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Infrastructure Development Institute—JAPAN

CONTENTS

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26th Infrastructure Technology Development Award 2024

Japan Institute of Country-ology and Engineering (JICE) was established as a public interest corporation to promote construction engineering in Japan by conducting cutting-edge research and development activities.

JICE is performing the Infrastructure Technology Development Award with the Center for Coastal Development Technology (CDIT), with the support of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT).

This Award recognizes outstanding new technologies related to the construction industry, with the aim of increasing the motivation for research and development among technology developers and improving the level of construction technology.

In principle, the applicants' technologies should have been developed within the past five years and applied to the real sites already.

27 technologies competed for the 26th Infrastructure Technology Development Award.

As a result of examination, researchers and representative of the applicant with the following technologies were awarded 26th prizes.

At the 26th Infrastructure Technology Development Awards, no technology won the Grand Prize.

And the three excellence prizes were "Dismantling Launching Girders in Locations Where Heavy Machinery Cannot Be Used", "Automatic Operation System for Ground Improvement Construction Machinery", and "High durability and ultra-low noise pavement (HDULNP)".

These technologies are introduced sequentially on the following pages.

Any inquiries/ comments please contact to JICE :
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Development of Backward-turning and Self-propelled Girder Dismantling Machine

Dismantling Launching Girders in Locations Where Heavy Machinery Cannot Be Used

1. Contents of the Technology

In the erection of steel bridges, Launching Method is adopted in many cases due to topographic conditions and/or environmental restrictions of the bridges. At the last stage of the launching erection, launching girders would be demolished by using heavy machinery, such as a mobile crane in general. However, in some cases, the mobile crane or other kinds of cranes could not be used due to some reasons, such as environmental issues and topographic conditions. To address such situations, Yokogawa Bridge Corporation (YBC) developed the Backward-turning and Self-propelled Girder Dismantling Machine (hereafter "B.S.G.D.M.") (Photo-1).

Photo-1 B.S.G.D.M. general view

Furthermore, we consider the system is suitable for replacement of main girders in extensive reconstruction / renovation work of bridges, as well as for the erection of new bridge girders in confined spaces. Overview of the technology is as follows.

1) A new method for dismantling launching girders when cranes cannot be used.
2) The launching girders are rotated backward, dismantled one block at a time.
3) The machine transports and removes the dismantled launching girders by moving backward.
4) Removal and transport are completed on the bridge piers without needing temporary platforms. Environmentally friendly, as no temporary platforms are required.

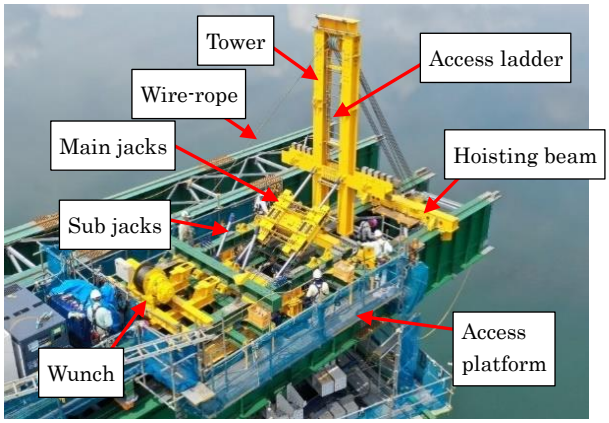

Photo-2 B.S.G.D.M. machine arrangement

The objective of this technology was to develop a launching girder dismantling machine that does not require heavy machinery like cranes. It can rotate launching girders backward, then load them onto itself, and will be a mobile carriage type for carrying them out (Figure-1, Photo-2). Descriptions of the B.S.G.D.M. are as follows.

- Maximum load: 1,600kN (launching girders + lifting beams)
- Width : 2,800mm (c. to c. of launching girders' webs)
- Length : 6,600mm (mobile carriage)
- Main Jack: [Push 500kN, Pull 200kN]x 4sets, Stroke 1,000mm x 2 = 2,000mm
- Sub Jack: [Push 500kN, Pull 200kN]x 2sets, Stroke 1,000mm
- Winch: Direct pull force 3.3t, Wirerope ϕ 20
- Mobile carriage: Cap.500kN, Speed: 20 / 24 m/min (50 / 60HZ)

For power supply by a generator and hydraulic pump placement, a secondary carriage is connected to the tale of the B.S.G.D.M. (Photo-3).

