Next Stage : Space

المرحلة التالية : الفضاء

The technology of Kajima Corporation is now reaching for the moon. Joint research and development between Kajima and JAXA began in 2016. The purpose of the joint project is to develop an unmanned remote construction system for constructing space bases in locations as distant as the moon or Mars. In order to construct under the harsh conditions of outer space, only the machine goes into space. This will enable construction in space by remote control from Earth and the automatic operation of the construction machine. It is no longer just a fantasy to finish a space base on the moon, or even farther on Mars, by the mid-century. This is because there is technology that has already been put into practical use here on Earth. Kajima's next generation construction system "A⁴CSEL" allows a human to send instructions via tablet terminal to multiple construction machines that operate automatically.

Technology that was born to enable work at a dangerous site where humans cannot go and to solve the serious shortage of workers at the construction site future is opening up the possibilities of utilization in the space. All construction sites will eventually become automated. Therefore, it is not surprising that the next stage may be in space. Kajima can see the next worksite as the company gazes at the stars.

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Road maintenance and management improvement technique

~ Upgrading of Existing Bridge Decks Using Ultra High Strength Fiber Reinforced Concrete ~

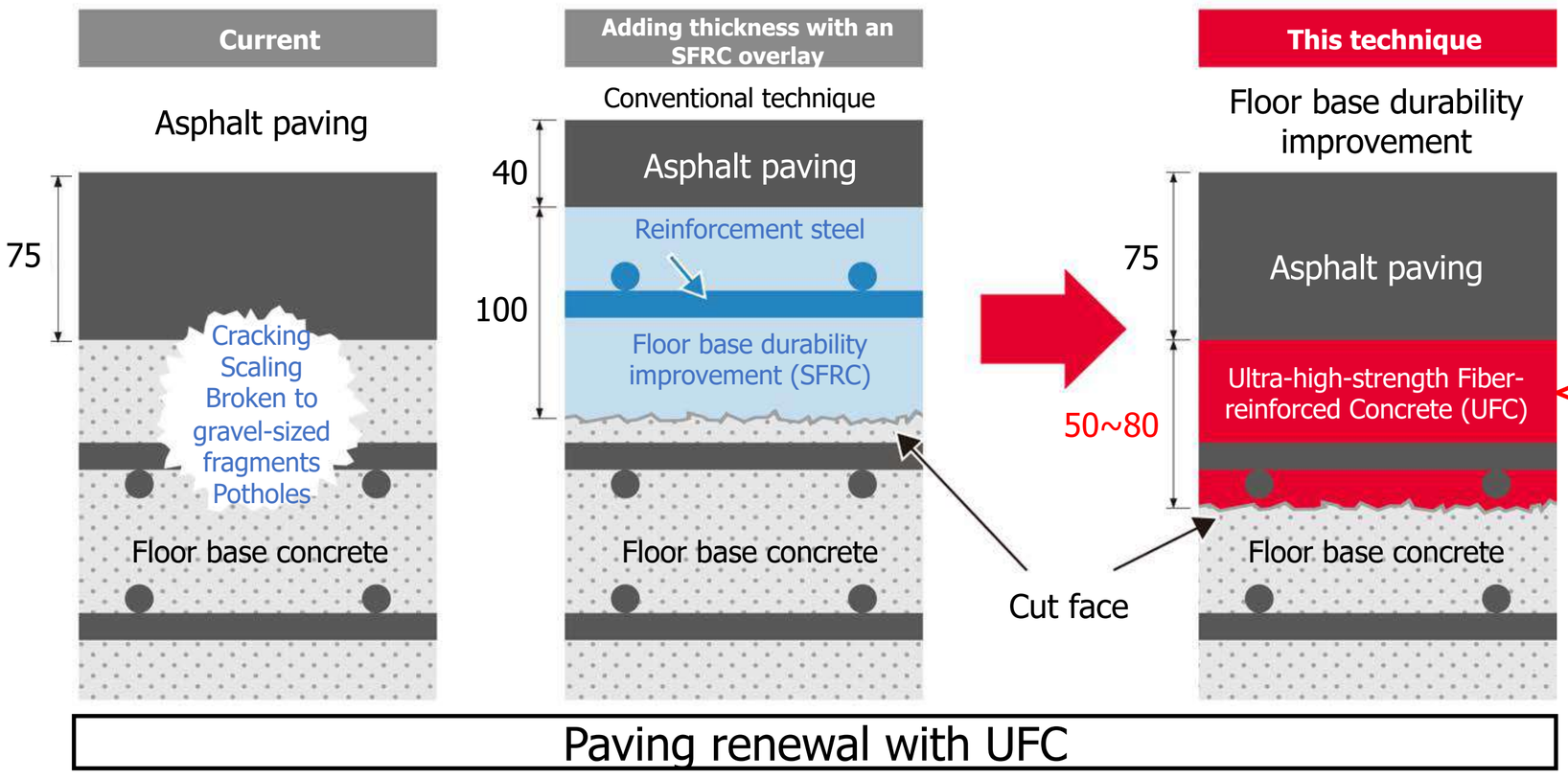
