Case Study: BIM and Geotechnical Project in Urban Area – Infinity Tower, Lisbon, Portugal

João Gondar[1], Catarina Fartaria[1] and Alexandre Pinto[1]

[1] JETsj, Geotecnia Lda., Lisbon, Portugal
jgondar@jetsj.com, cfartaria@jetsj.com, apinto@jetsj.com

Abstract. The Building Information Modeling (BIM) methodology is spreading across the Architecture, Engineering, and Construction (AEC) industry. The need of leaner processes from the concept to the execution of projects are opening space for this approach. One of the advantages of BIM methodology is an early coordination and communication among the different project's stakeholders, a key issue for the geotechnical project where uncertainty is high. This case study approaches the use of BIM for a geotechnical project of an excavation for a residential tower in Lisbon center, with a deployment area of about 4600m^2 and a maximum excavation depth of 17.60m. The solution proposed was a Bored Pile Wall (BPW), braced by temporary ground anchors and slab bands. The solution was modeled coordinated with the 3D BIM model from the architecture and was then exported to a soil analysis numerical software, as well as to a structural analysis software, allowing the proposed solution overall optimization.

Keywords: BIM, collaboration, bored piles wall (BPW).

1 Introduction

The recent rise in the real estate industry in Portugal associated with the urban planning decisions to release the surface area for leisure purposes is increasing the need to build new underground spaces, creating the need of constant coordination of this kind of projects with other building project's specialties.

The rise of Building Information Modeling (BIM) concept is promoting an increase in the collaboration among the different project specialties in the construction industry. The traditional design-bid-build process where the architect handles the design to the engineers and all the documentation is produced before it is delivered to the contractor is shifting to a more integrated design-build process, where the different project and subjects must team up much earlier [1]. The process is no longer linear but collaborative. This collaboration is especially important for projects where uncertainty is high, what is generally the case of geotechnical projects. This increased collaboration can lead to a rise in efficiency and a better time management [2].

The geotechnical construction sector is characterized by its both financial and physical risk, associated with its projects [3]. The lack of early design stage integration among specialties and the accurate and timely availability of geological and geotechnical information are some of the challenges faced by this sector and can potentially benefit from the BIM approach.

2 Case Study

The case study is related to the Infinity Tower, to be built in Lisbon. The main restrains defined were related to the topography, geological and geotechnical conditions, and the neighboring conditions.

2.1 Geological and Geotechnical Conditions

The characterization of the underground conditions was made through 9 boreholes with SPT tests and collect of sampling for visual and laboratory tests, done across the deployment area. The excavation area is located over the Lisbon Volcanic Complex materials, covered by a landfill deposit layer. It was divided into 4 geotechnical Zones: ZG1, regarding the landfill layer; ZG2 for pyroclastic tufts and low-quality basalts; ZG3 and ZG4 for medium to high-quality basalts.

2.2 Existing Topography

The existing topography, with the building deployment laying over a small hill, makes that the excavation depth to vary from 17.60m to 6.25m in opposed alignments.

2.3 Neighboring Conditions

The intervention zone is located on an urbanized area. At the west, it is limited by the Lisbon sub-urban railway line, at south side by a viaduct, and North-East and East fronts are limited by road and pedestrian streets, over a waste water tunnel.

Fig. 1. Deployment area surroundings

3 Proposed Solution

The proposed solution considered the existing restraints with the purpose to control the ground deformations and execute the excavation with the minimum interference with the surrounding infrastructures and services, taking in account the safety, constructability, and cost associated.

The conceived solution was a Bored Pilled Wall (BPW) with 600mm diameter piles spaced from 0.80m and 1.20m, according to the geological conditions. The total pile's length ranges from 21.60m to 10.30m, all with a minimum embedment length of 4.00m at the Lisbon Volcanic Complex materials.

The BPW was braced, at each floor level, by reinforced concrete slab bands and temporary ground anchors. The soil located between the piles faces will be covered by a shotcrete layer of 80mm minimum thickness, and geodrains will be installed with a minimum 3.60m of displacement to ensure the wall drainage.

In the west front, the wall will be held by one level of temporary ground anchors to be installed at level -2, spaced 3.60m. As already stated the remaining excavation sides will be braced with slab bands of 12.00m width and 0.35m minimum thickness, compatible with the architecture and the structure. The slab bands will ensure a stiff bracing to the solution [4].

These slab bands are temporarily supported by vertical steel profiles HEB260 embedded, at 600mm piles, 4.00m below the excavation bottom level. The slab bands above level -2 are supported by slimmer slab strips of 2.50m width, that will react against a temporary reinforced concrete structure, partially embedded at the BPW the west side.

4 Design Methodology

Among the elements received was the architecture project geometry in a 3D BIM model. The existing topography was designed in the BIM software, and then, 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.

Fig. 2. – 3D Architecture BIM model and the Retaining BIM model (left) and virtual view of the future tower (right)

The modeling of the bored pile walls was done according to with the architecture 3D BIM model. The solution was then tested using a numerical analysis software (PLAXIS2D) and the displacements and forces were analyzed considering the respective soil parameters. The geometry from the BIM model and the loads from the PLAXIS2D were then exported to a structural analysis software (SAP2000) using an IFC file type. The retaining solution was then adjusted according to the results obtained.

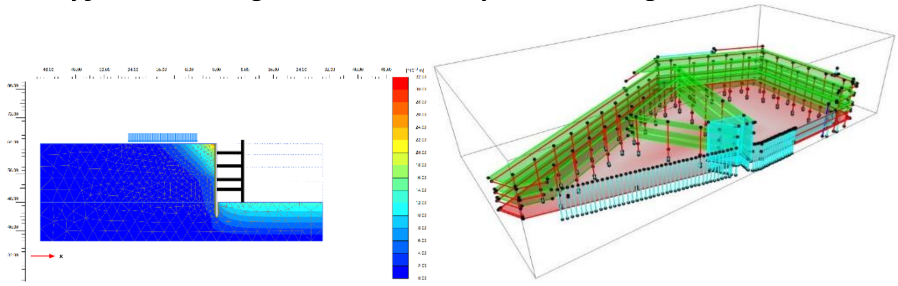

Fig. 3. Analysis in PLAXIS2D (left) and SAP2000 model, the last imported from a BIM file

5 Final Remarks

The use of BIM methodology allowed an accurate coordination with the architecture project and promoted efficiency in terms of project documentation, especially when changes in the design were needed. The interoperability among software allowed that the geometry from the 3D BIM model could be exported, avoiding the re-modeling and possible geometry inaccuracies. The 3D visualization of the project and the restrains helped to find engineering solutions.

References

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