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前方探査による断層破砕帯の支保選定と二車線最小断面での効率的な設備計画

―主要地方道宇治木屋線　鷲峰山トンネル―

京都府　松尾　真希

宇治木屋線（犬打峠）道路新設改良工事（犬打峠トンネル（仮称））は，宇治田原町から和束町を結ぶ延長2,953mのトンネルのうち，主に宇治田原町側1,941.5mのトンネルを施工する工事である．開通時に名称が鷲峰山トンネルとなった本トンネルでは，事前調査で複数の断層破砕帯が想定されており，切羽崩壊や支保工の変状が懸念されていた．また，仕上がり内空断面積は47.6m^{2}と，道路トンネルとして最小断面であり，工事中の安全性と施工性を確保することが課題であった．前方探査として，坑内弾性波探査，水圧ハンマーによる中尺ノンコア削孔検層，ドリルジャンボによる短尺ノンコア削孔検層を実施し，断層における適切な支保パターンを選定した．機械設備対策として，連続ベルトコンベヤ方式によるずり運搬，換気と電気設備が一体化したガントリー台車を採用し，安全性と施工性を確保し，計画工程を遵守した．

Selection of the Tunnel Supports in the Fault Zones Predicted by Exploration Ahead of Tunnel Face and Efficient Equipment Planning for the 2-Lane Tunnel with the Minimum Cross-Section

―The Principal Local Road, the Uji-Kiya Road, the Jubuzan Tunnel―

By Masaki Matsuo, Kyoto Prefecture

The Uji-Kiya Road (Inuuchi Toge) construction and improvement project (the Inuuchi Toge Tunnel (tentative name)) includes the construction of a 1,941.5-m-long tunnel on the Ujitawara Town side as a part of the 2,953-m-long tunnel connecting Ujitawara Town and Wazuka Town. The tunnel was named the Jubuzan Tunnel when it was opened. There were concerns about collapses of a tunnel face and deformation of the tunnel supports to build this tunnel, because the multiple fault fracture zones were predicted during the preliminary survey. It had a finished inner cross-sectional area of 47.6 m^2, the smallest cross-sectional area for a 2-lane road tunnel, so ensuring safety and workability was a challenge. The exploration ahead of a tunnel face consisting of the seismic refraction survey in the tunnel, medium non-core drilling logging using a hydraulic hammer, and short non-core drilling logging using a drill jumbo was performed, and the appropriate tunnel support patterns in the fault zones were selected. Regarding the types of mechanical equipment, transportation of the muck using a continuous conveyor belt system and a gantry carriage with integrated ventilation and electrical equipment were used to ensure safety and workability while adhering to the planned process.

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トンネル坑内湧水を地下水盆へかん養させる地域一体となった取組み

―新東名高速道路　神奈川県秦野市区間―

中日本高速道路（株）　柏木　　悠

新東名高速道路の建設において，地下水が豊富な丹沢山地南麓の神奈川県秦野市域に計画されたトンネル掘削（NATM）の施工にあたり，計画路線周辺の湧水や地下水を保全することが求められていた．そのため，地元の意向を尊重しながら，秦野地下水盆におけるトンネル掘削前後の水収支シミュレーションを行い，トンネル坑内湧水を有効利用する方法を採用し，トンネル掘削後に不足する地下水量を地下水盆へかん養させるシステムを構築する地下水保全方針を策定し，実施した．なお，当該区間は2022年４月に開通している．本稿は，トンネル掘削による湧水を地下水盆へ返水し，地域の水資源を守ることが実現した知見とプロセスを報告するものである．

Community Efforts to Recharge Water from Tunnels Into a Groundwater Basin

―The Shin-Tomei Expressway in Hadano City, Kanagawa Prefecture―

By Yuu Kashiwagi, Central Nippon Expressway Company Limited

The construction of the Shin-Tomei Expressway involved tunneling（NATM）in Hadano City, Kanagawa Prefecture, at the southern foot of the Tanzawa Mountains, where groundwater is abundant. It was necessary to conserve springs and groundwater around the planned route. Therefore, while respecting the wishes of the local community, a water balance simulation in the Hadano groundwater basin was conducted before and after tunneling. A groundwater conservation policy was formulated and implemented, adopting the method to effectively utilize the water inflow in the tunnel, and tha system to recharge the insufficient groundwater volume into the groundwater basin after tunneling was established. The section was opened in April 2022. In this paper, the authors report on the findings and the process by which the recharge of water inflow from the tunnels to the groundwater basin was achieved and local water resources were protected.

