INTERESTING FACTS FROM THE CONSTRUCTION OF THE HG UTILITY TUNNEL AND TS20 SUBSTATION AT VÁCLAV HAVEL AIRPORT IN PRAGUE

R. Bernard, I. Kohoušek.

SG Geotechnika, a.s., Prague, the Czech Republic.

ABSTRACT: The project itself addresses the efficient and optimal routing of cable and pipeline infrastructure in connection with the large number of planned projects by the future operator of the Prague airport complex. The construction of the Hangar G utility tunnel and the associated TS20 substation represents strategic underground infrastructure for the further development of Prague Airport. The utility tunnel, with a total length slightly exceeding 600 m, combines an excavated section constructed by the NATM method with a cut-and-cover section in an open excavation, with the aim of efficiently and safely routing the necessary cables and pipelines under full airport operation. The project also includes the aforementioned TS20 substation, ensuring the power supply connection for the technological infrastructure. The article describes the geological and geotechnical conditions, the construction technology, safety measures, and the coordination of the underpass beneath roads and utility networks from the perspective of TDS representatives. The greatest challenge was minimizing risks of low overburden (4.2–6 m) and weathered marlstone. Optimization of the excavation procedure, including modifications to the final lining and the cut-and-cover section, resulted in time and cost savings, while geotechnical monitoring confirmed the safety and stability of the structure. The implementation of the project demonstrates the suitability of combining mined and cut-and-cover technologies while maintaining operational safety and minimizing impacts on the surroundings. Within the project, the investor decided to deploy the BIM method (Building Information Modeling/Management) already from the design preparation phase, including the construction of both the utility tunnel and the substation itself.

1. INTRODUCTION

At the end of November 2024, a contract was signed between the client and the main contractor for the construction of the Hangar G utility tunnel (hereinafter “HG”) and the TS20 substation, the objective of which is to enhance the future infrastructure of the largest airport in the Czech Republic. Archaeological investigations and preparatory works for the construction of this project commenced immediately in December of the same year, so that this section of the utility tunnel can be put into operation before the end of the summer of 2026.

The client of this project is the state-owned company Letiště Praha, a.s. The main contractor is Metrostav CZ s.r.o. The general designer of the project documentation is the design company INGUTIS, spol. s r.o. For the construction of the mined section, the role of the mining designer is performed by SAGASTA s.r.o. The Investor’s Technical Supervision is provided by a consortium consisting of SGS Czech Republic, s.r.o. (consortium leader), SG Geotechnika, a.s., Pragoprojekt, a.s., and INFRAM, a.s. It is also appropriate to note that the principal construction activities related to the development of the HG utility tunnel and the TS20 substation are carried out by the following subcontractors. All reinforcement and concrete works in the cut-and-cover sections are performed by HOCHTIEF CZ, a.s.; all earthworks are carried out by BIGGEST s.r.o.; and the excavation works, including the construction of the permanent lining of the utility tunnel, are executed by the construction company POHL cz, a.s.

1.1 CONCISE DESCRIPTION OF THE PROJECT, ITS PURPOSE, AND JUSTIFICATION

By way of introduction, it is appropriate to note that the owner of Prague Airport is currently preparing a large number of projects within the framework of its transport and infrastructure development. The newly constructed utility tunnel within the premises of Prague International Airport is intended to serve in the future as a strategic underground route for the routing of technical infrastructure between Terminals 1 and 2, ultimately extending, upon full completion, as far as Terminal 3. Once the entire utility tunnel, together with the connected independent high-capacity TS20 substation, is completed, it will be possible in the future to minimize interventions in the airport's surface areas, ensure accessibility for maintenance and technological development, and last but not least, increase the operational reliability and safety of power supply to the hangar facilities. The utility tunnel project is divided by the Investor into several stages. At present, the first section with a length of approximately 600 m is under construction, with its continuation towards Terminal 3, i.e., further southeast of the Š11 shaft, envisaged towards the end of the current decade.

This paper addresses the construction of a new alignment of the utility tunnel, designated "Construction Stage 1 – Hangar G Utility Tunnel," which connects to the already operational alignment "HTS–Terminal Utility Tunnel – Stage 2" via the existing Š6 (Š5) shaft. On the opposite side, the new alignment will be connected, through the newly constructed Š11 shaft (located in the vicinity of the paved area of the future Hangar G), to "Construction Stage 2 – North–South Utility Tunnel," leading towards the aforementioned Terminal 3. The construction of the utility tunnel will thus interconnect the main backbone route of utility networks between the northern and southern parts of the Prague–Ruzyně Airport complex (from Terminals 1 and 2 to Terminal 3). The works are being carried out under full airport operation.

