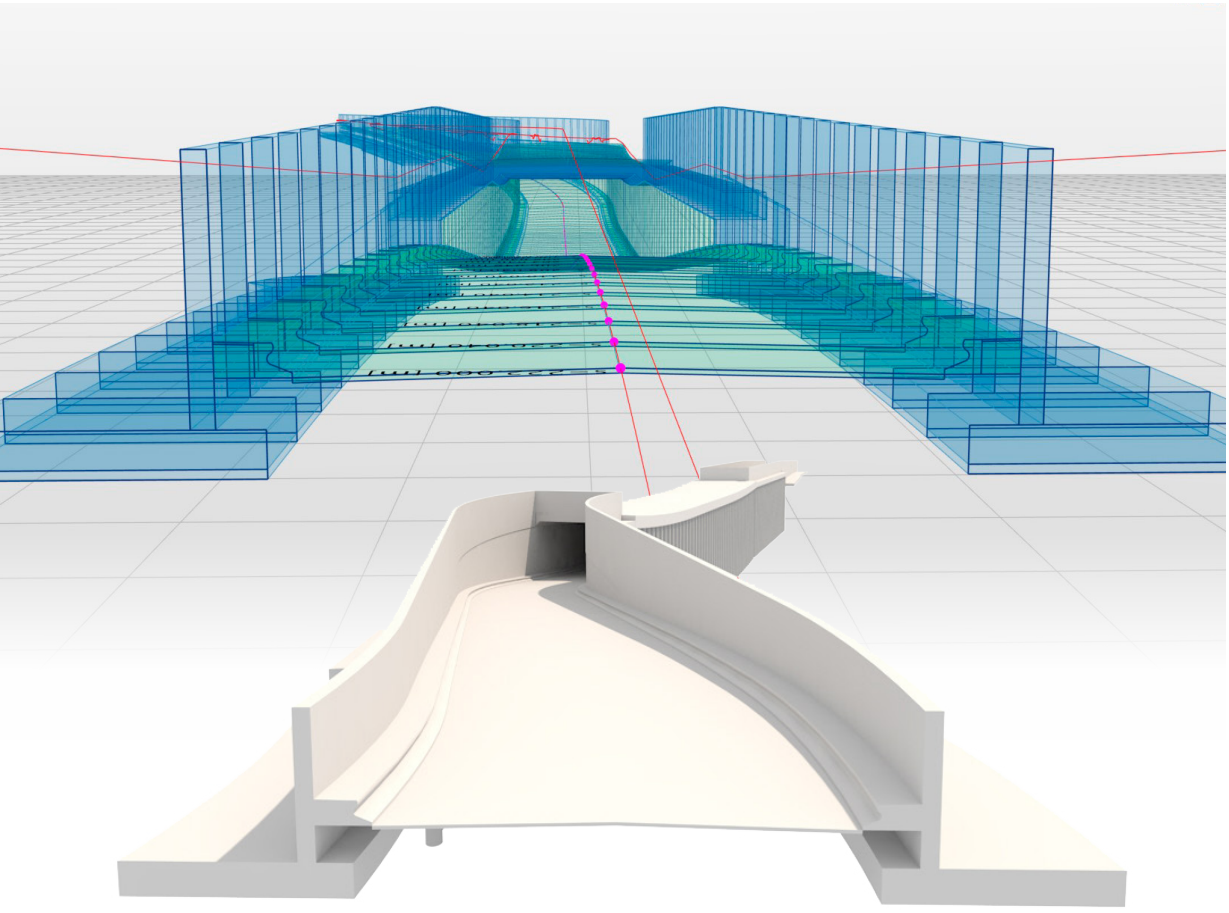


Ruby Line Porto Metro Project – 3D models in Allplan Bridge and Allplan

Allplan in Practice

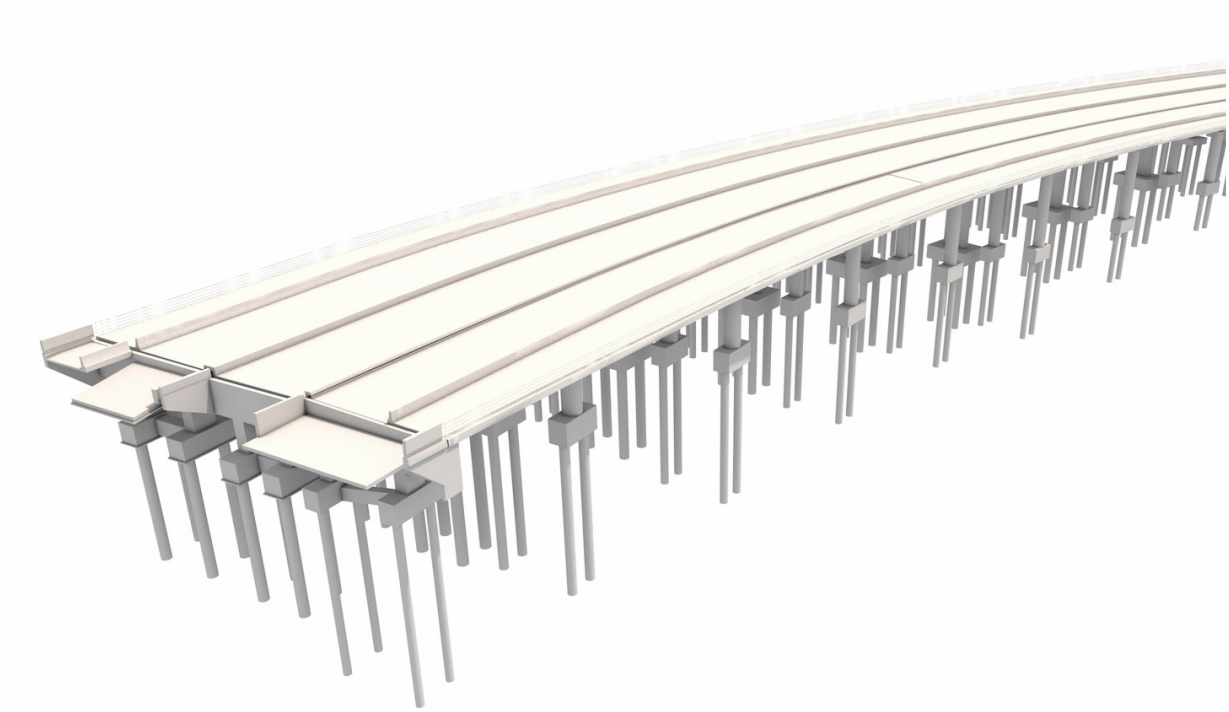
AN INNOVATIVE MINDSET – THE RUBY LINE PORTO METRO PROJECT

The two cities of Porto and Vila Nova de Gaia are separated by the Douro River yet are inextricably linked. As part of the Porto Metropolitan Area that makes up the second-largest urban area in Portugal, residents often travel between the two cities.

Yet with such a large population, the existing five operational bridges – one railway, three roadway and another one with a roadway deck plus a metro line deck – no longer offer sufficient capacity for the travel demand. To address this, Metro do Porto commissioned a new, 6.5km metro line to connect the two areas, which includes a new bridge over the Douro River supporting a metro line, cycle lanes, and large pedestrian path. The new line will not only provide extra capacity, but also encourage more sustainable travel while supporting the area's recovery from COVID-19.

QUADRANTE, a renowned international consulting engineering firm, is part of the Designer Consortium and responsible for the design of six main works packages, including the new track, new roads, four viaducts, three underpasses, multiple retaining walls, and the structures of seven new stations and platforms. One of the viaducts includes a substantial partial demolition of an existing viaduct, with two new viaducts to be built beside the remaining section. Meanwhile, another viaduct will be built over an existing major roundabout. In addition to three conventional subway stations, there are two

ALLPLAN ALLPLAN BRIDGE



Viaduct A –
3D model in Allplan

surface stations and one station that is both above and below ground are to be designed. The track is approximately half underground, half overground, with the tunnel design and construction being undertaken by the other member of the Designer Consortium. Additional works on the project – such as the bridge over the river – are also the responsibility of other parties. QUADRANTE commenced detailed design in September 2021, with completion expected in 2022. Construction is expected to take two and a half years, opening to the public by the end of 2025.