Photo-3 Secondary power supply carriage

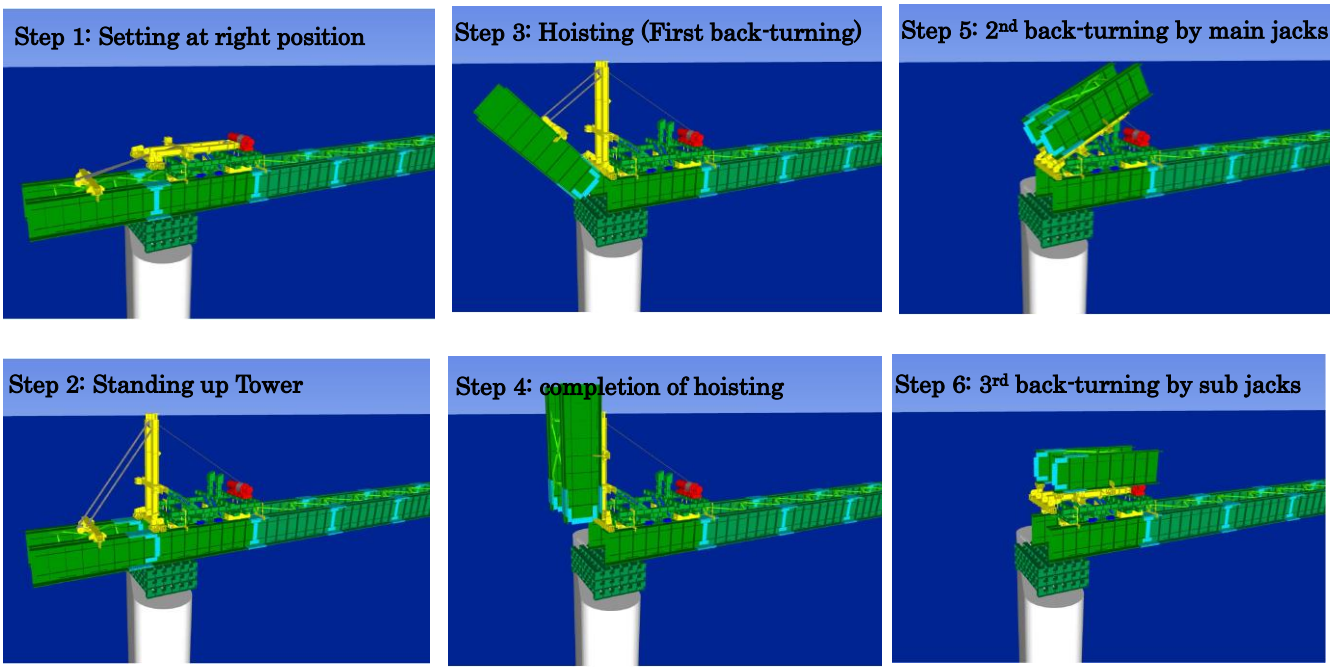

Figure-1 Illustration of Step-by-step operation

For easy replacement of the machine between G1 and G2, the machine is designed to be divisible into two parts as shown in Figure-2.

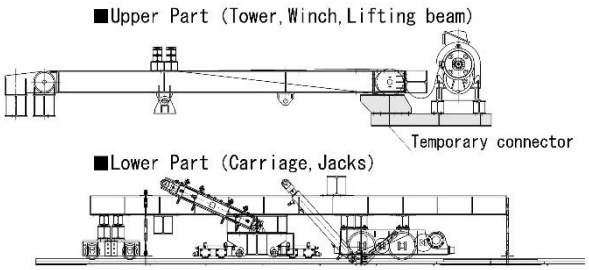

Figure-2 Separation of the B.S.G.D.M.

2. Novelty and Practicality of the Technology

As far as we know, the developed dismantling system is the first technology in Japan. Regarding the practicality of the system, its details are mentioned in section six, in which the actual operation in Shin-Nohbi bridge is introduced.

3. Scope of Application of the Technology

This technology could be applied effectively under the following conditions.

