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底設導坑の二段階切拡げなどによる土かぶり70mでの強風化花崗岩地山の掘削
―中央新幹線　第一中京圏トンネル(西尾工区)―

東海旅客鉄道(株)　川島　大輝

中央新幹線第一中京圏トンネル(西尾工区)は，品川方は主に砂岩・粘板岩で構成される美濃帯を，名古屋方は主に新鮮～風化花崗岩(領家帯花崗岩)をNATMにより掘削する工区延長約4.5kmの工事である．とくに名古屋方の直上は国道や工場，住宅地として土地利用がされており，慎重な施工が求められた．名古屋方は当初，硬質な花崗岩を本坑全断面掘削工法により掘削を行っていたが，土かぶり約70mに強風化花崗岩が出現したことにより，本坑断面での掘削が困難となったことから，頂設導坑先進方式へと切替えて掘削したものの，頂設導坑支保に著しい変位が発生し掘削が不可能となったため，前方地質を集中的に調査し，強風化花崗岩の物性を把握したうえで，各種補助工法を併用した底設導坑の二段階切拡げを採用する計画とした．本稿では，土かぶり70mで出現した強風化花崗岩の掘削で発生したトラブルと，底設導坑の二段階切拡げなどの対策を中心に報告する．

Excavation of Highly Weathered Granite Under a 70 m Overburden Using a Two-Stage Enlargement of a Bottom Drift
―The Chuo Shinkansen, the Daiichi Chukyo-Ken Tunnel, the Saio Lot―

By Daiki Kawashima, Central Japan Railway Company

The Daiichi Chukyo-Ken Tunnel (Saio Lot) of the Chuo Shinkansen is a construction project with a total length of approximately 4.5 km. On the Shinagawa side, the tunnel passes through the Mino Belt, which consists mainly of sandstone and slate. On the Nagoya side, excavation proceeds through fresh to weathered granite (Ryoke Belt granite) using the NATM method. The tunnel is excavated using the NATM method. In particular, the area directly above the Nagoya section is used for national highways, industrial facilities, and residential areas, requiring particularly careful construction. Excavation on the Nagoya side was initially performed through hard granite using an all-cross-section excavation. However, when a zone of highly weathered granite was encountered beneath approximately 70 m of overburden, all cross-section excavation became difficult. The method was therefore changed to a top drift excavation. Soon after, significant deformation developed in the support system of the top drift, making further excavation impossible. To address this issue, intensive geological investigations were conducted ahead of the tunnel face to determine the physical properties of the highly weathered granite. Based on these findings, a revised plan was adopted to use a two-stage enlargement for a bottom drift in combination with various auxiliary methods. This paper reports the challenges encountered during the excavation of highly weathered granite that appeared under a 70 m overburden and presents the countermeasures implemented, including the two-stage enlargement of the bottom drift.

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Ⅰ期線で大変状を生じた結晶片岩地山におけるⅡ期線施工

―東九州自動車道　九六位トンネル―

西日本高速道路(株)　岩元　和彦

本工事は，東九州自動車道における４車線化事業の一環として，大分宮河内ICと臼杵IC間にある九六位トンネル(延長2,338m)のⅡ期線を施工するものである．東九州自動車道の中では唯一，三波川変成岩類の分布域にある九六位トンネルはゆるみを生じやすい亀裂質の結晶片岩で構成され，現在供用しているⅠ期線施工時には切羽崩壊や支保の変状が複数箇所で発生した．供用線と近接するⅡ期線トンネルの掘削は，Ⅰ期線の地質とほぼ同じ状況の中を並行して施工されることから，同様の現象の発生が想定されるため，本工事では，掘削に伴う変位を抑制し，供用線に影響を与えない慎重な施工が求められる．Ⅱ期線施工ではⅠ期線施工時に変状した区間を，起点側から①初期変状区間，②大変状区間，③後期変状区間，④水圧区間の４つに大別して，それぞれの区間に対応した施工を考えることとしている，本稿では，現在まで施工が完了した①初期変状区間の施工時の変状とその対策について報告する．

Construction of the Phase II Section in Crystalline Schist Ground Where Severe Deformation Occurred During Excavation of the Phase I Section