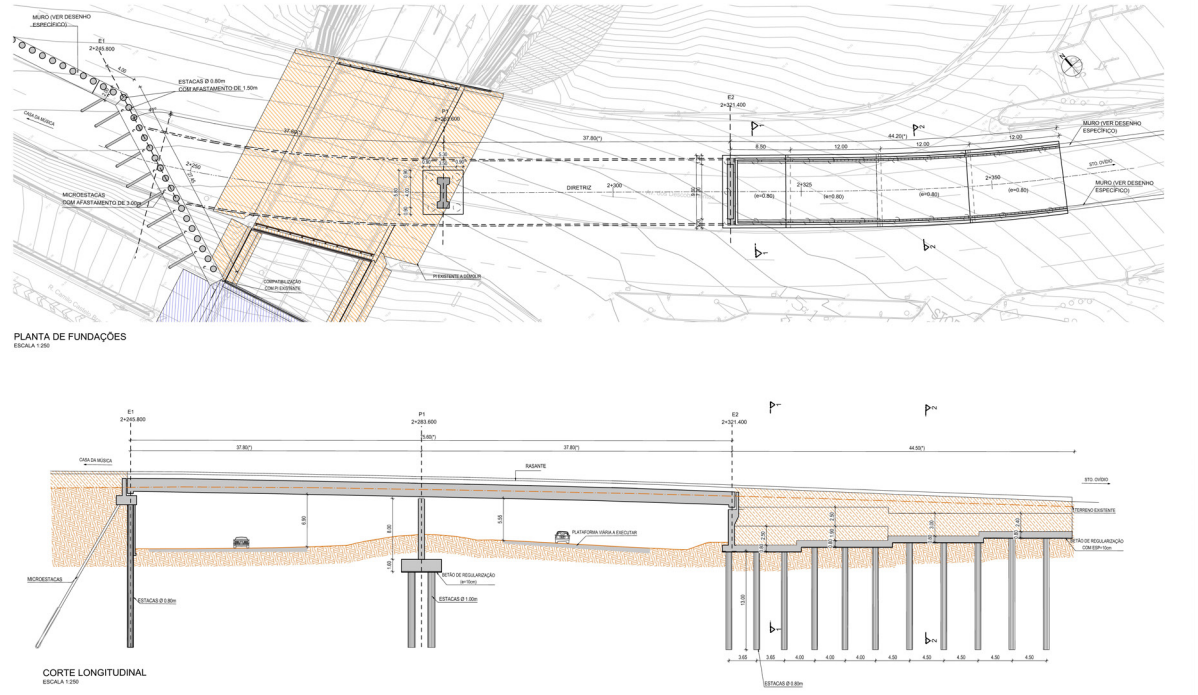
Building Information Modeling (BIM) has been a part of QUADRANTE's workflow for over 7 years on all their architectural building projects, yet their approach is unique. Rather than adding BIM to projects as an extra requirement to meet, they instead have a mindset they call 'Projects in BIM, not BIM of projects' – or, in other words, they work in BIM from the very first sketch. Having recently now introduced BIM on their transportation projects in 2021, the Porto Metro project is one of the first major projects where they have used Allplan Bridge as both their design and BIM platform – with great success.

COMMON BIM APPROACH AND DATA FORMAT

With such a complex project and several partners working on different sections, ensuring that each package of works is smoothly coordinated between the different parties is critical. Therefore, agreeing a common approach and data format for sharing information is also of the utmost importance for delivering the project successfully. Additionally, ensuring that all the sub-models for the various sections aligned between the different disciplines and partners is another crucial consideration.

In terms of QUADRANTE's work, one of the biggest challenges is the number of variations that would need to be modeled. Because the section of track traversed through tunnels, viaducts, retaining wall sections, and both above and below ground stations, there are a good number of different cross-sections needing to be taken into consideration. Similarly, the underground tunnels also has variable cross-sections. Designing the models for these elements and creating the documentation for them would be a time-consuming activity. In addition, building the project in BIM meant that all models would need to be kept updated so that everyone could access the current status of information as and when they required.

The urban location is another issue, as many of the proposed designs are located in built-up areas with space constraints. For example, one of the viaducts that QUADRANTE is responsible for is located next to a stormwater attenuation area, adjoining a 120-meter-long tunnel that needs to be constructed using box jacking. The space constraints meant a solution needed to be developed to support the hydraulic jacks during the construction phase without affecting the stormwater attenuation scheme.



