July 2026 No.103
Japanese Infrastructure

IDI NEWSLETTER

Infrastructure Development Institute - Japan

KITANOMAKI Rock Removal Work

Source: East Nippon Expressway Co., Ltd.

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Infrastructure Development Institute – Japan（IDI）
Plaza Edogawa-bashi 3F. 1-23-6, Sekiguchi, Bunkyo-ku, Tokyo, 112-0014, JAPAN

Launch of the IDI Newsletter

This new newsletter is sent to colleagues who had communication/collaboration with IDI (Infrastructure Development Institute-Japan) and dedicate themselves to better infrastructure in the world. We intend to provide information related to works, technologies, and related policies in Japan in the area of infrastructure development. We hope you find that some of the information contributes to your cases.

Until 2024, IDI released a quarterly publication known as 'IDI Quarterly.' 'IDI Newsletter' inherits basic ideas of the Quarterly but has more emphasis on freshness of information and communication with readers.

We would be delighted to hear your response to the articles. Based on your response, we will address it flexibly by, for example, rectifying the editorial plan and connecting your case with resource persons in Japan. As IDI works as a hub for a human network of consultants, contractors, and governmental organizations related to infrastructure, we may be able to help you connect with resource persons in Japan.

July 2026

安田吾郎

Goro Yasuda
President
Infrastructure Development Institute-Japan (IDI)

KITANOMAKI Rock Removal Work

PROJECT

Project overview ～Background and purpose of the work～

In 1996, an accident caused by a huge rock mass fall (maximum height: 70 meters; weight: 27,000 metric tons) occurred at the Toyohama Tunnel along National Route 229 in Hokkaido, in northern Japan. This accident claimed the lives of 20 people. After this accident, the national government decided to conduct a nationwide inspection of roadside slopes along national highways. During this inspection, a similar risk of rock mass falls was identified in the Kitanomaki Tunnel area on the Joshin'etsu Expressway. With the aim of preventing future large-scale collapses and ensuring the safety of the expressway, East Nippon Expressway Co., Ltd., which controls the route, launched a project to remove the rock mass in 2017.

Figure 1. Target slope (West side of KITANOMAKI-tunnel entrance)

Purpose

- NEXCO East is working on various preventive maintenance works to ensure that customers can continue to drive on safe and secure expressways.
- As one of the above works, it is conducting a disaster prevention project to eliminate the risk of future rockfall by removing unstable huge rock at the Kitanomaki Tunnel entrance.

History

- Falling rock : At least two rockfalls have occurred in the last 230 years. (Lower part of talus rock mass: As-A(1783))
- Since 1783, 8 earthquakes with a seismic intensity of 4 or higher have occurred. (Maximum : Tohoku regional, Pacific Coast Earthquake, seismic intensity 4.5)
- Response history

1993: Start of service (1996 Toyohama-TN collapse accident)
1996-2000: Survey, Inspection, Committee
2000-2002: Additional countermeasure (ground anchor, rockfall barrier, etc.)
2009-2014: Survey, Committee → Decide on a policy to remove

Construction

- Name: JOSHIN-ETSU Expressway KITANOMAKI Rock Removal Work
- Type of works
(i) Jetty, Stand. Rock shed, Rock bolt
(ii) Excavation, Remove temporary works
- Place: Matsuida Town, Annaka City, Gunma Prefecture
- Period
(i) 21/2/2017~17/9/2023
(ii) 9/2/2023~7/4/2029

Project owner : E-NEXCO Kanto Regional Head Office
Design Consultant : OYO Corporation
Contractor : OBAYASHI Corporation

Topographic and geologic characteristics

The project site is located near Usui Pass on the border between Gunma and Nagano Pref. and consists of bedrock that cuts through steep terrain. This area is composed of hard andesitic breccia formed 5 million years ago at the western edge of the Myogi Caldera, and the rock mass to be removed is situated in an extremely precarious location directly above the entrance to the Kitanomaki Tunnel. Multiple cracks had identified nearly vertically and extending slightly obliquely to the alignment of the expressway in the rock mass on the slope, which has an average gradient of approximately 70°. The rock mass enclosed by these cracks was prone to collapse.

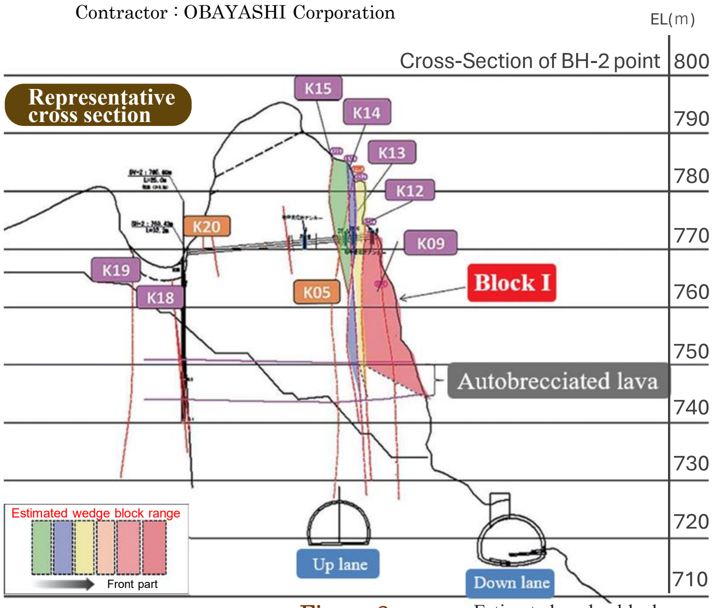


Figure 2 Estimated wedge block

Rock mass removing project plan on steep terrain ～General overview～

To enable rock mass removal work on steep terrain, temporary jetties were installed first(①). To minimize traffic congestion on the expressway, lane restrictions for the transport of large equipment and materials were kept to a minimum, while a 400-meter-long monorail (②) was installed to transport smaller equipment, materials, and workers.

