

施工 大規模急傾斜地における坑口部の斜面对策工

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—九州新幹線 三ノ瀬トンネル—

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九州新幹線西九州ルート三ノ瀬トンネルは、長崎県東彼杵郡東彼杵町内に位置する延長885mの山岳トンネルである。起点方坑口部の斜面傾斜がおおむね40°以上、坑口直上で平均傾斜60°前後の急斜面かつ、斜面長200mの長大法面となっている。事前の斜面評価においては、落石・崩壊対策が必要と評価された。このような大規模斜面对策工の施工実績は整備新幹線事業ではほとんどなく、工事施工中の安全性の確保や施工品質の確保が懸念された。また、施工範囲の一部が保安林に指定されており、保安林指定解除の継続が必要となるため、施工範囲を必要最低限とするなど、環境にも配慮した設計としている。本稿では、大規模急傾斜地における斜面对策工事の施工について詳しく報告する。

Measures for Slope Stability at Tunnel Portal on High Steep Slope

—The Kyusyu Shinkansen, the Sanose Tunnel—

By Masafumi Akiyoshi, Japan Railway, Construction, Transport and Technology Agency

The Sanose tunnel on the West Kyushu Route of Kyushu Shinkansen is an 885 m long mountain tunnel located in Higashi-sonogi Town, Higashi-sonogi District, Nagasaki Prefecture. A slope at the tunnel portal on starting side is generally more than 40 degrees. The slope just above the portal has length of 200 m and average angle of about 60 degrees. During the preliminary slope evaluation, it was decided that measures against rockfall and collapse are necessary. There are almost no experiences of measures for such large-scale slope stability in Shinkansen projects, so there were concerns about how to ensure safety and quality during construction. In addition, part of the construction area was designated as a forest reserve, which required delisting petition of the forest reserve designation. Therefore, the scope of the measures were kept to a minimum and it was designed in consideration of the environment. In this paper we report in detail on the measures for high and steep slope stability.

施工 扁平大断面トンネル覆工を現場流動コンクリートを用いて自動施工

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—すさみ串本道路 二色トンネル—

国土交通省 笹嶋 和彦

本トンネルは、アーチ部のコンクリート打込み締固めがトンネル品質に大きく影響する上半3心円大断面トンネルであり、覆工に流動性に優れた材料分離がないコンクリートを採用した。打込みにおいては、マニピュレータ方式配管切替え装置と吹上げ方式打込み装置および固定式天端吹上げ装置を用いて移動型枠内にコンクリートを打込み、型枠バイブレータで締固める自動施工システムの自動運転を試みた。この流動性に優れた覆工コンクリートは、JIS生コン工場と同様のものを製造可能であるが、本トンネルでは、生コン工場で製造したベースコンクリートをアジテータ車で現場まで運搬し、打込み直前の現場で増粘剤一液タイプ流動化剤を投入・攪拌管理し、時間変化の影響を抑制することを行った。現場流動覆工コンクリート自動施工は、施工を機械化し、各種センサで施工状況と締固め状態を数値で可視化、確認し、PCシステムで打込み装置と締固め装置を自動制御するものであり、施工むらや品質のばらつきをなくし、高品質、密充填覆工を可能にする。本稿では、現場流動覆工コンクリート自動施工の適用性と有効性について、扁平大断面トンネルの覆工初期の9ブロックの施工で確認できたので報告する。

Automated Lining Works for a Tunnel with Large Flat Cross-Section Using Flowable Concrete In-situ Produced

—The Susami-Kusimoto Road, the Nishiki Tunnel—

By Kazuhiko Sasajima, Ministry of Land, Infrastructure, Transport and Tourism

This tunnel have large cross-section with section of top heading formed 3-center circles. The quality of the tunnel is greatly affected by pouring and compaction of arch concrete. Concrete with high flowability and high segregation resistance was used for the lining of the tunnel. Pouring works were performed using an automated construction system. The system consisted of pouring into moving formwork using a manipulator-type pipe switching device, an upward concrete-injection device, and a fixed upward concrete-injection device at crown and compacting concrete using formwork vibrators. The lining concrete with high flowability can be produced at a JIS ready-mixed concrete plant. However, for this tunnel, the base concrete produced at a ready-mixed concrete plant was transported to the site by agitator trucks. Superplasticizer premixed thickening agent was added to the concrete and mixed in-situ just before pouring to control the effect of time variation. The automated production of the in-situ flowable lining concrete allows to mechanize the construction, visualize and confirm the works and compaction status numerically using various sensors and automatically control the pouring and compacting equipment using computer system. The system eliminates unevenness in concrete and quality variation and allows to produce high-quality, tightly compacted lining. In this paper we report on the applicability and effectiveness of the automated lining works using flowable concrete in-situ produced which were confirmed in the initial nine blocks of lining works of tunnel with the large flat cross-section.

