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CASE STUDY: BIM AND GEOTECHNICAL PROJECT IN URBAN AREA – INFINITY TOWER, LISBON, PORTUGAL

Parallel Session 10 – Underground Construction
14th August 14:00-16:00
Room 03/28

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CHINA-EUROPE CONFERENCE ON GEOTECHNICAL ENGINEERING VIENNA, AUSTRIA 2018

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1. INTRODUCTION

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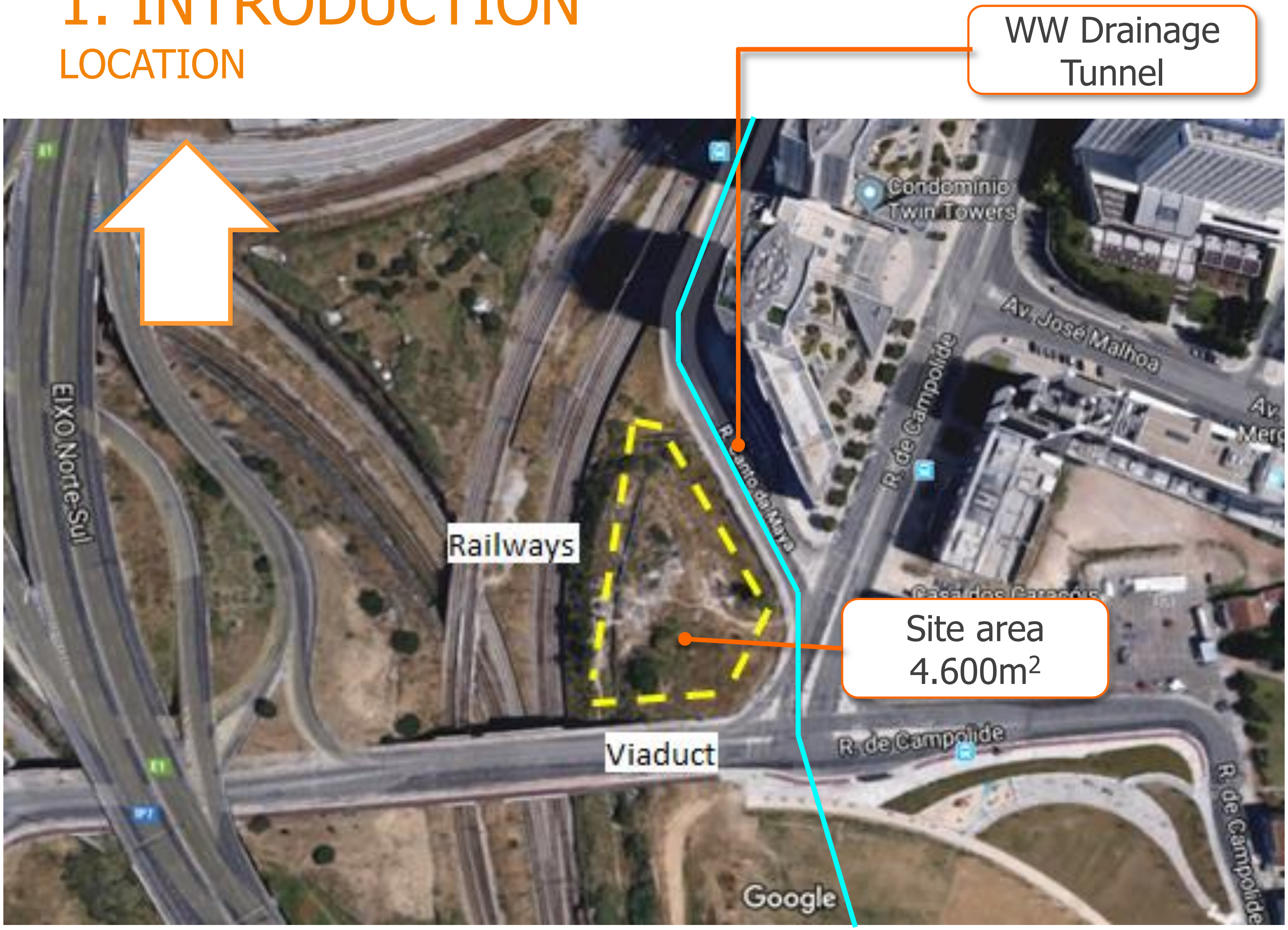
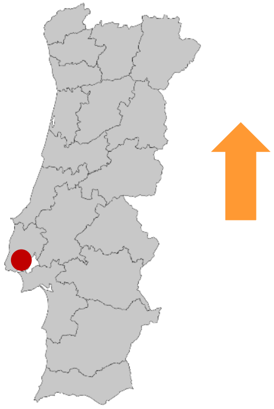
LOCATION





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2. INFINITY TOWER PROJECT

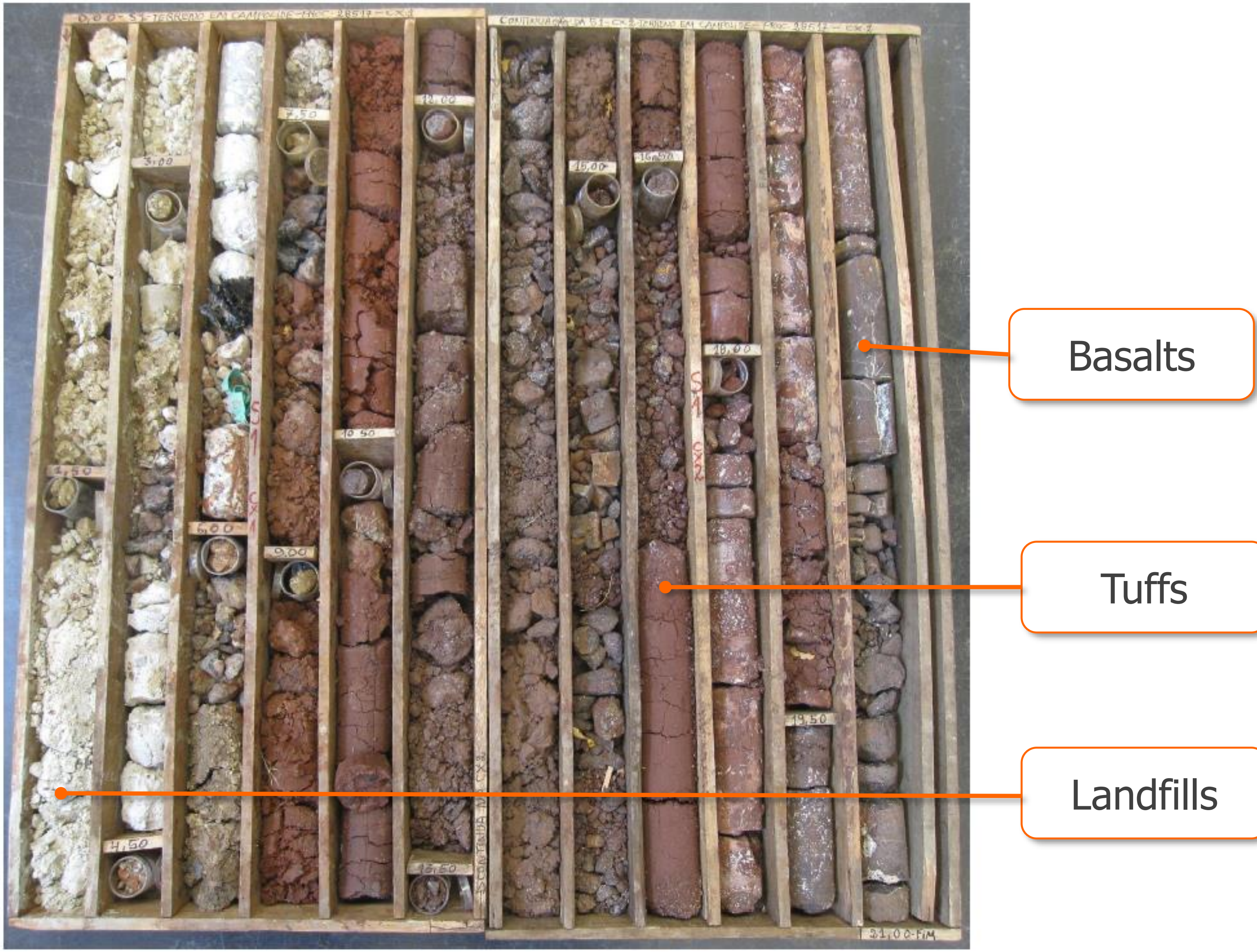
ARCHITECTURAL FEATURES

- The future tallest modern building of Lisbon will feature 26 floors and 4 basements.
- An iconic building in Lisbon's skyline with an impressive contemporary architecture.