1) It is possible to adopt to nominal launching erection of plate girders or box girdeers using launching girders.
2) In cases where launching girders are diffucult to dismantle because of its' enviromental ristrictions and/or the narrow area for crane operation or other reasons that prevent the use of a crane.
3) As for a extensive reconstruction work of bridges, for example, in city areas, it is applicable for the restoration of main girders even within a very limited area.

4. Effects of the Technology

In cases where launching girders were impossible to be demolished by using a crane, conventionally, other erection methods have been chosen instead of the launching erection method. However, if the technology is applied to such cases, launching erection will be possible. In other words, the technology expanded the applicability and possibility of the launching erection method.

This technology is also an enviromentally friendly dismantling system; for instance, any temporaly structure, such as a temporary piled stage for a crane to dismantle launching girders, is not required, thus reducing the impact on the natural environment.

Secondary we considered the developed method, and improved the machine, which increased the safety working conditions at high places. Workers demolished launching girders

safely, only on the platform attached to the machine, without any dismantling work on the river.

Thirdly, as for the work efficiency, the progress of the demolish work shows that the method is practical, as mentioned in section 6.

5. Social Significance and Development Potential of the Technology

Regarding the social significance, firstly, we consider that an environmentally friendly erection method for launching erection was established, and the alternatives/choices of steel bridges erection schemes were expanded significantly. Furthermore, in cases where yards for dismantling launching girders are too narrow or congested with buildings and/or houses for crane operation, this technology can be adopted.

Secondary, for extensive reconstruction works of old bridges in city areas, currently executed in many cases in Japan, this technology could be applied to restoration of main girders.

Lastly, we think the technology could be deployed overseas in similar launching erection.

6. Track Record of Application of the Technology

The Shin-Nohbi Bridge is located at the boundary of Aichi and Gifu prefectures over the Kiso River. Also, at the phase 1 of the bridge construction, main girders were erected by the launching method. At the last launching of main girders between P5 and A2, launching girders attached to the main girders were dismantled at P5 pier, where a temporally piled stage (access path) for a mobile crane could not be constructed due to the environmentally protected area.

Therefore, the developed B.S.G.D.M. was utilized in the project from April 2022 to May 2022. Phot 4 shows the step-by-step operation of the dismantling launching girders of the bridge. Figure-3 shows the location of the Phase 1 of the Shin Nohbi Bridge construction.

Figure-3 Location of Shin Nohbi Bridge

Photo-4 Step by step photos of the operation

The executed program (Table-1) shows two segments of launching girders, G1 and G2 (main girders), dismantled in three days.

Table-1 Executed Program

Description		First Day		Second Day		Third Day		Remarks
		AM	PM	AM	PM	AM	PM	
Launching(7.2m)							*)	*)Preparation for next launching.
G1 Side	Setting BSGDM							
	Demolishing Launching Girders							Back turning & Mounting on BSGDM
	Move to Yard							Self-propelling backwards
	Disassembling to Parts							
Replace BSGDM (G1[G2]→G2[G1])								
G2 Side	Setting BSGDM							
	Demolishing Launching Girders							
	Move to Yard							
	Disassembling to Parts							
	Preparation for Next Segment							

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Automatic Operation System for Ground Improvement Construction Machinery

1. Contents of the Technology

The "GeoPilot-AutoPile" technology enables the automatic operation of the deep mixing method, one of the ground improvement techniques. The system wirelessly connects construction machinery with the plant yard. A control unit installed on the construction equipment receives real-time information from the plant and adjusts the machinery's operation according to the changing conditions of the ground, including depth.

This control unit manages the slurry flow rate, penetration and withdrawal speeds, to ensure the automated machine operation (Figure-1). The configuration and features of the system are further illustrated in Table-1 and Figure-2.

2. Novelty and Practicality of the Technology

"GeoPilot-AutoPile" represents a breakthrough technology that simplifies operators' tasks by displaying real-time information on parameters such as lifting and motor speeds. The system streamlines operations by allowing operators to control these parameters with a simple touch of the control unit, replacing more complex manual monitoring.

As a fail-safe, sensors such as load cells to detect lifting loads and an emergency stop device have been integrated into the construction machine.

