GEO5

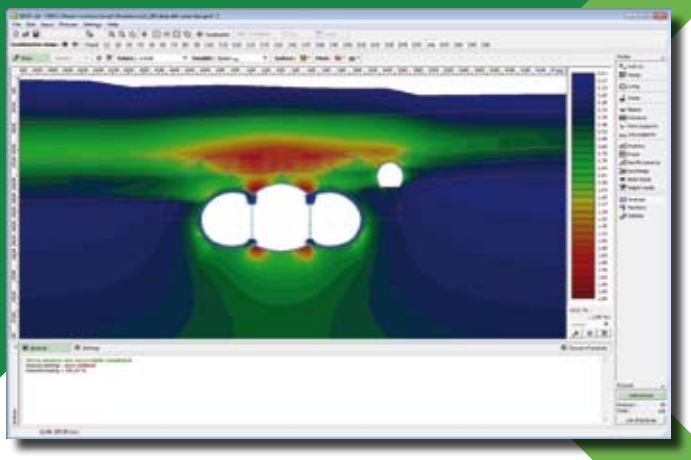
Fine Project Gallery

Location: Prague - Veleslavín, Czech Republic

Construction period: 2010–2014

Designer: METROPROJEKT Praha, a. s.,
Ing. Urbánková, Ing. Kuňák

Software: GEO5 FEM - Tunnel



Excavation of side station tunnels

Portal of the mined triple-span metro station

Completed final lining of a side station tunnel

5th operating section of Prague metro Line A

Nádraží Veleslavín station

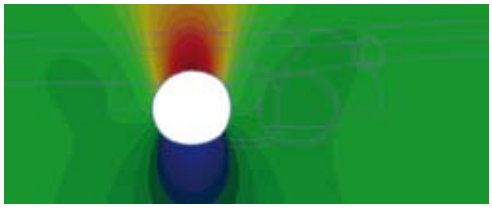
Nádraží Veleslavín station description

Nádraží Veleslavín station is the first triple-vaulted mined station with a cast-in-situ reinforced concrete lining on the Prague metro route. The excavated area of the left-hand and right-hand tunnels is 70.6m2; The excavated area of the central tunnel is 42.9m2. The maximum station height is 10.25m and the width is 22.34m. The total mined station length is 100m. A mined escape gallery ending in a shaft excavated from the surface is part of the station. The station construction started by driving the right-hand and left-hand station tunnels. The so-called horizontal excavation sequence consisted of top heading and invert. The 300mm thick primary lining is in C20/25 shotcrete. Two hinges were artificially created in the structure designed to make easier breaking of the lining in the area of the central bay possible. When the excavation of the side tunnels had been completed, EPB shields driving the interstation sections were pulled through them. After removing all auxiliary structures required for the pulling of tunnelling machines through, the waterproofing system consisting of a ray-on membrane and subsequently the secondary lining were installed. Water-retaining concrete C30/37 was used for RC structures, or C45/55 concrete for columns and longitudinal beams.

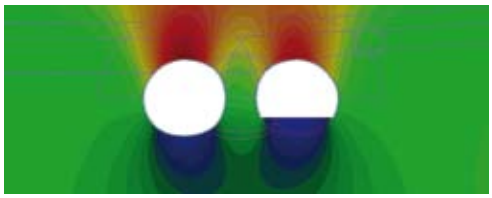
The station is divided into 3 independent expansion units. The excavation of the central station tunnel commenced after a prescribed technological interruption. The horizontal excavation sequence consisted of top heading and invert. The 300mm thick primary lining is in shotcrete C20/25. The parts of the primary lining of side tunnels where connecting openings were to be provided were step-by-step broken off. The installation of the spray-on waterproofing system and the final lining of the central tunnel followed. The construction of the escape structure started by escavating a shaft braced by secant pile retaining walls. Net dimensions of the shaft are 7.3m in diameter and 14m deep. When the primary lining of the right-hand station tunnel had been completed, the excavation of the 1st stage of the escape gallery (the part of the gallery parallel with the station) commenced. The excavated cross-sectional area is 13.2m2, the longitudinal gradient is 3.5% and the gallery length is 32.4m. The 2nd stage of the escape gallery excavation (the part of the gallery turning through a curve over the station and the gallery intersection with the central station tunnel) commenced after the completion of the secondary lining of the right-hand station tunnel and before the excavation of the central station tunnel. The gallery was driven on a 14.2m long, 9m-radius curve, at 3.5% incline. The final lining of the shaft and shaft is in C30/37water-retaining concrete.

