Southeastern Europe Tunnelling Conference (SETC-2025)
1-3 October 2025, Belgrade, Serbia

DOI:10.5937/SETC25001B

Gained Experience from the ongoing construction of the line-cross of the Metrolines U2 x U5 and following considerations of the new designed U5 Extension in Vienna

Dietmar Bach[a], Helmut Schweiger[b], Andreas Rohrmoser[b] and Dejan Eybl[b]*

[a] IGT Geotechnik und Tunnelbau ZT GmbH; d.bach@igt-engineering.com
[b] Wiener Linien GmbH & Co KG; helmut.schweiger@wienerlinien.at

Abstract: The U2xU5 line interchange (a new U5 line from Rathaus to Hernals and a U2 extension from Rathaus southwards to the Wienerberg area) is identified as one of the priority projects for strengthening high-capacity public transport services in Vienna within the Mobility Master Plan for STEP 2025.

In total, the U2xU5 line interchange comprises approximately ten kilometers of subway tunnel and twelve new stations. This will create six new high-capacity public transport hubs with transfer options to the subway or S-Bahn.

The U2xU5 1st construction section is a foundational phase for Vienna's new subway lines. It involves crucial work at Rathaus station (interchange for U2 and U5), the initial segment of the new U5 to Frankhplatz, and the conversion of an existing U2 stretch to become the new automatic U5. Concurrently, the U2 begins its southern extension with stations like Neubaugasse and Pilgramgasse, laying the groundwork for the larger network.

Due to challenging, water-saturated ground, we developed an innovative tunneling concept: a pilot tunnel to pre-dewater the ground for the main station tubes. Further optimizations included construction logistics and design, including raising the station alignment for better lifecycle costs. In addition, the interaction between the applied construction methods, the prevailling geotechnical and geological conditions, and the existing surface structure must be systematically considered. This project underscores how crucial early, interdisciplinary planning is for success, informing future U-Bahn expansions.

The second construction section (Frankhplatz-Hernals) heavily integrates lessons from earlier phases, particularly the successful pilot tunnel method, which is crucial for stations like Michelbeuern and Elterleinplatz with challenging ground. Line tunnels will feature both cyclic (using steel fiber inner shells where dry) and continuous tunneling. Significant technical challenges include large cross-sections at Währinger Gürtel (protected by a pre-constructed jet-grouting arch to minimize settlement) and Leo-Slezak-Gasse. At Leo-Slezak-Gasse, where large cross-sections are shallow, our strategy involves two pilot tunnels, micro-pile supports, a reinforced concrete outer shell, and careful, partial-excavation tunneling with short ring closures for safe and low-settlement advancement through the Miocene.

Keywords: Metro; urban area; soft soil; pilot tunnel; grouting

---

1. Line-Cross U2xU5

With the extension of U2 and the construction of U5, Vienna is currently realizing its largest and most important public transport infrastructure project. It essentially comprises the extension of the U2 line and the reconstruction and construction of the U5 line. Implementation is divided into two phases of construction, with the currently ongoing first phase subdivided into three major sections.

The first section concerns the U2 main line between Karlsplatz and Rathaus, which is being comprehensively modernized and prepared for fully automated operation. The second section covers

*Corresponding author: d.bach@igt-engineering.com (D. Bach).

the new U5 line: in its initial stage, it takes over the former U2 section between Karlsplatz and the new interchange station Rathaus and will be extended to the temporary terminus at Frankhplatz. The third and longest section involves the southern extension of U2 from Rathaus station to Matzleinsdorfer Platz, built largely using a tunnel boring machine (TBM).

The second phase of construction connects to Frankhplatz station and extends to Hernals, with intermediate stations at Arne-Karlsson-Park, Michelbeuern, Elterleinplatz, and Hernals, as well as three technical structures and one depot facility. The longest tunnel section, from Hernals to the Währinger Gürtel technical structure, will be constructed with a TBM, while the section from Währinger Gürtel to the existing network will be excavated using the cyclic tunneling method. In total, about 4.5 km of new metro tunnels will be built, creating high-capacity transfer opportunities to other metro lines, suburban rail (S-Bahn), and tram lines.