―The Higashi-Kyushu Expressway, the Kurokui Tunnel―

By Kazuhiko Iwamoto, West Nippon Expressway Company Limited

This project involves the construction of the Phase II section of the Kurokui Tunnel (length 2,338 m), located between the Oita-Miyakawauchi Interchange and the Usuki Interchange on the Higashi-Kyushu Expressway, as part of the project to expand the expressway to four lanes. The Kurokui Tunnel is the only tunnel on the Higashi-Kyushu Expressway situated within the Sanbagawa Metamorphic Belt. The tunnel passes through fractured crystalline schist that is highly susceptible to loosening. During construction of the Phase I section, which is currently in service, several instances of face collapse and support deformation occurred. Because the Phase II section is being excavated in close proximity to the operating line and under geological conditions nearly identical to those encountered during the Phase I construction, similar deformation phenomena were anticipated. Consequently, the project required particularly careful construction to minimize displacement caused by excavation and ensure that the existing line is not affected. For Phase II construction, sections where deformation occurred during Phase I construction were broadly classified into four categories starting from the starting point: (1) early-stage deformation section, (2) severe deformation section, (3) late-stage deformation section, and (4) hydrostatic pressure section. Construction methods were developed individually for each zone. This paper reports the deformation phenomena observed during excavation of the early-stage deformation zone (1) which has been completed to date, and presents the implemented countermeasures.

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45 地質状況に応じた注入式先受け・鏡補強の適用
―国道158号　狸平トンネル―

長野県　山口　有理

国道158号狸平トンネルでは，未固結で脆弱な地質が分布する両坑口部に加え，全長1,060mにわたり複数の断層破砕帯や多量湧水区間が確認されるなど，厳しい地山条件下で施工が行われた．本稿では，切羽地質状況に応じて注入材を選定した長尺鋼管先受け工法および長尺鋼管鏡ボルト，主に圧力管理方式を採用した注入管理，断層破砕帯区間で顕在化した地山変状への対応，ならびに掘削に伴い発生した多量湧水に対する水抜きボーリングの適用について述べる．とくに，圧力管理方式による注入管理の有効性や，切羽湧水対策および砂質地山対策として２種類のウレタン系注入材を使い分けるなど，切羽安定性確保の観点から施工を行った．これらの対応を通じて得られた知見をもとに，本トンネルの施工実績について報告する．

Application of Grouting-Type Forepoling and Face Reinforcement Adapted to Geological Conditions
―The National Route 158, the Tanukidaira Tunnel―

By Yuri Yamaguchi, Nagano Prefecture

Construction of the Tanukidaira Tunnel on National Route 158 was carried out under challenging geological conditions, including unconsolidated and fragile formations at both tunnel portals. In addition, multiple fault fracture zones and sections with heavy groundwater inflow were encountered along the entire 1,060 m alignment. This paper describes the application of the long steel pipe forepoling method and long steel pipe face bolts using grout materials selected according to the geological conditions encountered at the tunnel face; grout injection management based primarily on a pressure control approach; countermeasures implemented to address ground deformation that became evident within fault fracture zones; and the use of drainage boreholes to cope with large volumes of groundwater inflow generated during excavation. Particular emphasis was placed on the effectiveness of pressure-controlled grout injection management and on ensuring face stability through the selective use of two different polyurethane-based grout materials, depending on whether the objective was to control groundwater inflow at the tunnel face or to stabilize sandy ground conditions. This paper presents the construction results for this tunnel based on the knowledge gained through these measures.

研究

55 樹脂吹付けによる覆工剝落防止工法の概要と適用例

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鉄道トンネルはその中を列車が走行するため，覆工の剝落は列車の安全な運行を脅かす重大な事象となりえる．鉄道トンネルでは，2000年に検査体系が見直され，定期的に覆工に近づいて検査を行うことが義務づけられた．これ以後，列車の安全な運行を脅かす大規模な剝落は発生していないが，小規模な剝落は依然として起こっている．筆者らは，ポリウレア樹脂を吹付けることによる剝落対策工を開発した．ポリウレア樹脂は，24N/mm^{2}程度の引張強度を有し，200％以上の優れた伸び性能を有する樹脂で，吹付けでの施工が可能なことから，とくに凹凸を有するトンネル覆工の剝落防止に有効な工法である．本稿では，工法の概要と現場適用事例を紹介する．

Overview and Application of a Resin Spraying Method for Preventing Lining Spalling

By Kazuhide Yashiro, Railway Technical Research Institute

Because trains pass through railway tunnels, spalling of the lining can pose a serious threat to their safe operation. In 2000, the inspection system for railway tunnels in Japan was revised, mandating periodic close-up inspections of tunnel linings. Since then, no major lining spalling incidents that could endanger train operations have occurred, although small-scale spalling continues to be observed. The authors have developed a spalling prevention method that involves spraying polyurea resin onto the tunnel lining. Polyurea resin has a tensile strength of approximately 24 N/mm^2 and an excellent elongation capacity exceeding 200 %. Because it can be applied by spraying, it serves as an effective method for preventing spalling, particularly on tunnel linings with uneven surfaces. This paper provides an overview of the construction method and examples of its application in an actual project.