Geological conditions

Overall engineering geological conditions in the area of Nádraží Veleslavín station are difficult and complicated for tunnelling. This is the reason why the triple-vault station design was chosen. The very low overburden with low quality of the ground mass, the water table level and the existence of a busy road with a tram track running above virtually throughout the station excavation length can be marked as the main negative factors.Various anthropogenic fills are in the entire area of operations. The Quaternary cover is found below them. It passes to the pre-Quaternary sub-base consisting of claystone and siltstone shales with various degrees of weathering, depending on depth under the surface, ranging from completely disintegrated to competent rock. Tuffitic rocks start to thrust into the excavation profile in the last third of the station tunnels length.



phase 6



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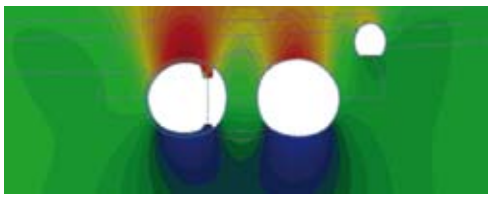
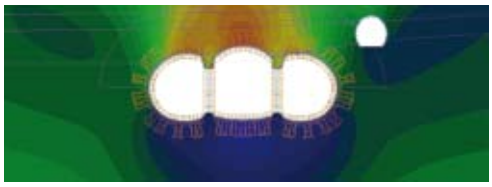
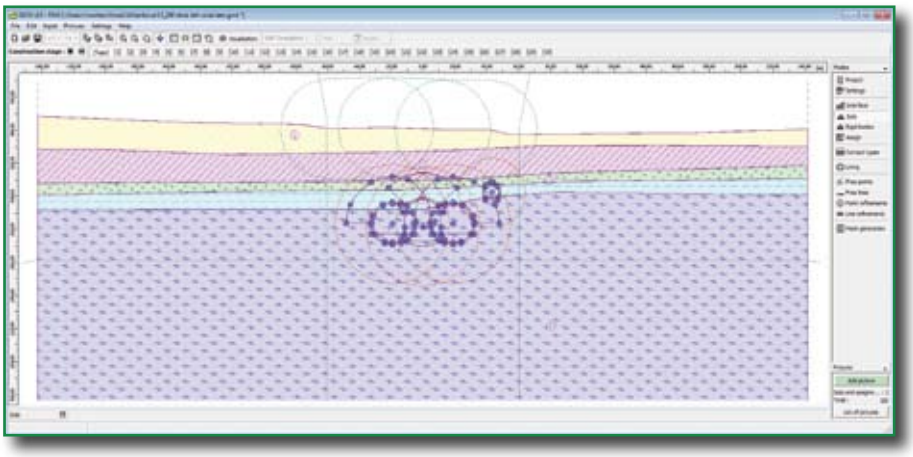


