CONSTRUCTION OF THE I.D METRO LINE IN PRAGUE IN THE ID1a PANKRÁC - OLBRACHTOVA SECTION – FINAL LINING AND TECHNICAL INTERESTING FACTS ABOUT THE INTERSTATION SECTION

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Abstract: Construction of the fourth line of the Prague metro began on April 1, 2022, in the most complex and longest stage in the Pankrác – Olbrachtova section, and is now halfway complete.

This article focuses on the waterproofing and final lining of the tunnels between stations and the Olbrachtova station tunnels in the direction of Pankrác station. The technology of continuous concreting of the ventilation shaft will be presented in more detail. The concreting of the front walls of the four tunnel crossings from the tunnel floor level was carried out at once without horizontal and vertical joints and was a technical challenge for the contractor. Furthermore, the unusual variability of the steel formwork in the double-track tunnel, which was manufactured and converted into five different cross-sections of the double-track tunnel, will be presented. For large concreting operations (over 350 m3), the contractor set up a noise-reducing docking area for truck mixers, which had a significant positive impact on the construction progress of this section.

Carrying out mining activities within the city limits with only vertical access places great emphasis on suitable technology, logistics, and work planning so that there is no negative impact on surface development and the permitted noise limits at night are observed.

1. GENERAL INFORMATION ABOUT THE PROJECT

The construction of the new Prague Metro D line is one of the largest and most complex underground transport projects in the Czech capital. It involves the construction of a 10.6 km line with 10 stations between Náměstí Míru and Písnice. The entire route will be operated automatically without drivers. This complex project combines various construction technologies (NATM, TBM, shaft and station excavation).

This large-scale transport project is divided into four construction phases. The first phase, which has been under construction for more than three years, is designated I.D1a and includes the construction of the Olbrachtova and Pankrác D stations and the interstation track tunnels, including the connection of the new D line to the existing Pankrác C station. The second phase will continue with the construction of line tunnels from Olbrachtova station to Písnice and the construction of three stations (Krč Railway Station, Krč Hospital, Nové Dvory). The third phase involves the Libuš, Písnice, and Depo Písnice stations. The final fourth phase involves the continuation of the line to the city center from the Pankrác D station via Bratří Synků Square to Míru Square.

1.1. BASIC INFORMATION ABOUT THE PROJECT:

Name: Operational section of metro line I.D – Pankrác – Olbrachtova section – construction part

Contract term: 04/2022 – 09/2029

Client: Dopravní podnik hl. m. Prahy a.s.

Contracting authority: Inženýring dopravních staveb a.s.

Contractor: Metro I.D Consortium
Subterra a.s. – lead member
Hochtief CZ a.s.
Strabag a.s.
Hochtief Infrastructure
Ed.Züblin
Tender documentation: Metroprojekt Praha a.s.
Implementation documentation: Metroprojekt Praha a.s.
Monitoring: Krtek D monitoring
Length of the construction part of the section implemented by Hochtief CZ: 1941.29 m
Number of stations: 2 bored stations

1.2. DISTRIBUTION OF OBJECTS ON THE INTERSTATION SECTION:

Table 1- Distribution of objects on the interstation section

Name of construction object	Stope area (m^2)	Length (m)
SO 12-20 - Excavated double-track tunnel and junction to the lay-by tunnel	85 to 220 m^2	394.41
SO 12-21 - Left excavated single-track tunnel	37 m^2	265.60
SO 12-22 - Right excavated single-track tunnel (including fork)	37 to 122 m^2	270.90
SO 12-23 – Lay-by single-track tunnel	41.5 m^2	157.46
SO 12-25 - Ventilation connection between single-track tunnels	33 m^2	15.00
SO 12-28 - Ventilation machine room	22 to 67 m^2	97.50
SO 13-20 Olbrachtova station – Right station tunnel	47 to 89 m^2	118.00
SO 13-20 Olbrachtova station – Left station tunnel	47 to 61 m^2	113.30
SO 13-20 Olbrachtova station - TGT north connection	39 to 87 m^2	25.70
SO 71-20 Excavated single-track tunnel connecting C-D	37 m^2	468.17
SO 11-29 – OL station tunnel	98 m^2	15.25
	TOTAL	**1941.29**