The current stage of construction of the HG utility tunnel and the TS20 substation is therefore situated on the northeastern edge of the built-up area of the entire airport complex and within its protective zone, and it connects to the existing utility tunnel at the HTS (Main Substation) at the Š6 shaft. Part of the works is located within a publicly accessible area of the airport along K letišti Street. At this connection point to the existing utility tunnel, a Technical Chamber (TK7) is being constructed, from which the excavation of the HG utility tunnel is commenced underground using the NATM (New Austrian Tunnelling Method). After approximately 300 m, the alignment transitions at the newly excavated Š9 shaft into a cut-and-cover section of the utility tunnel, which terminates at the newly constructed Š11 shaft. From there, the entire tunnel will be connected to the new TS20 substation via a connecting gallery. The overall concept of the project and its integration with the existing infrastructure are illustrated in Fig. 1. The cut-and-cover section of the utility tunnel was initiated within a non-public area of the airport (SRA zone); however, during construction it was temporarily excluded from the SRA zone due to airport safety regulations.

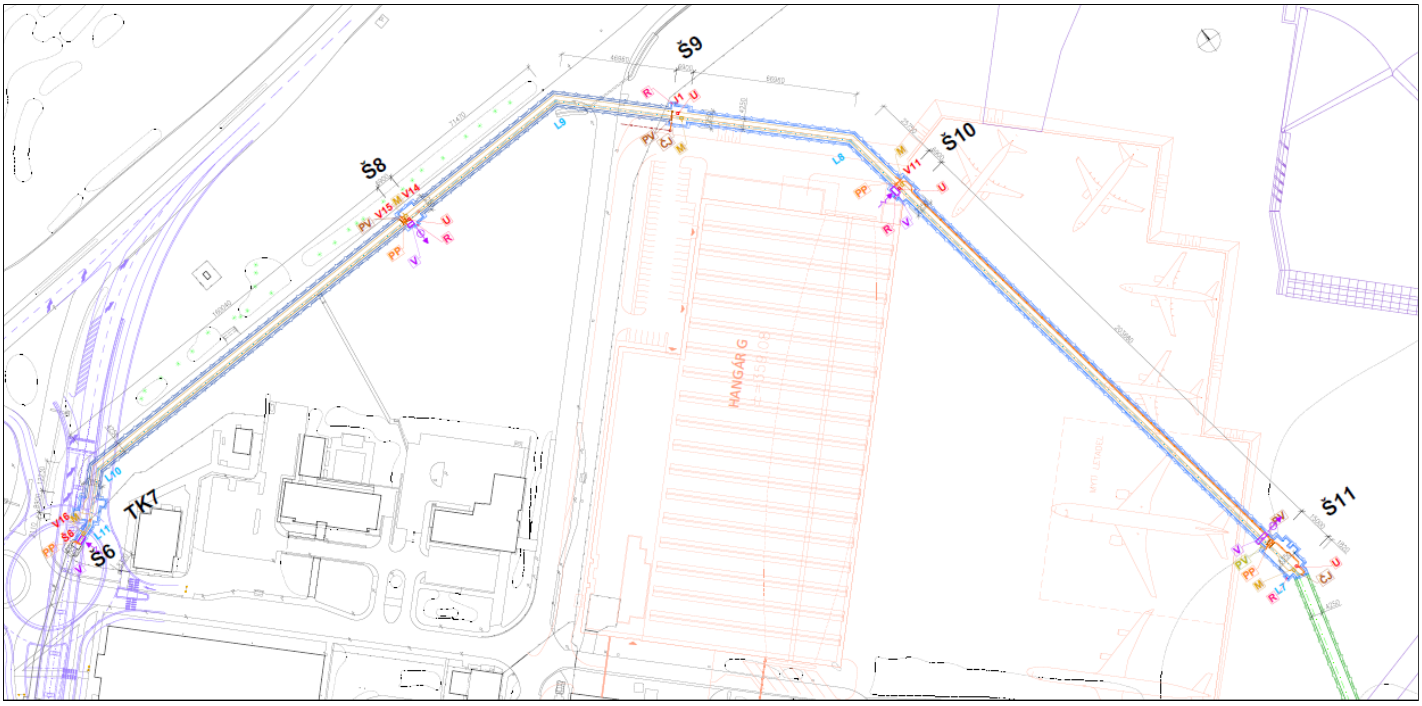

Fig. 1 Layout of the HG Utility Tunnel Project (SOCHŮREK, J.; ŠVEC. 2025)

2. DESIGN SOLUTION AND GEOLOGICAL CONDITIONS OF THE PROJECT

2.1 PROJECT PREPARATION AND CHANGES LEADING TO THE OPTIMIZATION OF THE CONSTRUCTION

The Hangar G utility tunnel project is being constructed using two different methods. One part is realized underground by tunnelling using the NATM (New Austrian Tunnelling Method), due to the crossing of several utility networks whose relocation would be technically and operationally complicated (gas, water supply, sewerage, etc.), as well as due to the crossing of a heavily trafficked public airport road serving the Terminal 1 and Terminal 2 complex. The second part of the utility tunnel is executed by means of an open cut-and-cover excavation with sloped sides, in which the tunnel structure is cast in situ on a base slab and subsequently backfilled. Regarding the structural dimensions of the utility tunnel, in the section between the Š9, Š8 and Š6 shafts (connection to TK7), the tunnel alignment is designed as an excavated section with an internal clear profile of 4.25 × 4.10 m. The sections between the Š9, Š10 and Š11 shafts are constructed from the surface; in this area, the utility tunnel is designed as a closed reinforced concrete box structure with internal dimensions of 4.25 × 3.60 m.