https://www.infinity-tower.com/

GEOTECHNICAL FEATURES

- Heterogeneous Urban Fills.
- About 20m excavation depth intersecting Urban Fills and the Lisbon Volcanic Complex: mainly basalts and clay tuffs
- Lisbon Volcanic Complex: formed 72 million years ago by several important volcanic episodes, showing mainly basaltic sheets, volcanic tuffs, pyroclasts, volcanic breccias, etc,


Basalts
Tuffs
Landfills

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3. PROPOSED EARTH RETAINIG SOLUTION

MAIN RESTRAINTS

- Geotechnical and Geological: Landfills + Lisbon Volcanic Complex.
- Topographic: small hill.
- Surrounding Infrastructures: Alcantara WW Drainage Tunnel.
- Surrounding Infrastructures: Roads + Roadway Viaduct.
- Surrounding Infrastructures: Railway Line.

GEOTECHNICAL AND GEOLOGICAL

- The ground characterization was made through 9 boreholes with SPT tests, continuous sampling collection for laboratory tests and piezometers.
- The area is covered by a landfill deposit layer, over the Lisbon Volcanic Complex (LVC).
- 4 main geotechnical Zones were established:
  - ZG1, regarding the landfill layer;
  - ZG2 for pyroclastic tuffs and low-quality basalts;
  - ZG3 and ZG4 for medium to high-quality basalts.

GEOTECHNICAL AND GEOLOGICAL

GEOTECHNICAL ZONES - ZG

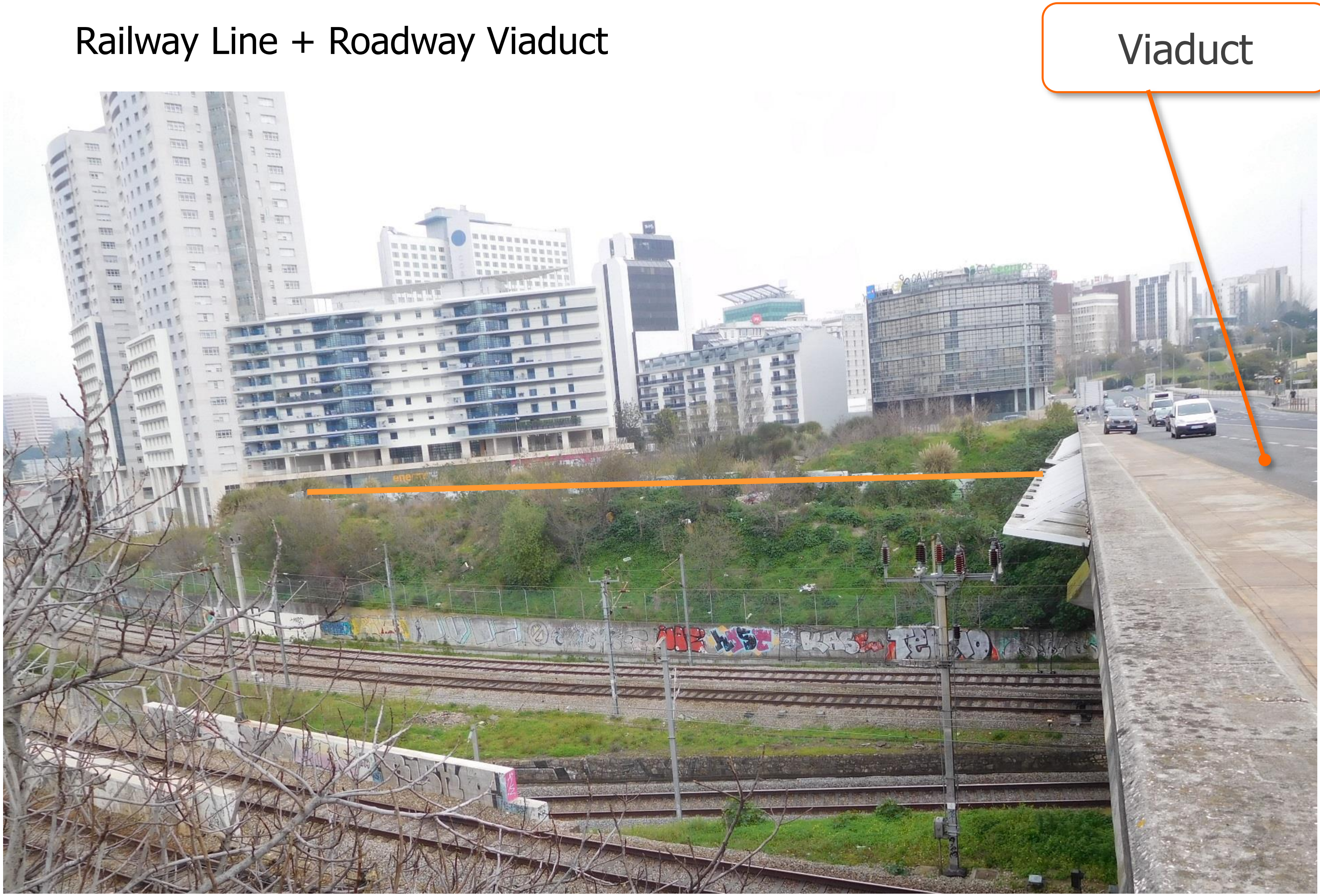
Geotechnical Zone	Description	γ (kN/m³)	Ø′ (º)	c′ (kPa)	Es (MPa)
ZG1	Landfill (5≤NSPT≤17)	18	30	0	15
ZG2	Pyroclastic tuffs and low-quality basalts W4 to W3-4; F5 to F4-5 with recovery ranging from 60% e 100% e RQD=0%	22	33	50	65
ZG3	Basalts W3 to W3-2, F4 to F4-5, with 90% recovery ranging and 20% ≤RQD≤75%, interbedded with basalts W3-2, F4-5 with 100% recover and 47%≤RQD≤74%	22	37	80	120
ZG4	Basalts W3-2 to F4-3, with 100% recovery and 56%≤RQD≤76%	22	45	100	150

TOPOGRAPHY

- The existing topography, with the building location laying over a small hill, leads to an excavation depth ranging from 18m to 7m at the opposite alignments

