Challenges to design and construction of cable cars in historic sites. Vila Nova de Gaia cable car.

Session 4: Sustainability of ropeways (Access to UNESCO World Cultural Heritage Sites by Ropeway)

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ABSTRACT

Implementing a cable car project in an urban area is challenging due to the requirements to be fulfilled, such as architectural aspects, space available for the stations and towers' construction and the flyby of the existing buildings.

This particular project have had an additional specificity, it is located in the special protection area surrounding the UNESCO classified "Historic Centre of Oporto, Luiz I Bridge and Monastery of Serra do Pilar" classified by UNESCO as a World Heritage Cultural Site.

This unique particularity had a significant impact on site physical's restrictions, both in terms of the space available and the top station's location.

Introduction

Gaia cable car project arises from a public tender for “Design, Construction and Operation”, whose main purpose is to transport people by cable between the higher ground “Jardim do Morro” and the Douro river bank promenade, as shown below in picture 1 (Project’s axis initial alignment – yellow line).

Location and description

The cable car is located in the historic area of Vila Nova de Gaia. The top station is located near the Luiz I bridge upper deck, the metro station and also the Monastery of Serra do Pilar classified by UNESCO as a World Cultural Heritage Sites, while the bottom station is located near the Municipal Market and the wine cellars.

This project have had this particularity of being located inside the special protection area surrounding and with its top station just on the limit of the Historic Centre of Porto World Heritage.

In the image below there are represented:

- Classified World Heritage limits – green line;
- Special Protection limite – dotted red line;
- Project's axis alignment – yellow line