Fig. 1. Future routes of the U2 and U5 (Source: Stadt Wien, Generelle Planung, 2023).

Both in the planning process and during construction, optimization approaches are continuously identified and integrated into project development in cooperation with Wiener Linien. For instance, the tunnel lining of the running tunnels at U5/2 Frankhplatz station was built in steel fiber reinforced concrete. At U2/21 Neubaugasse station, an innovative tunneling concept adapted to the complex inner-city conditions was applied.

Both optimizations form essential elements of the second construction phase, which is already being planned accordingly.

2. Geological Conditions

The alignment lies within the Vienna Basin. Miocene sediments of the Paratethys Sea (Pannonian, Sarmatian) are overlain by Pleistocene terrace deposits and by recent alluvial gravels of the Alserbach (both Quaternary sediments).

Below the Quaternary, the Miocene sediments of the Vienna Basin appear, primarily Pannonian deposits dominated by silts and clays, transitioning into the sandy and locally gravelly sediments of the Sarmatian.

The following geological layers are expected along the relevant sections:

- Fill, topsoil
- Quaternary: recent deposits of the Alserbach
- Quaternary: deposits of the Pleistocene terraces (city terrace, slope, Arsenal terrace)
- Miocene: deposits of the Vienna Basin (Lower Pannonian, Sarmatian)

3. Station U5/2 Frankhplatz

3.1. Overview

The U5/2 Frankhplatz section connects to the existing U2 line after Rathaus station and runs 634 m along Landesgerichtsstraße and Garnisongasse to the end of the construction lot.

U5 will be Vienna’s first fully automated metro line. Glass platform screen doors with automatically controlled sliding and swing doors will ensure precise, safe boarding and alighting.

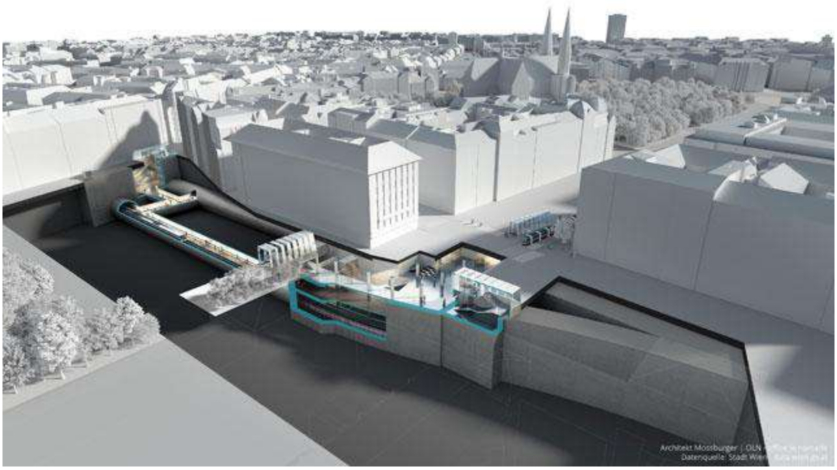

Fig. 2. General overview of the Frankhplatz station (Source: Wiener Linien).

3.2. Optimization of the tunnel lining with steel fiber reinforced concrete

As part of Vienna’s metro network expansion, Wiener Linien and the planners are pursuing measures to improve sustainability and resource efficiency. One such step was the optimization of the tunnel lining. By using steel fibers instead of conventional reinforcement steel, the total amount of steel required can be reduced. This improves sustainability, increases cost-effectiveness, and reduces construction time.

During the works of the first construction phase at U5/2 Frankhplatz, a suitable opportunity arose to produce experimental tunnel lining blocks in steel fiber reinforced concrete, with and without polypropylene fibers. Since the running tunnels in this section will serve only as emergency escape routes until the extension of U5 (second construction phase), they are currently not in operational use.