Plan view

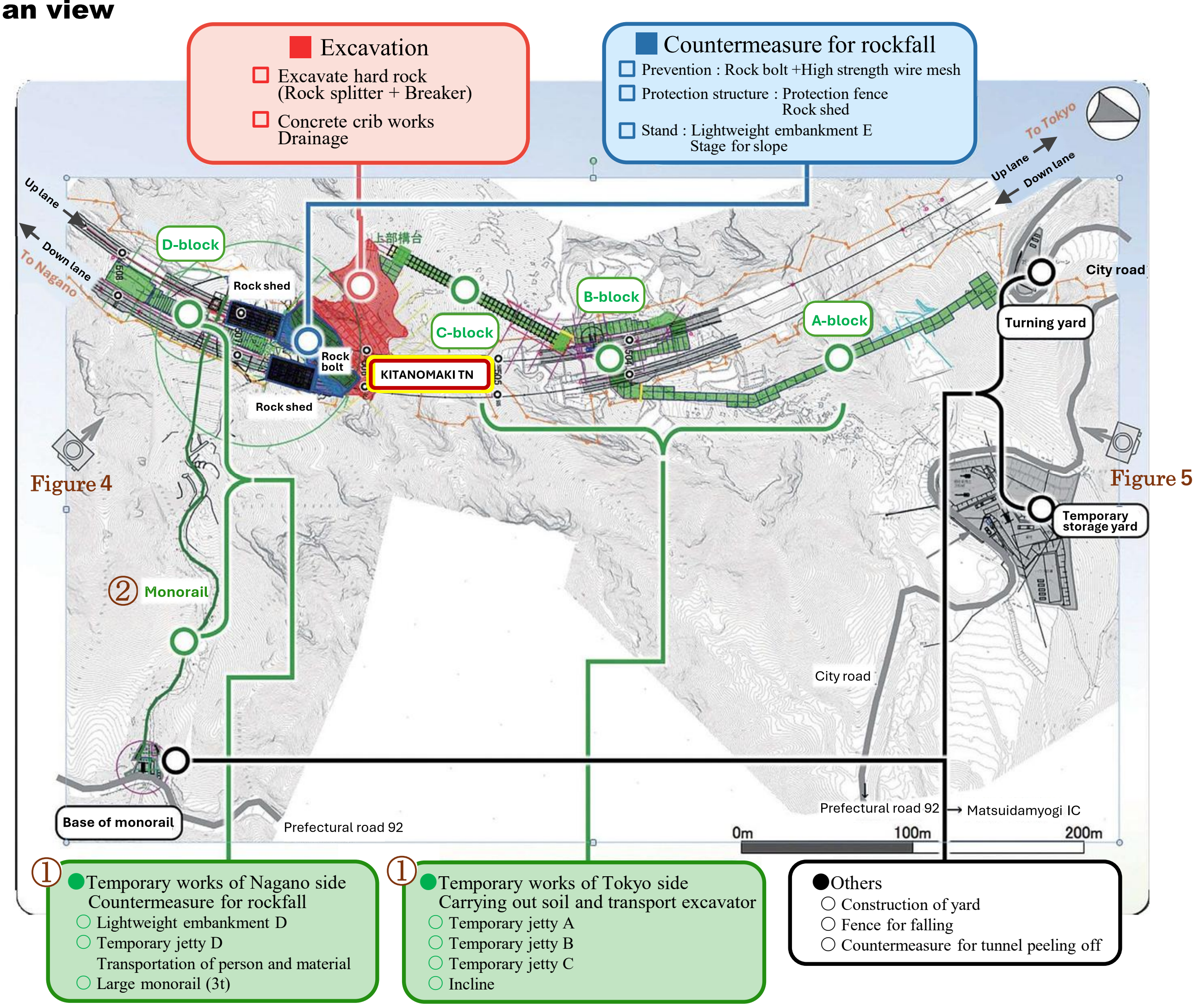


Figure 3

Bird's eye view

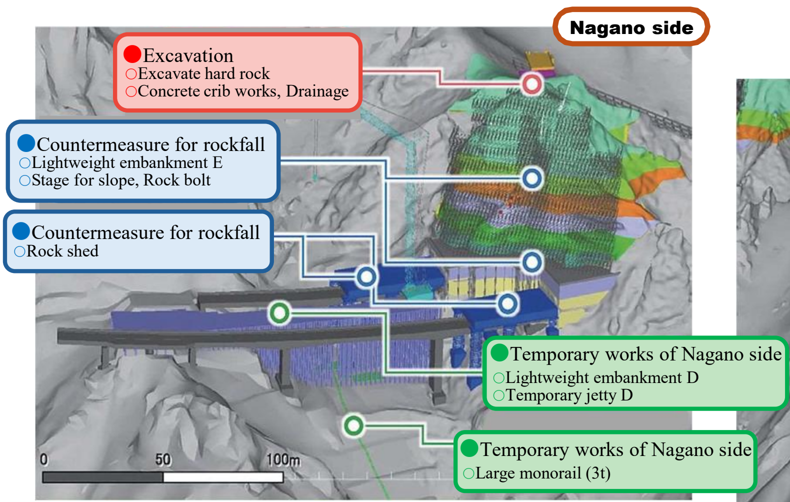


Figure 4

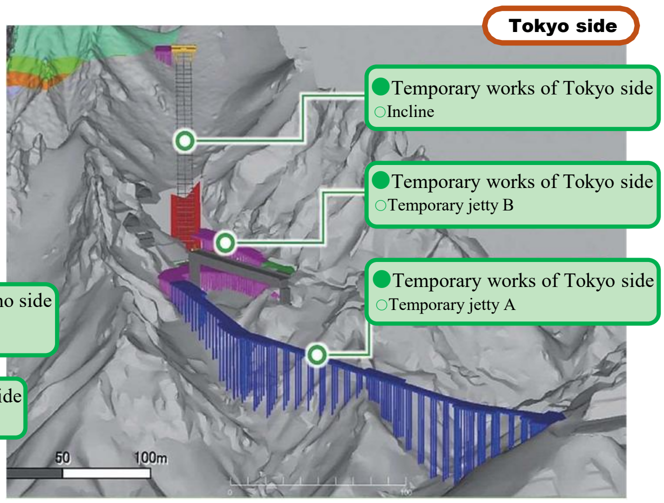


Figure 5

Source: East Nippon Expressway Co., Ltd.

Point of plan

Preventing rockfall

To prevent rockfall during rock removal work, We installed scaffolding extending over 34 levels (approximately 60 meters). Additionally, to prevent rock detachment from the surface, 1,200 rock bolts (3 to 6 meters in length) were installed to stabilize the slope.

