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盤膨れが懸念される地山での自動変位計測にもとづくインバートの設計・施工

―北陸新幹線　加賀トンネル北工区―

鉄道・運輸機構　今林　泰史

北陸新幹線加賀トンネルは，金沢・敦賀間のうち，石川県と福井県の県境に位置しており，高崎起点391km937m～397km400m間の延長5,463mの山岳トンネルである．本トンネルはほぼ全区間にわたり，インバート部の変状が懸念される新第三紀中新世の凝灰岩層および泥岩層が分布している．一般的に地山試料を用いた室内試験結果が膨張性地山の判定指標として用いられるが，一部のトンネルでは施工後に盤膨れが確認されることがあり，とくに対策の困難な供用後の盤膨れ防止を含めた施工時の対策が必要とされている．そこで，水頭差から路盤部の鉛直変位を自動計測する「インバート変位計®」を設置し，計測状況により大きな変位を確認した区間についてはインバート部の形状をより円形に近づけるために曲率を大きくした断面とするインバート変状対策を実施した．

Design-Build of Invert Concrete Based on Displacement Automatically Measured in Ground With Potential for Heaving

―the Hokuriku Shinkansen, the Kaga Tunnel, Northern Lot―

By Yasufumi Imabayashi, Japan Railway, Construction, Transport and Technology Agency

The Hokuriku Shinkansen Kaga Tunnel is a 5,463m-long mountain tunnel（kilometerage 391km937m to 397km400m from origination of Takasaki）and is located on the border between Ishikawa and Fukui Prefectures in the section from Kanazawa to Tsuruga. Throughout almost ground along this tunnel, Neogene Miocene tuff and mudstone were distributed and there was concern about deformation of invert. The results of laboratory testing using ground samples are normally used as decision indexes for squeezing ground but heaving is confirmed in some tunnels after construction and it is necessary to implement measures at the time of construction works including heaving prevention measures which are particularly difficult to implement after the tunnel opens. Therefore, we installed “Invert Displacement Meter®” that automatically measures vertical trackbed displacement through the differential head, depending on the measurements results, we implemented invert deformation measures giving a cross-section with a larger curvature in order to get closer to a circular-shaped invert for sections where large displacement was confirmed.

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補助工法を駆使して脆弱な日南層群地すべり地帯を掘る

―東九州自動車道　九平トンネル―

国土交通省　弓場　　進

九平トンネルは，宮崎県宮崎市大字鏡洲に位置する延長410.3mの道路トンネルである．本トンネルは，砂岩頁岩混在層が主体の脆弱な日南層群を掘削するものであり，隣接する芳ノ元トンネル工事においても地すべりや大きな変位量が報告されており，難工事が予想された．本トンネルでも全線にわたり地すべりブロックが確認され，挙動を観測しながら施工を行ったが，掘削時の切羽状況は想定以上に脆弱であり，数回の崩落も発生した．さらに大きな変位，変状が発生し，地すべり活動も活発化したが，さまざまな対策工を採用して，掘削開始から19.5か月で無事貫通した．本稿では，設計の概要と掘削時の状況，および採用した対策工などについて報告する．

Excavation of Landslide Zone in Weak Nichinan Group Using Various Auxiliary Methods ―the Higashi Kyushu Expressway, the Kokonohira Tunnel―

By Susumu Yumiba, Ministry of Land, Infrastructure, Transport and Tourism

Kokonohira Tunnel is a 410.3m-long road tunnel located in Kagamizu, Miyazaki City, Miyazaki Prefecture. In the tunnelling works weak Nichinan group mainly consisting of mixed layers of sandstone and shale was excavated and it was expected to be difficult works as there were reports of landslides and large displacements during construction works in the nearby Yoshinomoto Tunnel. Landslide blocks were also confirmed throughout this tunnel and construction works were conducted while measuring their behaviour but ground condition which was appeared on the face at the time of excavation was weaker than expected and several collapses occurred. Larger displacement and deformation occurred and landslide activity increased but we employed various measures and completed penetration without problem 19.5 months after excavation began. This report contains an outline of the design, the situation during excavation and the measures that were employed.