2. WATERPROOFING LAYER AND FINAL LINING

After completion of the excavation, all parts of the tunnels were reprofiled so that the substrate was properly prepared for the installation of the waterproofing layer. In the case of the vault, this consists of a protective geotextile and a 3 mm thick PVC foil. The geotextile, weighing 800 g/m^2, is attached to the primary lining using discs. The PVC foil itself is then installed. The foil and disc are joined using a hot air gun, and the individual insulation strips are joined using an automatic welding machine with double welds with overlap. In the case of the bottom, longitudinal drainage is first installed, followed by the concreting of gap concrete and gradient concrete. This layer is then protected with geotextile with a total weight of 2,000 g/m2 and, if necessary, with a layer of screed. External sealing joint strips with a safety injection system connected to collection boxes are then welded onto the waterproofing. The strips are supplemented by two pairs of 19/11 and 11/6 mm injection hoses. The first is intended for microcement-based system activation injection and the second for chemical-based safety injection.

The waterproofing layer is followed by the final lining. This consists of C30/37-XC1-Cl 0.20-Dmax 16 concrete with a maximum permeability of 50 mm, concrete reinforcement, KARI mesh, and truss arch frames. The bottom usually consists of 24 m long concrete sections and 48 m long expansion joint sections. The vault consists of 8 m long concrete sections, except for the double-track tunnel, where the typical length of one section is 10 m. The minimum reinforcement cover is set at 50 mm on the inside and 40 mm on the outside of the final lining and is ensured by means of spacers. The relevant reinforcement bars are welded in accordance with the requirements for protection against stray currents. For structures where sections of the same profile are repeated, a fully automatic steel formwork is usually used. In other cases, system formwork is used. After concreting a given section and removing the formwork, a protective coating is always applied to prevent drying and the formation of shrinkage cracks. The formwork removal strength is set at 11 MPa. All material for the construction of the final lining is transported underground to its destination via the VO-OL hoisting shaft.

For large concreting (over 350 m3), the contractor set up a noise-reducing docking area for truck mixers. The noise reduction effectiveness of the shelter was assessed on the basis of several measurements. Measurements were taken inside the shelter, where the noise source was located, and then outside the structure's shell. Based on the difference between the values measured by an accredited laboratory, the effectiveness of the shelter can be demonstrably confirmed.

Figure 1-Noise-reducing shelter

The shelter is composed of Purteco P507 foam insulation (200 mm), wire mesh, geotextile (500 g/m^2), waterproof tarpaulin, waterproof Peri plywood (10 mm), and a truss frame structure. Based on measurements of the difference in values, the effectiveness of the shell was determined to be 27 dB. The gate had an effectiveness of 21 dB. This structure enabled the smooth transport of concrete underground, even during critical night hours (10:00 p.m. – 6:00 a.m.).

3. CONTINUOUS CONCRETING OF VENTILATION SHAFT ON THE METRO D LINE

As part of the construction of the new Prague Metro D line, ventilation shaft was concreted using continuous concrete pouring technology, which enabled smooth progress of work while maintaining high quality of execution. The chosen technological procedure is an effective solution, especially for deep vertical structures with high demands on precision, safety, and construction organization.

The concreted ventilation shaft has a clear diameter of 5.6 m and a depth of 23.44 m from the already concreted neck with the ventilation machine room. The concreting itself began on August 4, 2025, at 8:00 a.m., with completion scheduled for August 8, 2025, at 3:00 p.m.

The reinforcement and subsequent concreting were carried out using four PERI UP support towers, which were placed on the surface and stabilized by bracing them to the concrete surface. Pre-assembled VARIOKIT truss girders were connected to the distribution beams of these towers, creating a supporting structure for the formwork and technological equipment.

Figure 2 – Ventilation shaft implementation

The formwork was moved by a 7.5 kW hydraulic system with a central connection of all hydraulic cylinders, which enabled synchronized and smooth lifting of the entire structure. Four ENERPAC RRH-606 hydraulic cylinders with a maximum load capacity of 400 kN were mounted on the supporting surface structure. The maximum stroke of a single cylinder was 166 mm, and the movement was transmitted by DYWIDAG DW 15 tie rods.

The formwork was lifted at regular intervals – every odd hour, the hydraulic cylinder was lifted once, while every even hour, two lifts were performed. This rhythm ensured uniform concreting and optimal conditions for concrete hardening.