At the commencement of excavation works (02/2025) and following the evaluation of all available information on the geotechnical conditions along the utility tunnel alignment, the main contractor presented an optimization of the project for the execution of both the primary and secondary linings of the excavated sections, as well as a corresponding optimization of the construction procedure for the cut-and-cover sections. In both cases, these measures represented a simplification of the construction process compared to the original tender documentation. A significant benefit of the proposed changes was the achievement of both time and cost savings. In the first case, the optimization comprised, on the one hand, improvements to the excavation procedure and the execution of the primary lining, and, on the other hand, a modification of the tunnel cross-sectional shape together with the associated dimensions of the secondary lining. The principal simplification of the primary lining construction during excavation based on the principles of the observational method, consisted in modifying the top heading excavation from two partial headings to a single heading, i.e. eliminating the vertical subdivision of the heading. Furthermore, the new design solution removed the invert within the top heading and, at the same time, reduced the number of reinforcement bars in the primary lining steel ribs from four to three. The optimized tunnelling design also included modifications to the anchoring and face support system, which was subsequently further optimized (lightened) in accordance with the principles of the observational method also during the actual excavation works (Fig. 2). Finally, compared to the original design, the planned 20 m long exploratory horizontal borehole was omitted from execution.

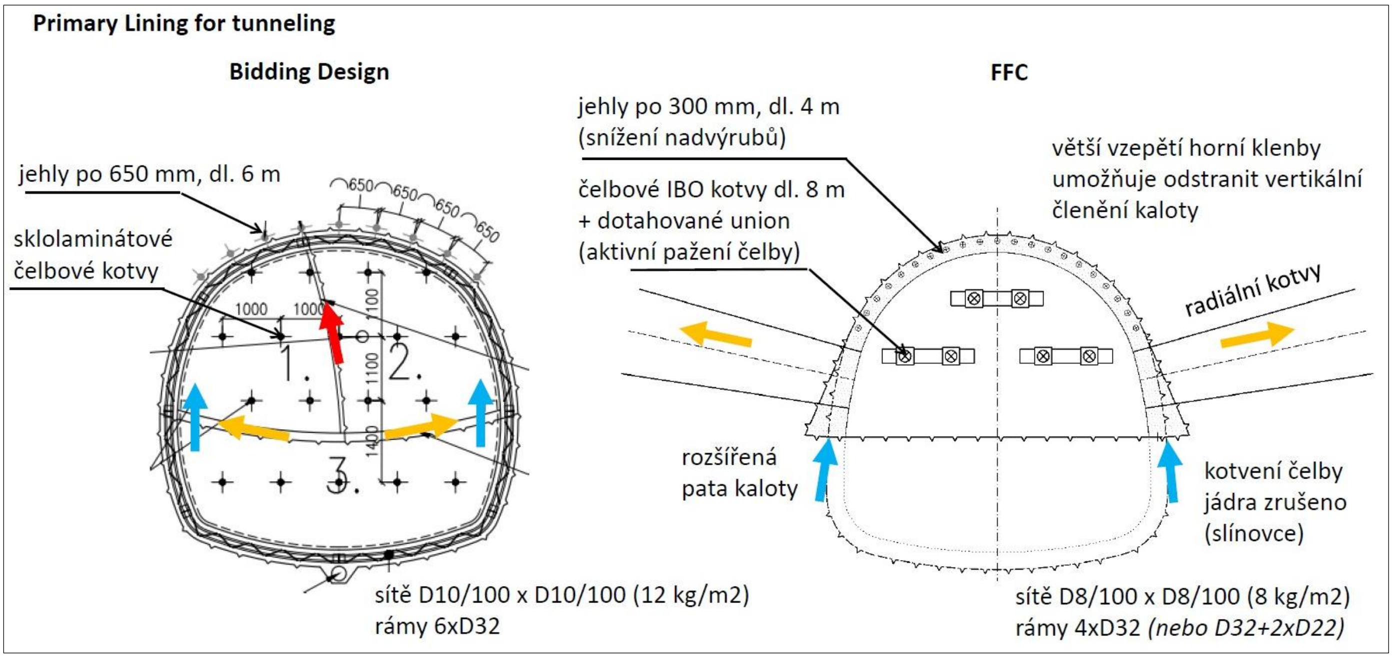

Fig. 2 Optimization and modification of the primary lining of the utility tunnel (BALÁŽ, M.; MAŘÍK, L. 2025)

The objective of optimizing the shape of the utility tunnel cross-section and the thickness of its lining was to reduce the theoretical excavation area and to achieve a more favourable geometry of the primary lining, which better resists ground pressure, increases the stability of the construction during excavation, and thereby reduces the risk of extraordinary or hazardous events.

