

## **Labor-Saving Lining Construction Using Low-Carbon Self-Compacting Concrete (FY2022 Tawarayama-Toyota Road No. 1 Tunnel Construction Project)**

Ministry of Land, Infrastructure, Transport and Tourism, Chugoku Regional Development Bureau, San-in West National Highway Office; Sato Kogyo Co., Ltd.; Gifu Kogyo Co., Ltd.; Namacon Nagato Co., Ltd.; Chugoku High-Pressure Concrete Industry Co., Ltd.; Chiba Institute of Technology

### Reasons for the Award

The Tawarayama-Toyota Road No. 1 Tunnel construction project in fiscal year 2022 is a trial project for the Ministry of Land, Infrastructure, Transport, and Tourism's Productivity Improvement Challenge. Due to the large empty cross-section inside the tunnel, it was deemed necessary to improve the productivity of the lining. Furthermore, the Ministry of Land, Infrastructure, Transport and Tourism's Green Challenge promotes "the realization of a carbon-neutral, recycling-oriented society throughout the entire infrastructure life cycle." With the



aim of simultaneously achieving productivity improvement and reduced environmental impact, a "self-compacting lining construction system" and "low-carbon self-compacting concrete" were applied.

The "self-compacting lining construction system" is a construction method that involves pressing self-compacting concrete through a pouring opening at the bottom of the slide center to construct the lining. This eliminates the need for compaction and pipe switching work, thereby reducing the occurrence of problems and enabling improved productivity while ensuring the quality of the lining. However, achieving the high flowability required for self-compacting concrete necessitates using cement with high CO<sub>2</sub> emissions during production. Therefore, "low-carbon self-compacting concrete" utilizing fly ash sourced near the site was employed to reduce the concrete's CO<sub>2</sub> emissions.

Applying these technologies enabled the construction of a high-quality lining free of surface bubbles and unfilled areas. Furthermore, concrete placement achieved labor-saving construction by halving the number of workers and reducing work time by 40%. Given its high contribution to addressing current challenges in the construction industry, such as labor shortages and environmental considerations, and its expected adoption in future tunnel construction, this technology was evaluated as deserving of the technical award.

## **Application of Precast Blocks Produced by Construction 3D Printers to Large-Scale Civil Engineering Structures— FY2021 Seisho Coast Rock Foundation-Type Submerged Breakwater Development Project-**

Ministry of Land, Infrastructure, Transport and Tourism, Kanto Regional Development Bureau,  
Keihin River Office; OBAYASHI CORPORATION

### Reasons for the Award

R3 The Seisho Coast Rock-Type Submerged Breakwater Construction Project is a critical infrastructure project aimed at preventing coastal erosion. The original plan involved installing temporary steel pipe sheet pile cofferdams at the breakwater's tip, placing precast blocks inside them, and filling the interior with underwater non-separable concrete. However, due to the three-dimensionally expanding shape, all 52 PCa panels of varying sizes had to be connected on-site using PC steel bars and installed underwater as six large blocks. This method involved risks such as evacuating equipment during high waves and underwater operations, presenting numerous challenges in terms of schedule, safety, and quality. To address these challenges, the number of components was reduced from 52 panels to 6 blocks. However, the resulting complex shape made fabrication difficult using conventional steel formwork. Therefore, a construction 3D printer was utilized to produce the block outer shells (embedded formwork), enabling the realization of a rational structure. This method eliminated the need for panel connection work on-site, significantly shortening the period from delivery to installation. Safety was also enhanced. The number of sling wires required during block installation was reduced, lowering the risk of entanglement with divers' air supply hoses and improving overall work safety. Furthermore, quality was secured as the weight per block was reduced, minimizing the risk of damage from collisions with adjacent blocks during installation. This project represents Japan's first attempt to apply 3D printing to large-scale civil engineering structures. By proposing an innovative approach unconstrained by existing concepts and construction methods, it substantially reduced the risk of schedule delays in onshore operations along the coastline. This achievement was highly recognized and deemed worthy of the Technology Award.



## **Establishment of Tunnel Construction Technology under Deep Overburden in Proximity to the Median Tectonic Line – San-en Nanshin Aokuzure Tunnel (Tentative Name) Main Tunnel Project –**

Ministry of Land, Infrastructure, Transport and Tourism, Chubu Regional Development Bureau, Iida National Highway Office; HAZAMA ANDO CORPORATION; Penta-Ocean Construction Co., Ltd.

### Reasons for the Award

The San-en Nanshin Aokuzure Tunnel (Tentative Name) is a 4,998-meter road tunnel under construction along the border between Nagano and Shizuoka Prefectures on the San-en Nanshin Expressway. It runs parallel to the Median Tectonic Line, one of Japan's largest faults, at a distance of 500 meters. Construction required navigating fragile and complex geology with maximum overburden exceeding 600 meters. To address these high ground pressure conditions, the construction method was fundamentally revised.