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φ17.68mの大断面シールドを住宅地直下で掘進する際の諸課題と取組み
―新名神高速道路　枚方トンネル―

西日本高速道路(株)　岡　　伸彦

新名神高速道路八幡京田辺JCT・IC～高槻JCT・IC間に位置する枚方トンネルは，上下線各約３kmで片側３車線のシールド工法を採用したトンネルである．本トンネルの特徴は，シールド外径が17.68mの大断面シールドとなっていること，地上部は閑静な住宅街や工場群があるエリアを通過することである．本稿では，既往の文献などを踏まえて計画した，掘削土砂の塑性流動性の確保，周辺地盤の緩み発生防止，シールド掘進中の振動・騒音の緩和のための取組みについて報告する．

Various Issues and Measures When Excavating Directly Below a Residential Area Using a Large Shield TBM with a Diameter of 17.68 m
―The Shin-Meishin Expressway, the Hirakata Tunnel―

By Nobuhiko Oka, West Nippon Expressway Company Limited

The Hirakata Tunnel, located between the Yahata Kyotanabe JCT/IC and the Takatsuki JCT/IC on the Shin-Meishin Expressway, has two three-lane tubes that are approximately 3 km long on both the inbound and outbound lanes adopting the shield technique. The tunneling conditions are a large shield TBM with an outer diameter of 17.68 m, and it passes under a quiet residential area and an industrial area. In this paper, the authors report on the measures planned based on existing literature to ensure the plastic fluidity of the removed soil, to prevent loosening of the surrounding ground, and to mitigate vibration and noise during shield tunneling.

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割れ目を多く含みスレーキングしやすい層と交差するトンネルの盤ぶくれに関する考察

(公財)鉄道総合技術研究所　川越　　健

断層破砕帯や割れ目を多く含む弱層によってトンネルが変形する事例が見られる．本稿では，割れ目を多く含む地層の性状や，そのような弱層がインバートと斜交する角度や交差する位置が盤ぶくれに及ぼす影響に着目して研究を行った．近年に盤ぶくれが生じたトンネルの分析から，割れ目を多く含み，スレーキング指数が大きい弱層が分布する箇所で盤ぶくれ量が大きい傾向にあることがわかった．また，そのような弱層が緩い傾斜でインバート下へ潜る箇所でインバート掘削面の変位量が大きいことがわかった．さらに，それらを再現した数値解析から，盤ぶくれの発生位置や変位量は，弱層がインバートと斜交する角度や交差する位置といった交差関係が影響することを示した．トンネルの変形を防止するためには，割れ目を多く含み，スレーキングしやすい弱層とトンネルインバートの交差関係を考慮してトンネルの構造を選定することが重要である．

A Consideration about Heaving in a Tunnel Which Intersects a Layer Easy to Slake, Containing Many Cracks

By Takeshi Kawagoe, Railway Technical Research Institute

Cases of tunnel deformation due to fault fracture zones and weak layers containing many cracks have been observed. In this paper, we focus on the properties of layers containing many cracks and the effects of the skew angle and relative position between such weak layers and the tunnel invert on ground heaving. Analysis of tunnels that have recently experienced ground heaving has revealed that the amount of ground heaving tends to be greater in areas where weak layers with many cracks and a high slaking index are distributed. It was also found that the amount of displacement on the invert excavation surface was large where such a weak layer goes under the tunnel invert at a gentle slope. Further, numerical analysis that reproduced these results showed that the location of the heaving and the amount of displacement were affected by the crossing relationship, such as the skew angle and relative position between the weak layer and the tunnel invert. To prevent deformation of the tunnel, it is important to select the tunnel structure while taking into consideration the crossing relationship between the tunnel invert and the weak layer, which contains many cracks and is prone to slaking.

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令和 6 年能登半島地震による道路トンネルの被害

（国研）土木研究所　日下　　敦

令和 6 年能登半島地震では，能登半島の広い範囲内の複数の道路トンネルで，地震による被害が発生した．とくに被害が大きかった大谷トンネルと中屋トンネルにおいては，覆工の崩落が発生した．おさよトンネルと椎木北浦トンネルでは，覆工が塊状に落下した．いずれも山岳トンネル工法（NATM）により建設されたトンネルであった．本稿は，これら 4 トンネルを中心に，現地調査により把握された被害状況を報告するものである．収集整理した施工時の記録を整理し，現段階での被害メカニズムを推定した結果，被害の主要因は地震により地山に大規模な変形が発生したことによるものと考えられた．また，被害が大きかった箇所は，地山性状に起因して施工が難渋した箇所と整合する傾向が認められた．

Damage to Road Tunnels Caused by the 2024 Noto Peninsula Earthquake

By Atsushi Kusaka, Public Works Research Institute

The 2024 Noto Peninsula earthquake caused damage to multiple road tunnels in a wide area of the Noto Peninsula. In the Otani Tunnel and the Nakaya Tunnel, where damage was particularly severe, the lining collapsed. In the Osayo Tunnel and the Shiiki Kitaura Tunnel, the lining fell in clusters. All of these tunnels were constructed using the conventional method (NATM). In this paper, the authors report the damage situation identified through field surveys, focusing on these 4 tunnels. After collating and organizing the construction records, the damage mechanism was estimated at the current stage, and it was determined that the main cause of the damage was the large-scale deformation of the ground caused by the earthquake. It was also found that the points with the most severe damage tended to coincide with areas where construction was difficult due to the properties of the ground.