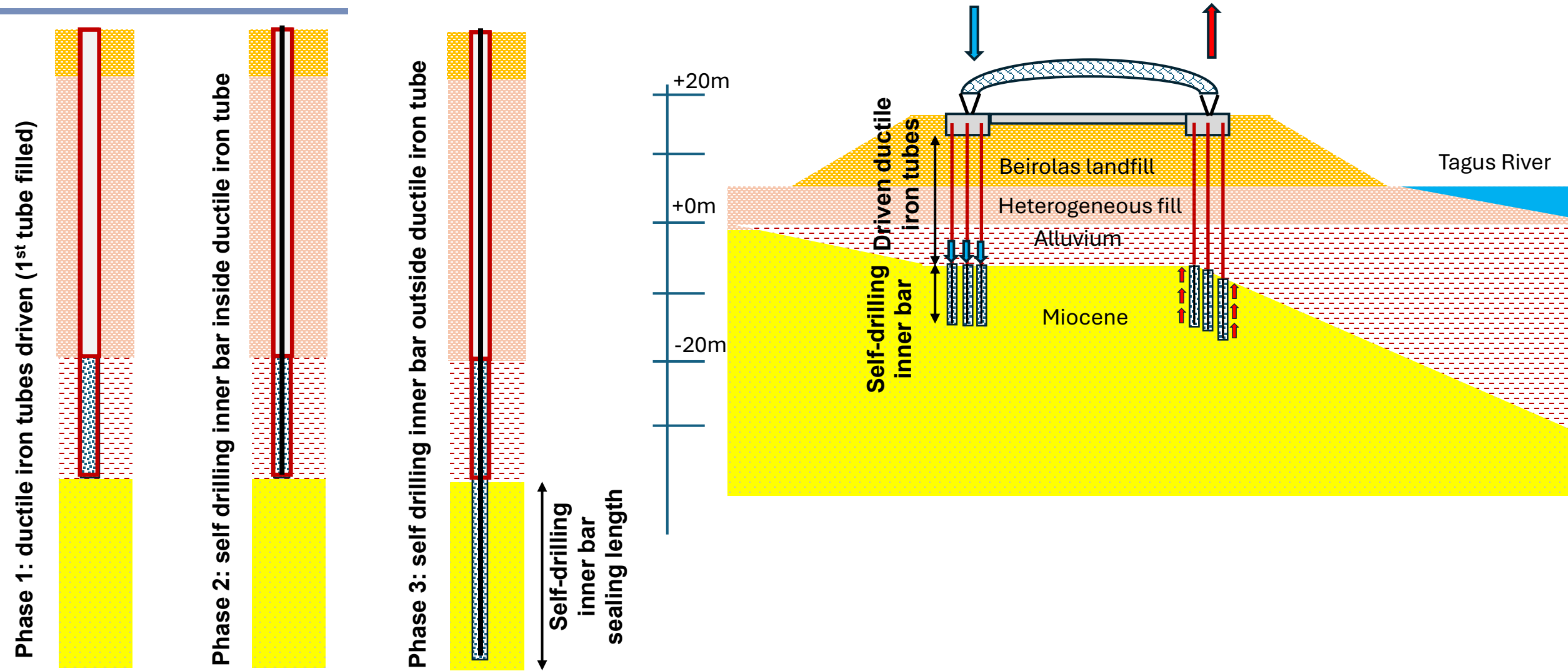
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- ❑ During the driven operations, the first (lower) tube was filled with micro-concrete, to avoid the tubes clogging and facilitate redrilling
- ❑ In this hybrid solution ductile iron micropiles worked as foundation stiffener, for compression loads and as self-drilling inner bar permanent casing, for tension loads