MAIN RESTRAINTS – Topography

Railway Line + Roadway Viaduct



MAIN RESTRAINTS – Surrounding Infrastructures

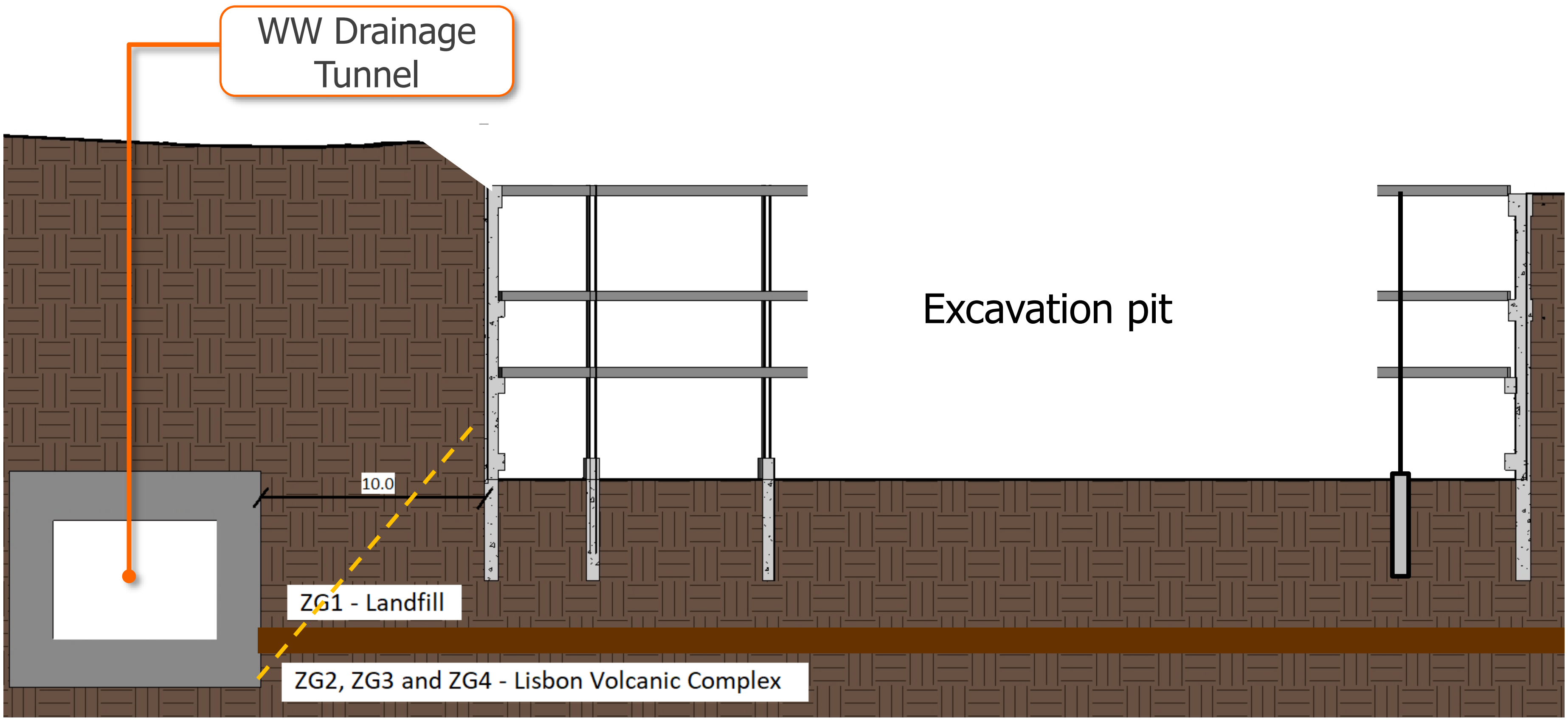
Alcantara Stream, 1912

MAIN RESTRAINTS – Surrounding Infrastructures

Alcantara Waste Water Drainage Tunnel, 1945

MAIN RESTRAINTS – Surrounding Infrastructures

Alcantara Waste Water Drainage Tunnel, close to excavation pit



PROPOSED SOLUTION

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- Control the ground deformation;
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- Improve Safety + Decrease Schedule + Decrease Costs.

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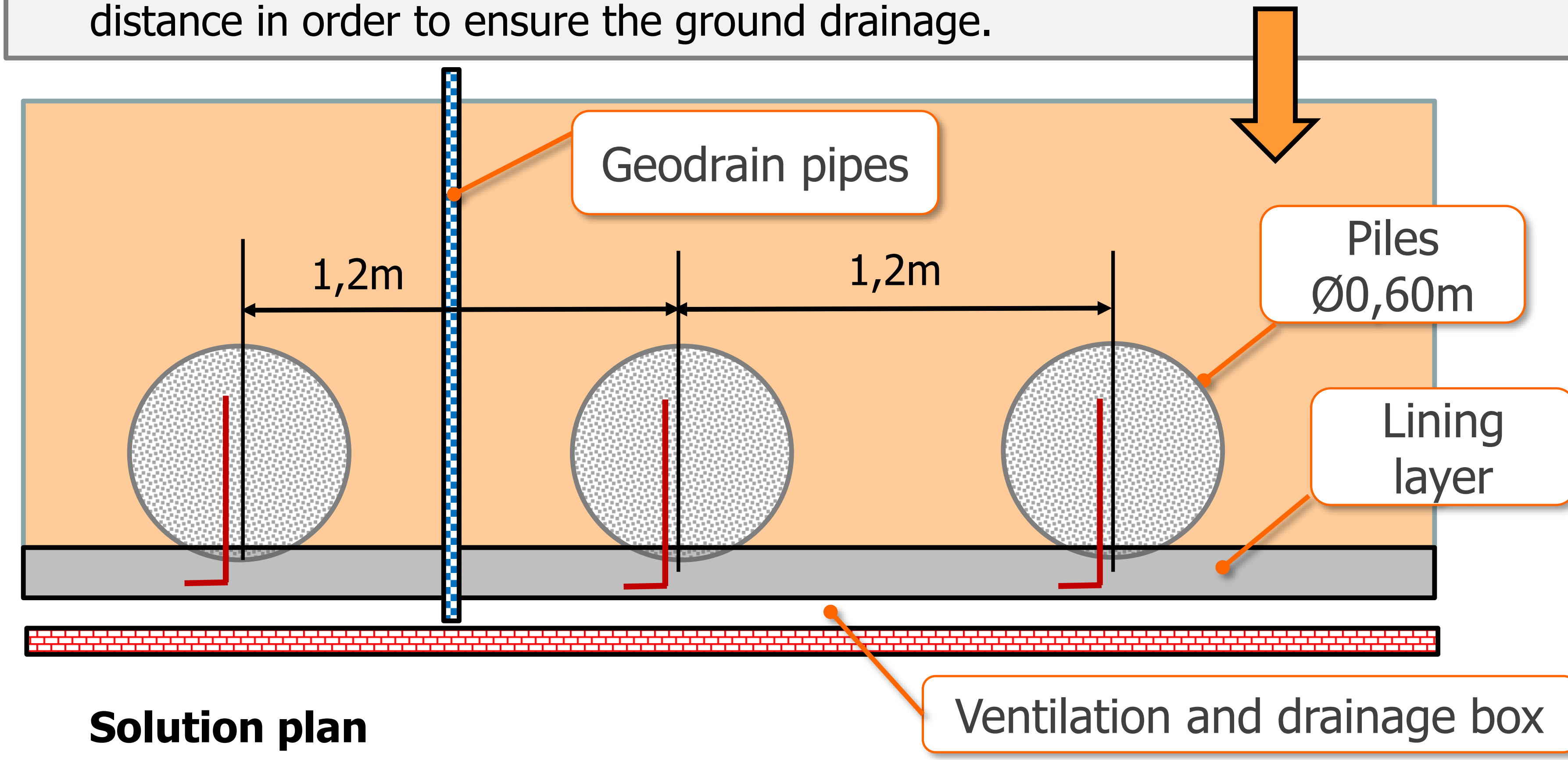
- Bored Pilled Wall solution with 600mm diameter pile and a plan space ranging between 0.80m and 1.20m.
- The total pile's depth ranges from 21.60m to 10.30m, all with a minimum embedment length of 4.00m.