The production of these blocks required intensive coordination between all project stakeholders during construction. A comprehensive monitoring program accompanies the works to provide insights into material behavior and realistic design parameters. These “test blocks” are therefore generating valuable experience and practical knowledge for durability and implementation, forming a sound basis for the planning and tendering of the second construction phase.

Comparable linings had already been produced in steel fiber reinforced concrete during the construction of the U3 Zippererstraße station in 1999. Core samples and laboratory testing from that project have provided important conclusions on long-term performance, useful for current and future planning.

4. Station U2/21 Neubaugasse

4.1. Overview

The future U2 station "Neubaugasse" will be one of the busiest transfer hubs in the Vienna metro system, connecting the existing U3 line running longitudinally under Mariahilfer Straße with the new U2 line crossing it. Mariahilfer Straße is one of Vienna's most prominent shopping streets, featuring major retail centers and very high pedestrian volumes in a densely built-up residential area.

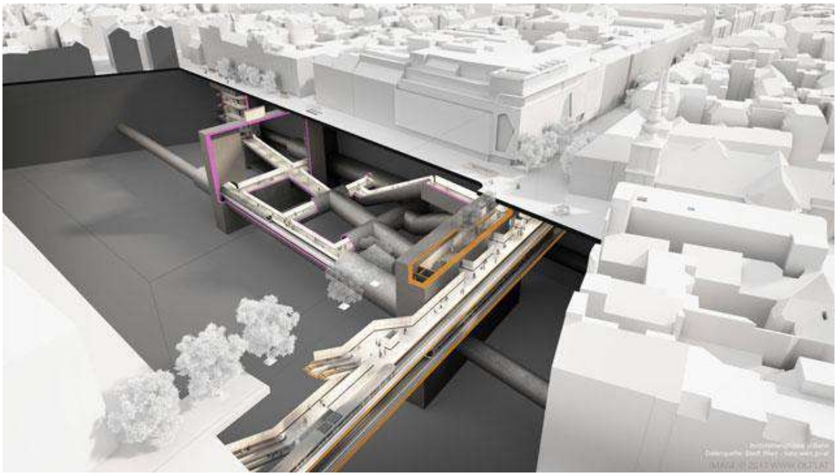

Fig. 3. General overview of the Neubaugasse station (Source: Wiener Linien).

4.2. Optimization of the tunneling concept

Based on a detailed 3D subsurface model prepared by MA29, it could not be ruled out during the design phase that tunneling in the silty-clayey Miocene soils (Vienna Marl) would encounter sand lenses extending several tens of meters, potentially containing groundwater.

As the U2/21 section lies within a very densely built urban area, full groundwater relief from the surface using wells was not feasible. Consequently, an innovative tunneling concept was developed and implemented for driving the two station tunnels.

Before excavation of the main station and running tunnels, pilot tunnels with an excavation area of approximately 20 m² were driven in the crown zone. Their primary function was to provide controlled groundwater relief within a smaller excavation profile compared to the station tunnels (~95 m²). At the same time, the pilot tunnels offered additional significant advantages for subsequent tunneling in the inner-city environment.

To ensure both rapid ring closure during excavation of the pilot tunnels and a controlled removal of their primary lining when enlarging to the full station and running tunnels, steel fiber reinforced shotcrete with a thickness of ≥15 cm was applied as support. This material provided the required strength and flexibility for advancing the tunnel cross-section. Excavation proceeded in full-face with round lengths of 1.0–1.3 m. Where pre-support was required, lattice girders could be installed.

Only after completing appropriate drainage boreholes from the pilot tunnels was excavation of the full cross-section of the station and running tunnels undertaken.

Fig. 4. Pilot tunnel within the excavation profile of the station tunnel (Source: IGT Geotechnik und Tunnelbau).

After completion of the pilot heading, radial drainage and vacuum wells were installed within its standard cross-section to ensure reliable advance groundwater relief. To avoid interfering with the excavation of the station and running tunnels, the supply and discharge of water from these drainage boreholes was routed towards the Mariahilfer Straße shaft.