Foundations Solutions: Micropiles Hybrid Solution



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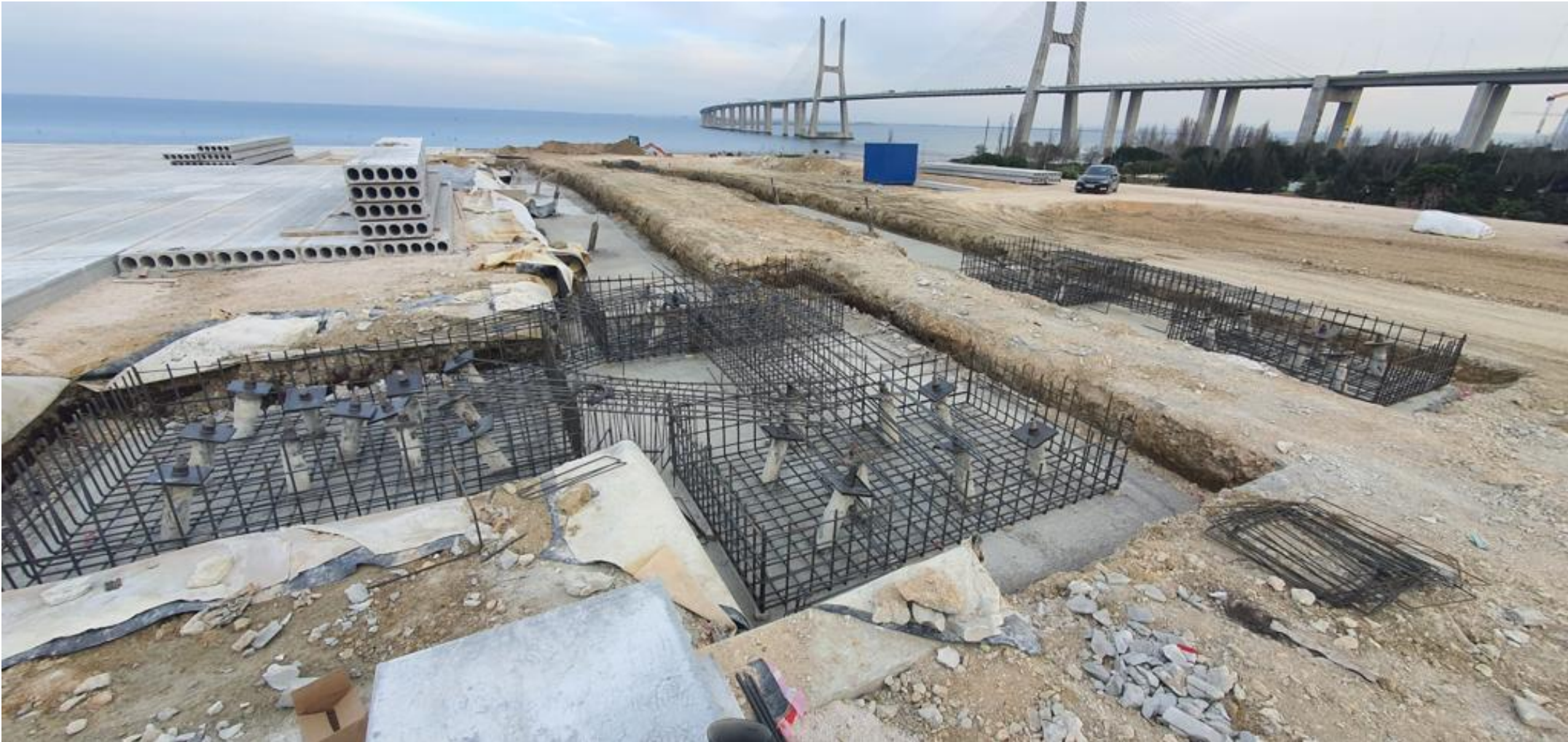