By replicating the movements and decisions of experienced operators, the control unit provides precise instructions, resulting in simplified operation, shorter training periods, consistent quality, and enhanced safety.

3. Scope of Application of the Technology

This technology is applicable to machine-based deep mixing methods, including both large and small equipments (CI-CMC method).

Figure-1 GeoPilot-AutoPile Systems Confliguration Overview

Table-1 Comparison of manual and automatic operation

Stage	Action	GeoPilot-AutoPile
Starting penetration	Transmission of start signal	Clicking start icon
	Activating auger-motor	Automatic
	Penetration of mixing blades	
Discharging cement slurry	Controlling flow rate	
Completion of penetration	Stopping penetration of mixing blades	
	Stopping grout pump	
	Transmission of end signal	Clicking end icon
Tipping process	Pulling up of mixing blades	Automatic
	Penetration of mixing blades	
Withdrawal	Transmission of start signal	Clicking start icon
	Stopping auger-motor	Automatic
	Pulling up of mixing blades	
Completion of withdrawal	Stopping withdrawal	
	Stopping auger-motor	
Completion	Transmission of end signal	Clicking end icon

4. Effects of the Technology

In terms of productivity, the throughput of manual pouring and that of the "GeoPilot-AutoPile" automated pouring are equivalent. However, the automated system offers a more comfortable working environment, as operators can monitor the plant status remotely from the operators' seats, reducing the strain of prolonged high-intensity tasks.

Figure-2 Operation monitor touch screen

Additionally, the system reduces the learning curve for operators by approximately one-third due to the automation of the complex pouring process. As for safety, automatic control helps prevent hazardous situations, such as the accidental entanglement of wire winches, allowing operators to focus more on the surrounding environment. The technology also minimizes material waste caused by human error, contributing to environmental sustainability.

5. Social Significance and Deployability of the Technology

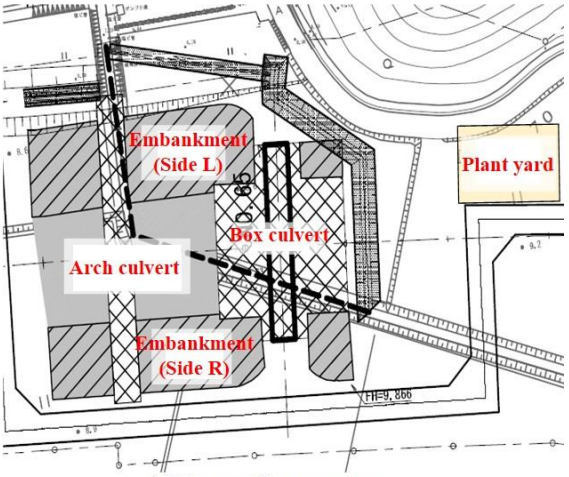
This project holds social significance by addressing the shortage of young engineers in an aging society. By accelerating their training, the system helps pass down the expertise of veteran engineers. In the future, the system's unmanned operation capabilities could allow a single operator to manage multiple construction machines, significantly reducing labor costs.

6. Track Record of Application of the Technology

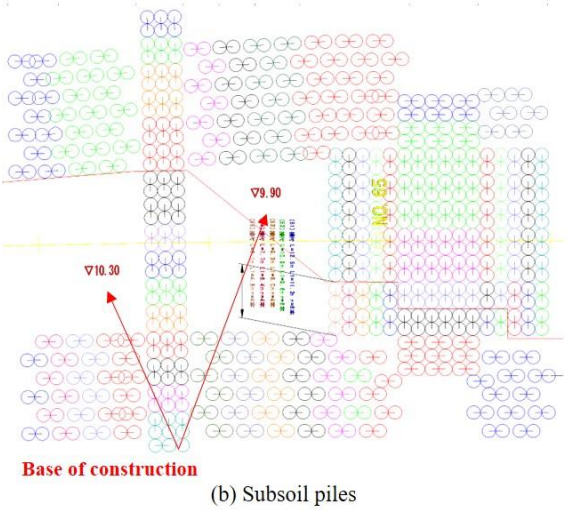
This system was implemented during a ground improvement and culvert construction project in Itako City, Ibaraki Prefecture. Figure-3 shows the ground improvement plan. Before the culvert and embankment were constructed, ground improvement works were conducted. The maximum improvement depth reached 13.3 meters, and the total stabilized soil volume amounted to 16,000 m³. A large construction machine was used due to the need for stabilizing columns to penetrate hard layers (Photo-1).