تكنولوجيا تجديد إدارة صيانة الطرق

~ تحسين أسطح الجسور الحالية باستعمال الخرسانة المسلحة بالألياف عالية الصلابة ~

Jointly developed by Central Nippon Expressway and Kajima Corporation

Repair and reinforcement technique to improve the load bearing capacity and durability of the road bridge floor base

Ultra-high-strength Fiber-reinforced Concrete (UFC) offers excellent durability and strength characteristics to allow the top of the existing floor base of a road bridge to be replaced in a thin layer. The technique drastically improves floor base loading bearing capacity and durability, contributing to a long-term maintenance cost reduction.



Reinforcing steel fiber

Features

Sophisticated UFC technique allows reinforcement without changing the design cross section

High material density drastically improves floor base durability

150 Mpa class ultra-high strength achieved without special heat curing on the site

Fluidity is flexibly adjustable according to reinforcement bar arrangement and lateral and longitudinal inclinations of the existing floor base

Load bearing capacity and fatigue resistance evaluation of UFC-repaired/reinforced floor base by dynamic wheel loading test

Dynamic wheel loading test

Construction test

Test construction with a dedicated finisher

UFC cast over a simulated existing floor base and cured on site

Mixing steel fiber into the concrete mix

Construction by machine

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Road maintenance and management improvement technique

~ Prestressed Concrete Tendon Tension Monitoring System with Optical Fiber Sensor ~