PROPOSED SOLUTION

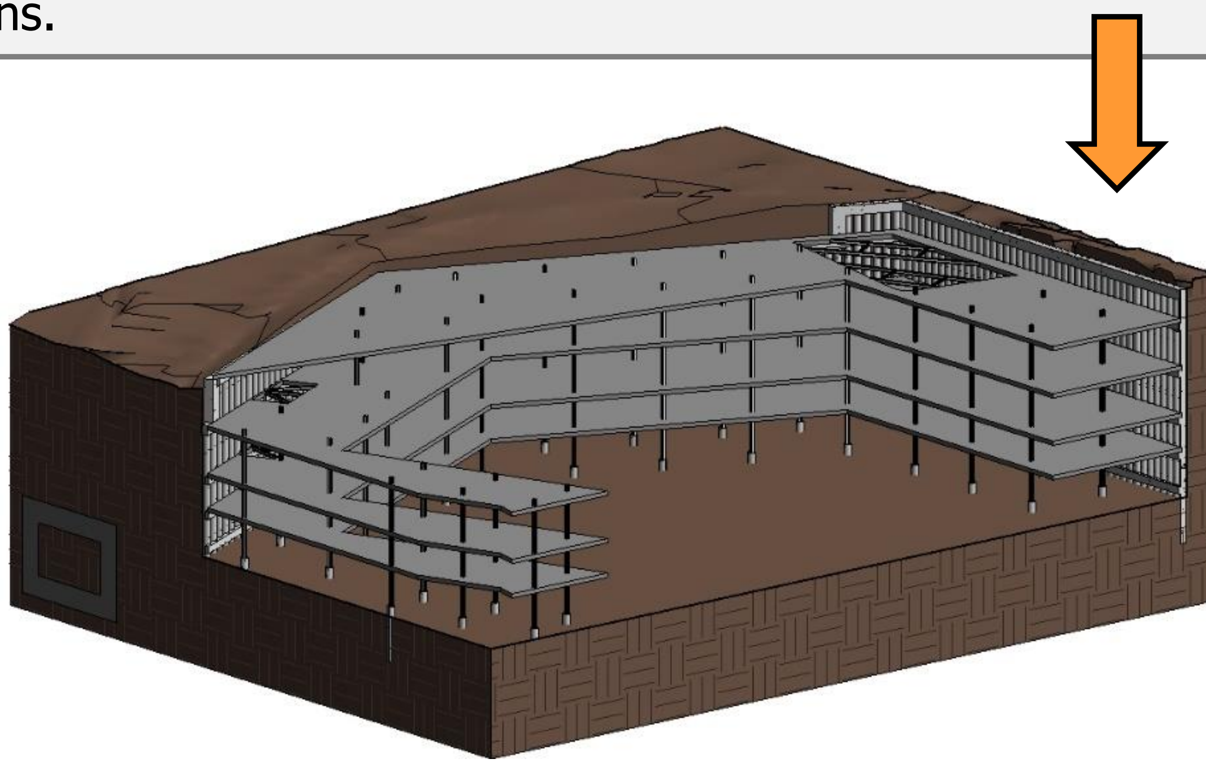
- The ground between the piles will be lined by a shotcrete layer of 150mm minimum thickness
- Geodrain pipes with 3m length will be installed with a minimum of 3.60m plan distance in order to ensure the ground drainage.



Solution plan

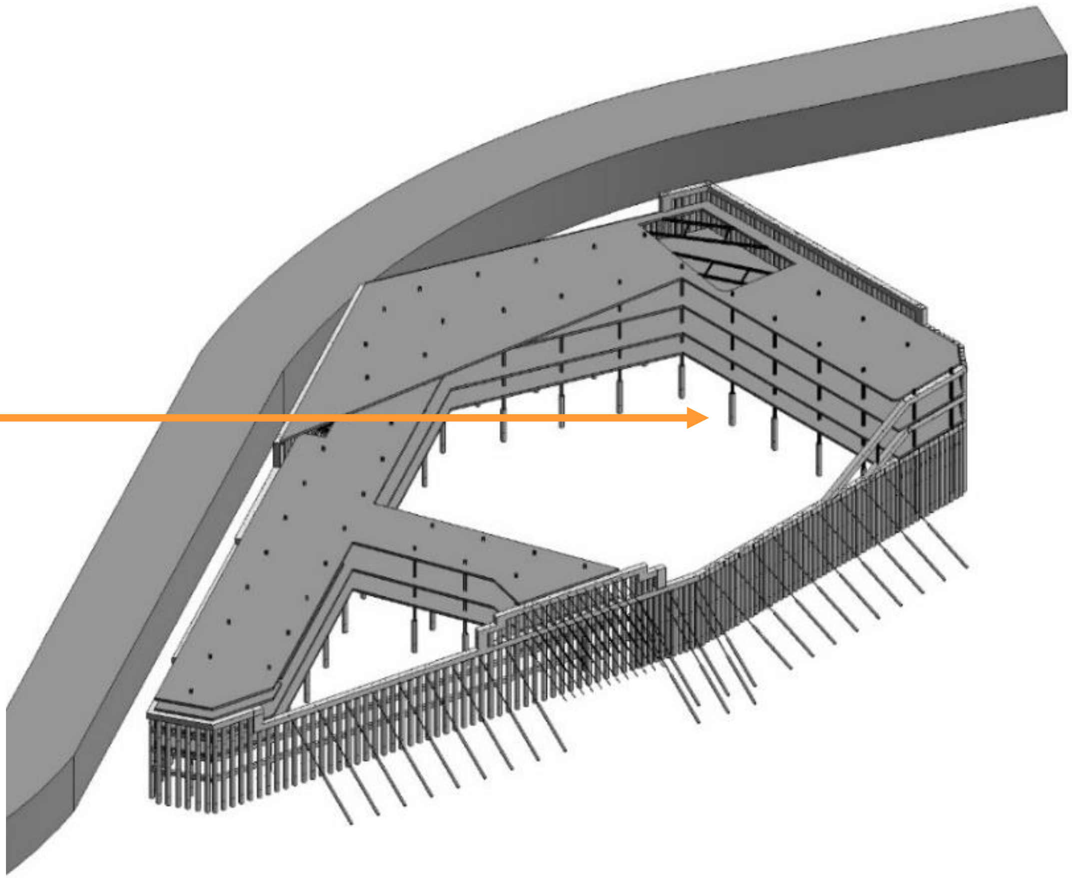
PROPOSED SOLUTION

- In the west view, the wall will be braced by one level of temporary ground anchors to be installed at level -2 with 3.60m plan space.
- The remaining excavation alignments will be stabilized with slab bands of 12m width and 0.35m minimum thickness, compatible with both the architecture and structural solutions.