The primary objective of the optimized design of the permanent lining was to achieve a more favourable stress distribution within the structure and to reduce the risk of crack formation in the secondary lining, as the lining provides not only the load-bearing function but also the watertightness of the utility tunnel. The formation of cracks, which can be remediated only from the intrados of the lining, may - due to the risk of reinforcement corrosion - have a negative impact not only on watertightness but, above all, on the service life of the load-bearing structure, which is designed for a design life of 100 years. The minimum thickness values of both the primary and secondary linings remained unchanged compared to the tender documentation. One of the features of the newly proposed secondary lining is a favourable modification consisting in the replacement of the two arc radii of 3.613 mm and 1.825 mm by a single arc with a radius of 2.125 + 350 + 300 = 2.775 mm. For clarity, Fig. 3 illustrates the difference between the optimized design of the permanent lining in the excavated section of the utility tunnel and the solution according to the tender documentation.

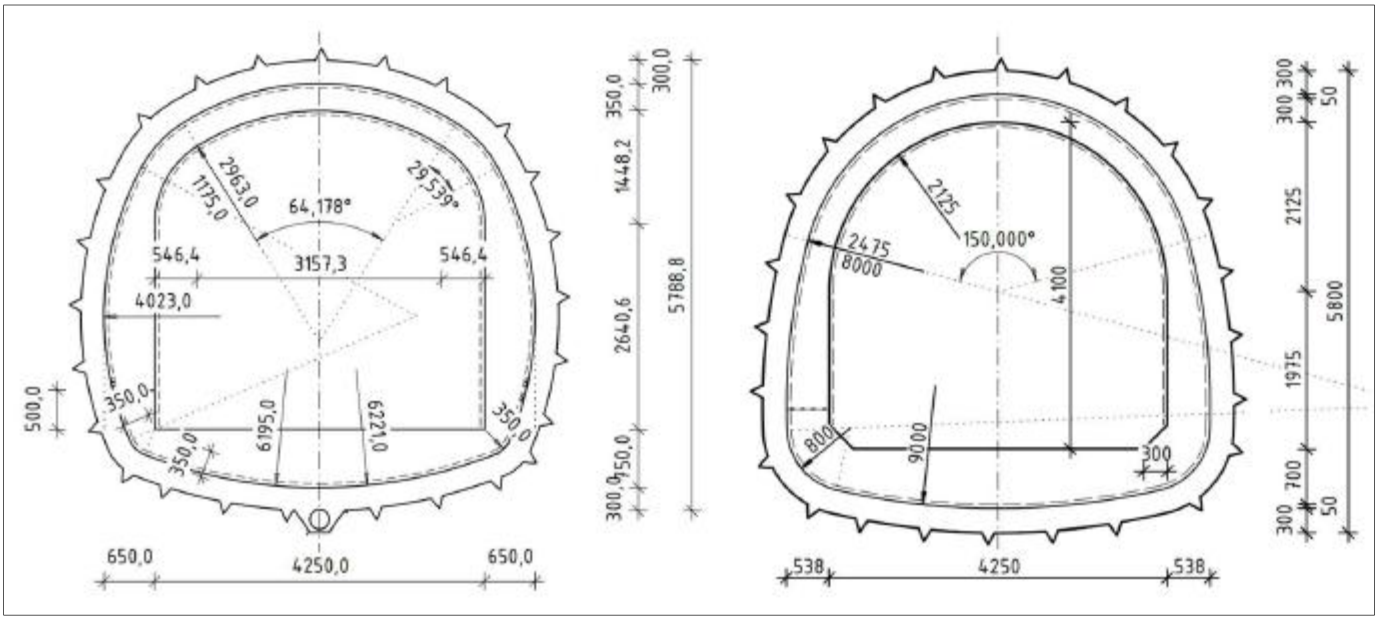

Fig. 3 Cross-section of the utility tunnel – original design on the left, optimized solution on the right (BALÁŽ, M.; MAŘÍK, L. 2025)

2.2 GEOLOGICAL AND HYDROGEOLOGICAL CONDITIONS OF THE

The geological structure of the area of interest comprises rocks of the Upper Proterozoic and the Lower Palaeozoic (the surface of Ordovician shales occurring at depths of approximately 30 to 43 m below ground level), Cretaceous sediments, and Quaternary deposits. The Cretaceous sequence is represented by layers of Cenomanian and Turonian sandstones, claystones, and spongilites. Within the Cenomanian sedimentation, these include the Peruc Member (claystones and sandstones) and the overlying Korycany Member of marine origin (sandstones). At the beginning of the Lower Turonian, sedimentation of spongilitic marlstones (opuka) of the Bílá Hora Formation took place. The Turonian marlstones form the surface of the bedrock throughout the entire area of interest. Their base occurs at depths ranging from approximately 19 to 28 m below ground level, while their upper surface lies between 1.0 and 8.0 m below ground level (predominantly around 5 m).

The marlstones are variably weathered, primarily as a result of frost action. Layers of completely decomposed marlstones, consisting of fragments and weathered debris with a clayey matrix, irregularly alternate with horizons of weathered marlstones that are of low strength and densely fractured, with predominantly open joints filled with clay. At depths of approximately 2 m below the bedrock surface, horizons of slightly weathered marlstones begin to occur; these are competent, exhibit slab-like parting, and contain predominantly closed joints. Within the slightly weathered marlstones, decimetre-thick layers of sound, very strong silicified spongilites occur irregularly. The Cretaceous rocks in the area of interest are intensely fractured. According to archival sources, the marlstones are dissected by two joint systems oriented in the W–E and NNW–SSE directions.