1. Prevention structure for rockfall (Figure-6)
   (ⅰ) Rock bolt +High strength wire mesh
2. Protection structure for rockfall (Figure-6)
   (ⅱ) Protection fence (Also serves as a stage)
   (ⅲ) Rock shed (Steal material SAM)
3. Countermeasure for tunnel (Figure-6)
   ★Anti-peeling sheet + Back filling

Countermeasure for rock fall and tunnel

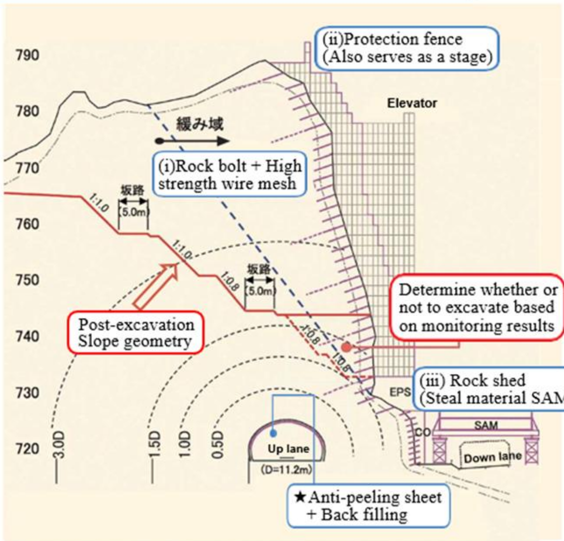


Figure 6. Overview of countermeasure for rockfall and tunnel

Excavation method and rock removal plan

The total volume to be excavated was approximately 95,000m³, the majority of which consists of hard bedrock. To mitigate the impact of flying rock and vibrations on the existing tunnel, a "low-vibration hydraulic rock-splitting method" that does not involve blasting was adopted. The specific process involves drilling holes with a crawler drill, inserting and expanding a three-blade rock-splitting machine, called "Bigger", to create cracks, breaking the rock into smaller pieces with a breaker, and then hauling it away with a crawler dump truck. For hauling, an incline* capable of accommodating the entire dump truck was installed behind the rock blocks to ensure an efficient transport route.

**An incline is a system installed on steep slopes where it is difficult to construct access roads or temporary jetty, enabling the efficient and safe transport of heavy equipment such as construction machinery and dump trucks. Since it minimizes terrain alteration, it is an environmentally friendly construction method. The incline installed at this site covers a 25-degree slope over a distance of 152 meters and is designed to transport loads of up to 80 metric tons. It transports two large dump trucks (40 metric tons each) loaded with excavated soil in 6 minutes and 40 seconds one way. Since the bedrock excavation site was located a top a cliff with no flat ground and a very limited work area, this equipment was installed to improve productivity and shorten the construction schedule.*

To transport materials and equipment via the temporary platform, temporary works and incline shown in Figure 7 were installed.

Temporary work

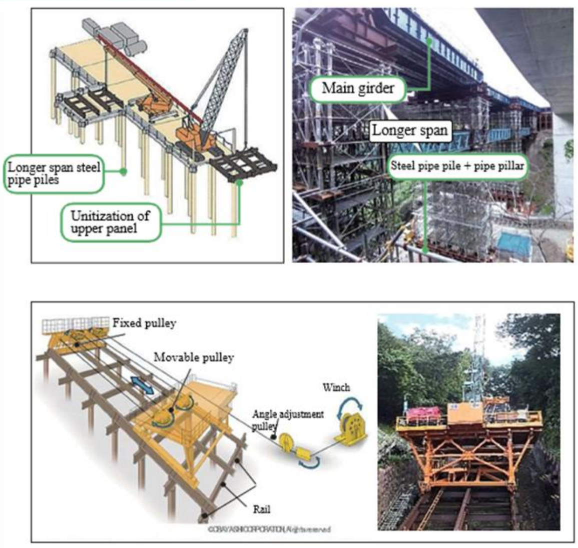


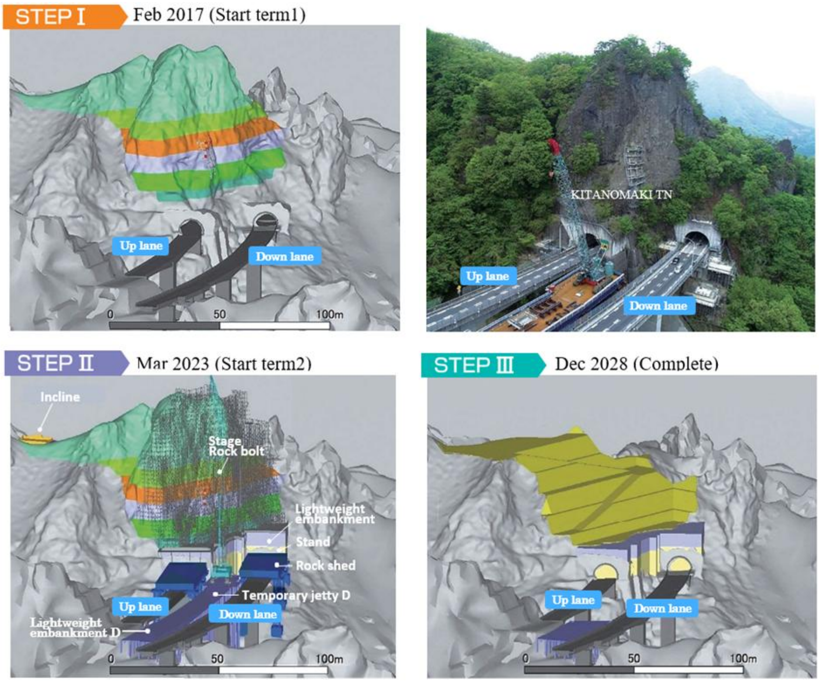
Figure 7. Overview of temporary work & Incline

1. Temporary works to secure access routes for the transport of excavated rock, soil, and equipment using the precast girder method
2. Using an incline to improve the efficiency of heavy-load transport
   → Installed for the transport of large dump trucks loaded with removed rock pieces and soil

Source: East Nippon Expressway Co., Ltd.