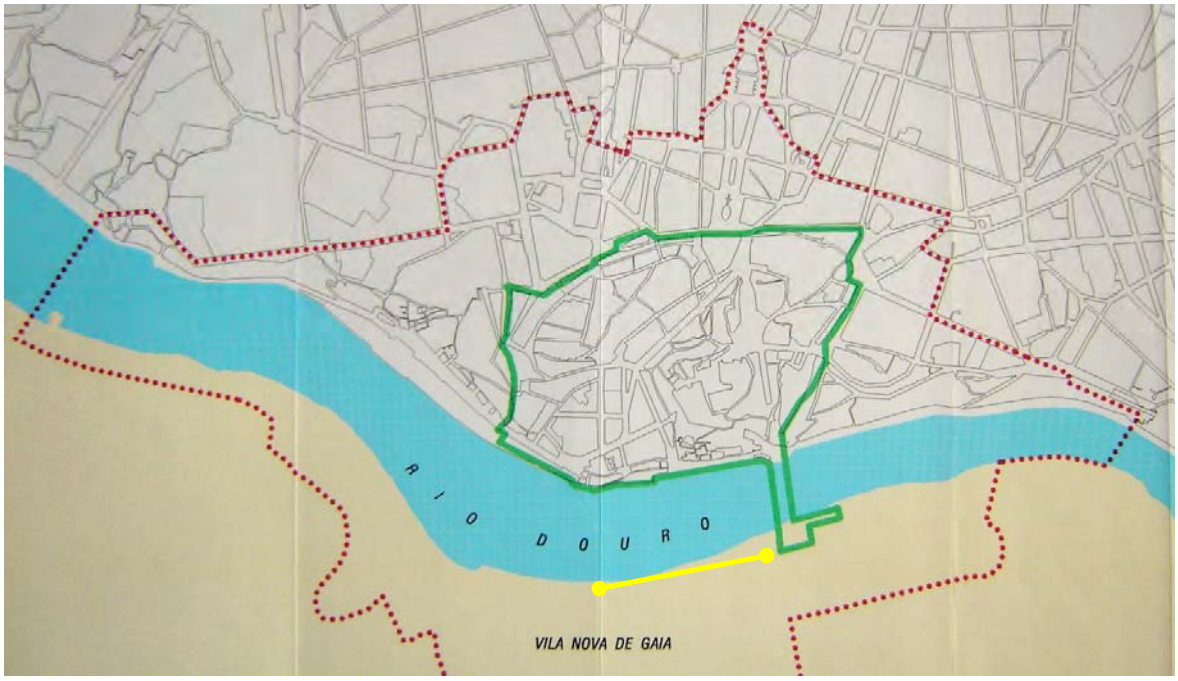
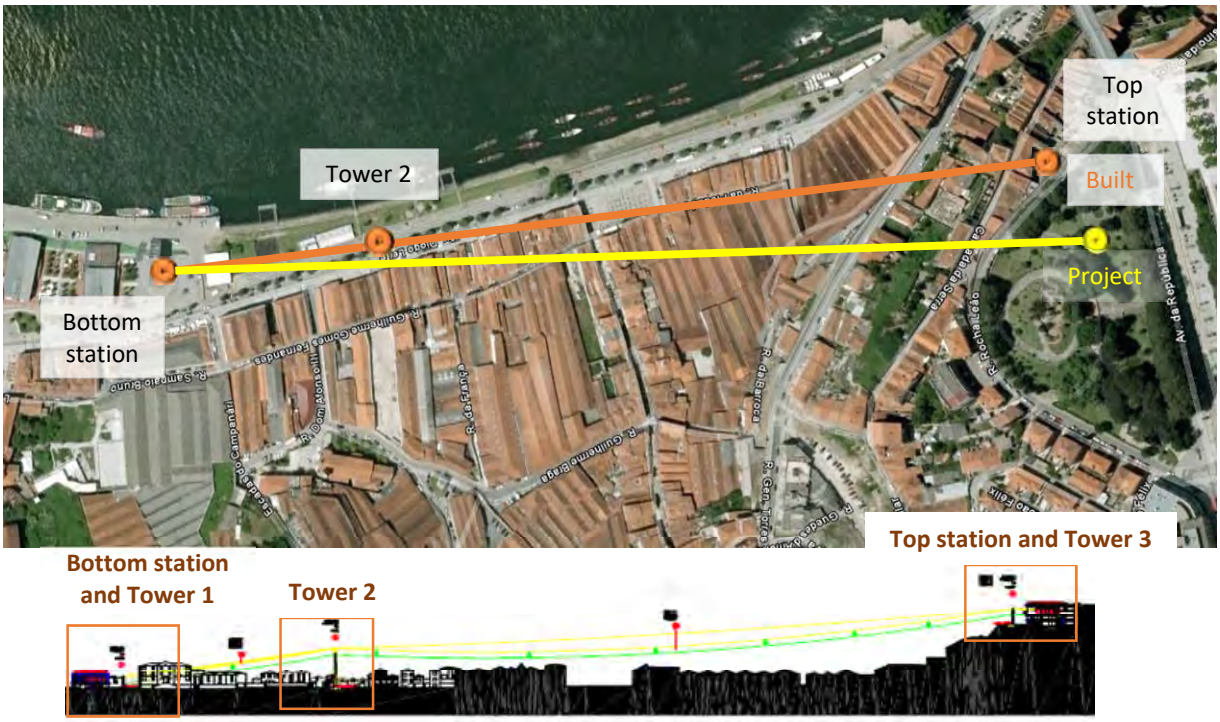


Image source: “http://whc.unesco.org”