Viaduct C – Plan and longitudinal profile

The viaduct to be partially rebuilt also posed some difficult challenges, not only in aligning the new viaduct sections to the remaining section, but also as this section of carriageway must remain open during the works. Similarly, the viaduct by the major roundabout would also need careful modeling and consideration of how it would be built while minimizing disruption to traffic.

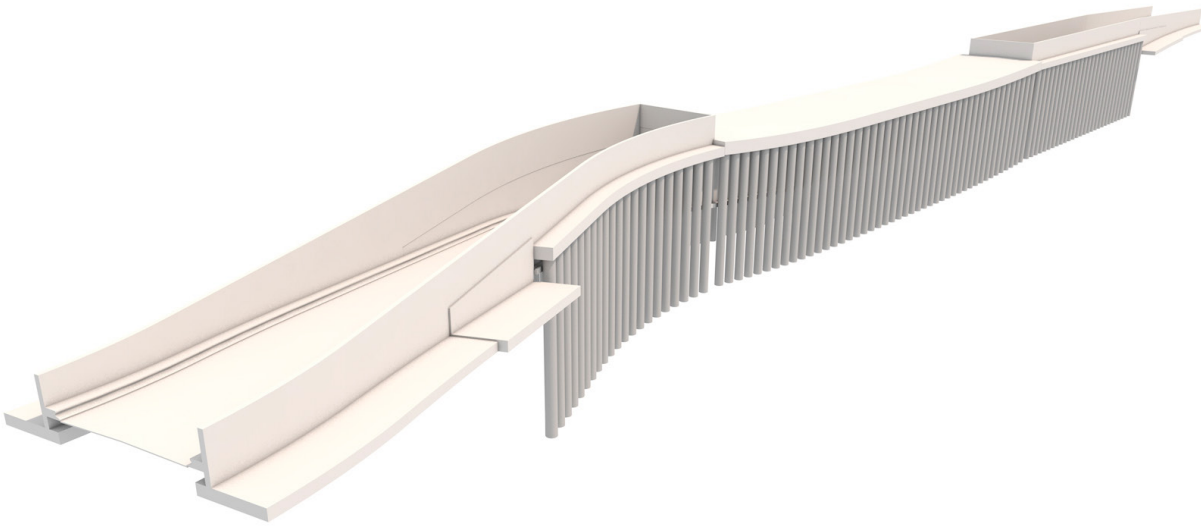
PARAMETRIC DESIGN WITH ALLPLAN

The team encountered some initial challenges with structuring IFC files and organizing BIM levels. However, this was overcome when a collective agreement was made between all the partners involved on the project. After that, sharing files and models is accomplished more easily.

Allplan and Allplan Bridge were chosen as the QUADRANTE design solution not only for Open BIM functionality, but principally for the powerful parametric design options offered. QUADRANTE implemented a new, parametric workflow in order to develop their viaduct designs. In fact, they further improved Allplan Bridge's capabilities by creating a tool that manipulates the TCL file so the user can create tables of the viaduct girders in Excel, which significantly accelerated their workflow. They were then also able to use the Excel file for further analysis.

For example, the team used the tool to create dynamic cross-sections of the area that would need to be reserved for the trains on the track. The size of this area depends on the gradient of the track – the elevation difference between the left and right rails. A static table that would define the width of the reserved area was created and imported into Allplan Bridge. However, when a table was required that was the inverse ratio of the radius of the curves on the static table, that was created using the tool QUADRANTE developed and then quickly imported into Allplan Bridge.

For the track model, the team imported the near 7-kilometer-long railway alignment axis into Allplan Bridge. As it was provided in LandXML format from the rail engineers, QUADRANTE used Bimplus to import the file. To create the model, they developed a series of cross-sections, including the track rails, drainage, cable channels, emergency evacuation areas, and the reserved area for the trains themselves, as already mentioned above. The team created a combined cross-section for the different track sections by adding the cross-sections for the individual elements, including overground, underground, viaduct, retaining wall, and station sections. Allplan Bridge is extremely useful here, as preparing the model as well as all the documentation and tables for the different variations along the route would have been extremely time-consuming otherwise. In addition, keeping the model updated and available in real-time without a BIM approach would have been a difficult task.