天ヶ瀬ダム再開発トンネル式放流設備(全長617m)のうち、減勢池部($L=170\text{m}$)は主ゲートからの放流水を減勢させるための超大断面(最大掘削断面積 650m^2)水路トンネルである。トンネルは $C_H\sim C_M$ 級の砂岩・泥岩内に介在するD級の破砕帯を最大土かぶり厚40mで通過するため、NATM・発破掘削による側壁導坑・中央導坑先進多段ベンチカット工法で施工する。側壁導坑の掘削時に破砕帯の幅が当初想定より広いことを確認したため、地質構造モデルを見直して二次元FEM解析を実施した結果、ベンチ掘削時の側壁補強工としてRC円柱支保工が必要となった。本稿では、RC円柱支保工とトンネル支保工・覆工の設計および施工を報告する。

Design and Construction of Waterway Tunnel with Super-Large Cross-Section Through Fracture Zone

—The Amagase Dam Redevelopment Project, Stilling Basin—

By Naoto Yoshida, Ministry of Land, Infrastructure, Transport and Tourism

The spillway tunnel (total length : 617 m) for the Amagase Dam redevelopment includes a waterway tunnel with super-large cross-section (maximum excavated cross-sectional area: 650m^2) as the stilling basin ($L=170\text{m}$) to regulate the discharge of water from the main gate. The tunnel passes through a D-class fracture zone within C_H to C_M -class sandstone and mudstone with a maximum soil cover of 40 m. The tunnel was constructed using the drill and blast tunneling with center and side drifts and multiple bench cutting. During the excavation of the side drift the width of the fracture zone was found to be wider than initially assumed. After reviewing the geological structure model and conducting the two-dimensional FEM analysis, it was found that RC columns as tunnel support were necessary to reinforce the side wall during bench cutting. In this paper we report on the design and construction of the RC columns, tunnel supports and lining.

近年、完成後の山岳トンネルにおいて盤ぶくれが発生し、その抑止対策工事を行った事例報告がなされており、山岳トンネルにおいて供用後の盤ぶくれ防止は重要な課題となっている。本研究は、過去の事例から山岳トンネルにおける盤ぶくれの発生要因を分析し、模型実験や数値解析を通じ、その発生メカニズムのひとつとして、完成後の盤ぶくれには地山の吸水に伴う強度低下が大きく関与していることを示した。そのうえで、これまでは盤ぶくれの懸念が少ないと考えられたものの、完成後に盤ぶくれが起きた地山に対して、長期にわたって盤ぶくれを防ぐインバート構造の提案を行い、事前調査や掘削時の状況から判断して、実際の施工現場でインバートの構造を選択できるフローを提案した。

Study on Invert Arch Structure That Prevent Floor Heaving After Completion of Mountain Tunnels

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

Recently, many cases have been reported in which mountain tunnels have been occurred floor heaving after completion and inhibition measures were forced. Prevention of the floor heaving after completion of mountain tunnels has become an important issue. In this study we analyzes the occurrence factors that caused floor heaving in mountain tunnels in the past. Through model experiments and numerical analysis, we present that strength reduction caused by swelling in the ground plays a major role as one of the occurrence mechanisms that cause the floor heaving. We propose an invert structure that can prevent the floor heaving for a long period of time in a ground that was currently considered as small amounts of concern about floor heaving, but where it occurred after completion. We also propose a workflow for selecting an invert structure at the practical construction site based on conditions during the preliminary survey and excavation.

第46回国際トンネル協会(ITA)の総会および併催される世界トンネル会議(WTC)は2020年5月にマレーシアのクアラルンプールで「Innovation and Sustainable Underground Serving Global Connectivity」のテーマを掲げて開催の予定であった。しかし、新型コロナウイルスの感染拡大の状況を踏まえ、ITA史上初のバーチャルでの総会および会議の開催となった。本稿では、ITA総会およびWTCにおける内容のうち、ITAの全体的な動向およびワーキング(WG)などの技術的な活動の概要を可能な範囲で収集し得た情報について報告する。

46th ITA General Assembly and World Tunnel Congress Report By Japan Tunnelling Association

46th meeting of the International Tunnelling and Underground Space Association (ITA-AITES) and the World Tunnel Congress in conjunction with the meeting were scheduled to be held in Kuala Lumpur, Malaysia in May 2020 with the theme of 'Innovation and Sustainable Underground Serving Global Connectivity'. However, considering the spread of the novel coronavirus, the general assembly and conference were held virtually for the first time in the history of ITA. In this paper we report the information that could be collected to the extent possible from the contents of the ITA General Assembly and WTC on the overall trends of the ITA and technical activities of the Working Groups and others.