Challenges and solutions

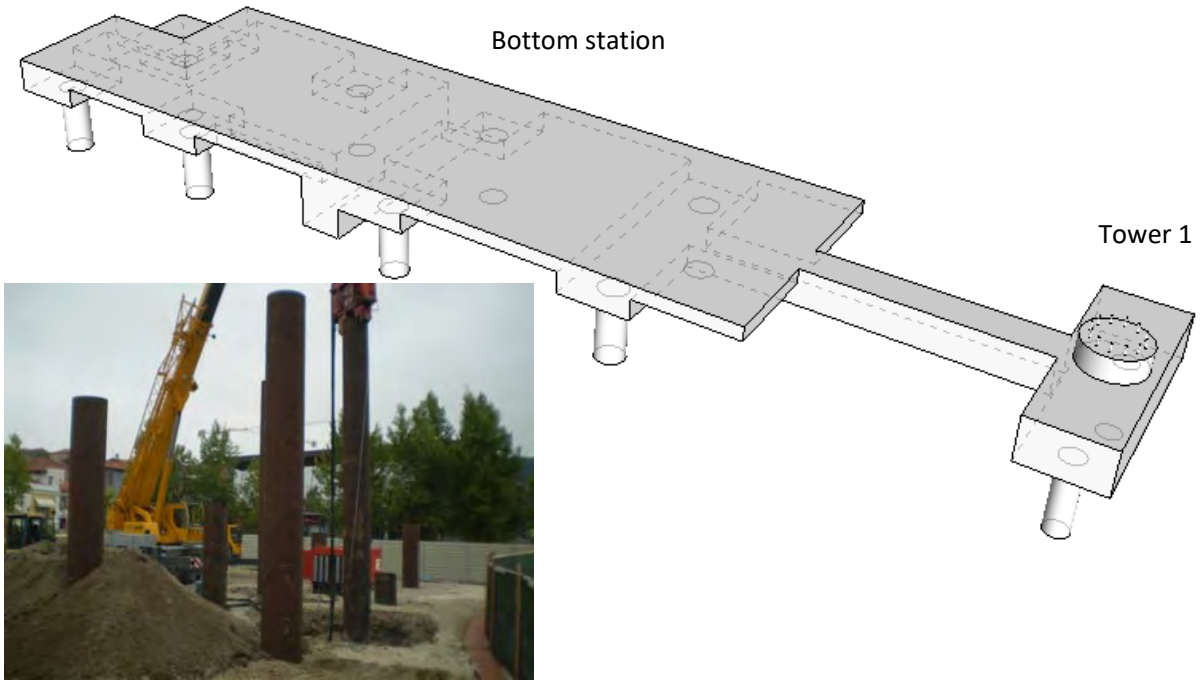
The first and most significant challenge to the project was the need to change the top station’s location to the hillside at a lower level compared to the initial one on the top of the Jardim do Morro (Morro Garden), as shown in the pictures below – Plant / Profile and Aerial view of the cable way.


Top station
Tower 2
Built
Project
Bottom station
Top station and Tower 3
Bottom station and Tower 1
Tower 2


Palácio da Bolsa
Hotel Ribeira Do Porto
Ponte Luís I
Top station
Jardim do Morro
Rio Douro
Caves Cálem
Cableway
Tower 2
Bottom station
Igreja Paroquial de Santa Marinha
Sandeman
Offley
Google

Bottom station and Tower 1

Soil improvement foundation by pre-loading techniques was taken into account, however, one of the main goals of the construction was to ensure that the foundation would not have future settlements that could put at risk the cable car once in operation.

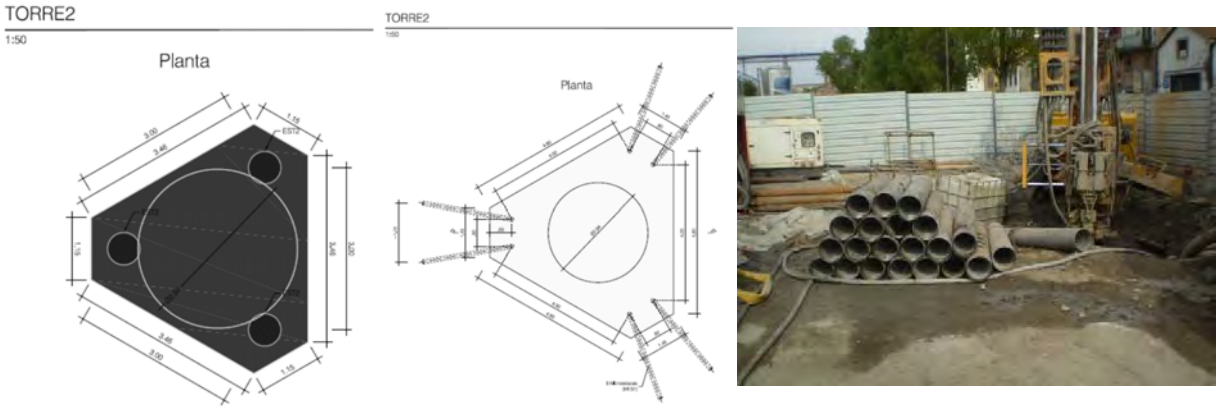


Having taken this into account the station's foundation was built with Pile driving steel tubular – 8 units with 30m deep.