Underpass A –
3D model in Allplan

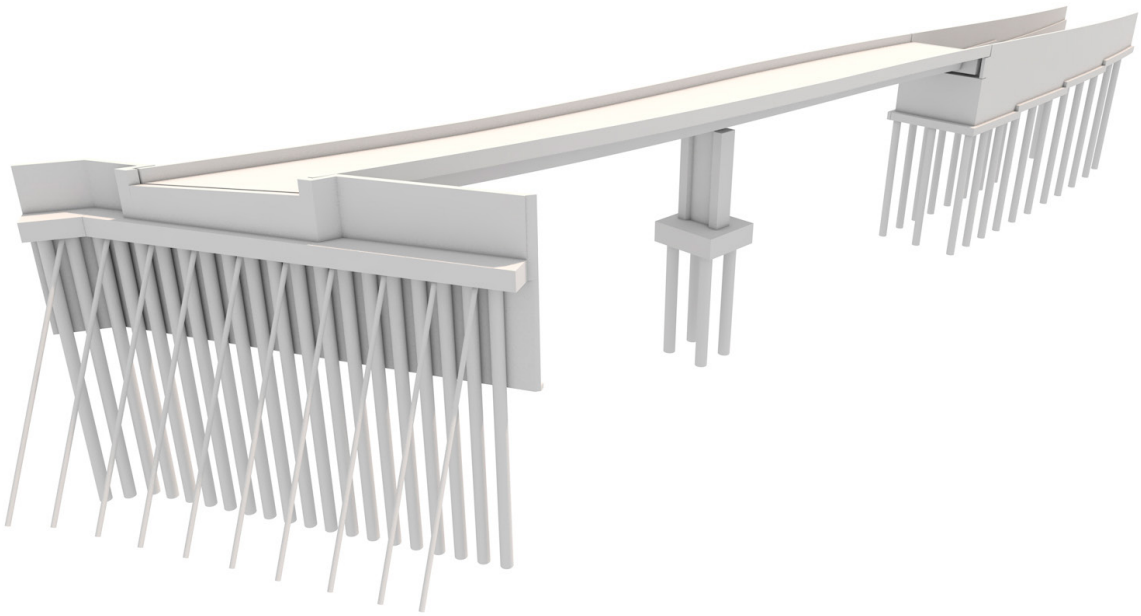
Where the depth is not suitable for NATM tunneling method, these shallower sections of tunnels were designed for top-down construction. Here the team imported the LandXML axis using Bimplus again, and designed cross-sections. They used PythonParts to model the piles along the walls of these tunnel sections as that would speed up the modeling process rather than having to individually model each pile. Once the tunnel model was complete, the adjacent section of the NATM-constructed tunnel model was imported using Bimplus to check that the two tunnels would line up exactly.

Precision was also necessary for designing the substantially re-built viaduct. For this section of the works, three viaducts would need to be designed and located in such a way as to be adjacent yet without each individual structure touching. Being able to visualize the interaction between the three structures without a 3D model would have been incredibly challenging. With Allplan Bridge, however, the structures were designed and precisely aligned with the existing viaduct portion without any clashes. Similarly, when planning the box jacking section of a tunnel, the visualization that Allplan enabled in 3D allowed the team to develop a solution within the limited space available by importing a terrain model of the area. The final proposal used a platform to support the hydraulic jacks during construction without affecting the stormwater attenuation area.

Being able to rule out clashes between existing tracks and stations, different disciplines, and external sub-models is another benefit. The station structures were developed and exported using the tools in Allplan, and then coordinated with other team members such as the architect, MEP designer, and other structural engineers. Then, in Bimplus, the team at QUADRANTE could check the federated model and resolve conflicts, visualize the works, and implement any required changes directly from within Allplan. This made the process much more seamless as well as making it easier to manage changes. With a complex project such as this with many different interactions between different components – both new and existing – being able to effectively manage changes helped mitigate their impact and keep the project design process on track.