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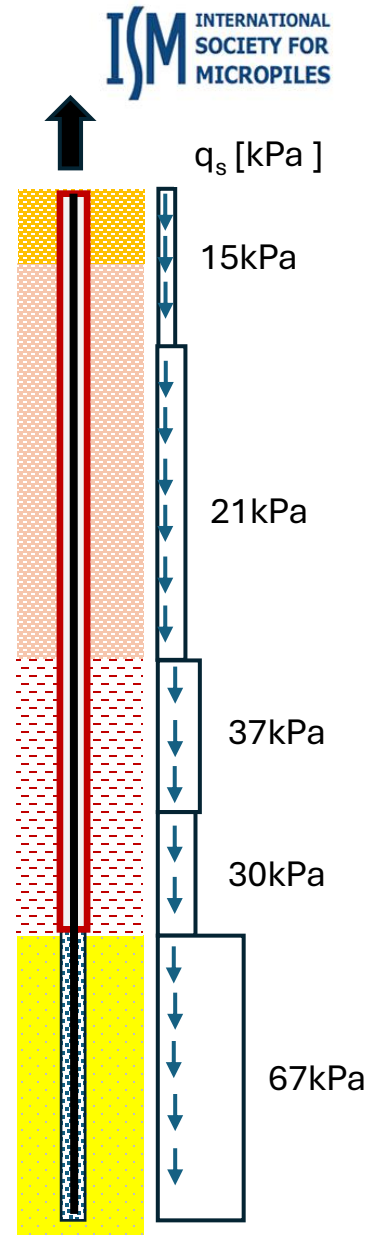
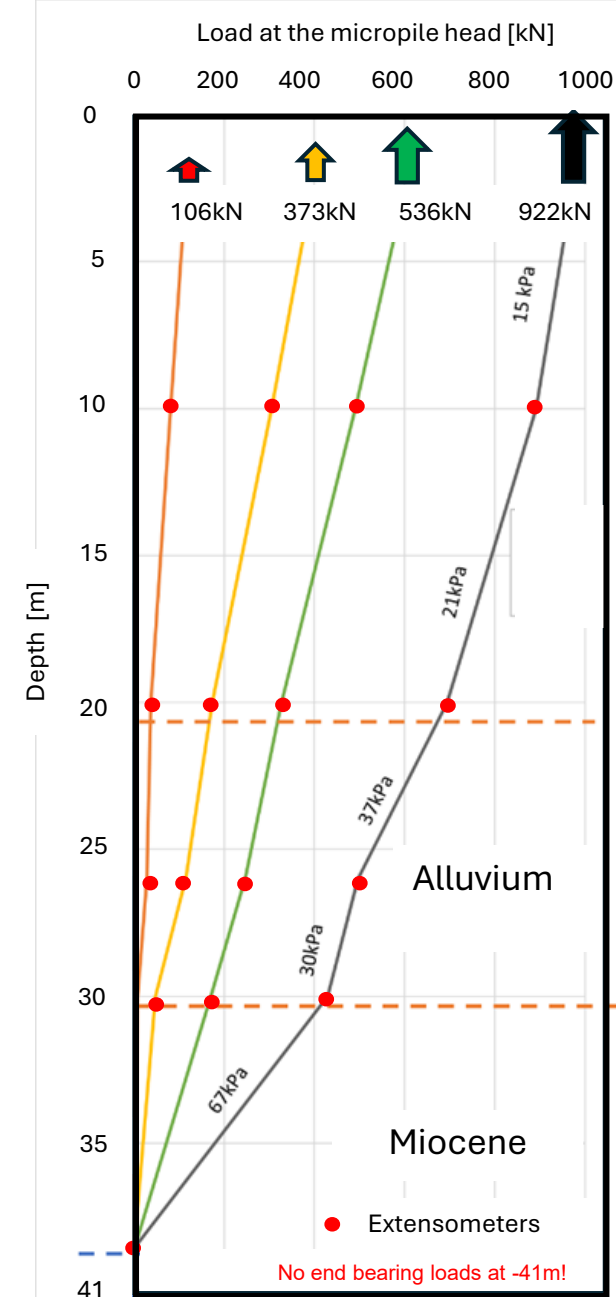


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Micropiles Compression Full Scale Load Test