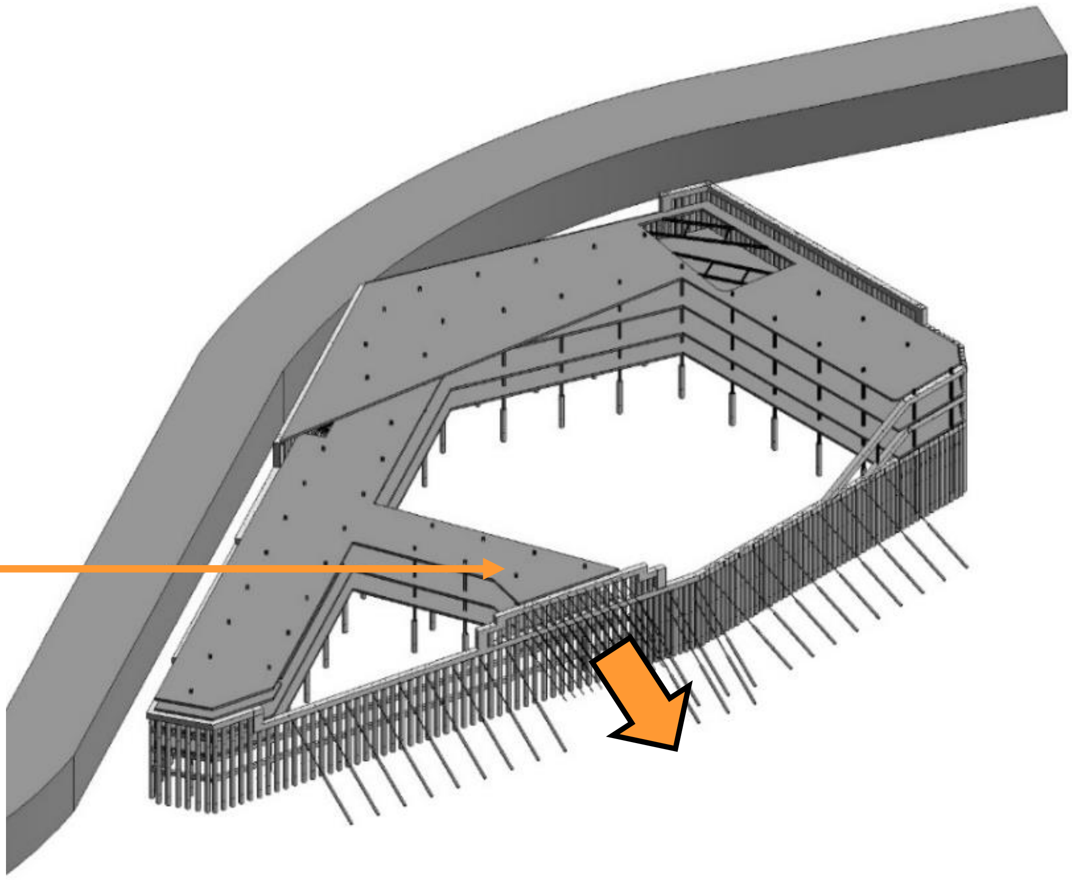
PROPOSED SOLUTION

- The slab bands will be supported by vertical steel profiles HEB260 embed in 600mm bored piles, 4m below the excavation final level.



PROPOSED SOLUTION

- The slab bands will be supported by vertical steel profiles HEB260 embed in 600mm bored piles, 4.00m below the bottom level of excavation.
- The slab bands above level -2 will be supported by slimmer slab strips of aboute 7m width that will react against the piles wall at the west view.



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4. DESIGN METHODOLOGY

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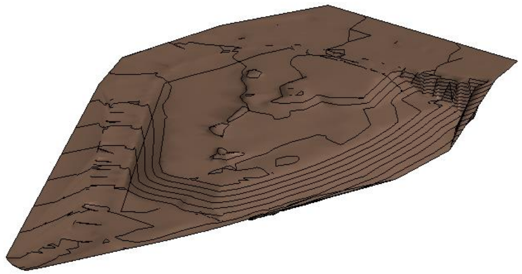
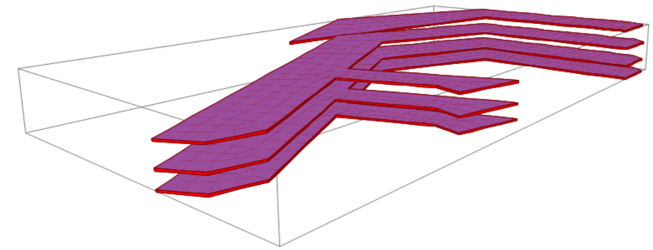




Preparation

- Units
- Phasing
- Levels
- Geolocation

Topography

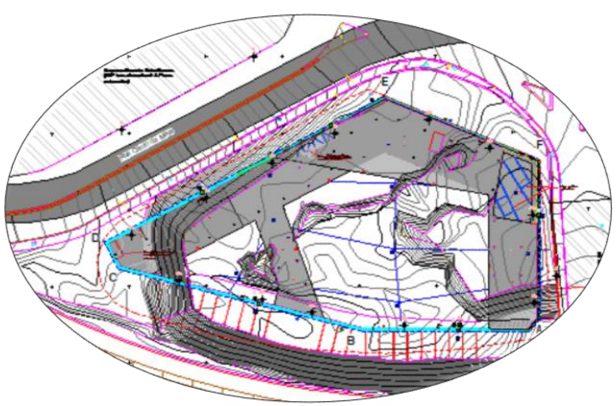
- Earthworks quantities
- Restraints

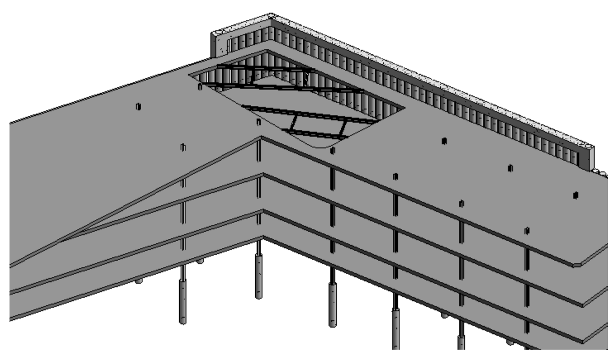
Structure

- Bored Piles
- Slab bands
- RC beams
- Steel profiles
- Ground anchors

Analysis

- Plaxis
- SAP2000





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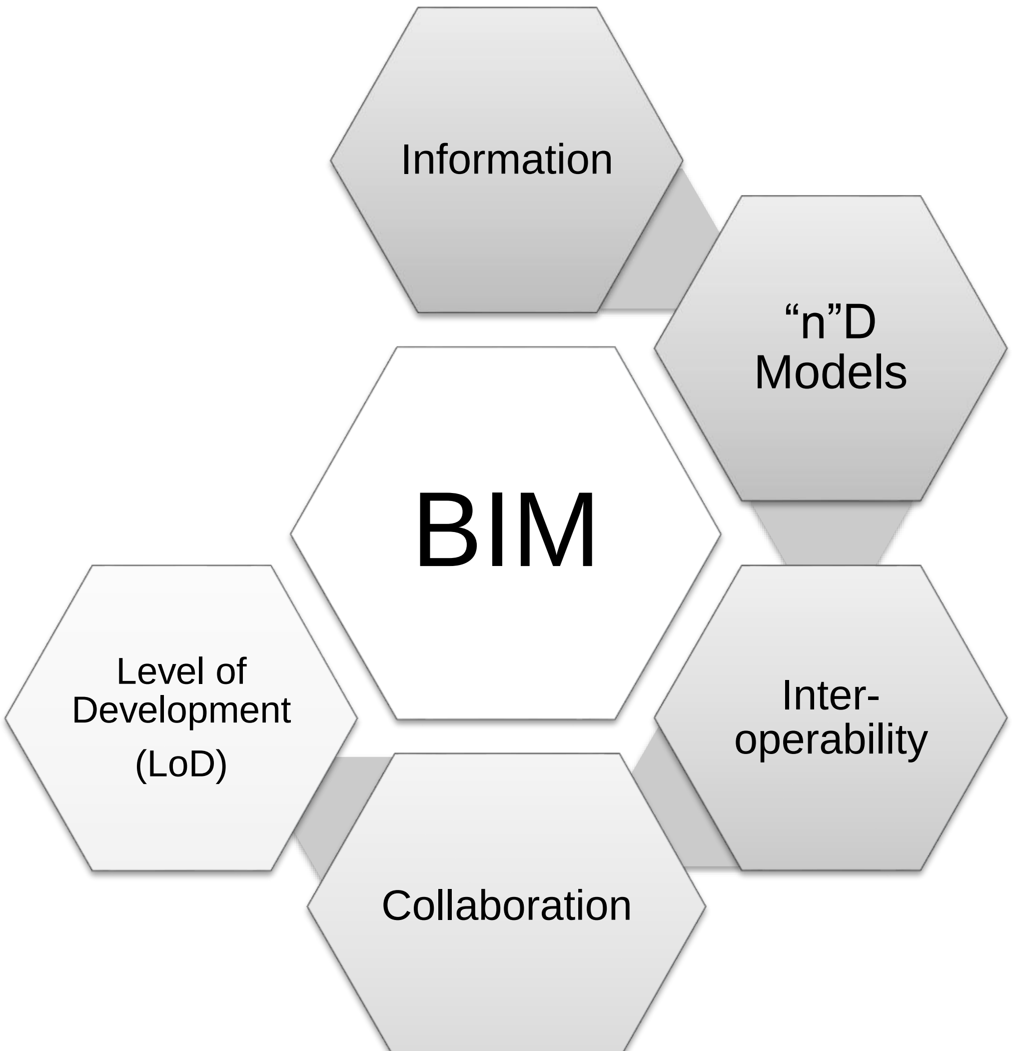


- **Information**

  Centralized in the 3D objects.

