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## 坑内外からの対策工を駆使して地すべり地帯を突破

―北海道新幹線　幌内トンネル―

鉄道・運輸機構　小林　治生

北海道新幹線幌内トンネルは北海道山越郡長万部町内に位置する延長555mの山岳トンネルであり，複数の地すべりブロックと交差する．当該箇所は，八雲層(泥岩，頁岩)を主体とした固結度の低い地山が分布しており，掘削中の切羽の安定性，地すべりブロックの滑動による施工中および施工後の安全性について懸念があった．そこで，当工区では坑外からは地すべりブロックを包含する形状でのセメント改良土による押さえ盛土を，坑内からは水抜きボーリング，フォアパイリングをそれぞれ施工し，変状対策および地下水対策を行った．その結果，地すべりブロックの滑動および変状の抑止に成功し2024年3月に無事トンネルを貫通させた．本稿では幌内トンネルと地すべりブロックとの交差区間における設計と施工計画およびその施工実績について報告する．

## Excavating through Landslide Zones by Implementing Measures from Inside and Outside of the Tunnel

―The Hokkaido Shinkansen, the Horonai Tunnel―

By Haruki Kobayashi, Japan Railway, Construction, Transport and Technology Agency

The Horonai Tunnel on the Hokkaido Shinkansen is a 555 m-long mountain tunnel located in Oshamanbe Town, Yamakoshi County, Hokkaido Prefecture This tunnel is to go through several landslide blocks. The ground condition is made up of poorly consolidated ground, mainly consisting of the Yakumo Formation (mudstone and shale), so there were concerns about the stability of faces during excavation and safety during and after construction due to the sliding of the landslide blocks. Therefore, cement-improved soil was used in this lot to fill the gaps from outside of the tunnel and dewater boring and forepiling were implemented from inside of the tunnel as measures against deformation and groundwater inflow. As a result, the sliding and deformation of the landslide blocks were successfully prevented, and the tunnel was safely penetrated in March 2024. In this paper, the authors report on the design and construction plan for the crossings of the Horonai Tunnel and the landslide blocks, as well as the construction results.

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## 急傾斜地下で偏圧を受けるトンネルの斜面対策と坑内からの補強

―山梨リニア実験線　第2大ノ入トンネル―

東海旅客鉄道(株)　清水　智彦

山梨リニア実験線第2大ノ入トンネルは，山梨県上野原市秋山地内に位置する410mのトンネルであり，今後は中央新幹線の一部となる計画である．最大土かぶりが約30mと小さく，中腹部には1.5m程度と土かぶりが非常に小さく急傾斜の偏土圧地形を呈した区間が存在した．そのため各種補助工法を組み合わせて掘削し，小土かぶり表層は斜面安定対策を実施するとともに，供用後の状態把握のため，各種計測設備を設置した．供用後の観測データより斜面の安定不足が懸念されため，再現解析を実施し変状メカニズムを特定したうえで対策工を検討した．対策工は斜面対策と坑内からの補強を実施し，それらにより変状の抑制効果が確認された．本稿では各種調査と変状メカニズムの特定，対策工の施工について報告する．

## Measures for Stability of the Tunnel Subjected to Asymmetric Earth Pressure in Steeply Inclined Ground and Reinforcement from Inside of the Tunnel

―The Yamanashi Maglev Test Line, the Daini Onoiri Tunnel―

By Tomohiko Shimizu, Central Japan Railway Company

The Daini Onoiri Tunnel on the Yamanashi Maglev Test Line is a 410 m-long tunnel located in Akiyama, Uenohara City, Yamanashi Prefecture, and is planned to become part of the Chuo Shinkansen in the future. The minimum depth of the tunnel was only about 30 m, and there was a section in the hillside with a shallow depth of about 1.5 m and a steep slope with an asymmetric earth pressure. For these reasons, a combination of various auxiliary methods was used for excavation and slope stabilization measures were implemented on the surface of the shallow depth, and various measurement facilities were installed to evaluate the condition after the tunnel is put into service. Since there were concerns about the dificiency in slope stability based on post-service observation data, an analysis to replicate the deformation of the slope was performed to identify the deformation mechanism and consider measures. Slope measures and reinforcement from the inside of the tunnel were implemented, and the effectiveness of these measures in preventing deformation was confirmed. In this paper, the authors report on various surveys, identification of the deformation mechanism, and implementation of measures.