(1) Construction by automatic operation system

The project site had multi-layered soft ground, consisting of humic soil (Avp), silt (Avc), and sandy soil (Avs). As cement requirements varied between layers, the amount of cement slurry and the construction speed (penetration and withdrawal rates of agitator blades) had to be adjusted for each layer.



(a) Extent of improvement



(b) Subsoil piles

Figure-3 Ground improvement plan

Photo-1 Construction status

GeoPilot-AutoPile automatically adjusted the slurry discharge rate based on changes in construction speed, ensuring consistent ground improvement. Figure-4 illustrates the system's performance during construction, showing that the automated process met the target construction speed and slurry flow rate.

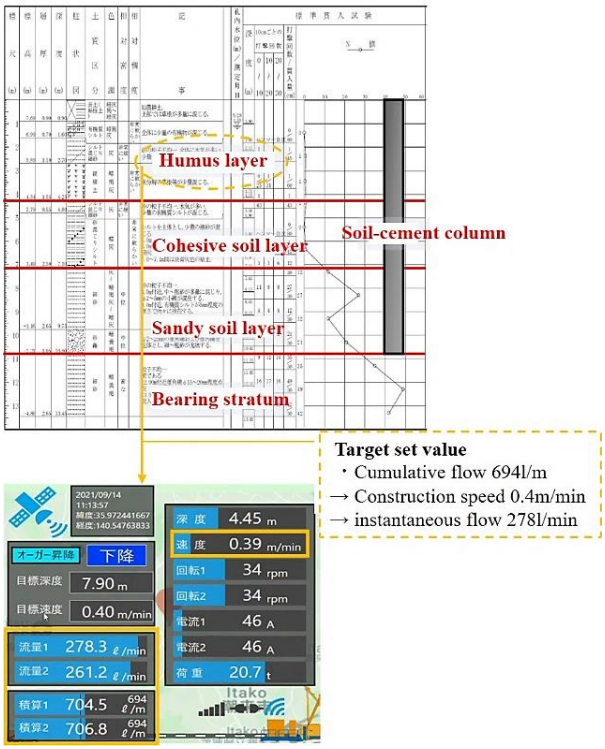


Figure-4 Construction with GeoPilot-AutoPile

(2) Comparison with manual operation system

A comparison between skilled manual operators and GeoPilot-AutoPile was conducted on test piles. The results (Figure-5) show that GeoPilot-AutoPile consistently maintained the target construction speed. In contrast, manual operation resulted in a slightly deeper penetration (by 0.5 meters) and approximately two minutes longer construction time. Despite this, GeoPilot-AutoPile's performance was comparable to that of traditional manual systems.

Table-2 compares the volume of slurry discharged, showing minimal differences, and confirming that the system controlled the grout pumps accurately. Photo-2 displays the excavation of the improved ground, demonstrating high-quality results, regardless of the operator's experience level.

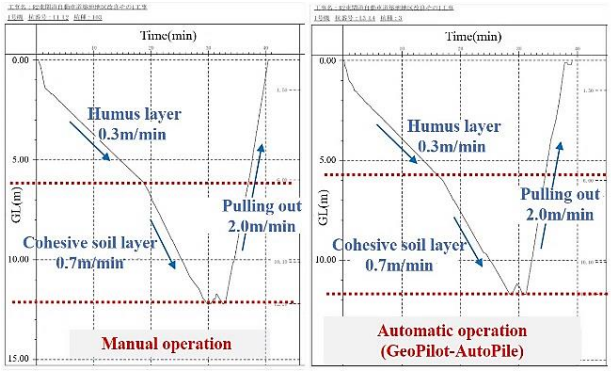


Figure-5 Conparison and automated operation

Table-2 Comparision of slurry discharege rates

Operation system	Manual (L)	Automatic (L)
Target value	6,463.0	6,245.0
Actual value (No.1)	6,851.1	6,845.3
Actual value (No.2)	6,916.5	6,818.9
Ratio	1.07	1.09

Photo-2 Excavation of improved constructed by GeoPilot-AutoPile

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High durability and ultra-low noise pavement (HDULNP)

Development of small-aggregate porous asphalt mixtures

1. Contents of the Technology

Metropolitan Expressway Co., Ltd is in charge of construction, renovation, maintenance, and repairment for urban expressways in Tokyo and its surrounding areas under contract with the national and local governments of Japan. It was established as a public corporation in 1959, privatized in 2005, and continues to operate today.