- **“n”D Models**

  Time (4D), Budget (5D), Sustainability and facility management (6D and 7D).

- **Interoperability**

  Capacity to seamlessly exchange information within different platforms.

- **Collaboration**

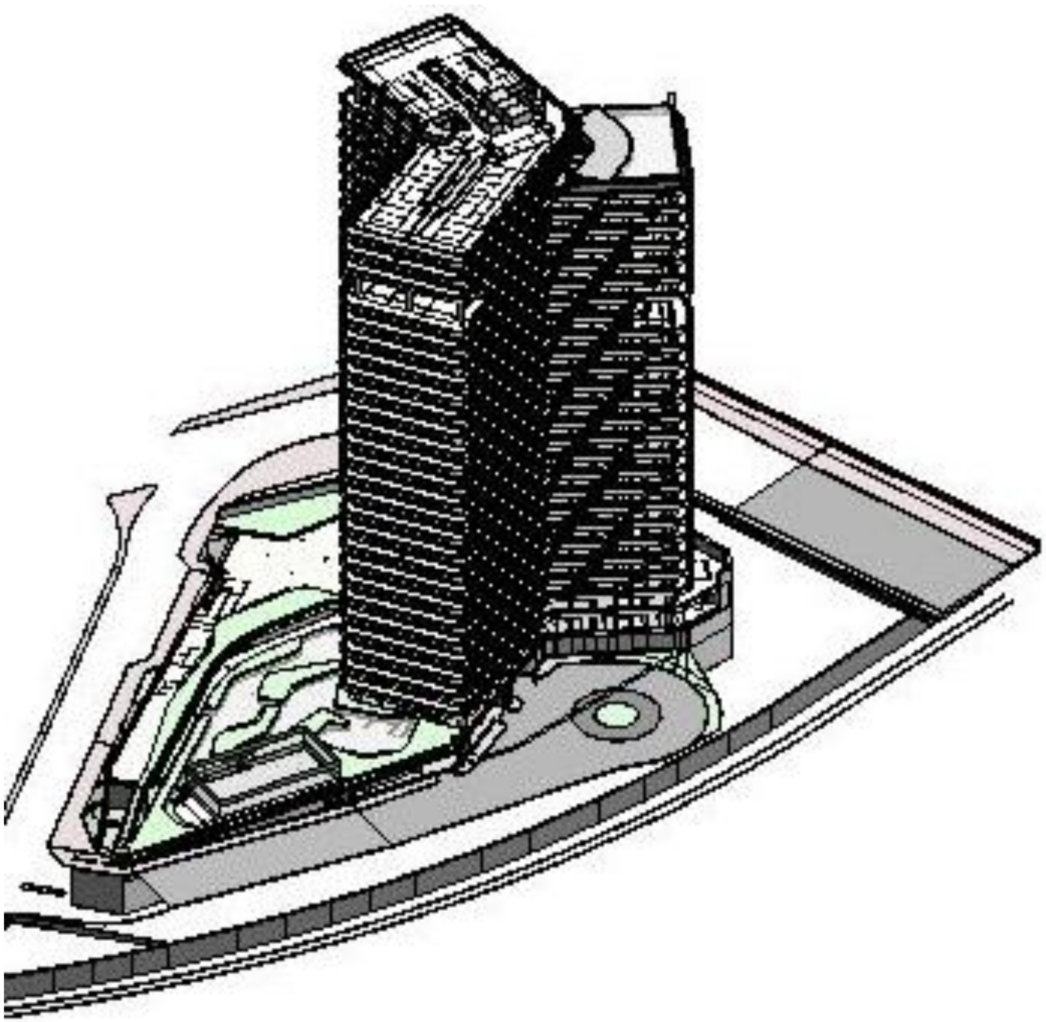
  Promotes an early stage design team-up.

- **Level of Development**

  Level of information associated with the objects.

DESIGN METHODOLOGY

- Among the elements received was the architecture project geometry in a 3D BIM model.
- The existing topography was modeled in the BIM software.



DESIGN METHODOLOGY

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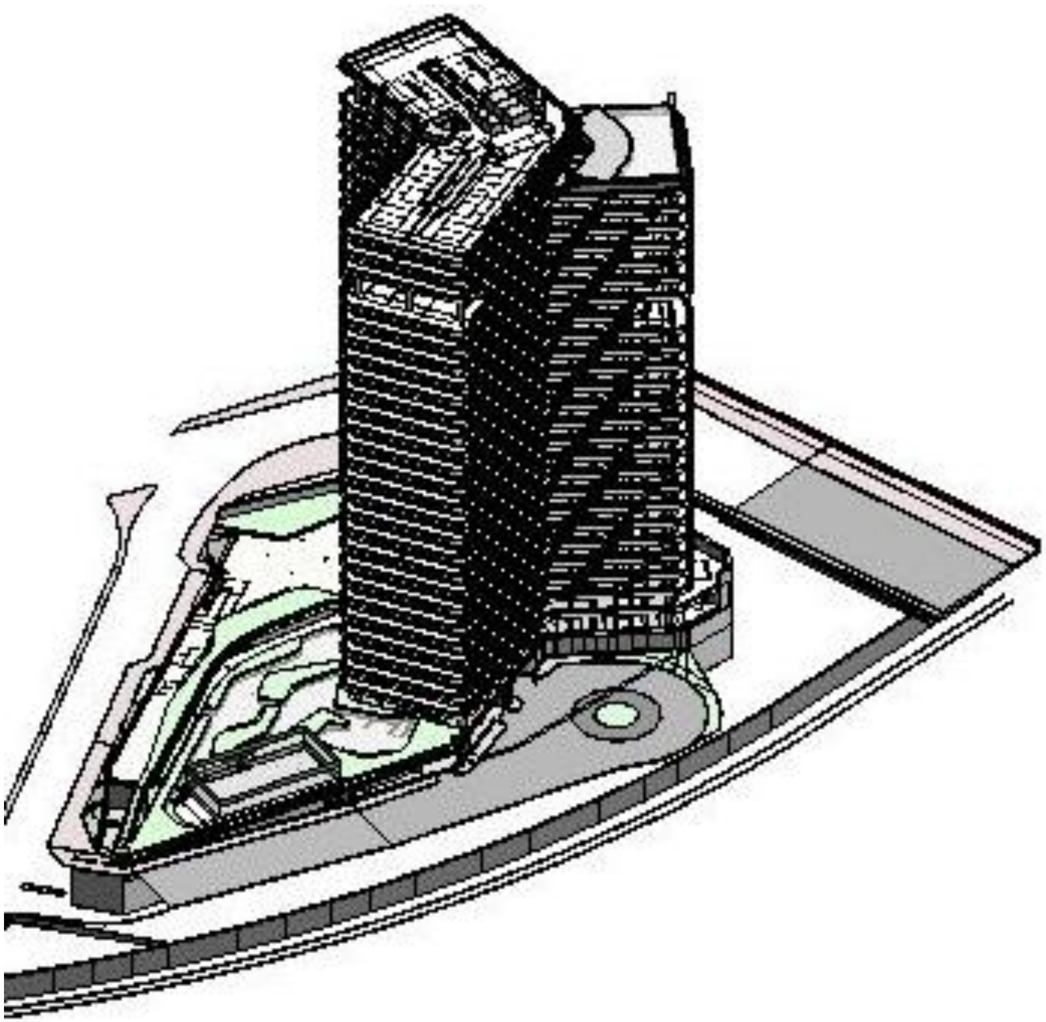
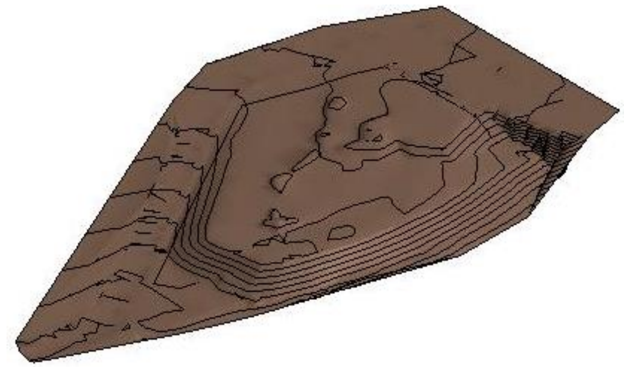
- The existing topography was modeled in the BIM software.