Fig. 5. Radially arranged drainage measures in the pilot tunnel (Source: IGT Geotechnik und Tunnelbau).

In addition to their primary function – providing safe groundwater relief through a smaller excavation profile compared to the significantly larger station cross-section (~95 m²) – the pilot tunnels offered a range of project-specific and technical advantages:

- Targeted and anticipatory groundwater relief and pre-drainage
- Reduced risk when encountering pressurized sand lenses
- Optimized excavation of the station tunnel
- Supplementary geological investigation

5. U5 second construction section

5.1. General

The second construction stage of Line U5 introduces five new stations: Frankhplatz, Arne-Karlsson-Park, Michelbeuern, Elterleinplatz, and Hernals.

From Frankhplatz, the line runs northwest to Arne-Karlsson-Park, providing a major interchange with seven tram lines. Skirting the General Hospital in a broad left curve, the alignment continues south to Michelbeuern, connecting to the existing U6. Turning westward, the line reaches Elterleinplatz, serving the district center of Hernals and connecting to tram services.

The final section runs beneath Hernalser Hauptstraße, terminating at Hernals station with interchange to S-Bahn line S45, trams, and buses. An operations and stabling facility directly adjoins the station, marking the end of this construction stage.

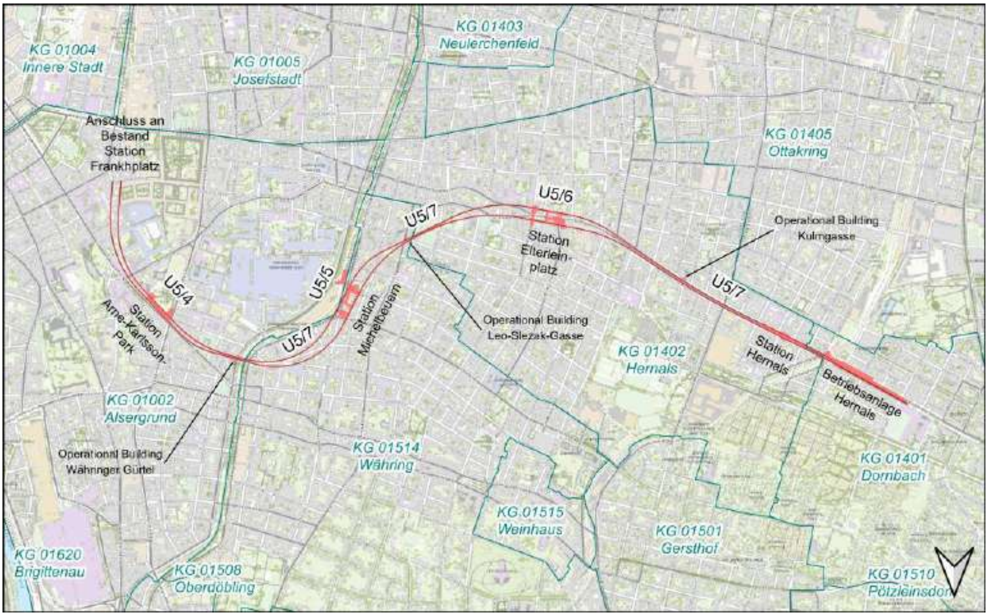

Fig. 6. Overall Site Plan U5 second section (Source: IGT Geotechnik und Tunnelbau).

5.2. Geotechnical Challenges

5.2.1. General

Experience from earlier sections will be applied, particularly at Michelbeuern and Elterleinplatz stations. However, additional challenges arise, especially regarding Miocene groundwater management in Sarmatian sands near Hernals, the 2.7 km TBM drive in variable geology, and cyclic tunneling for large cross-sections at crossover structures.

5.2.2. Groundwater Management

Due to construction depths predominantly within Miocene layers, dewatering from the surface is planned, as commonly applied in Vienna. Between Frankhplatz and Elterleinplatz, the Miocene is silt-dominated; beyond Elterleinplatz toward Hernals, sandy deposits increasingly prevail.

