

塑性流動と吸水膨張を伴う押出し性地山を円形支保工で突破

—北海道新幹線 渡島トンネル(南鶉工区)—

鉄道・運輸機構 鳥井 宏之

北海道新幹線渡島トンネル(南鶉工区)は、全区間で土かぶりが大きく(最大約300m)、事前調査では把握しきれなかった複雑な貫入岩および強い変質作用を受けた新第三紀の堆積岩の出現により掘削がきわめて難航している。地山強度比が最小0.04を記録するなど、全体的に地山強度不足による塑性流動化に加え、膨張性粘土鉱物であるスメクタイトの含有量が最大87%に達する特殊な地質条件となっており、当初設計の馬蹄形断面で内空変位が最大283mmに達するなど、顕著な押出し現象が生じた。地山情報を詳細に把握するため、坑内水平先進ボーリングや空中電磁探査を追加実施し、対策工として円形支保工を採用した。円形断面により支保工の軸力伝達性能を向上させ、その耐力を最大限に活用することで、不良地山に対する安定性の向上を図っている。本稿では、主に円形支保工の採用区間における、坑内水平先進ボーリングや空中電磁探査による調査結果、円形支保工の採用による掘削実績とその評価結果について報告を行う。

Tunneling through Squeezing Ground Subject to Plastic Flow and Water-Induced Swelling Using Circular Supports

—Hokkaido Shinkansen, Oshima Tunnel, Minamiuzura Lot—

By Hiroyuki Torii, Japan Railway Construction, Transport and Technology Agency

Excavation of the Oshima Tunnel (Minamiuzura Lot) of the Hokkaido Shinkansen has been extremely challenging due to a large overburden along the entire route (up to approximately 300 m) and the presence of complex intrusive rocks and highly altered Neogene sedimentary rocks that could not be fully identified during preliminary surveys. The geological conditions were particularly difficult: the competence factor was recorded as low as 0.04, resulting in plastic flow due to insufficient ground strength, while the content of smectite, an expansive clay mineral, reached as high as 87%. As a result, significant squeezing occurred, with internal displacement reaching a maximum of 283 mm in the originally designed horseshoe-shaped cross-section. To obtain more detailed information on the ground conditions, additional in-tunnel horizontal pilot boring and airborne electromagnetic surveys were conducted, and circular supports were adopted as a countermeasure. The circular cross-section improves the axial load-transfer performance of the supports, allowing their load-bearing capacity to be fully utilized and thereby enhancing stability in poor ground conditions. This paper reports primarily on the results of surveys conducted using horizontal probe drilling and aerial electromagnetic surveys in the sections where circular supports were adopted, as well as the excavation performance achieved with the circular support system and the results of its evaluation.

大断面シールドトンネルの掘進と非開削によるトンネル拡幅

—横浜環状南線(圏央道) 公田笠間トンネル—

東日本高速道路(株) 伊藤 潔

横浜環状南線は、首都圏3環状道路の一つである圏央道の一部を構成する路線で、横浜市金沢区から戸塚区を結ぶ延長約9kmの一般有料道路である。当該路線の約7割がトンネルや掘割などの地下構造で計画され、そのうち公田IC(仮称)から栄IC・JCT(仮称)間に「公田笠間トンネル」が位置する。トンネルは、延長1,724m、離隔約1.0mの併設トンネルであり、直径約15mのシールドを往復させて構築した。トンネルの発進到達立坑付近は小土かぶりでのトンネル掘進を行った。また、シールドトンネル内において、非常駐車帯を設ける必要があるため、坑内から非開削によるトンネル断面の拡幅作業を実施した。本稿ではこれらの施工実績を報告する。

Excavation of a Large-Section Shield Tunnel and In-Tunnel Widening —Yokohama Ring Expressway South Line (Ken-O Expressway), Kuden-Kasama Tunnel—

By Kiyoshi Ito, East Nippon Expressway Company Limited

The Yokohama Ring Expressway South Line forms part of the Ken-O Expressway, one of the three ring roads in the Tokyo metropolitan area. It is a general toll road extending approximately 9 km between Kanazawa Ward and Totsuka Ward in Yokohama. Approximately 70% of the route is planned as underground structures, including tunnels and cut-and-cover sections. The Kuden-Kasama Tunnel is located between Kuden Interchange (tentative name) and Sakae Interchange and Junction (tentative name). The tunnel consists of twin parallel tunnels, each 1,724 m long, with a clear distance of approximately 1.0 m. The tunnels were constructed by driving a 15 m diameter shield in both directions. Tunneling was carried out under a shallow overburden near the starting and arrival shafts. In addition, since emergency parking bays were required within the shield tunnels, the tunnel cross sections were widened using an in-tunnel widening method. This paper reports on the results of these construction works.