The Quaternary deposits cover the entire area of interest (in the relevant tunnelling section predominantly to a thickness of around 5 m) and are represented by aeolian and aeolian–deluvial sediments of various ages. The aeolian–deluvial stony clay and clayey loam deposits are overlain by younger aeolian sediments, consisting of wind-blown loess and loess loams containing rock fragments. The ground surface is formed by a humic layer with a thickness of 0.4 to 0.6 m, locally by anthropogenic fills, or by existing paved surfaces.

The groundwater level in the Cretaceous aquifer is mildly confined and occurs at depths of approximately 22 to 28 m below ground level. The northern part of the area (approximately the section between the Š9 and TK7 shafts) is drained in an NNE direction towards the valley of the Únětický Stream. Neither the exploratory boreholes nor the excavation works encountered the groundwater table down to an elevation of 342 m ASL (the lowest invert level along the entire utility tunnel alignment); only locally increased moisture along joints was observed. The clayey weathering products and similar joint infill prevent enhanced infiltration of precipitation water, and their low permeability does not allow the formation of more extensive groundwater aquifers.

2.3 IMPLEMENTED GEOTECHNICAL MONITORING

The geotechnical monitoring (hereinafter referred to as GTM) was designed and implemented in accordance with the principles of the NATM observational method, with the objective of continuously verifying the assumptions of the design documentation, monitoring the behaviour of the rock mass, and timely identifying any adverse phenomena associated with the low overburden of the excavated section of the utility tunnel. Particular emphasis was placed on minimizing the impacts of excavation on surface airport facilities and on the intersected utility networks.

Control monitoring during the tunnelling works included in particular:

- monitoring of primary lining convergence,
- engineering–geological documentation of the tunnel face and visual inspection of the lining,
- measurement of ground surface deformations,
- monitoring of settlements of affected structures (including shafts) and roadways.

The following Fig. 4 presents the GTM layout from the map interface (GIS) of the Monitoring Information System (MIS) used on this project by the GTM provider. Measurements were carried out at regular intervals, which were adjusted depending on the current support of the excavation and the distance of the tunnel face from the monitored profile. The measured values were continuously evaluated and compared with pre-defined threshold values. At no time were values recorded that would have required the activation of emergency scenarios. As the encountered environment of variably weathered marlstones, without any inflows of groundwater, proved to be temporarily stable in most cases, close cooperation among all involved parties even allowed for a reduction of the primary lining support during tunnelling works, or, where appropriate, a slight extension of the advance length at the tunnel face. For clarity, Fig. 5 also shows the GTM situation of excavated collector as created by the GTM contractor (KOSTOHRYZ, O., 2025).

Particular attention was paid to high-risk operations, which included the tunnelling beneath a public roadway, and particularly the double underpass of top heading beneath gas pipelines (high pressure line and medium pressure line), located in an area where the overburden was less than 5 m. In these sections, the lightened support system designed by the mining designer during the tunnelling works was, naturally, not applied.

The monitoring results confirmed the correctness of the selected construction methodology as well as of the optimized design of both the primary and secondary linings. The behaviour of the rock mass corresponded to the design assumptions, and deformations remained within permissible limits, which allowed the tunnelling works to proceed smoothly without the need for additional remedial measures. At the same time, the results of the geotechnical monitoring constituted a key basis for decision-making regarding the extent of primary lining optimization during tunnelling and finally served as an essential input for the finalization of the design of the secondary (permanent) lining of the utility tunnel.