Process planning

Work step

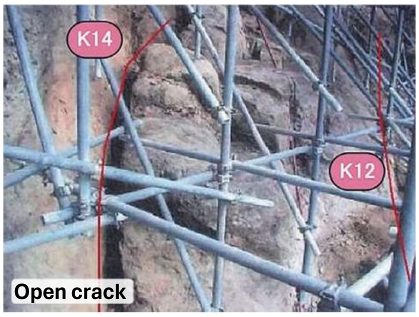


Protection measures for expressway (Installation of rock sheds)

Rock sheds were installed at the tunnel portals on both the upper and lower lanes to protect the expressway from flying rocks during rock removal work. To avoid placing loads on the expressway bridge, these structures were designed as freestanding structures independent of the existing bridge on the expressway.
Construction was carried out during nighttime road closures. After the girders were installed, lightweight expanded polystyrene-which offers excellent shock absorption-was placed as a cushioning material, and the structure was covered with protective sheeting. Although this shed is designed to withstand rockfalls from a height of 70 meters, it cannot withstand a rockfall of up to 2,000 metric tons; therefore, the basic policy was to excavate and remove the boulders themselves.

Topography/geology


Andesite tuff breccia



Open crack


Alteration veins


Autobrecciated lava

Conclusion

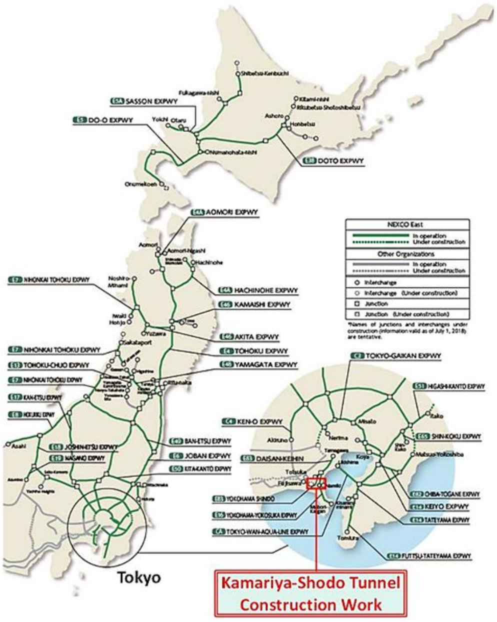
During the course of this rock mass removal project, an unexpected natural rockfall occurred along the monorail route, reaffirming the high risk of rockfalls in that area. In response, we are continuing construction while implementing additional measures, such as installing additional protective barriers. Although this is a long-term project with a construction period of approximately 11 years, we aim to fundamentally improve the safety of the expressway by making full use of the latest civil engineering technologies.

Source: East Nippon Expressway Co., Ltd.

Tunnel Construction Project in Yokohama – Lessons from Large Scale Urban Excavation

PROJECT

This project is a remarkable undertaking showcasing advanced technology of a large scale tunnel directly beneath an urban residential area. It involves the construction of a tunnel approximately 1,200 meters long connecting the Yokohama-Yokosuka Expressway to the Kamariya Junction on the Yokohama Ring Road South Line; it forms part of the Ken-O Expressway (Figure 1). The geological formation consists of tuffaceous sandstone dating from the Pliocene epoch of the Neogene Period to the Pleistocene epoch of the Quaternary Period. Since the tunnel is being constructed at a shallow depth directly beneath a residential area, careful consideration of the surrounding environment was required. Construction was divided into three sections: Section A, Section B, and Section C. Section A involved four closely spaced parallel tunnels; Section B involved an ultra-large-cross-section twin tunnel with a width of 29.5m and a cross-sectional area of 485m² (up to five lanes); and in Section C, a double box culvert was constructed within an NATM tunnel in the shallow section (Figure 2). Excavation of the maximum cross-section in Section B was completed in March 2023, making it one of the world's largest road tunnels constructed using the conventional NATM method (Figure 3).



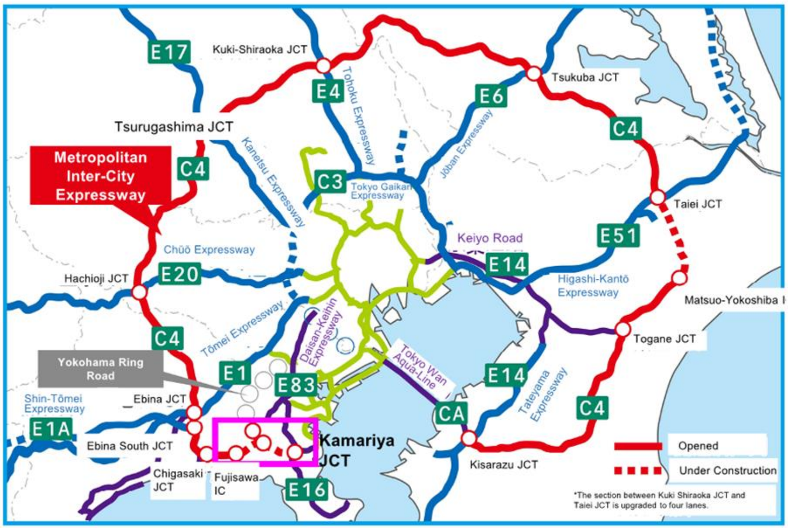


Figure 1. Construction Location

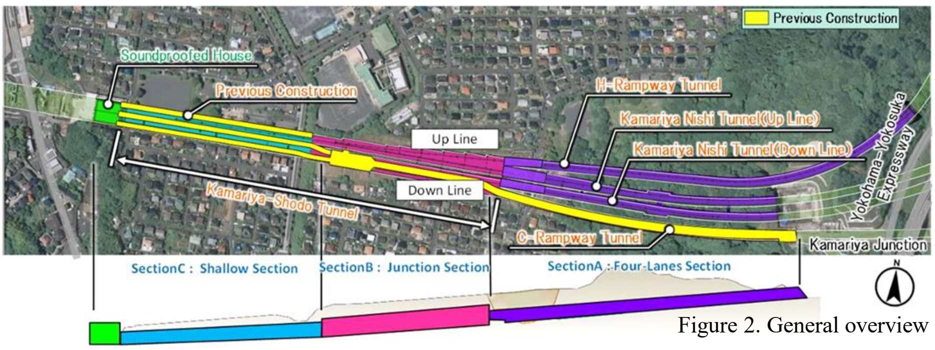


Figure 2. General overview

Figure 3. Completed excavation of ultra-large-cross-section

Source: East Nippon Expressway Co., Ltd.