山岳トンネル発破掘削におけるICT・DXによるオートメーション化の取り組み

—三遠南信自動車道 三遠南信6号トンネル—

国土交通省 勝又 祐希

三遠南信自動車道は、長野県飯田市の中央自動車道を起点として、静岡県浜松市浜名区引佐町に至る延長約100kmの高規格道路である。このうち、三遠南信6号トンネル(仮称)は、長野県下伊那郡喬木村に位置する、掘削断面約74m²、延長455mの2車線道路トンネルである。本工事では、山岳トンネルでの発破掘削において、国土交通省が推進するi-Construction 2.0の柱である、施工のオートメーション化、データ連係のオートメーション化、施工管理のオートメーション化に取り組んだ。本稿では、それらの取り組みによる、施工時の安全の確保、省人化、省力化、生産性向上、加えて職員の施工管理の省人化の効果について検証した結果について報告する。

Initiatives for Automation of Blasting Excavation in Mountain Tunnels Using ICT and DX —San-En Nanshin Expressway, San-En Nanshin No.6 Tunnel—

By Yuki Katsumata, Ministry of Land, Infrastructure, Transport and Tourism

The San-En Nanshin Expressway is a high-standard highway approximately 100 km long extending from the Chuo Expressway in Iida City, Nagano Prefecture, to Inasa Town, Hamana Ward, Hamamatsu City, Shizuoka Prefecture. The San-En Nanshin No. 6 Tunnel (tentative name), located in Takagi Village, Shimoina County, Nagano Prefecture, is a two-lane road tunnel with an excavation cross-sectional area of approximately 74 m² and a length of 455 m. In this project, ICT and DX technologies were applied to blasting excavation in the mountain tunnel, focusing on the three pillars of the i-Construction 2.0 initiative promoted by the Ministry of Land, Infrastructure, Transport and Tourism: automation of construction works, automation of data linkage, and automation of construction management. This paper reports the results of an evaluation of the effects of these initiatives in ensuring safety during construction, reducing manpower and labor requirements, improving productivity, and reducing the manpower required for construction management.

施工

57

長距離シールドの高精度線形管理と深さ50mで水中到達

—霞ヶ浦導水事業 石岡トンネル第4工区—

(株)銭高組 河内 浩二

本工事は、霞ヶ浦導水事業として、茨城県小美玉市に位置する堅倉立坑から同市の美野里立坑に至る延長約4,100mの区間において、仕上がり内径 ϕ 3,500mmの導水路トンネルを構築する泥水式シールドトンネル工事である。到達立坑となる美野里立坑は、地上部が住宅地や農耕地などに近接し、周辺環境への影響抑制が求められた。また到達部は N 値50以上の砂層と N 値10~30以上の粘性土層が互層をなし、地下水压0.4MPa以上の高水压環境にあることから、NOMST壁の切削時に湧水や地盤沈下が懸念された。そこで、立坑内を水で満たした状態で土留め壁を切削する水中到達工法を採用し、約4,100mの長距離掘進を経て高い到達精度で到達工を完了した。本稿は、その施工事例を報告するものである。

High-Precision Alignment Control of a Long-Distance Shield Tunneling and Underwater Arrival at a Depth of 50 m

—Kasumigaura Water Conveyance Project, Ishioka Tunnel, Lot No. 4—

By Koji Kawauchi, The Zenitaka Corporation

As part of the Kasumigaura Water Conveyance Project, this project involves the construction of a water conveyance tunnel with a finished internal diameter of 3,500 mm over a distance of approximately 4,100 m using a slurry shield TBM, extending from the Katakura Shaft to the Minori Shaft in Omitama City, Ibaraki Prefecture. The Minori Shaft, which served as the arrival shaft, is located close to residential and agricultural areas, requiring measures to minimize impacts on the surrounding environment. In addition, the ground at the arrival point consists of alternating sand layers with N -values of 50 or higher and cohesive soil layers with N -values of 10–30 or higher. Because the site is also subject to high groundwater pressure exceeding 0.4 MPa, there were concerns about groundwater inflow and ground subsidence during excavation of the NOMST retaining wall. To address these conditions, an underwater shield arrival method was adopted, which involves cutting of the retaining wall while the shaft is filled with water. Following approximately 4,100 m of long-distance shield tunneling, the shield arrival was successfully completed with a high degree of accuracy. This paper reports on the construction techniques adopted in this project.