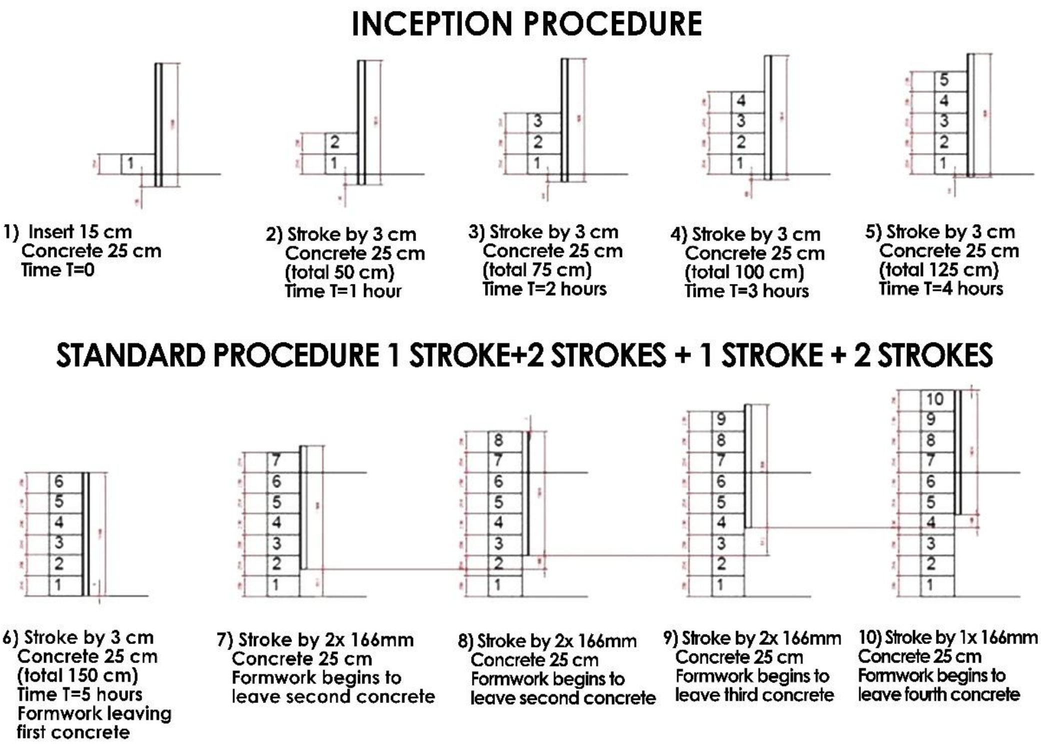

Figure 3 – Formwork lifting procedure

C30/37 C370D3R.16 cast concrete was used for the concreting, with the first two deliveries accelerated with RX40 setting accelerator to ensure the stability of the fresh concrete in the initial phase of concreting. The concrete mix was placed into the formwork using a 0.75 m^3 concrete bucket.

The concrete placement was completed on August 8, 2025, at 7:00 a.m., with the concrete pouring itself being completed by removing the formwork five hours later. The total concrete pouring time was 100 hours, which corresponds to an average daily progress of 5.63 m.

The construction of the ventilation shaft using continuous concreting technology confirmed the suitability of this method for deep vertical structures in urban infrastructure conditions. The quality of the final work, the smooth logistics of concrete transport from the concrete plant, the high work pace, and the smooth running of the entire project testify to the precise and professional approach of all parties involved in the project, both in its preparation and implementation.