In Hernals, sand layers up to 10 m thick are strongly water-bearing and pressurized. Lowering groundwater below excavation level is therefore essential. Initial short pumping tests proved insufficient, necessitating large-scale relief.

A long-term pumping test (July 2025, duration 11 weeks) with six wells and four monitoring points investigated well design, screen sizes, filter gravels, and redundancy. Results indicated that sufficient groundwater relief is possible with wells at 15–20 m spacing, large diameters, and total pumping rates of ~10 l/s. Resulting settlements were only in the millimeter range and not structurally significant.

5.2.3. Closed-form construction – mechanized tunneling

Blocks and boulders:

In the area of the Kulmgasse operations building, sandy sediments from the Sarmatian era predominate; during the detailed investigations at the base of the TBM drives, gravel and stones were also found. Therefore, the density of the exploratory boreholes was increased from approx. 80 m to 40 m despite structural limitations.

A specific horizon of blocks could not be proven, so an irregular occurrence must be assumed. Blocks in the cross-section therefore cannot be ruled out; one such block was encountered about 10 m below the invert. This finding must in any case be taken into account in the cutter head design.

Fig. 7. Block approx. 10 m below tunnel invert (Source: Porr Bau GmbH, 2021).

Sticking Potential of the Miocene

Between the Elterleinplatz and Michelbeuern stations, the TBM alignment runs through Miocene geological strata, which consist predominantly of clayey silt. Due to the higher plasticity, a certain impact on the already very high sticking potential is to be expected.

Varying Ground Conditions

The alignment runs through varying ground conditions, particularly in the area between the Währinger Gürtel operations building and the Michelbeuern station. This area is characterized by very heterogeneous layers (from clayey silt to sandy gravel) as well as by fluctuating groundwater levels. These changing geological conditions pose a challenge for tunneling in EPB mode, so conditioning tests were carried out.

In conclusion, the tests showed that the extremely strong sticking tendencies of the "Vienna Clay" can be reduced to a certain extent by using suitable conditioning agents in the closed EPB (Earth Pressure Balance) mode. Furthermore, sufficiently stable and flowable earth paste masses can be produced in the tests, confirming the fundamental suitability of the chosen tunneling machine (EPB shield). However, achieving the required consistency sometimes necessitates considerable quantities of additives, foaming agents, and the use of polymers.

5.2.4. Closed-form construction – conventional tunneling

Three track-changing facilities are planned for the second construction stage, two of which are located mostly beneath existing buildings and will therefore be built using the closed-form construction method. Each of these two track changes is combined with an emergency exit and an operations building. The drives will be initiated from a shaft constructed using the open-cut method.

For this purpose, separate large-scale cross-sections will be excavated from the shafts. Due to the required length of the track changes and the variable track spacing, several different cross-section types are necessary. The resulting largest cross-section of the widened areas has an excavation area of approximately 133 m².

Conventionally excavated tunnels of this dimension in inner-city unconsolidated rock require special solutions to both stabilize the cavity during tunneling and to minimize the impact on existing buildings. The first track change passes under residential buildings, listed monuments, and a district heating tunnel. The overburden in this area is between 9 m and 10 m. Special attention is being paid to the district heating tunnel, whose invert at the critical point slightly intersects the crown of the cross-section. Fig. 8 shows the existing surface buildings (green), the existing underground structures of the district heating collector (blue), the planned shaft for the Währinger Gürtel operations building (purple), and the subsequent jet-grouting arch of the cross-section (grey).