OVERVIEW OF THE JUNCTION SECTION

Structural Features and Construction Management of the Kamariya-Shodo Tunnel

Section B of the Kamariya-Shodo Tunnel is the junction area where two box culverts, four main lanes, and ramp tunnels branch and merge. The two large section tunnels gradually widen every 20–30 meters, forming ultra-large cross-sections with a maximum width of 29m on the up line and 25m on the down line. The tunnels were constructed extremely close to each other, with only about 1 m of separation. The soil cover was less than one tunnel diameter (7–14m), and the minimum distance to nearby houses was approximately 6m, raising concerns about ground settlement. To ensure safety, pilot tunnels were excavated in both directions to assess geological conditions in advance. Tunnel behavior and support stresses were measured and analyzed to verify construction validity. Double supports were applied in the large section of the up line, and invert supports were used throughout to prevent settlement. The All Ground Fasten (AGF) method was adopted as an auxiliary measure in all sections, achieving stable excavation under challenging urban conditions (Figure 4).

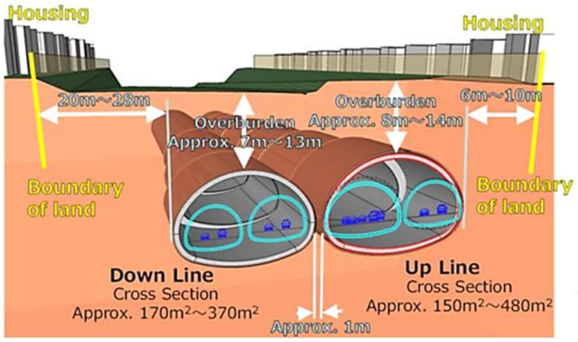


Figure 4. Overview of the junction section

Geological Overview of the Junction Section — Characteristics of the Nojima Formation

As shown in Figure 5, the geology of the junction section mainly consists of tuffaceous sandstone belonging to the Nojima Formation, ranging from the Neogene Pliocene to the Quaternary Pleistocene periods. At the bottom of the four-lane section lies an interbedded zone of sandstone and mudstone, including lenticular layers of pumice-mudstone. The tuffaceous sandstone forms a massive and homogeneous soft-rock layer with few fractures, but its uniaxial compressive strength varies widely-from 1.4 to 5.9 MN/m². Furthermore, as shown in Figure 6, thin layers of pumice and mudstone are interbedded, raising concerns that these could affect tunnel deformation and the stability of the tunnel face. This made the project extremely challenging, requiring meticulous construction planning, construction management, and monitoring.

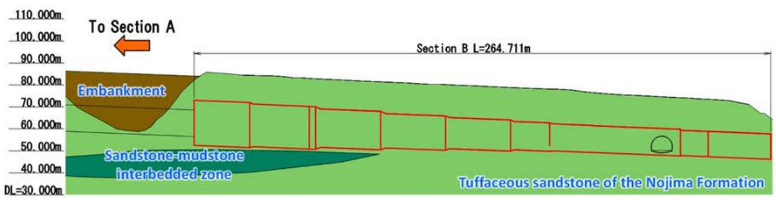


Figure 5. the geology of the junction section

Figure 6. thin layers of pumice and mudstone

CONSTRUCTION METHOD

Excavation Procedure of Section B – Efficient Widening and Closure Techniques

Excavation of Section B was conducted in three stages: entry from the downstream tunnel excavated earlier, excavation of a pilot tunnel from the partially completed section, and widening to the final large cross-section. The excavation sequence was adjusted according to tunnel size. Smaller sections (Dlu-1-K, DULu-5-K) used the early closure method with an auxiliary bench, while larger sections (DULu-4-K to DULu-1-K) applied the short bench-cut method with a temporary upper bench invert. In the upper-half advancing area, upper and lower excavations with primary invert closure were repeated in three stages to shorten closure time (Figure 7).

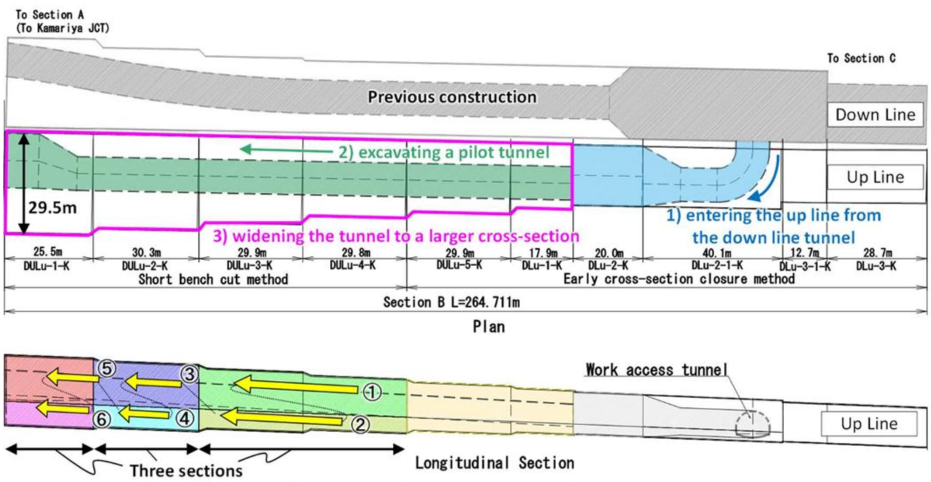


Figure 7. the excavation procedure of the junction section

Source: East Nippon Expressway Co., Ltd.

Machine Selection for Section B – Efficient Excavation with Large Scale Equipment

Due to changes in the heading division, large excavation machinery was introduced to improve efficiency and stability. The upper half of the tunnel base was lowered to the S.L. position, creating a more stable temporary closure shape. Two 1.4m³ twin headers (2,100kg class) were used, one equipped with a two-piece boom (340F) to reach the required height of 12.1m in DULu-1-K. Hydraulic cutters, double-nozzle spraying machines with erectors, and jumbos were installed to accelerate support installation. Mucking was performed using a 25t articulated dump truck and a 4.0m³ wheel loader. To minimize vibration and noise near residential areas, steel frames from the pilot tunnel were carefully removed with a 0.8m³ cutter. Two spraying machines were used simultaneously to shorten concrete spraying time (Figures 8–10).