The tower 1 was built, similarly the bottom station, with 2 piles with 30m deep connected at their top level to the station with a concrete beam. All the surrounding building were monitored to vibrations induced by the pile driving process.

Tower 2 (32m high)

The foundation was design with pile driving (3units with 30m deep), however due to possible vibrations induced to the cellars old buildings and the possibility of ruin, during the construction works, it had to be changed micropiles (6 un with 30m deep).



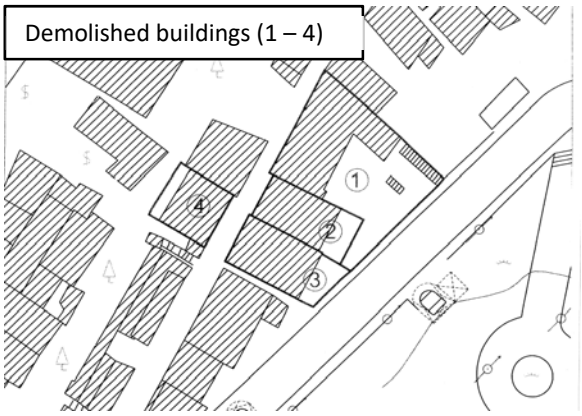
Top station and Tower 3

Both stations were similar in architectural terms, although the need to change the top station's location, had as consequence an huge impact on the project as a whole.

This singular change had a tremendous impact on the project as a whole, having as major consequence an increase on the station building volumetry and its cost.

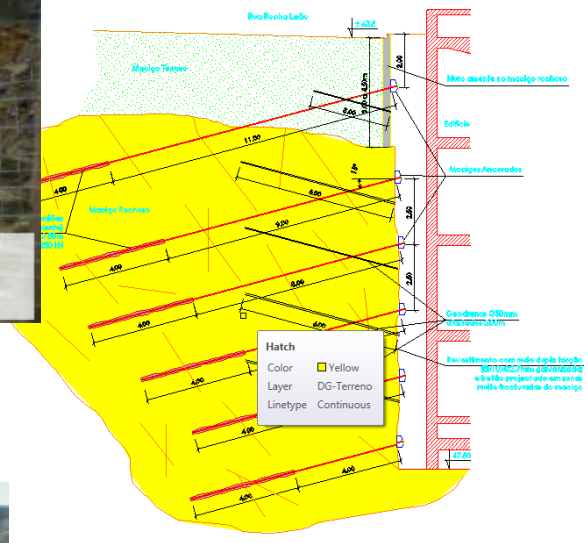
This small change led to big adjustments / changes in project and construction:

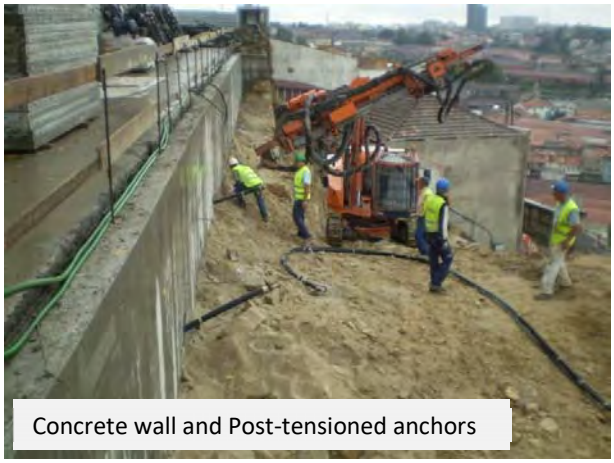
- Four (4) buildings had to be demolished for the construction of the top station. The space on the hillside surrounded by old buildings, lack of space to put machinery to handle with the demolishinghe demolishing led to this work had been made by hand;



- Rock excavation. Due to the urban surrounding area with buildings the rock excavation had to be done by non-blasting method (Darda rock splitters and Excavator with Jackhammer);
- Vertical face excavation stabilized with concrete wall, post-tensioned anchors and shotcrete and ground nails;

Top station excavation (15m deep) and vertical excavation.