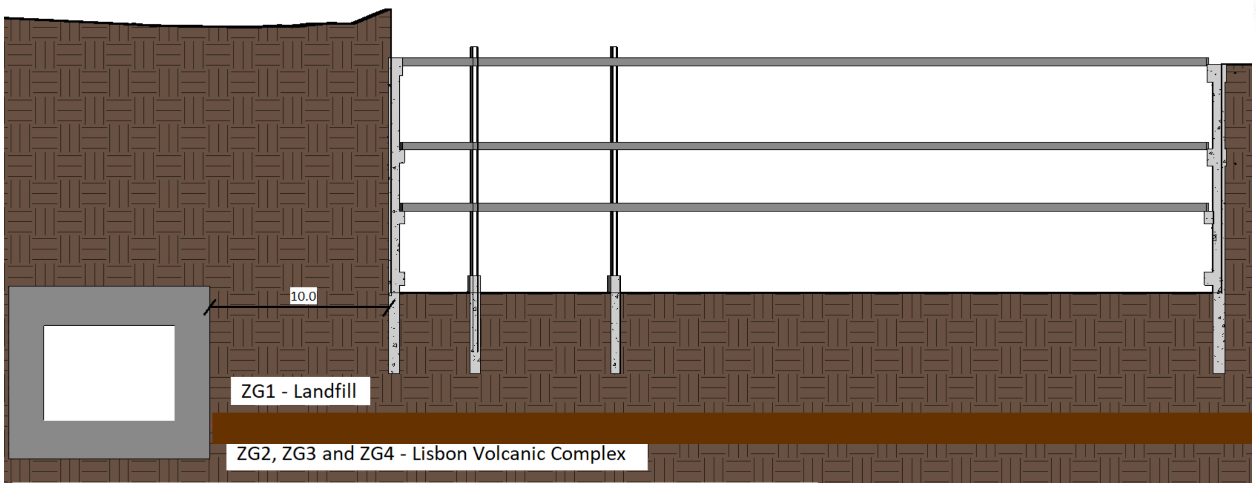
- The architecture model was linked to the file and the geographic position of the surface was coordinated with the architecture model and the existing lot boundary and topography.

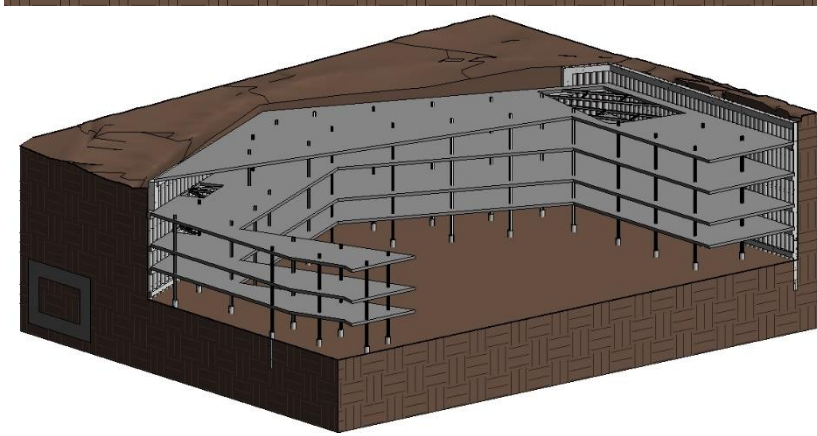


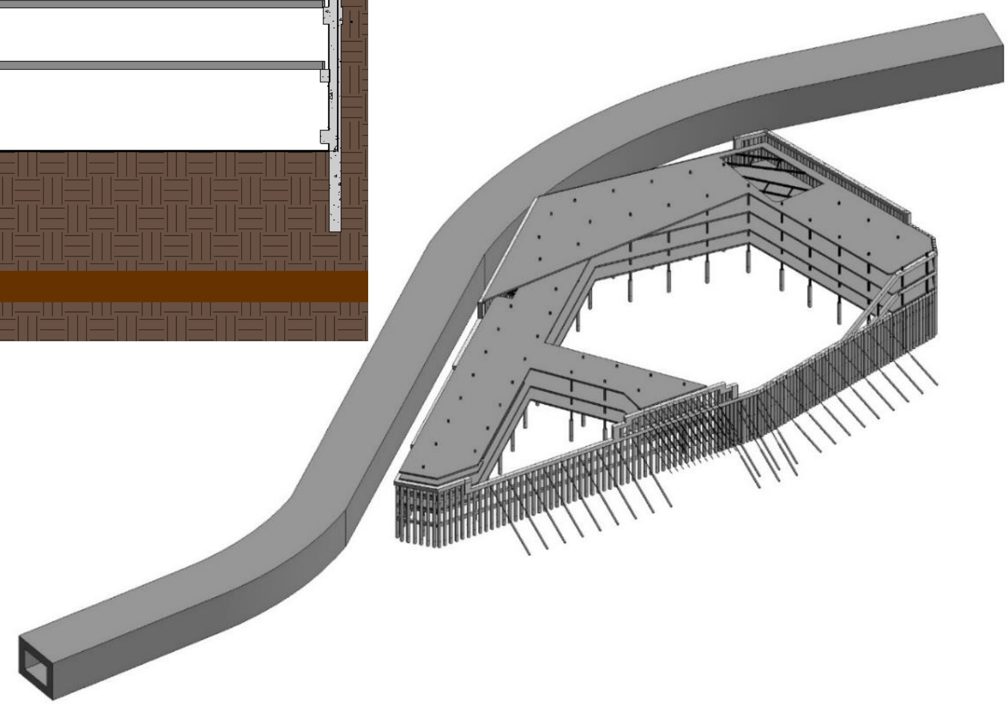
DESIGN METHODOLOGY

- The modeling of the bored piles wall was done according to the architecture 3D BIM model.