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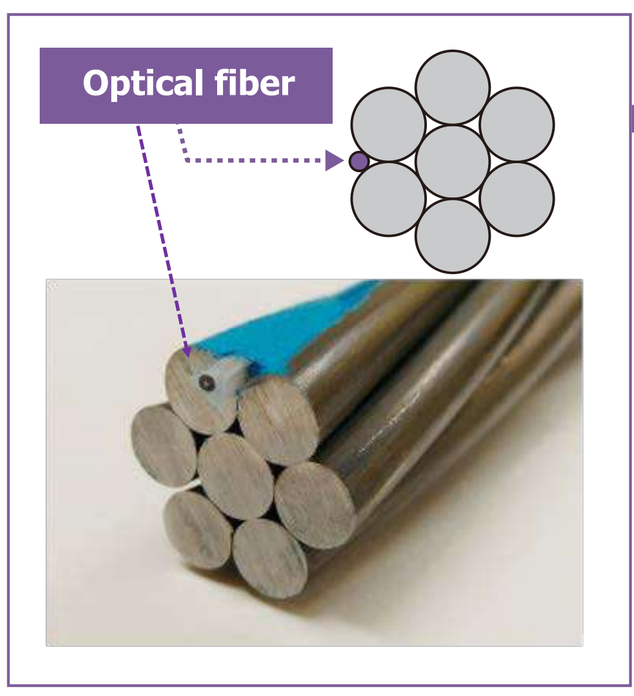
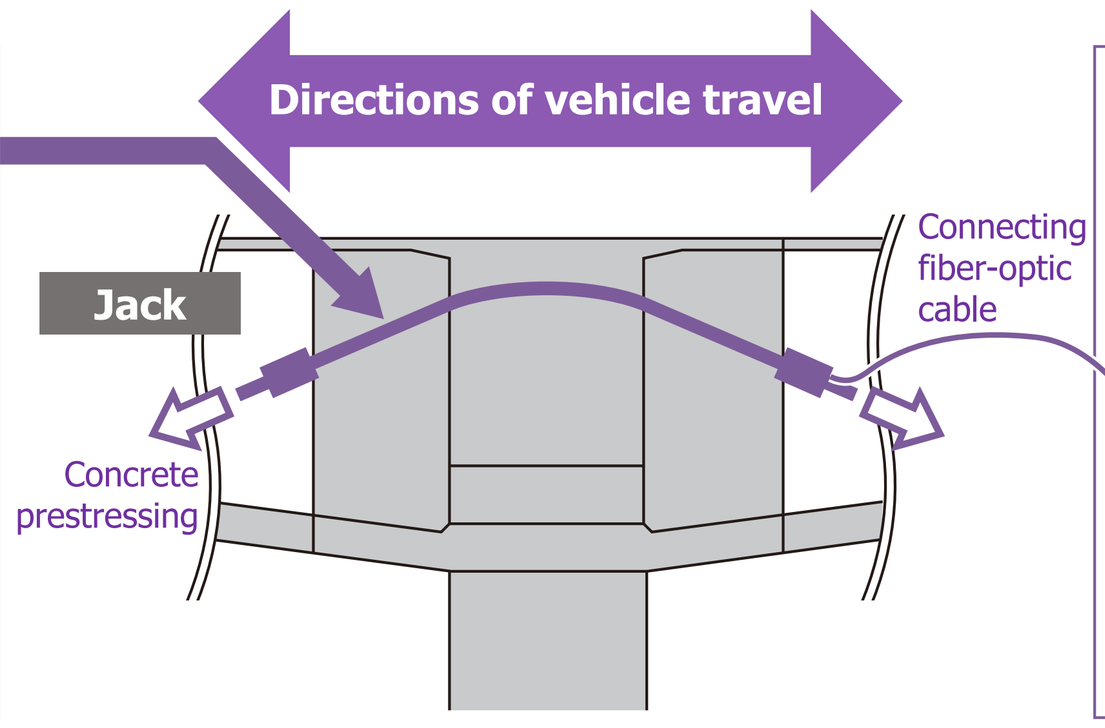
~ نظام مراقبة شد الخرسانة مسبقة الإجهاد المزود بمستشعر الألياف البصرية ~

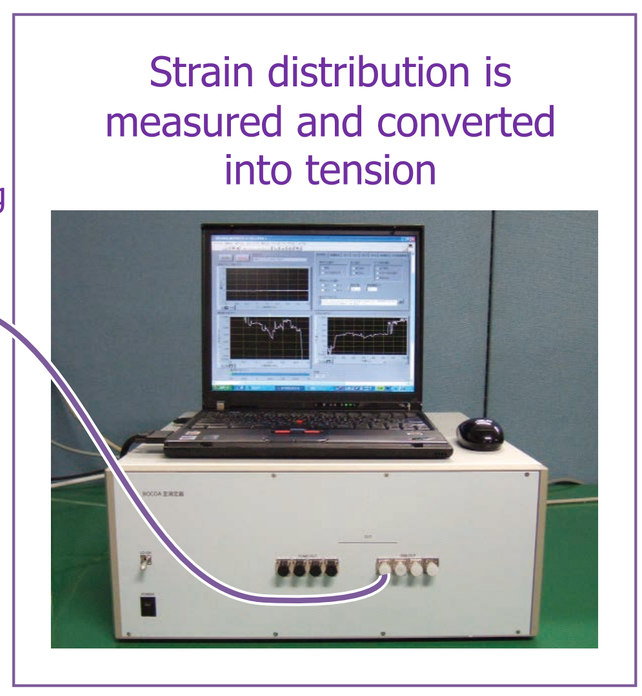
Optical fiber-embedded steel strand in prestressed concrete can monitor distributed tension force along the whole length of strand. This technique does not only assists construction management of prestressed concrete structures, but also improves effectiveness and efficiency of road maintenance after construction.