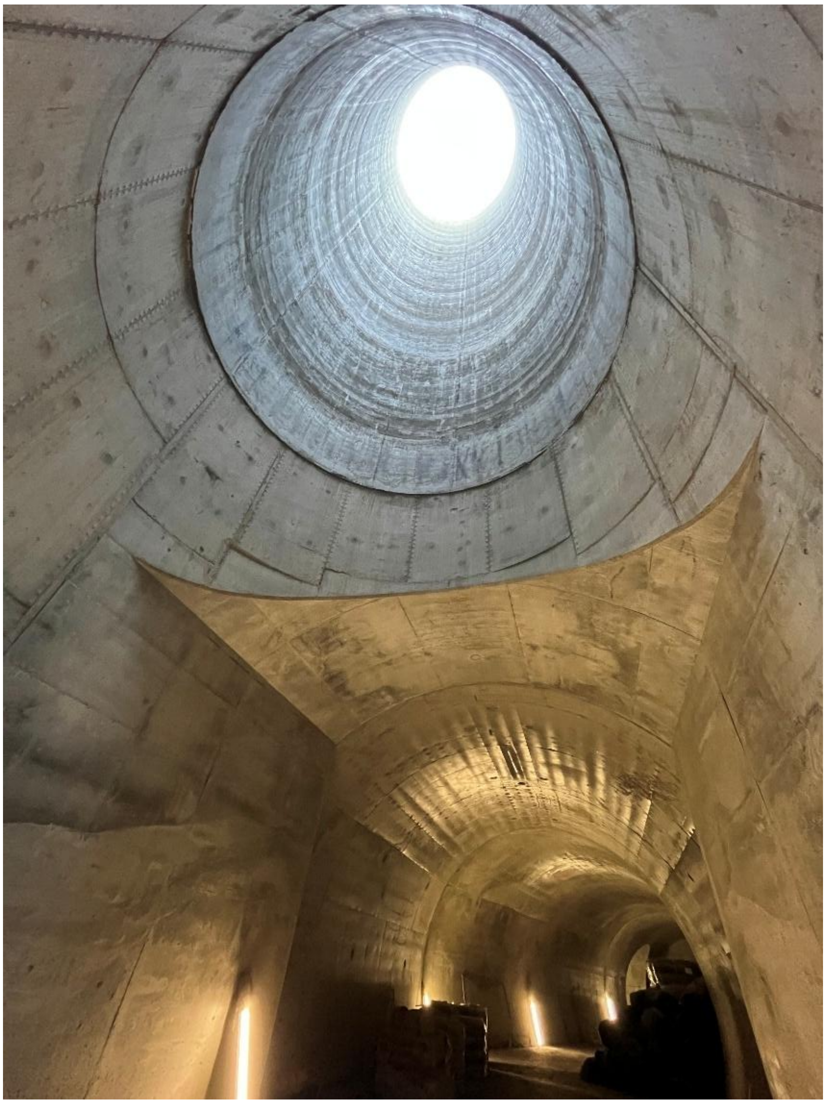

Figure 4 – Ventilation shaft after continuous concreting

4. CONCRETING OF FRONT WALLS

As part of the metro construction, the front walls of the final lining were concreted in places where there were complex spatial intersections of tunnel junctions. These were two separate front walls, which were among the most demanding concreting operations of the entire construction in terms of both design and technology, mainly due to their dimensions, height, and complicated geometry at the junctions.

The first front wall is located at the point where the double-track tunnel splits into a continuing double-track tunnel and a branching single-track lay-by tunnel. The front wall here formed a clearly defined structural divide between the main tunnel tube and the branch line, and it was necessary to ensure a smooth connection of the final lining of all the profiles involved.