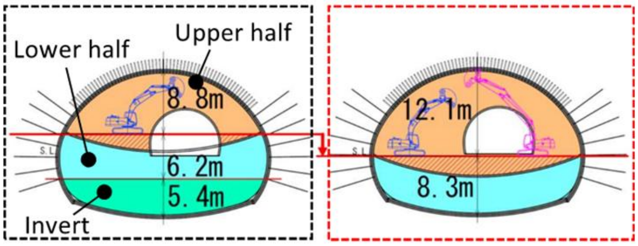


Figure 8. Changes to the division of heading

Figure 9. Upper half excavation

Figure 10. Upper half spraying

Erection of Large Section Steel Arch Supports – Enhancing Efficiency and Rigidity in Tunnel Construction

The upper half steel arch supports were installed using two double-nozzle spraying machines equipped with erectors. The supports were divided into four segments, allowing four booms to operate simultaneously. To accommodate the new cross-sectional shape, the erectors were improved by extending each boom by 3.6m, adding sliding catches, and arranging the booms symmetrically (Figure 11). The erection process began by moving the four segments to the tunnel face, pre-bolting all joint plates except the center, then connecting and securing the two arch halves with bolts. To prevent downward bending at the crown, the number of shoulder bolts was increased from two to four, improving overall rigidity (Figure 12).

Figure 11. Erection of the upper half steel arch support

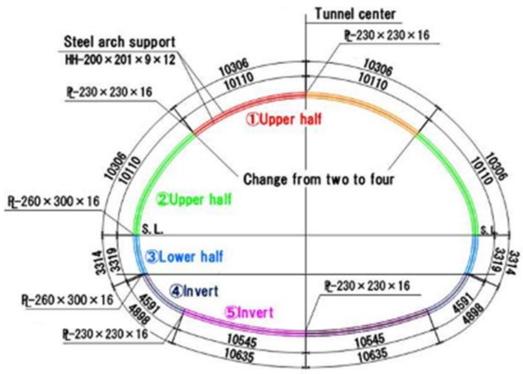


Figure 12. Steel arch support dia-gram (DULu-1-K)

Combined Construction of the Lower and Primary Invert – Streamlining Excavation and Support Installation

In the upper half excavation section, the removal of the temporary invert, excavation of the lower half and primary (permanent) invert, and installation of supports were performed as a combined operation to shorten the time required for reopening the ground. Two large cutting machines excavated down to the invert base (Figure 13). The six-piece support and invert frame were transported from the outside storage area to the tunnel face using a 10t flatbed truck. Each half was assembled near the face and lifted into position with a 4.9t crawler crane, then connected to the upper support (Figure 14). This integrated approach improved efficiency and stability in large-section tunnel construction.

Source: East Nippon Expressway Co., Ltd.

Figure 13. Excavation of the lower half and primary invert

Figure 14. Erection of the lower half and primary invert support

CONSIDERATIONS FOR THE NEIGHBORHOOD AND SAFETY MEASURES

Minimizing Vibration Impact – Environmental Considerations and Safety Measures in Tunnel

In the junction section, where the soil cover was less than 1D, vibration control was a key concern due to the large cross-section size and proximity to residential areas. The AGF method (L = 12.5m, φ 114.3) was adopted for forepoling, and a newly developed non-impact drilling bit was introduced to reduce vibration. Unlike conventional bits driven by blows, the non-impact bit uses rotational force only, significantly minimizing vibration. Measurements showed vibration levels around 55 dB, compared to 60dB in previous projects. A total of 933 AGF pipes were installed without impact, completing the work smoothly and without complaints from nearby residents. The same non-impact bits were also used for rock bolts, further reducing environmental disturbance (Figures 15 and Table 1).

Table 1 Results of vibration measurement during AGF construction.

Measurement position	AM8:00 - PM7:00		PM7:00 - AM8:00	
	Max	Ave	Max	Ave
Above the tunnel	55.3	47.6	51.8	43.0
Boundary of land	36.9	28.0	31.7	20.1

(Units:dB)

Figure 15. AGF drilling bits

Safety Measures – Divided Excavation of the Upper Half

The upper half of Section B required excavation of a large 275m² cross-section, for which two 2,100kg twin-header machines were used. However, the 4–5 hour excavation cycle created a risk of face weathering and potential collapse before spraying could be applied. Past experience in similar geology showed that face stability could be maintained for approximately two hours. Based on this, the upper half was excavated in two stages, allowing face spraying to be completed within the two-hour stability window and significantly reducing collapse risk. In addition, photo-image analysis was introduced to quantitatively assess cracking and weathering at the tunnel face, enabling engineers to determine the appropriate spraying thickness and further enhance safety (Figure 16).

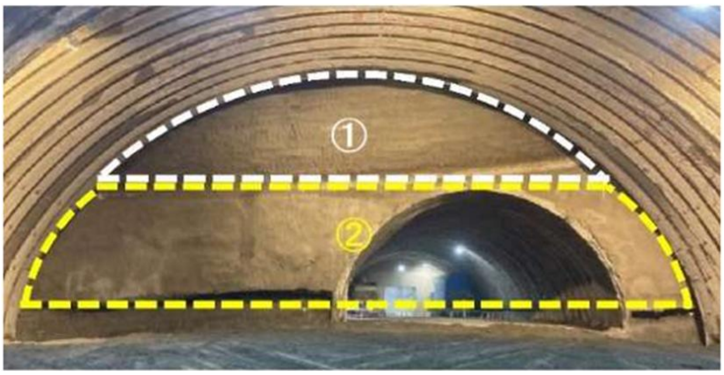


Figure 16. Excavation of the upper half divided in two stages

Safety Measures for Large Cross-Sectional Excavation

In Section B, the upper face reached a height of approximately 12m, making direct visual confirmation of geological conditions difficult. To address this, a Skydio drone capable of safe indoor flight and live streaming was introduced. The drone captured close-range images of the excavation face, which were monitored both on-site and remotely via smartphones or the safety support room. To further restrict unnecessary access near the face, danger signs were projected onto the upper face, and a red laser line clearly marked hazardous areas. Given the tunnel's maximum face width of 29m and the presence of multiple large machines, conventional one-person monitoring was deemed insufficient. The monitoring team was therefore increased to two workers to ensure full coverage. Illumination was also enhanced by installing seven rows of LED tunnel lights per section, securing a target illuminance of 300 lx at the face. Ventilation relied on a tip-dust-collection system using the pilot tunnel, supported by two large dust collectors (1,800m³/min) and wind-gate scaffolding to maintain a clean and safe working environment (Figures 17–21).