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土日 4 車線開放に向けた供用中トンネルのインバート設置工事

―上信越自動車道　閼伽流山トンネル―

東日本高速道路(株)　鈴木　二朗

閼伽流山トンネルは上信越自動車道碓氷軽井沢IC～佐久IC間に位置する延長1,960mのトンネルである．下り線内では，インバート未施工区間において最大路面隆起量約130mmの盤膨れが発生した．対策工は，長期的なトンネルの安全性を確保するため，インバートを延長149m設置する工事を行ったものである．昼夜連続規制において2車線トンネルを1車線ずつ半断面施工で行い，トンネル規制内という狭小施工ヤードのもと通行止めを行わず，高速道路利用者の安全性の確保を第一に施工を行った．本稿は，試験的な試みとして渋滞解消の観点から土日交通開放を前提とした平日5日間での施工を計画し，その施工サイクルを検証できたことから，本工事の設計・施工の概要と試験施工の検討内容について報告する．

Installing Invert Concrete in Tunnel In-Service With the Aim of Opening 4 Lanes at Weekends

―the Joshin-Etsu Expressway, the Akarusan Tunnel―

By Jiro Suzuki, East Nippon Expressway Company Limited

Akarusan Tunnel is 1,960m in length and is located between Usui Karuizawa IC and Saku IC on the Joshin-Etsu Expressway. Heaving occurred on the outbound lane in a section where invert concrete was installed and maximum road surface displacement reached approx. 130mm. Measures to install 149m of invert concrete were taken in order to ensure long-term tunnel stability. Invert concrete was casted under one lane in two-lane tunnel at narrow construction site where the one lane was closed for 24hours, works were conducted placing ultimate priority on the safety of passengers of expressway tunnel which was not closed. This report contains plans for construction works during 5 weekdays with the prerequisite of opening to traffic at weekends from the point of view of relieving congestion on an experimental trial basis and, because it was possible to verify this work cycle, it also contains an outline of the design and construction for these works and investigation details of trial works.

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中流動覆工コンクリートをICT活用で自動施工

―湯浅御坊道路　川辺第二トンネル―

西日本高速道路(株)　信永　博文

中流動覆工コンクリートの自動施工は，流動性に優れ材料分離がないフレッシュコンクリートを，マニピュレータ方式配管切替え装置で移動型枠内に打込み，型枠バイブレータ(VB)で締固めることを基本にしている．この覆工コンクリート自動施工の具現化は，覆工コンクリート施工をパターン化し，ICTを活用，各種センサで施工状況と締固め状態を数値化，可視化し，確認しながらマニピュレータ方式打込み装置と型枠バイブレータ(VB)を自動制御するものである．本稿では，この覆工コンクリート自動施工の適用性と有効性がモデル施工で確認でき，打込み時と打止め時のコンクリート圧力，締固めエネルギー，脱型枠時強度，出来形と反発度などの覆工施工パラメータの基本データが得られたので報告する．

Automated Lining System of Middle-Performance Concrete Using ICT

―the Yuasa-Gobo Road, the Kawabe Dai-Ni Tunnel―

By Hirofumi Nobunaga, West Nippon Expressway Company Limited

Automated lining system for middle performance concrete is basically consisted of pouring fresh concrete that has superior fluidity and unseparated state in a sliding form using a device of switching pipe with manipulator and compacting it with form vibrators(VB). The realization of automated concrete lining is based on patterning concrete lining, using ICT, digitizing and visualizing with all kinds of sensors to evaluate status of working and compacting and automatically controlling pouring device with the manipulator and form vibrators(VB). In this report, we show that it was possible to confirm the adaptability and effectivity of this automatic concrete lining through model construction and we were able to obtain basic data on parameters of lining such as concrete pressure while pouring and pausing, compacting energy, strength at the time of form removal and complete shape and degree of rebound.