phase 17

phase 22

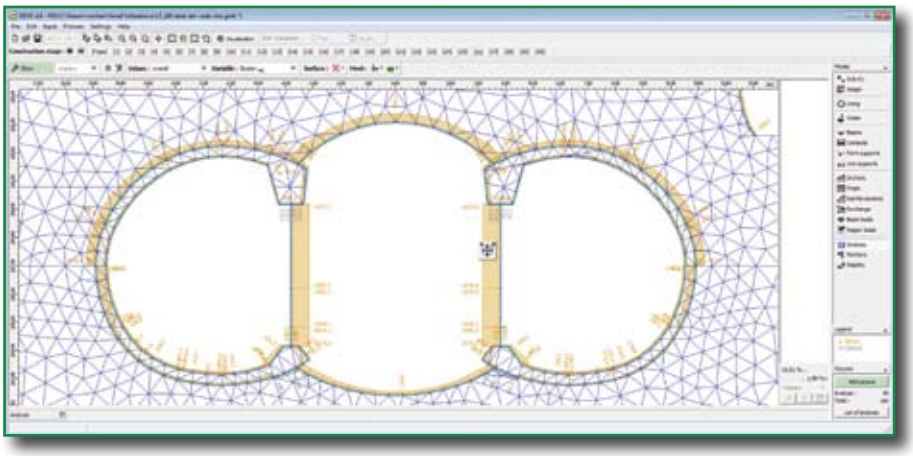


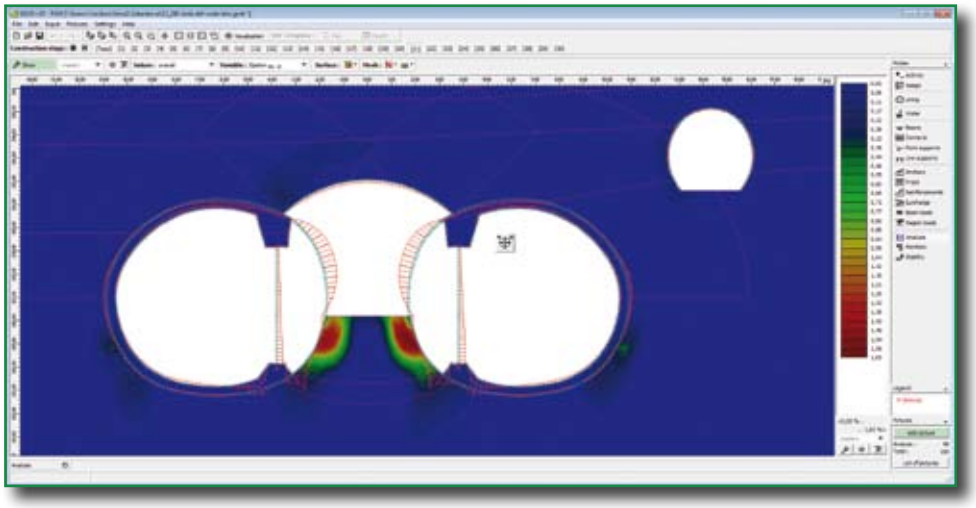
phase 30



Models

2D models were carried out using GEO5 FEM (Tunnel) program for three typical cross-sections. A two-dimensional problem was always solved for the planar deformation condition. The models are defined in a way guaranteeing that the construction phases allowed for the tunnel construction procedures (including an escape gallery). Up to 31 construction phases are solved in the models. The ground environment is inhomogeneous, isotropic and elasto-plastic, with Mohr-Coulomb plasticity surfaces. With the exception of longitudinal beams above and under columns, the lining is defined as an elastic isotropic material and is modelled by means of framework elements with respective properties. The beams are defined as 2D elements with concrete properties defined. The stiffness of columns between individual station bays is modified in the model so that the stiffness of alternating columns and gaps between them is taken into account as much as possible.





Conclusion

The GEO5 FEM program advantage lied in the modelling speed. We carried out countless numbers of variants and studies. We managed, albeit in 2D models, to give relatively faithfully a true picture of both the ground environment and structures. A 3D model was developed using Midas GTS program for the purpose of verifying the assumptions. The final lining was further modelled in Scia Engineer program and stress on the final lining interfaces obtained from GEO5 FEM program was used as the ground mass induced loading. The Nádraží Veleslavín station construction was successfully realised and the values of warning states determined on the basis of deformations of structures and rock mass in models carried out in GEO5 FEM program were not exceeded during the course of the construction.