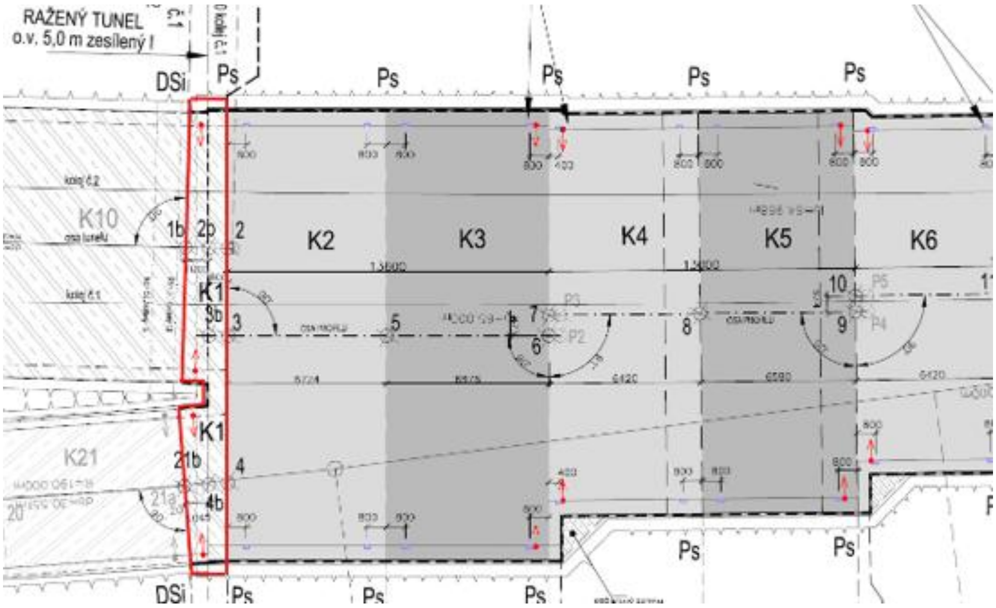

Figure 5 – Junction at the place of branching to the lay-by tunnel

The second case involved an even more complex spatial arrangement, where a double-track tunnel splits into two separate single-track tunnels, supplemented by another branch to junction C–D (a tunnel connecting the metro line D under construction with the existing metro line C). At this point, four tunnel axes of four tunnels of different sizes converged, which placed high demands on the accuracy of the formwork, coordination of the reinforcement, and concreting technology.

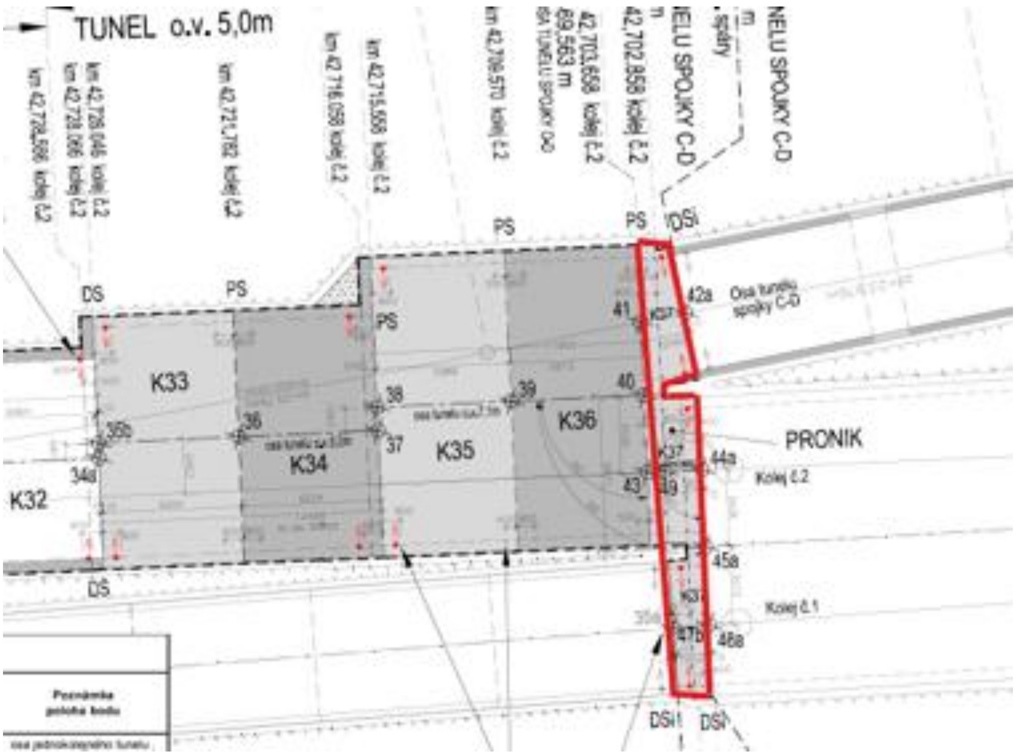

Figure 6 – Junction to C-D connection

Each of the front walls was constructed from a single monolithic concrete block with a volume of approximately 89 m^3 of concrete. The maximum height of the structure reached 9.5 m, which significantly influenced the design of the formwork system and the concreting process itself.

For technological and static reasons, all penetrations were concreted from floor level as a single unit, without horizontal or vertical working joints. This procedure ensured high spatial rigidity of the structure, elimination of potential leaks, and even load transfer from the connecting parts of the final lining.

Before concreting began, a complete waterproofing layer was installed, including the laying of hoses for possible safety injection. This was followed by the installation of reinforcement.