Concrete wall and Post-tensioned anchors

- Concreting the roof after the equipment assembly, become a huge study to plan the flat formwork and support substructure with scaffold towers passing throughout the equipment.

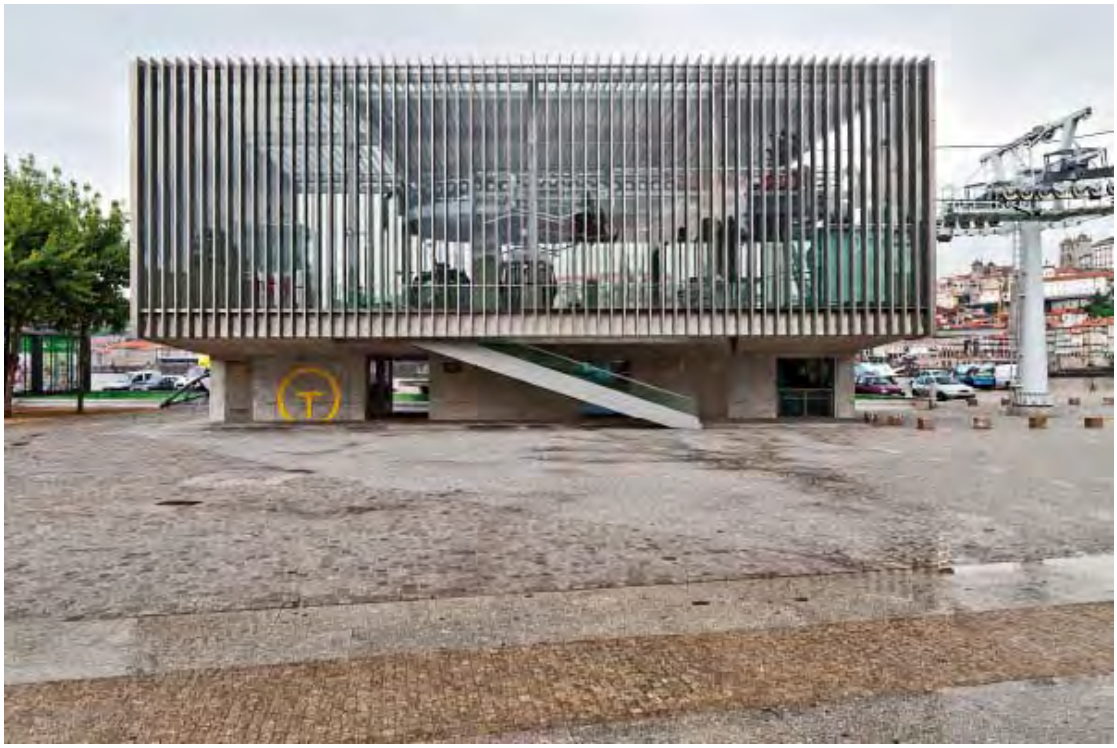
During the excavation works for the implantation of the tower 3, what was supposed to be rock it turned out to be ordinary soil, therefore the foundation was connected to the top station building by 2 concrete beams.

Installation – Technical main data and photos

Technical main data:

Drive station	Top station
Return station	Bottom station
Horizontal length	562 m
Vertical rise	49,6 m
Operating speed max.	4,0 m/s
Capacity	940 ppp
Travel time (max. speed)	3,5 min
Number of cabins / carriers	12 un
Cadence cabins	30 seg.

Bottom station



Top station

Conclusions

This paper is intended to give an idea of the adversities and challenges involved in the development of a cable car project in an urban area, the way they were overcome and the changes needed to its completion.

It is also intended to shed some light on how these kind of projects are subject to several risks related to its location on an urban area, still for more when talking about sites located beside UNESCO Heritage Cultural Sites.

Ultimately, the changes introduced in a project might put at risk the viability of an installation and its operation due to an increase in costs and jeopardize its long-term sustainability.