Optical fiber-embedded steel strand



Side view of a bridge pier



Measurement unit

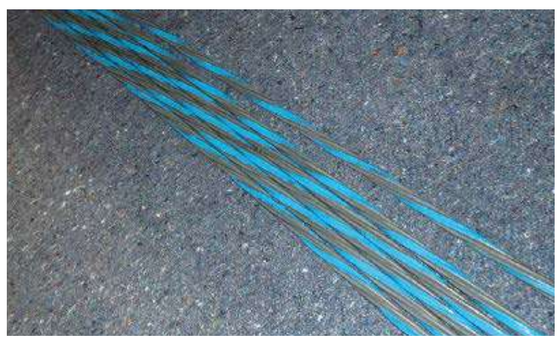
■ Strain distribution can be measured along the whole length of strand when prestressing.

■ Re-measurement can be made any time afterward, thus the technique is also helpful for maintenance.

■ Optical fibers' chemical stability contribute to long-term durability. The technique has an over 20 years of successful implementation record in other industries.

■ Optical fibers are embedded in the factory so that the strand can be handled in the same way as normal strand wires on the construction site.

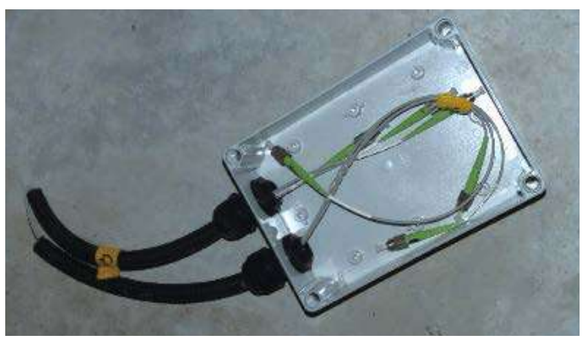
■ Use of typical communication optical fiber.