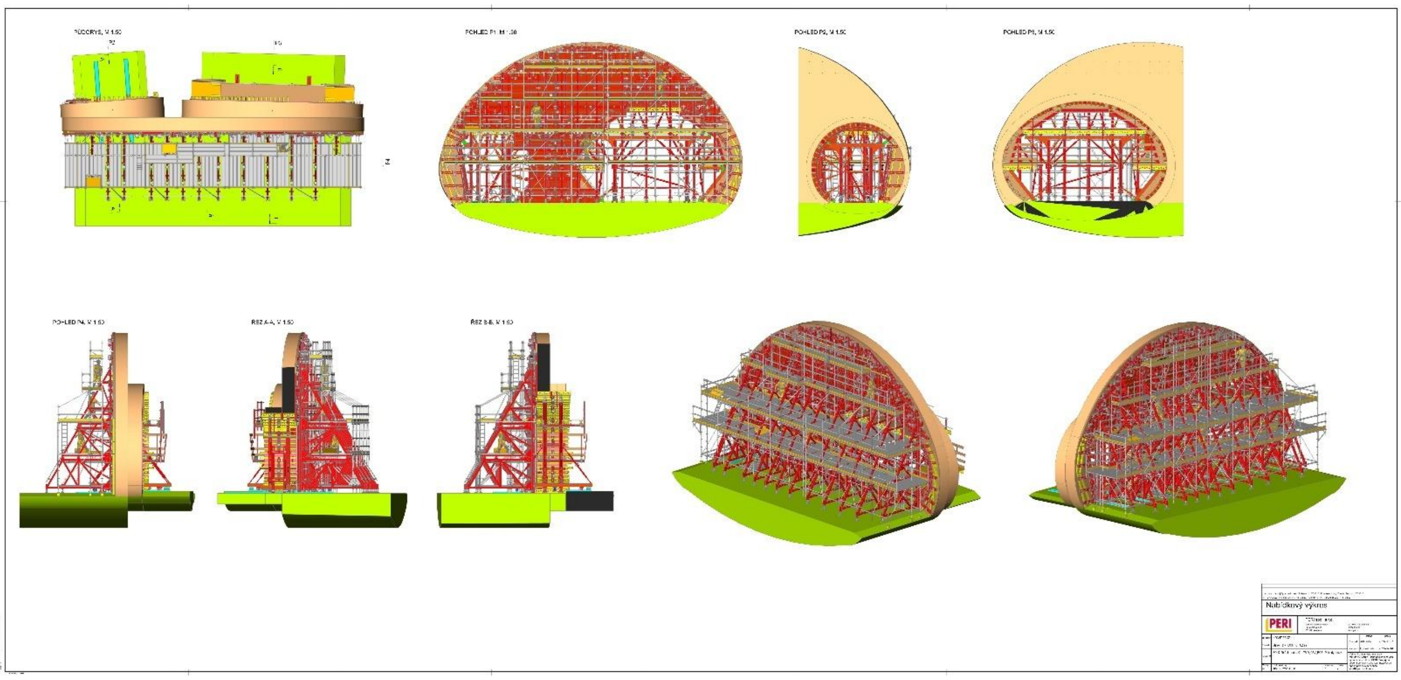

Figure 7 – Drawing of formwork for the junction to the lay-by tunnel

The concreting itself proceeded smoothly, with emphasis on the even placement of the concrete mixture in layers of varying heights so as to prevent uneven loading of the formwork. The concrete was compacted systematically using internal vibrators, taking into account the density of the reinforcement and the complexity of the structure. After the concreting was completed, appropriate care was taken to minimize the risk of shrinkage cracks.

Figure 8- Formwork for the front wall of the junction to the C-D connection

The construction of the front walls at the tunnel intersections represented a significant milestone in the construction of the interstation section of metro line D between Pankrác and Olbrachtova. Thanks to the monolithic design, precise preparation, and masterful concreting technology, high-quality final lining was achieved even in the structurally extremely complex junctions of the tunnel system.

Figure 9 – Front wall of the junction to the lay-by tunnel

5. FORMWORK FOR THE DOUBLE-TRACK TUNNEL

The double-track tunnel between Pankrác D station and the junction to single-track tunnels is 471 meters long. Nine different cross-sections of the tunnel are designed for this nearly half-kilometer-long tunnel. A modifiable formwork carriage was used for the concreting of five of these cross-sections. This was used in profiles ranging from 89.1 m2 to the largest profile of 122.7 m2. The formwork and equipment were required to be of the usual design, but with great emphasis on the easy reassembly of the formwork into the next profile in the shortest possible time and with limited access for assembly. All assembly work was carried out underground with no possibility of crane access from above and using lifting equipment with a maximum load capacity of 5 tons. This challenge was taken up by the Opava-based company Ostroj a.s., which managed to complete the complex task.