Nichireki Co., Ltd. has offered a wide range of road pavement materials and methods since its founding in 1943. Its products include modified asphalt, asphalt emulsions, bridge deck waterproofing materials and methods, in-place basecourse recycling methods, and surface treatment methods.

Photo-1 Metropolitan Expressway (Edobashi Junction)

The Metropolitan Expressway is an urban expressway located in the capital of Japan, Tokyo, and its surrounding areas, with a total length of 327 km. The Metropolitan Expressway connects to intercity expressways, and its average number of vehicles per day exceeds 1 million.

For the purpose of driving safety in rainy weather and reducing noise, drainage and low-noise pavement using porous asphalt mixtures (maximum aggregate size 13 mm) has been adopted. However, because of the large amount of air voids, there is a disadvantage that the coarse aggregate is easily scattered in case of heavy traffic roads. If the coarse aggregate is scattered and the road surface becomes rough, the ride comfort and fuel efficiency may decrease, and noise and vibration tend to get worse. Furthermore, if the aggregate scattering progresses and potholes happen to occur, the tires of passing vehicles could be punctured or the aluminum wheels could be damaged. This disadvantage was an issue that should be resolved for drainage and low-noise pavement.

As shown in Photo-1, since the Metropolitan Expressway was built to weave between buildings, its alignment includes many sharp curves, and the buildings are close to the roads. Therefore, it is necessary to ensure driving safety in rainy weather and reduce the noise load on the surrounding environment, so it is desirable for the pavement surface layer to adopt drainage and low noise functions.

2. Novelty and Practicality of the Technology

However, as mentioned above, aggregates of porous asphalt mixtures might scatter and create potholes, which lead to damage passing vehicles. To solve this problem, it was decided that the surface layer thickness was to be thinned from 40 mm to 30 mm, and even if a pothole did form, it was expected that vehicle damage would be avoided by mitigating the impact on tires. In order to thin the layer to 30 mm, it was necessary to reduce the maximum particle size of the coarse aggregate from 13 mm to 5 mm. However, reducing the maximum particle size of the coarse aggregate leads to weaken the aggregate scattering resistance of the mixture.

In order to improve the aggregate scattering resistance of the mixture, it is necessary to increase the amount of modifier (thermoplastic elastomer) added to the binder. However, there is a limit to the amount that can be added because there are restrictions on temperature and viscosity from the viewpoints of ensuring the quality of the binder and the ease of handling during transportation by truck.

As a solution to this problem, by utilizing a material that has not been used before, it has become possible to significantly increase the amount of modifier added while ensuring the

quality and ease of handling of the binder. As a result, a "Damage-resistant small-particle-size porous asphalt mixture" that has overwhelming aggregate scattering resistance, despite reduced maximum particle size of the coarse aggregate from 13 mm to 5 mm, was developed, giving birth to "high-durability ultra-low noise pavement (HDULNP)".

Photo-2 Conventional high-performance pavement (left) and HDULNP (right)

3. Scope of Application of the Technology

Because the material can be applied using standard paving equipment, it can be used not only on expressways but also on the surface of general roads.

Photo-3 HDULNP construction status

4. Effects of the Technology

HDULNP contains a wide range of advantages, including "low fuel consumption", which improves the fuel efficiency of vehicles traveling on it by 4.5%; "low carbon", which reduces CO_2 emissions; "economic efficiency", which extends the replacement cycle and reduces life cycle costs; "ultra-low noise", which reduces road noise by 7.8dB compared to conventional low-noise pavement; "drainage", which suppresses water splashing and hydroplaning; and "safety", which reduces vehicle damage caused by potholes.