Figure 17. Drone photography and monitoring in safety support room

Figure 18. Observation video by drone

Figure 19. Safety measures in the vicinity of the face

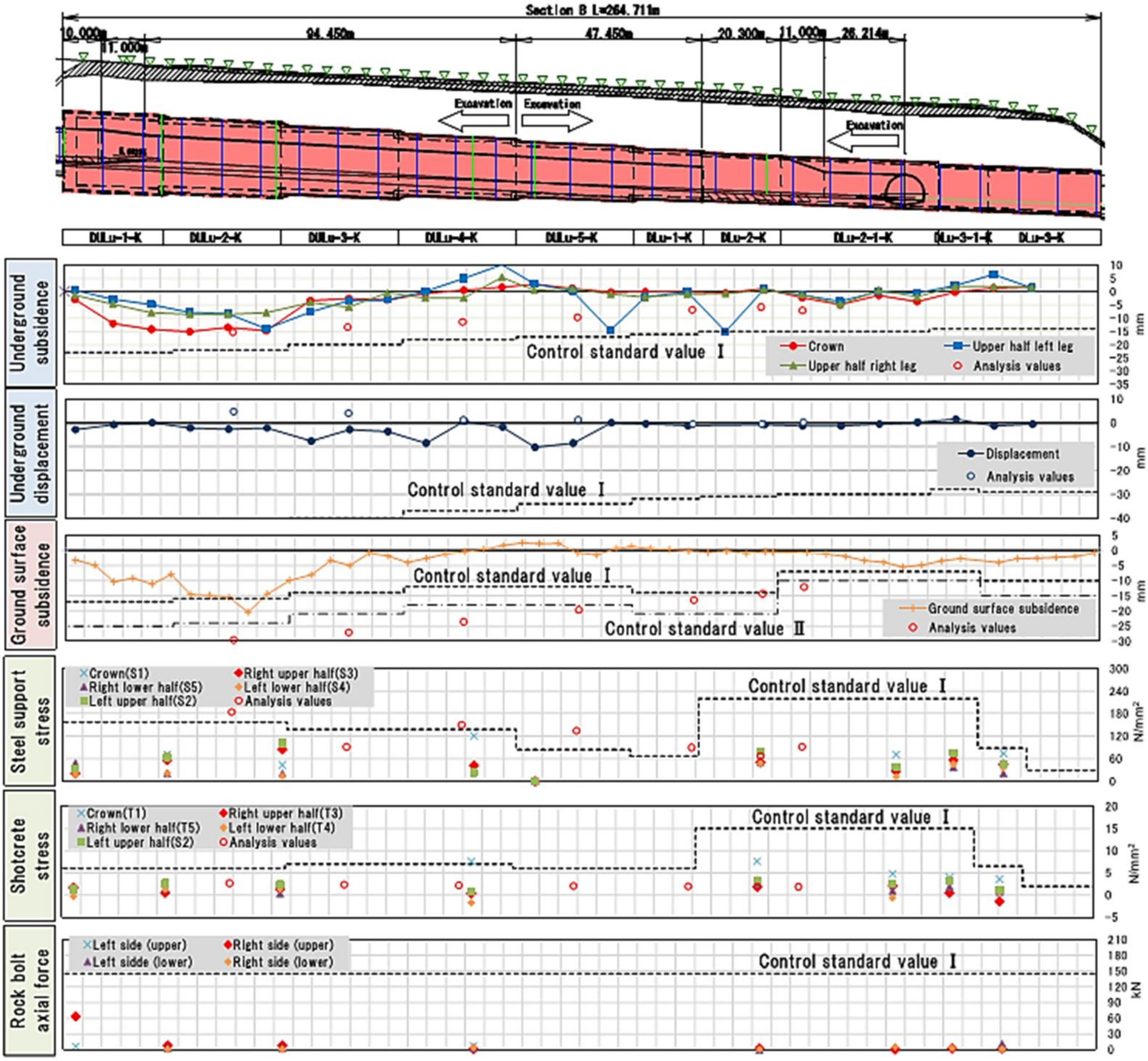
Figure 20. Position of face monitor-ing workers

Figure 21. Tunnel lighting and venti-lation for the large section

MEASUREMENT EVALUATION

Comprehensive monitoring was conducted in Section B to evaluate ground surface subsidence, underground displacement, and stresses on steel supports, shotcrete, and rock bolts. Control standards for each excavation stage were established based on analytical predictions and agreed tolerances from the design phase. During the up-line excavation, allowable displacement values were adjusted using the ratio of measured to predicted final displacement, enabling proactive management anticipating future changes. The management levels are defined as the percentage of the calculated permissible value: 50% for Standard I and 75% for Standard II. At completion, measured subsidence, displacement, and support stress remained below Standard I, and even the DULu-2-K section-where Standard I was exceeded-stayed within Standard II. All results were equal to or less than analytical predictions, confirming stable behavior within the expected range.

Source: East Nippon Expressway Co., Ltd.



CONCLUSION

In the upbound tunnel of Section B, which has the largest excavation cross-section, we implemented construction techniques such as adjusting excavation zones, optimizing the placement of construction equipment, and closing the cross-section early at each stage to minimize the impact on the surrounding residential areas. As a result, construction of the upbound tunnel-which features an extra-large cross-section was completed safely and smoothly. Control standards were established for each stage, and continuous monitoring confirmed that excavation behavior remained within or below predicted analytical values. This achievement provides valuable reference data for future planning of large-scale, wide-section road tunnels and projects under special conditions. Looking ahead, excavation of an unprecedented large twin tunnel with a minimum separation of 1m is scheduled.