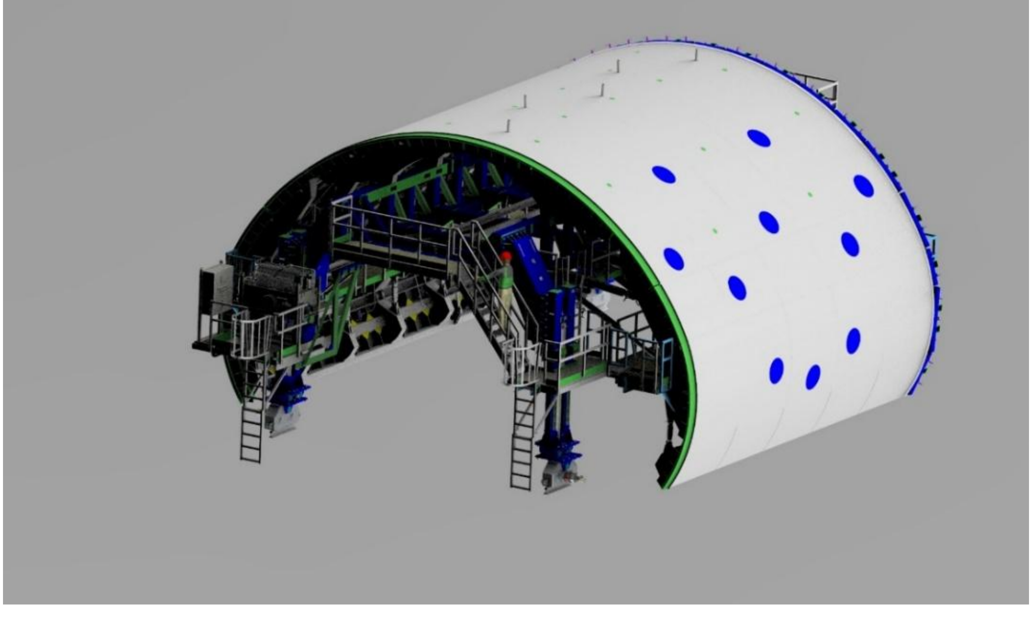

Figure 10 - 3D model of a steel hydraulic formwork for a double-track tunnel

The basic structure of the formwork is assembled from welded components and forms the supporting frame of the formwork itself. The main parts of the formwork are the bridge structures, portal, legs, base, and drive mechanism. The formwork is powered by hydraulic motors using a hydraulic unit. The formwork is moved between individual sections on S49 rails. The form consists of three segments that are bolted together. The length of one segment is 2 m. The individual segments are equipped with filling (inspection) windows or DN 125 filling valves. Vibrating pneumatic motors are located on the steel shell of the formwork to ensure the required compaction of the concrete mixture. With a basic formwork length of 10 m, the total weight of the equipment is 110 tons.

The use of this steel formwork created further logistical challenges in terms of precise planning of individual procedures, concrete pouring directions, formwork relocation, and, last but not least, conversion to individual profiles. Thanks to the professional cooperation between the fitters from Ostroj a.s. and the implementation team, the individual conversions were carried out without any negative impact on the construction schedule. The average conversion time was 7 days, depending on the size of the profile. The concrete pouring itself then proceeded smoothly without any major problems.

Figure 11 - Concrete pouring using a steel hydraulic formwork for a double-track tunnel

6. CONCLUSION

After completion of excavation work on the interstation section of the C-D connection in October 2024, all activities focused on the construction of waterproofing and final lining. During April, these activities were completed on the interstation section, including the excavated part located in the extraction shaft, where only the supply opening for transporting technology remained in the ceiling. Concrete track slabs are already being poured, and preparatory work on the construction of the track superstructure has begun. Work on the construction site is continuing at the planned pace, and the underground spaces no longer look as monumental and dusty as they did during the excavation. The approaching opening is already in the air, and we can only wish the people of Prague and future passengers that they will be able to enjoy it as soon as possible.

LITERATURE

Project: „Construction of the I.D metro line in Prague – ID1a Pankrác – Olbrachtova section, Construction technology part" METROPROJEKT Praha a.s., Construction documentation, 2022-2026

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