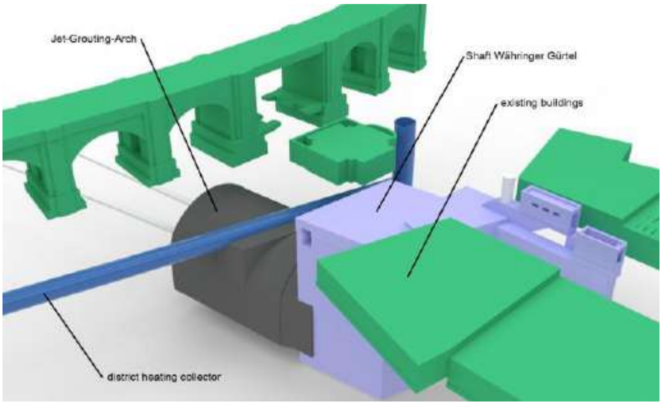

Fig. 8. Overview of the Währinger Gürtel area (Source: IGT Geotechnik und Tunnelbau).

The geological strata projected for this area (alluvial fans and quartz gravel) are well-suited for the creation of jet-grouting (DSV) columns. Furthermore, surface access is available over the entire length of the track change, divided into several phases. These conditions allow for a jet-grouting arch to be created in advance to secure the cavity of the track change before excavation work begins and to transfer the resulting rock loads into the stiff quartz gravel. Calculations have shown that the chosen concept can achieve a settlement-friendly and safe conventional tunneling of the track change cross-sections.

The second track change, which will also be built using the closed-form construction method, has an overburden of about 13 m to the top of the ground (GOK), although some buildings directly above the facility have basements with a depth of about 5 m below GOK. A particularly critical structure is one built with a two-story underground garage and two upper floors. The remaining distance between the outer crown edge of the large cross-section and the underside of the single foundations is about 3.8 m. The entire conventionally excavated part of the track change will be driven in silty-clayey Miocene or Sarmatian strata, using the innovative tunneling concept shown in Fig. 9.

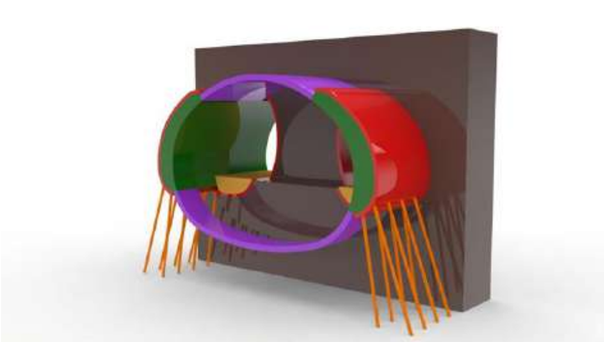

Fig. 9. Tunneling concept cross-section Leo-Slezak-Gasse (Source: IGT Geotechnik und Tunnelbau).

Initially, two pilot tunnels (red) are driven along the haunches of the widened cross-sections. In these tunnels, cast-in-place concrete slabs (green) are constructed, founded on micropiles (orange). The cast-in-place concrete slabs serve as a support for the subsequently constructed crown and invert arch (purple) and also provide longitudinal bracing. Calculations have also shown that the chosen concept enables a geotechnically safe and robust construction of the large cross-section.

6. Conclusion

With the sections of the second construction stage currently under construction and in planning, the Vienna subway network continues to grow and develop.

However, the completion of the U5 construction work does not mark the end of Vienna's subway expansion. With the extension of the U2 by approximately 4.0 km and the U1 by approximately 2.5 km, further challenging projects are in the pipeline, where past and future experiences will play a decisive role.

References

IGT Geotechnik und Tunnelbau. Available online: https://igt-engineering.com/. (accessed: 2025)

Planungsteam U5NEU2, Magistratsabteilung 18 Stadtentwicklung und Stadtplanung, 2021. Generelle Planung Abschnitt Frankhplatz – Elterleinplatz.

Planungsgemeinschaft Folgeauftrag Generelles Projekt U5-U2-U1, Magistratsabteilung 18 Stadtentwicklung und Stadtplanung, 2023. Generelle Planung Abschnitt Elterleinplatz – Hernals.

Wiener Linien, (n.d.). General overview of the Neubaugasse station. Available online: https://www.wien.gv.at/verkehr/planung-linie-u5