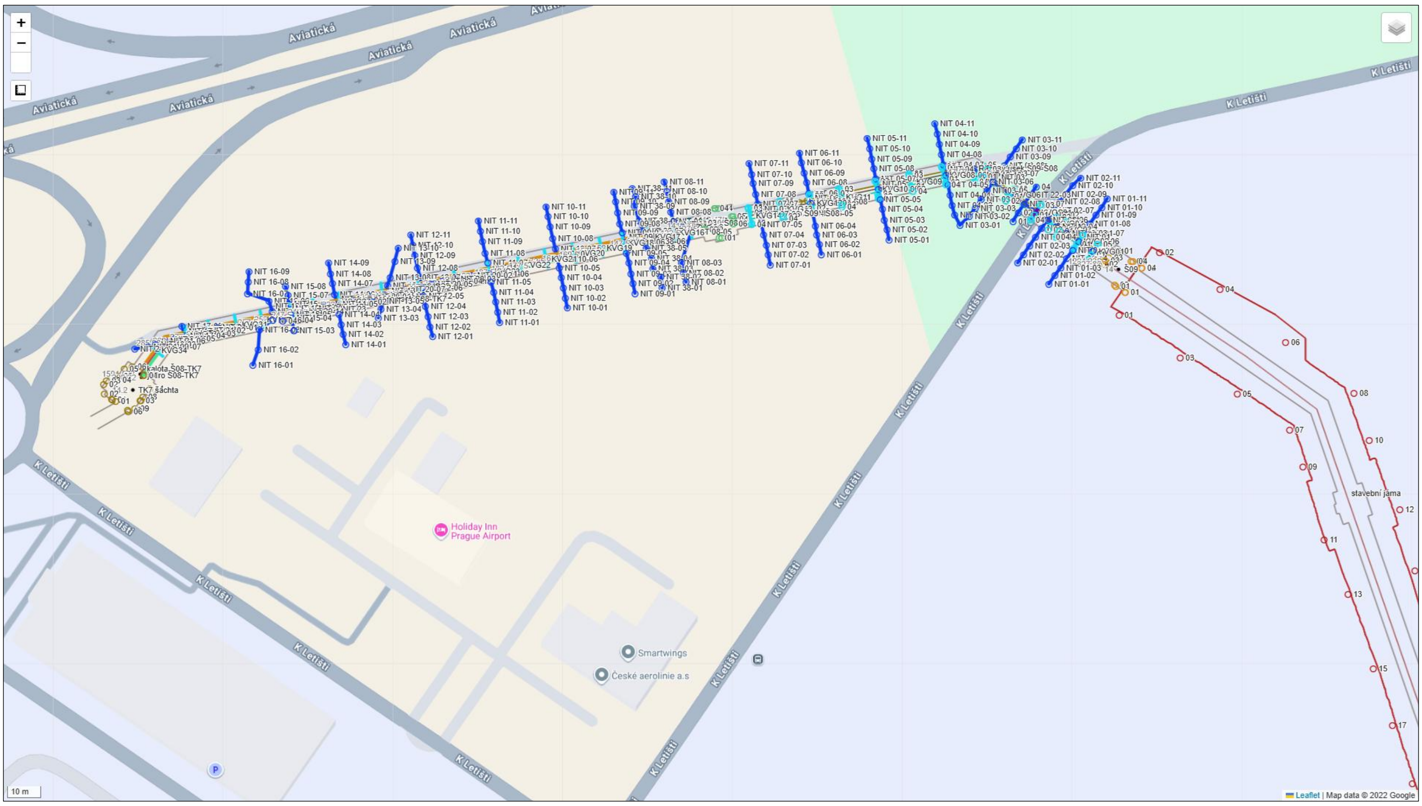

Fig. 4 Arrangement of GTM elements from MSI (GIS) used on the project; https://siisel.cz/Project/Edit/55#gis-map

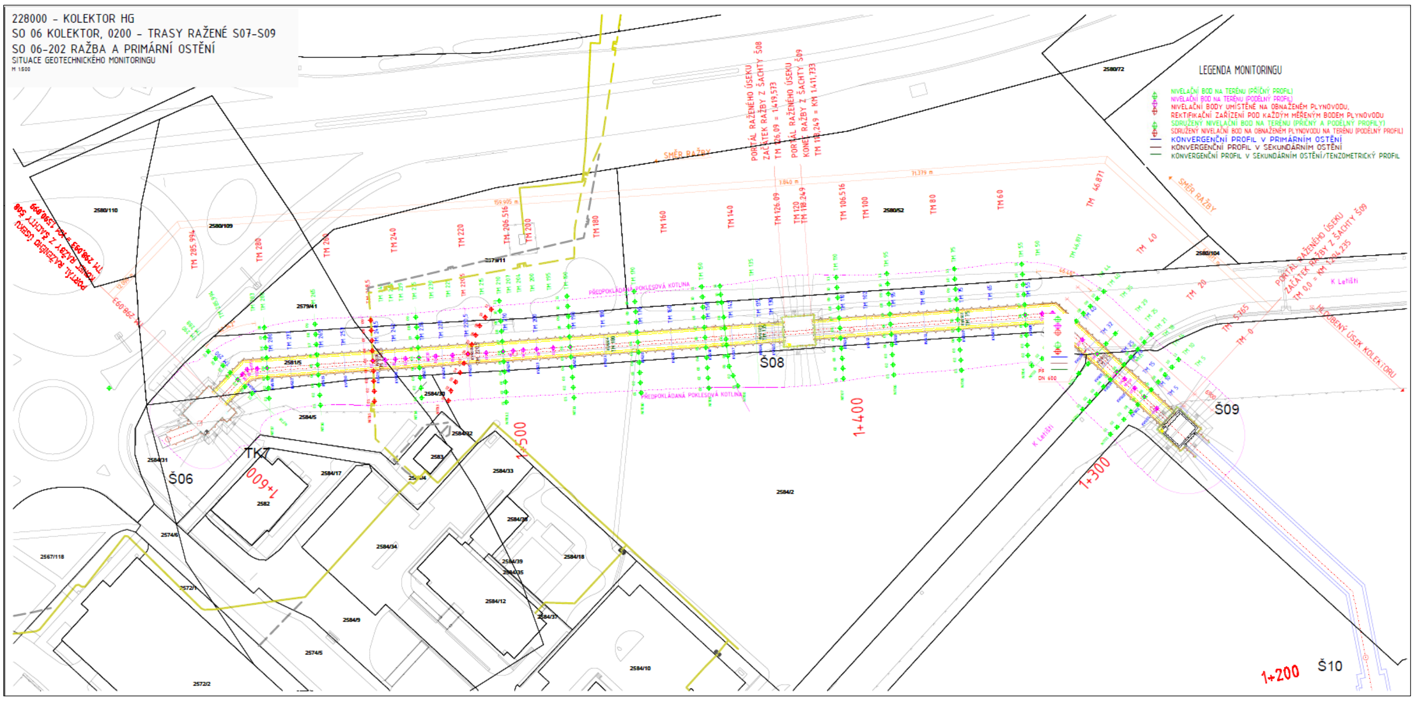

Fig. 5 Situation of Geotechnical Monitoring of excavated part of the collector according to the GTM project (KOSTOHRYZ, O., 2025)