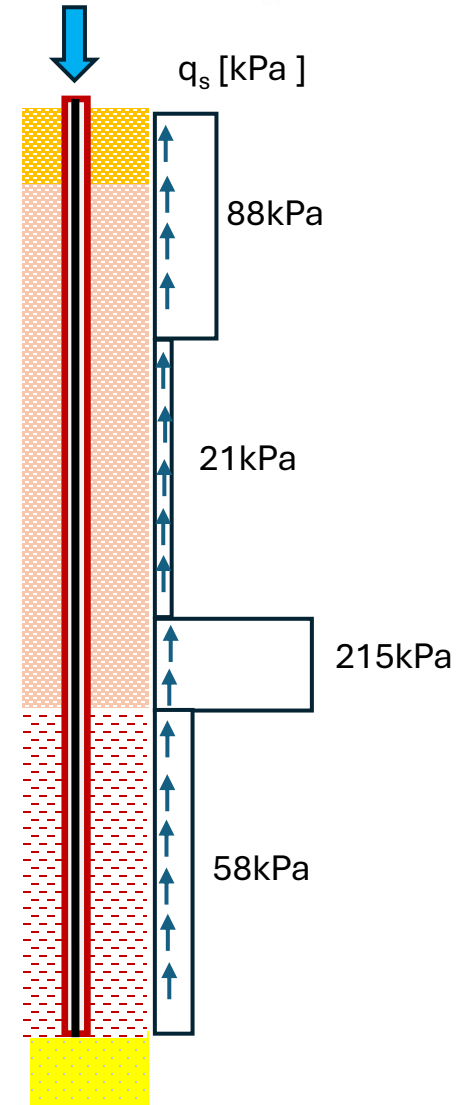
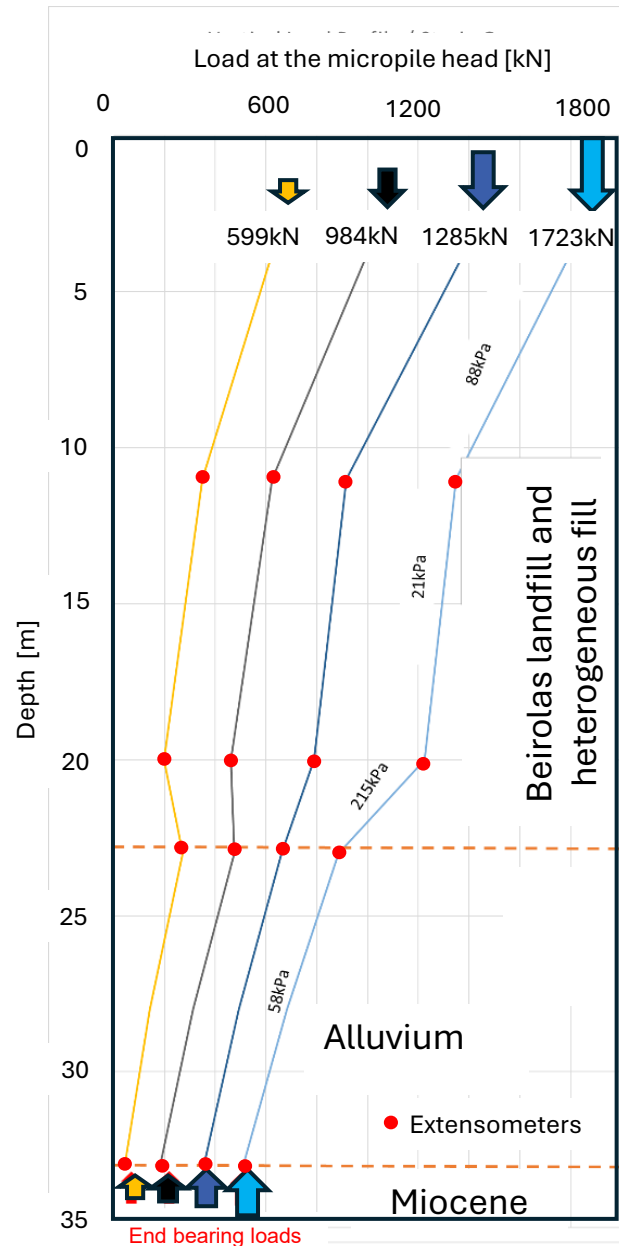


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Final Remarks

- ❑ Considering the tight construction schedule, as well as the other restraints, the adoption of versatile and high-rate micropiles solutions proved to be (once more) a successful option!



An aerial photograph of a large, green, rectangular park area, likely the Parque de S. João in Lisbon. The park is divided into several sections by paths and small structures. In the background, a city skyline is visible, including a large cable-stayed bridge on the left and various buildings. The sky is blue with some clouds.

**Thank you
for your kind attention!**

**Acknowledgments: Lisbon Municipality, Main Contractor
(Oliveiras) and Geotechnical Contractor (Geosol)**

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