① A double support system using high-specification formwork and high-strength rock bolts was applied, establishing a construction method that leverages the “yielding” effect to accommodate ground deformation. By delaying the installation of secondary support by 6 to 8 meters from the tunnel face and postponing the closure timing of the invert support by approximately 13 meters from the face, we reduced the load on the secondary support and developed a rational construction method to ensure tunnel stability.

② We developed ultra-high-strength shotcrete with a design strength of  $54 \text{ N/mm}^2$ , 1.5 times that of standard high-strength shotcrete, and applied it for the first time in domestic mountain tunnel construction. Considering the aforementioned “deflection” effect, the mix design for this concrete was optimized to achieve an initial strength comparable to the current mix ( $\sigma_{10} = 10 \text{ N/mm}^2$ ).

These construction techniques established a rational construction method to ensure tunnel stability even under strong earth pressure with complex and fragile geology. This enabled the realization of tunnel construction at Aokuzure Pass, 40 years after the initial planning. The established techniques are highly regarded for significantly expanding design and construction options under similar conditions and contributing greatly to the advancement of civil engineering technology. They were recognized as deserving of a technical award.

## **Japan's First Large-Scale Concrete Face Rockfill Dam (CFRD) as a Major Dam Project – The Challenge of the Nanma Dam –**

Japan Water Agency; TAISEI CORPORATION

### Reasons for the Award

The Nanma Dam is a concrete-faced rockfill dam (CFRD) constructed in Kanuma City, Tochigi Prefecture, as part of the Omoigawa River Development Project undertaken by the Water Resources Agency. This project aims to regulate floods, maintain normal streamflow functions, and supply water for public waterworks. A CFRD achieves waterproofing by covering its upstream face with concrete slabs, known as the face slab.

The construction of this dam type had been suspended for an extended period in Japan due to challenges with waterproofing. These challenges stemmed from deformation of the face slab caused by settlement of the embankment section and the numerous concrete joints in the face slab. However, advancements in recent construction techniques, such as the thin-layer compaction method and slipform construction, have enabled the resolution of these issues. Consequently, the Nanma Dam adopted the CFRD design.

For large-scale CFRDs, the waterproofing wall structure and waterstop system are critical challenges. These challenges were addressed through design innovations such as double reinforcement of the face slab, use of copper waterstop plates, and a dual waterstop system. On the construction side, ensuring dense concrete placement for the face slab was critical. Efforts focused on securing concrete watertightness through trial construction at similar scales, developing new methods for transporting low-slump concrete, and establishing concrete curing methods for long slopes. Through these measures, Japan's largest CFRD was successfully completed.

In summary, this project is recognized as deserving of the Technical Award. It is evaluated that the establishment of this technology as a benchmark for CFRD construction in Japan and its future application will contribute to technological advancement and regional community development.



## **Emergency Restoration of a Mountain Tunnel Damaged by a Vehicle Fire – Sanyo Expressway, Amagoyama Tunnel Temporary Lining Restoration Project –**

West Nippon Expressway Company Limited (Kansai Branch); Kajima Corporation

### Reasons for the Award

In the early hours of September 5, 2023, an accident occurred on the downbound lane of the Amagoyama Tunnel on the Sanyo Expressway, where 23 vehicles were destroyed by fire. It took over 40 hours to extinguish the blaze, and the tunnel interior sustained unprecedented, extensive damage. The accident caused significant societal disruption, including a long-term closure, due to extensive damage such as the widespread spalling of the concrete lining.



Amid calls for an early reopening, investigations into the tunnel's safety and the extent of the fire damage were conducted. Restoration work plans and construction details were formulated based on the assessment of the damage. Following deliberations by a technical review committee of experts, emergency work was carried out around the clock.

For areas severely affected by the fire damage, a new method was adopted, pioneering the regeneration of tunnel linings in sheet pile tunnels. This involved using a twin-head cutter to remove vulnerable sections approximately 20 cm deep from the designed inner surface, followed by re-installing the lining concrete. This “inner lining method” was applied to areas deeply impacted by the fire damage. For the concrete mix design, a unique formulation was adopted to balance workability, self-compacting properties, spalling prevention, and rapid restoration. The maximum coarse aggregate size was set to 15mm. To enable formwork removal the following day and reduce drying shrinkage cracking, the mix incorporated fiber reinforcement and a high-performance AE water-reducing agent containing a thickening agent.