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# 地質変化に富む地山のトンネル掘削と特殊荷重条件下での覆工設計

## ―西九州自動車道松浦佐々道路　松浦１号トンネル―

国土交通省　柳田　博史

国道497号松浦１号トンネル新設工事は，西九州自動車道における松浦佐々道路の一部区間であり，全長1,204mの高規格道路トンネルをNATMにより施工するものである．新第三紀中新世の佐世保層群に属する堆積岩類を基盤岩として，その上に中新世後期の玄武岩が被覆する標高110m程度の小高い丘陵地を，最大土かぶり65m程度でトンネルを構築する．地質は複雑に入り組んでおり，坑口部では硬質な岩塊を含む脆弱な玄武岩層が出現し，この荷重作用下において，先受け工・鏡補強・変位抑制のためのサイドパイル・１次インバートによる断面閉合など，各種補助工法を用いたトンネル掘削が必要になった．その後も，変位を伴う泥岩優勢互層の掘削，硬軟層境の掘削により大きな変位や崩落も発生し，支保パターンの選定，補助工法の追加など，種々の対策工が必要なトンネルであった．また，坑口部の玄武岩荷重作用区間の覆工設計は，将来的な荷重が作用しても長期的に構造の安定が確保できるよう，力学的機能を付与させる考え方とし鉄筋コンクリート構造(複鉄筋)とし，トンネル周囲の地山改良を実施することで，トンネルの要求性能を満足させる仕様を決定した．本稿は，このような頻繁な地層変化，特殊荷重条件下でのトンネルの施工実績について報告するものである．

## Tunneling in the Ground with Variable Geological Conditions and Lining Design under Special Load Conditions

## ―The Nishi-Kyushu Expressway, the Matsuura-Saza Road, the Matsuura Ichigo Tunnel―

By Hiroshi Yanagida, Ministry of Land, Infrastructure, Transport and Tourism

The new construction project of the Matsuura Ichigo Tunnel on the National Route 497 is to construct a 1,204 m-long high-standard road tunnel using NATM as a part of the Matsuura-Saza Road on the Nishi Kyushu Expressway. The tunnel with a maximum earth covering of about 65 m is constructed in a small hilly area at an elevation of about 110 m which is composed of basalt of the late Miocene age based on sedimentary rocks belonging to the Sasebo Group of the Neogene epoch of the Miocene age. The geological condition is complex and intricate, with a weak basalt containing hard rocks appearing at a portal. Under these loading conditions, various auxiliary methods such as the presupport, the stabilization method for the face, the side piles for displacement control, and early closure by primary invert concrete were necessary to excavate the tunnel. Even after that, large displacements and collapses occurred due to the excavation in alternation of strata dominant mudstone with displacement, and excavation at the boundary between hard and soft strata, requiring various measures such as selection of support patterns and additional auxiliary methods. The lining design for the portal subjected to the basalt load was based on the idea of imparting mechanical functionality to ensure long-term structural stability even if an additional load is applied in the future, and specifications as adopting a reinforced concrete structure (two-layer reinforcement) and improving ground around the tunnel were determined to satisfy the required performance of the tunnel. In this paper, the authors report on the results of tunnel construction under such frequent geological changes and special load conditions.

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# 格子状に地盤改良した掘削底盤の盤ぶくれ対策効果に関する研究

（公財）鉄道総合技術研究所　牛田　貴士

主に都市部の掘削工事で用いられる掘削土留め工の設計では，土留め壁に発生する変位や応力に加えて，盤ぶくれなどの底盤安定も重要となる．底盤改良は盤ぶくれの検討を満足しない場合の対策工のひとつである．これには地盤改良体で止水壁や難透水層を造成する方法のほか，掘削底面付近を改良して根入れ部における摩擦抵抗の向上を図る方法がある．そのような場合，全面改良が一般的であるが，底盤改良に止水性を期待しない場合には部分的に改良することで施工量を低減できる可能性がある．そこで本稿では，模型実験と二次元土―水連成の弾塑性FEMによるシミュレーション解析を用いて，格子状に部分改良した掘削底盤の挙動解明に取り組んだ研究を紹介する．

## The Effectiveness in Heaving Suppressions of Excavation Bottom with Grid Shape Ground Improvement

By Takashi Ushida, Railway Technical Research Institute

It is important to suppress the heaving of the excavation bottom in addition to the displacement and stress generated in the retaining walls in the design of retaining works, which are mainly used when excavating in urban areas. Ground improvement is one of the general heaving suppressions when the evaluation of the heaving is not satisfied. It includes the cut-off walls and aquiclude that were built by ground improvement, as well as upgrading of frictional resistance at embedment by improving around the excavation bottom. In such cases, whole improvement is general, but if the ground improvement is not expected to have water-sealing properties, partial improvement may reduce the amount of construction work. In this paper, we introduce the study to clarify the characteristic behavior of the grid shape ground using model experiments and two-dimensional Soil-water coupled elastoplastic finite element analysis.