2.4 RISK IDENTIFICATION

The identified risks were continuously assessed and managed throughout both the preparation and implementation phases of the project through a combination of technical, organizational, and safety measures. A key element was the application of the principles of the observational method during excavation, which enabled a prompt response to the actual geotechnical conditions encountered, particularly in sections with low overburden and the presence of decomposed marlstones. Increased attention was devoted to the excavated sections beneath heavily trafficked airport roads and in the vicinity of strategic utility networks, where measures were adopted to limit deformations of the rock mass and to minimize impacts on the surface. Risks associated with logistics and the movement of construction equipment within the airport premises were mitigated through strict coordination with representatives of the client and the airport operator, clear definition of traffic routes, and the implementation of operational regimes within the SRA and NON-SRA zones. In the cut-and-cover sections of the utility tunnel, the stability of the temporarily sloped excavation was secured by a set of measures, including appropriate slope geometry, continuous inspection of their condition, and adaptation of the construction procedure to the current geotechnical conditions.

This comprehensive approach to risk identification and management was one of the key factors that enabled the excavated sections of the utility tunnel to be constructed without extraordinary events while maintaining full airport operations.

3. UTILITY TUNNEL CONSTRUCTION – FOCUS ON THE EXCAVATED SECTION

3.1 CONSTRUCTION PROCEDURE OF THE TUNNEL INCLUDING PREPARATORY WORKS

The excavated section has a total length of 299 m, while the remaining part of the utility tunnel is constructed in an open cut-and-cover excavation. The excavated section, commenced in June 2025, is bounded by the newly constructed TK7 (connected to Š6) and Š9 shafts. From the Š9 shaft to the Š11 shaft, the utility tunnel is constructed within a sloped cut-and-cover section. For the tunnelling works, the most applied method in the Czech Republic was adopted, namely conventional mechanized tunnelling using NATM, including the construction of both the temporary (primary) and permanent (secondary) linings. Based on the principles of the observational method - i.e. on the geotechnical properties of the rock and soils actually encountered - the originally assumed ranges of the NATM support classes were continuously refined. The excavation was horizontally subdivided into the top heading and core with an invert. The temporary (primary) lining was designed using shotcrete, welded wire mesh (KARI mesh), and lattice girders installed at spacings corresponding to the actual geological conditions. The excavated tunnel profile 29 m^2 is horseshoe-shaped with an invert and has overall dimensions of 5.9 × 5.8 m. The permanent structure of the utility tunnel is designed in watertight concrete and is executed using a travelling formwork in 10 m long blocks. The excavated section of the utility tunnel runs beneath an overburden of less than 6 m; near the connection to TK7, the overburden decreases due to the longitudinal gradient of the tunnel and reaches less than 5 m, which entailed various risks during construction. The breakthrough of the excavated top heading between the Š9 and Š8 shafts was achieved in the first decade of October. The subsequent completion of the top heading excavation by breakthrough into TK7 was carried out approximately one month later, in November 2025.

For the successful commencement of tunnelling works, the designed Š8 and Š9 shafts first had to be excavated and subsequently secured to depths exceeding the invert level of the utility tunnel. Finally, due to the complexity of relocating all utility networks, the TK7 technical chamber was constructed at the connection point to the previously built section of the tunnel. All of these shafts were temporarily supported by soldier pile walls with steel walers, timber lagging, and tie-back anchors installed at three levels. The shaft located in the publicly accessible part of the site (outside the SRA zone) was secured first, enabling the commencement of tunnelling towards TK7 at the beginning of June. Subsequently, the Š9 shaft was completed in its temporary support system so that tunnelling from this location could also be initiated by another crew of the contractor in July 2025. All underground works at the excavation headings were carried out on a 24/7 basis to ensure continuous face advance in accordance with the Detailed Design Documentation and to fully exploit the advantages of the NATM approach. Owing to the aforementioned complications, TK7 was secured only in October; however, it was completed just in time to allow connection with the excavated utility tunnel.

A significant factor in the successful implementation of the works was the close cooperation between the contractor, the mining designer, and the Investor's Technical Supervision. Thanks to the ongoing operational evaluation of the actual conditions encountered, it was possible to flexibly adjust the excavation methods while maintaining the safety of the works and the surrounding environment.