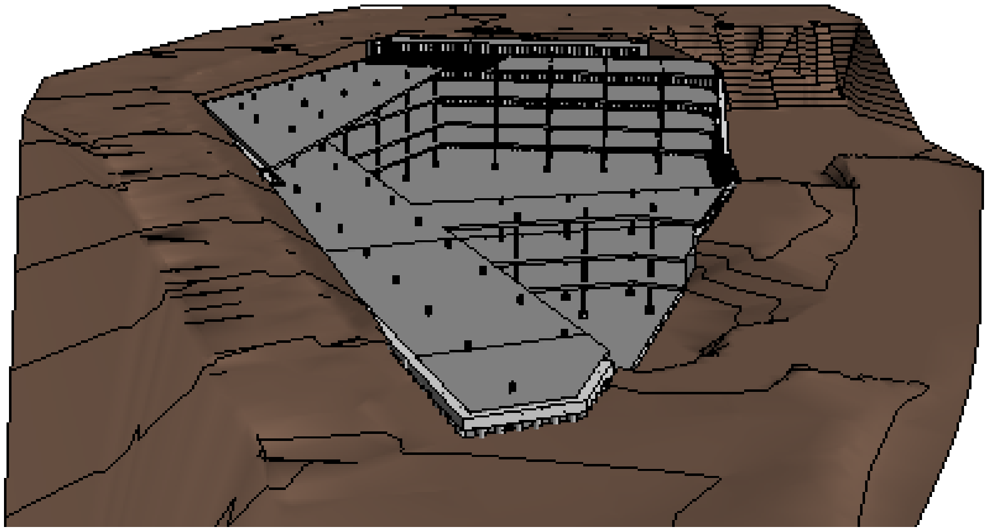








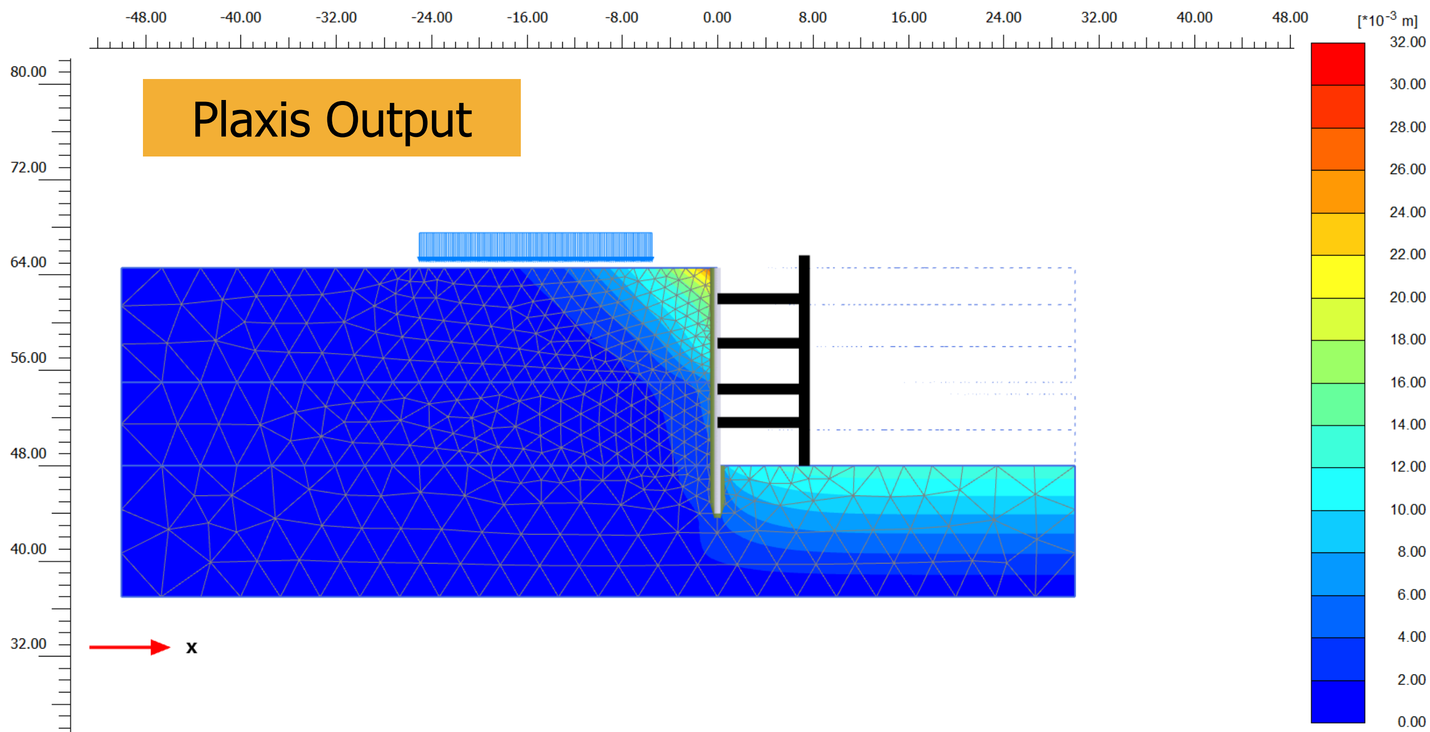
DESIGN METHODOLOGY



DESIGN METHODOLOGY

- The solution was evaluated using the geotechnical software (PLAXIS2D)

- Displacements and efforts were estimated and analyzed considering the geotechnical zones and correspondent parameters.

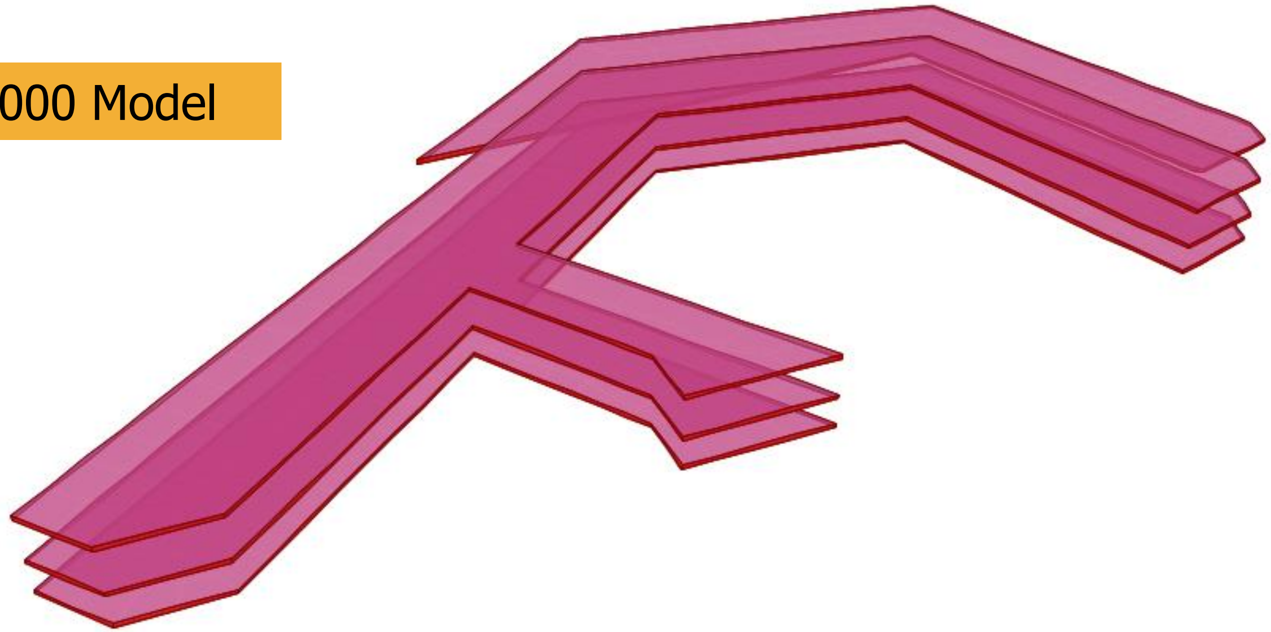


SAP2000 MODEL IMPORTED FROM A 3D BIM FILE

- The geometry of the slabs were exported to a structural analysis software (SAP2000) using an IFC file type.

- Loads obtained from the PLAXIS2D were introduced on the SAP2000 model and the deformations compatibility was checked on a iterative way

SAP2000 Model



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5. FINAL REMARKS

FINAL REMARKS

- The use of BIM methodology allowed an accurate coordination with the architecture and others engineering projects and promoted efficiency in terms of project documentation, especially when changes were needed.
- The interoperability among software allowed that the geometry from the 3D BIM model could be exported.
- The 3D visualization of the project and the restrains helped to find out the best engineering solutions, including the compatibility check between the several architecture and engineering solutions.
- The BIM model will be a very useful at both the construction and the building maintenance / management under operation phases

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