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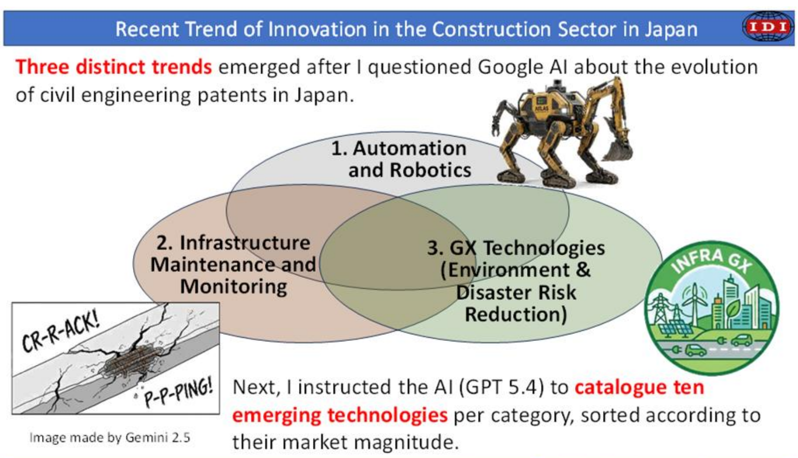
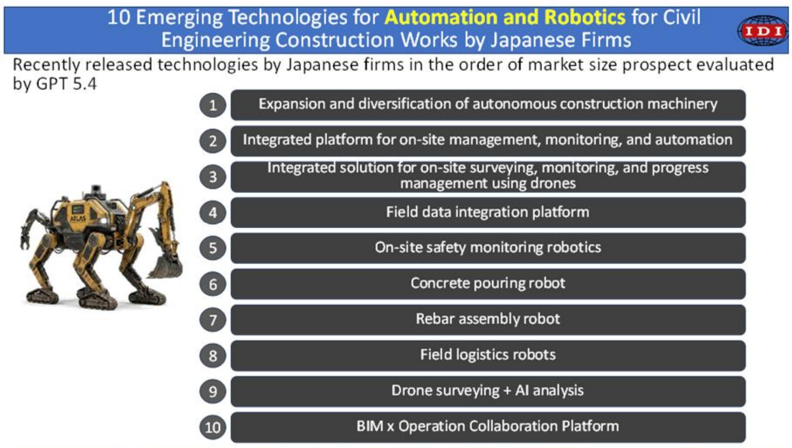
Source: East Nippon Expressway Co., Ltd.

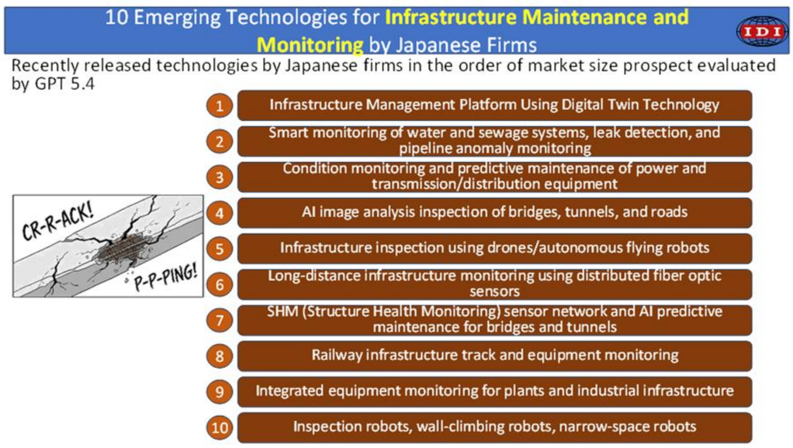
Japan Construction & Construction Machinery Forum

by Goro Yasuda (IDI President)

Japan Construction & Construction Machinery Forum 2026 was held in Istanbul on 2nd June, 2026. The Forum was one of the events in KOMATEC 2026 (18th International Construction Machinery, Technology and Equipment Trade Fair). Four speakers from Japan including Goro Yasuda, the President of IDI were invited to make presentations in front of the audience including the board members of CECE (Committee for European Construction Equipment). Three slides in the right and one in the top of the next page shows a portion of the presentation. It analyzes recent trends in patents filed by Japanese companies in the construction sector using AI. Three trends were extracted: "Automation and Robotics," "Infrastructure Monitoring and Measurement," and "GX Technology (Environment and Disaster Prevention)." For each trend, the top 10 were ranked in order of "expected market size". In addition to these materials, Goro presented the latest Japanese technologies, focusing on those developed by IHI Infra-square Co., Ltd., which operates bridge-related businesses in Turkey.







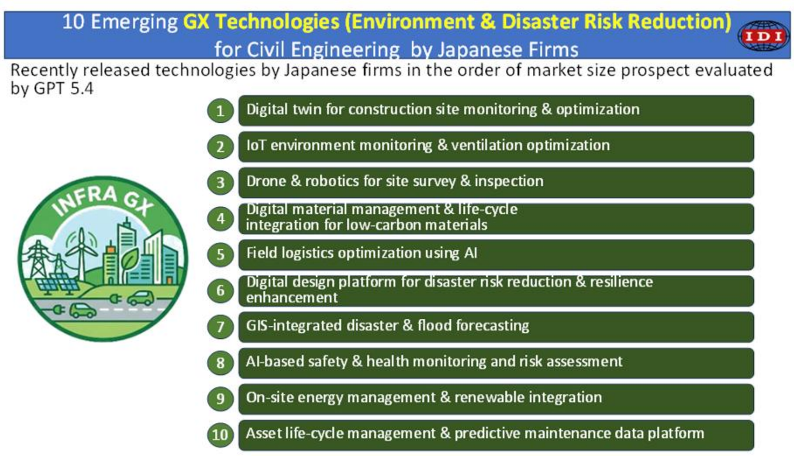


Photo 1. Presentation by IDI

Photo 2. Invited speakers, distinguished guests and organizers

Photo 3. KOMATEK's Entrance

Photo 4. Indoor Exhibition

About IDI and IDI Newsletter

Infrastructure Development Institute-Japan (IDI) is a general incorporated association operating under the guidance of Ministry of Land, Infrastructure, Transport and Tourism of Japanese Government.
IDI provides consulting services to facilitate international assistance to developing countries, to promote international exchange of information and human resources, and to support globalization of project implementation systems targeting both developed and developing countries in the field of infrastructure.

IDI has been publishing a free quarterly journal called "IDI Newsletter" since1996 to introduce information related to public works and construction technologies developed in Japan, to foreign countries. We have distributed the journal to administration officials in more than 80 countries around the world via e-mail.

It will be highly appreciated if you could send us your opinions, impressions, etc. regarding the articles. We also welcome your specific requests regrading technologies you would like to see on following Newsletter issues.

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