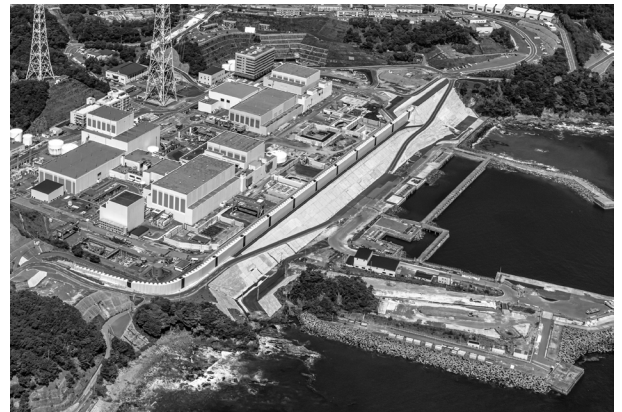
Initially, the damage was so severe that restoration seemed impossible. However, restoration was completed in just 102 days after the disaster. This achievement received significant gratitude and recognition not only from highway users but also from Society at large. Recognized as deserving of a technical award due to its substantial social contribution, the project was honored accordingly.

# **Raising of the Seawall at the Onagawa Nuclear Power Station – Construction of Japan’s Highest-Class Seawall Incorporating Lessons from the Great East Japan Earthquake –**

Tohoku Electric Power Co., Inc.; Kajima Corporation

## Reasons for the Award

The Onagawa Nuclear Power Plant is the nuclear power plant closest to the epicenter of the Great East Japan Earthquake. Although it experienced a seismic intensity of 6 and a tsunami approximately 13.0 meters high during the disaster, it did not suffer severe damage. However, to further enhance the safety of the nuclear power plant and its surrounding area, a seawall 29.0 meters high and 800 meters in total length will be constructed.



The seawall was designed using a design seismic motion (maximum acceleration of 1000 gal) that incorporates various uncertainties based on the latest knowledge gained from the Great East Japan Earthquake, and a design tsunami (25m, exceeding the assumed tsunami water level of 23.1m). Its safety was confirmed by also considering the impact load from tsunami debris (2000kN) and the effects of liquefaction.

Construction faced significant challenges, including the need to complete an enormous volume of work with high precision within a short timeframe to ensure the nuclear power plant's tsunami safety early on, and the addition of supplementary reinforcements during construction to further enhance safety beyond the initial design. To overcome these challenges and achieve completion, various innovative approaches were implemented. These included developing specialized scaffolding for high-precision steel pipe pile installation, applying the high-pressure jet grouting method to the unprecedented rock-crushed fill, formulating a highly feasible construction plan through temporary material fabrication and trial construction, and utilizing low-heat, high-flow concrete effectively incorporating Type IV fly ash.

As described above, this project was recognized as deserving of the Technology Award. It was evaluated as contributing to societal development by ensuring the safety of nuclear power plants, while also making a significant contribution to the advancement of civil engineering technology.

# Niigata Station Area Development Centered on Continuous Grade Separation

Niigata City; East Japan Railway Company,  
Joshinetsu Construction Project Management Office

## Reasons for the Award

The Niigata Station Area Improvement Project aims to comprehensively develop the station's surrounding urban area, including urban infrastructure such as elevated conventional rail lines, grade-separated roads, and station front plazas, to strengthen urban functions befitting a hub on the Sea of Japan coast.

The core element of the project, the continuous grade separation, involved the elevated construction of approximately 2.5 km centered on Niigata Station. Work commenced in 2006 using a temporary track system.

Full-line elevation was completed in 2022, with the main railway construction finishing in 2024, concluding this large-scale project spanning 18 years.

The area around Niigata Station was divided into northern and southern districts by ground-level tracks, causing traffic congestion on surrounding roads. The narrow Bandai Plaza in front of the station, combined with a switchback-style bus terminal, presented challenges for safety and traffic management.

The elevated track plan aimed to reduce the project scale by ensuring traffic flow on surrounding intersecting roads during construction and streamlining the station area through the relocation of railway facilities. This allowed for the expansion of Bandai Plaza, the city's iconic square.

During construction, civil engineering techniques tailored to local conditions were adopted. These included establishing a technology to suppress alkali-silica reaction by blending 20% fly ash into ready-mixed concrete and adopting track structures suited for snowfall regions.

Elevating the conventional lines eliminated narrow level crossings and enabled the development of a planned urban road running north-south through the city center. Directly beneath the station, Japan's only "dedicated bus terminal for route buses" was established, and "same-platform transfers between Shinkansen and conventional lines" were realized, strengthening the transportation hub and improving transfer convenience.

Thus, this project was recognized as worthy of the Technical Award for resolving regional challenges, strengthening transportation hubs in regional cities, and contributing to the development of the Japan Sea National Land Axis and regional revitalization.