Features of HDULNP
Economical: Low fuel consumption,
reduced life cycle costs
Eco-friendly: Ultra-low noise, low carbon
Safety: Reduces splashes, slippage, and potholes

5. Social Significance and Deployability of the Technology

High durability ultra-low noise pavement has superior low noise and fuel efficiency (reduced CO_2 emissions) compared to conventional drainage and low-noise pavement, and also has excellent durability that allows these functions to be maintained for a long period of time.

As Japan moves towards a society with a declining working population, the number of workers engaged in pavement replacement is expected to decrease year by year. However, by adopting this highly durable pavement material on heavy traffic roads nationwide to extend the replacement cycle and reduce the area required for pavement replacement each year, it is possible to respond to the declining working population of the society. In addition, its excellent fuel efficiency reduces the consumption of gasoline and diesel for all vehicles that run on it, and since this fuel efficiency is sustained for a long period of time, it can greatly contribute to the realization of a low-carbon society.

In addition to cars (engines), efforts are also being made to improve fuel efficiency with tires and pavement. According to the Japan Automobile Tire Manufacturers Association, tires are graded into five levels in order of lowest rolling resistance and best fuel economy as follows: AAA, AA, A, B, and C; with AAA, AA, and A being fuel-efficient tires, and B and C being non-fuel-efficient tires. As fuel efficiency improves by 1% for each grade increase, replacing a C tire with an AAA can improve fuel efficiency by 4%. This technology of HDULNP has improved fuel efficiency by 4.5% compared to conventional drainage and low-noise pavement, so it can improve fuel efficiency even more than efforts of tire development.

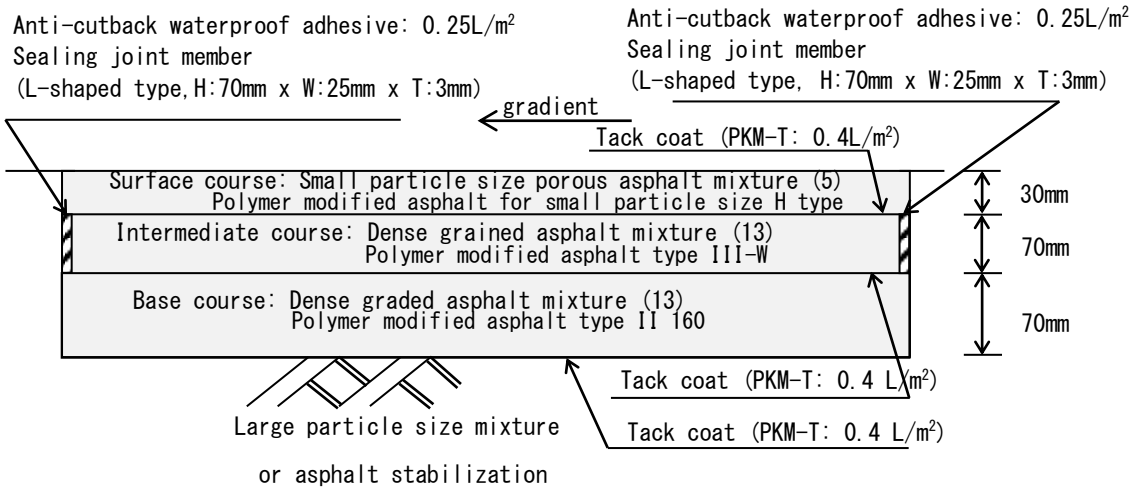

Figure-1 Pavement structure of the Metropolitan Expressway's earthwork section

Table-1 Comparison of vehicle fuel economy with conventional pavement

Type of Mixture	Fuel economy (At the beginning of operation)
Drainage and low noise pavement (Conventional porous AS mixture)	13.4km/L
HDULNP (Small-aggregate porous AS mixture)	14.0 km/L (4.5% improvement)

6. Track Record of Application of the Technology

The Metropolitan Expressway plans to use this material on 4.65 million m² (73%) of the total pavement area of 6.35 million m² of the Metropolitan Expressway, excluding tunnel sections, and has currently adopted this material on 2.08 million m² (33%). In addition to the Metropolitan Expressway, the East Nippon Expressway has also adopted this material.

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About IDI and IDI-quarterly

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 Quarterly” 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 90 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 Quarterly issues.

For various reasons, IDI Quarterly will cease publication for the time being.
We apologize to all our readers and would appreciate your understanding.