STRAIGHTFORWARD DESIGN PROCESS

When choosing a BIM solution for use in their special structures division, QUADRANTE evaluated many different options. Through its use on the Porto Metro project, Allplan – and Allplan Bridge in particular – have become essential to their daily work. The powerful tools made the design of this complex project much more straightforward, especially with regards to variant analysis. The structure of the program enabled options from the concept stage to be considered more easily and with



left:
VIADUCT C –
3D model in Allplan

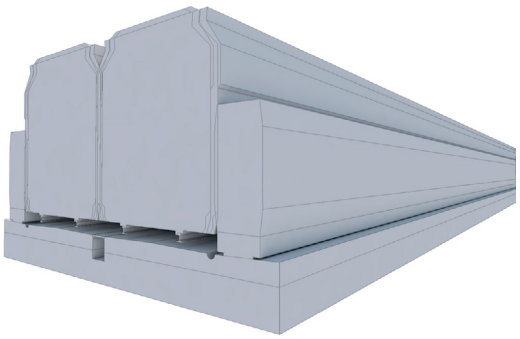
bottom:
Track model in Allplan

significant levels of detail, even at such an early stage of the process. In addition, it is especially useful to have a detailed model to discuss options with the client during the initial design.

The drawing production is another area that was accelerated thanks to Allplan. Around 100 drawings per station design are required, which would have had to have been drawn individually using 2D methods. With Allplan, sections, elevations, and details could be quickly and easily produced from the model, with the added benefit of automatic updates should the model change. This made producing the construction documentation a more straightforward process that saved a considerable amount of time.

Effective change management is key to keeping the project on track. When designing bridges, tunnels, railways, and roads, there are often many changes to the geometry – and the Porto Metro project is no exception. The functionality that Allplan offers significantly reduced the impact of changes on the schedule, particularly during the concept phase when many different variants are being explored. However, producing more detailed models (LOD 300) earlier in the design phase also helped reduce changes further along in the process. Having the model geometry already prepared at the concept stage provided time savings from the very start of the project, as it was easier to adapt should any changes be needed. Subsequent design activities were more efficient, and it was easier for the team to finalize their detailed designs.

The move to doing Projects in BIM has required a mindset shift for QUADRANTE's infrastructure team, not just in terms of the process, but also being open to change and flexibly adapting to a new way of working. However, with Allplan Bridge, QUADRANTE has made a significant leap forward in this area, particularly with regards to implementing parametric design. Their innovative spirit and pioneering problem-solving led to not just the successful execution of this project, but new tools that they can implement on future works. Even the traditional way of working may not be kept for those clients who do not value BIM. This is because projects in BIM have become embedded in QUADRANTE's approach after experiencing the benefits of it on their various international projects, including this complex, multi-faceted new metro line.



"The move to doing projects in BIM has required a mindset shift for QUADRANTE's infrastructure team, not just in terms of the process, but also being open to change and flexibly adapting to a new way of working. However, with Allplan Bridge, we have made a significant leap forward in this area."

José Rolo Duarte,
Operations Director – Transports,
QUADRANTE, Portugal

ABOUT QUADRANTE

Founded in 1998, QUADRANTE is a global Engineering and Architecture consulting and design group covering services in the following fields of expertise: buildings, transports, industry and energy, water utilities, environment, airports and construction management and supervision.

At QUADRANTE we aim to improve the sustain-ability performance of our projects and services, with the purpose to partner with our Clients to Create and Build Sustainable, Responsible and Long- Lasting Infrastructures for a better world.

As a multidisciplinary consulting and design group in Engineering, Architecture, Environment and Sustainability, we take a holistic view of the construction sector, and develop an integrated and evolutionary sustainability research in the design of our buildings and infrastructures.

Driven by more than 250 experts working across three continents (Europe, Africa, and Latin America), our mission is focused on the continuous pursue for sustainable, economically optimized and technically advanced solutions – DESIGNING . DELIVERING . ADDING VALUE.

ABOUT ALLPLAN

ALLPLAN is a global provider of BIM design software for the AEC industry. True to our "Design to Build" claim, we cover the process from the first concept to final detailed design for the construction site and for prefabrication. Allplan users create deliverables of the highest quality and level of detail thanks to lean workflows. ALLPLAN offers powerful integrated cloud technology to support interdisciplinary collaboration on building and civil engineering projects. Around the world over 500 dedicated employees continue to write the ALLPLAN success story. Headquartered in Munich, Germany, ALLPLAN is part of the Nemetschek Group which is a pioneer for digital transformation in the construction sector.

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