3.2 CONTINUOUS ACTIVITIES OF THE TECHNICAL SUPERVISION TEAM

During the project implementation, the client contractually engaged a team of specialists providing technical supervision in the required disciplines. This primarily included quality control of concrete structures and control of proper procedures for electrical installations (low-voltage and high-voltage systems), cost control during construction, structural assessment of the proposed structures, geotechnical assessment of all surface geotechnical structures, and coordination with BIM models. The technical supervision team also included an underground construction specialist overseeing the tunnelling sections, which were carried out under mining regulations (ČPHZ – activities performed using mining methods). A Health and Safety Coordinator in accordance with applicable regulations was also part of this structured supervision team. As the entire project was designed and executed in a BIM environment, a BIM Manager was also included in the technical supervision team.

During tunnelling, the technical supervision team established a control regime to ensure that all cycles in continuous operation were systematically recorded and that the quality and safety of the works, as well as the quality of materials - including the application of shotcrete - were consistently monitored.

Prior to the start of construction, the client set up a cloud-based Common Data Environment (CDE), Autodesk Construction Cloud (ACC) by Autodesk, intended for document sharing, task management, defect tracking, and version control of design documentation and models during construction. The technical supervision team personnel also used a digital site diary in their daily activities, where all records from their inspections and from the contractor’s activities were stored. Individual supervision members reviewed and approved successive partial steps and construction stages to ensure uninterrupted project progress and the required quality. At the same time, they played an important role in the assessment of changes arising from various construction needs. The following figures present, for illustration, photographs from the excavation process in the top heading (Fig. 6) and the core (Fig. 7).

Fig. 6 Unsupported tunnel face of the top heading in variably weathered marlstone during excavation from the Š8 shaft towards the TK7 shaft (photo by the author)

In addition to the routine control of material quality and construction works, the technical supervision team also provided continuous monitoring of geotechnical and structural parameters, evaluated the results of geotechnical monitoring, commented on adjustments to the tunnelling procedures, and coordinated the activities of all project participants, including subcontractors. The technical supervision team also ensured compliance with legislative and safety regulations (including within the framework of activities performed using mining methods – ČPHZ), including the inspection and approval of both the temporary and final lining of the utility tunnel. A key role was played in operational communication between the mining designer, the client's representative, and the contractor, which enabled flexible responses to the actual geotechnical conditions encountered, minimized risks, and ensured the smooth progress of the excavated sections of the utility tunnel.

Fig. 7 Excavation of the core of the utility tunnel from the Š8 shaft towards the TK7 technical chamber (photo by the author)

3.3 BIM APPROACH

One of the main objectives of applying the BIM method was to create a Project Information Model (PIM), an integral part of which consists of digital models of the structure – BIM models (consisting of 3D geometry and associated alphanumeric information). Communication among all project participants was carried out in a controlled manner through the shared data environment ACC, which ensured accurate information flow and rapid access to current, i.e. valid, documents. Another goal was to achieve effective coordination of individual disciplines, manage changes arising during construction, and create a high-quality basis for the future management and operation of the utility tunnel. BIM models were primarily used as coordination tools when resolving conflicts with existing utility networks and when optimizing the design of the utility tunnel structures in response to the actual geotechnical conditions. During the execution of the mined section, approved changes to the design documentation – triggered by the application of the NATM observational method – were continuously reflected in the BIM models, in particular modifications to the cross-sectional shape of the utility tunnel, the lining dimensions, and the excavation procedures themselves. This made it possible to maintain a unified and up-to-date overview of the technical solution for all parties involved. A significant benefit of the BIM approach was also the support provided to the investor's technical supervision, which had access to a current digital model of the structure, including links to individual structural and technological units. BIM models thus served as an auxiliary tool for verifying compliance of the construction with the design documentation, for assessing change requests, and for coordinating the continuity of individual construction stages – especially in the environment of an active airport with limited possibilities for operational interventions. Last but not least, the BIM models were prepared with regard to the future operational and management phase of the collector. The digital models currently being finalized will contain structured data on structural elements, technological equipment, and utility routes. After completion of the construction, these data will serve the airport operator as a basis for planning maintenance, inspections, and further development of the technical infrastructure. The application of the BIM approach therefore represents an important step toward the long-term sustainability and operational efficiency of underground structures within the airport complex.

4. CONCLUSION

The Hangar G utility tunnel and TS20 substation project represents an example of the successful implementation of an underground structure under the extremely demanding conditions of an operating airport. The combination of cut-and-cover and excavation construction methods, the application of the NATM, and the consistent coordination of all stakeholders made it possible to achieve a high technical standard of construction while maintaining uninterrupted airport operations.

The construction of the HG utility tunnel confirmed that even with very shallow overburden above the underground construction and within the environment of an international airport, it is possible - through the application of NATM principles, the observational method, and rigorous geotechnical monitoring - to achieve safe and economically efficient construction. The experience gained is transferable to other underground structures of a similar nature, not only in airport infrastructure but also in similarly urbanized environments with high operational demands.

5. ACKNOWLEDGEMENTS

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Title, Name, Surname of the Author: Ing. Radek Bernard, Ph.D.

Affiliation: SG Geotechnika, a.s., Prague

E-mail: *radek.bernard@geotechnika.cz*.

Title, Name, Surname of the Author: Ing. Ivo Kohoušek

Affiliation: SG Geotechnika, a.s., Prague

E-mail: *ivo.kohousek@geotechnika.cz*