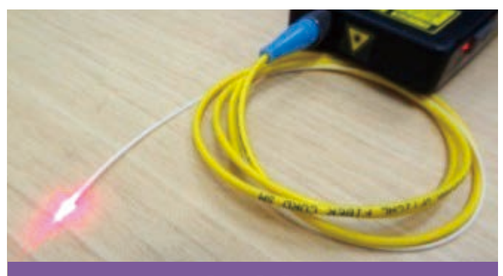
1 Optical fiber-embedded strand

2 Prestressing

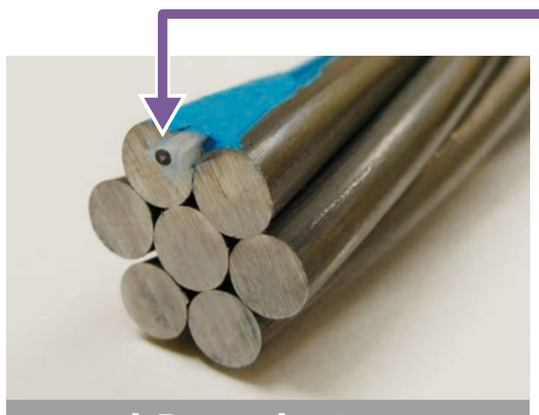
3 Measurement



4 Optical connectors for re-measurement (in the girder)

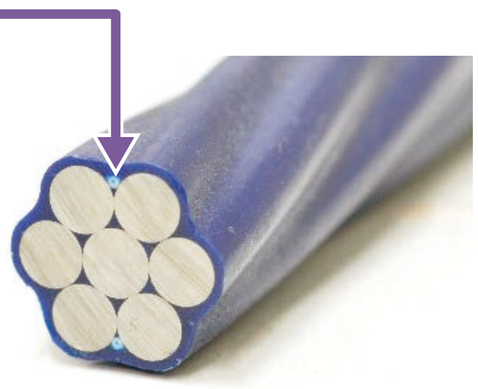


Optical fibers



a) Bare wire type

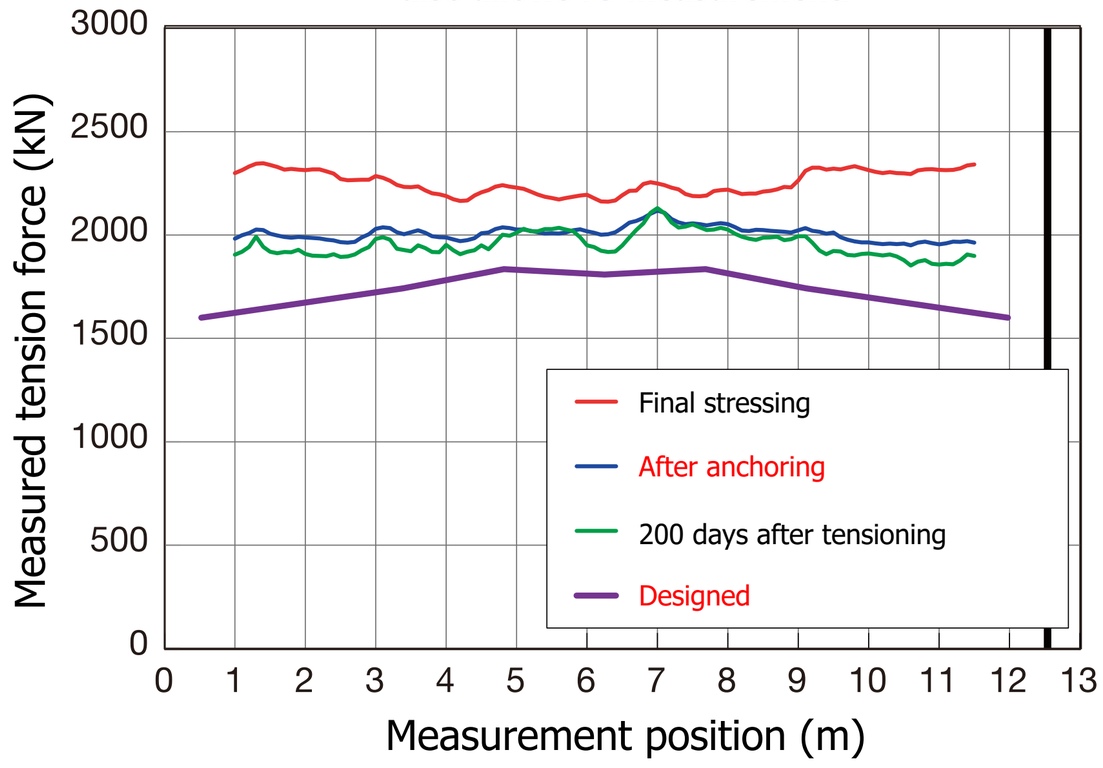
Glued along the gap of the strand



b) ECF type

Optical fiber embedded in epoxy coating (along the gap of the strand)

It has been verified that the technique is capable of supporting greater tension force than designed force and also allows re-measurement.



This system has been jointly developed by Sumitomo Electric Industries, Hien Electric Industries and Kajima Corporation.

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Road maintenance and management improvement technique

~ Ground Anchor Tension Monitoring System with Optical Fiber Sensor ~

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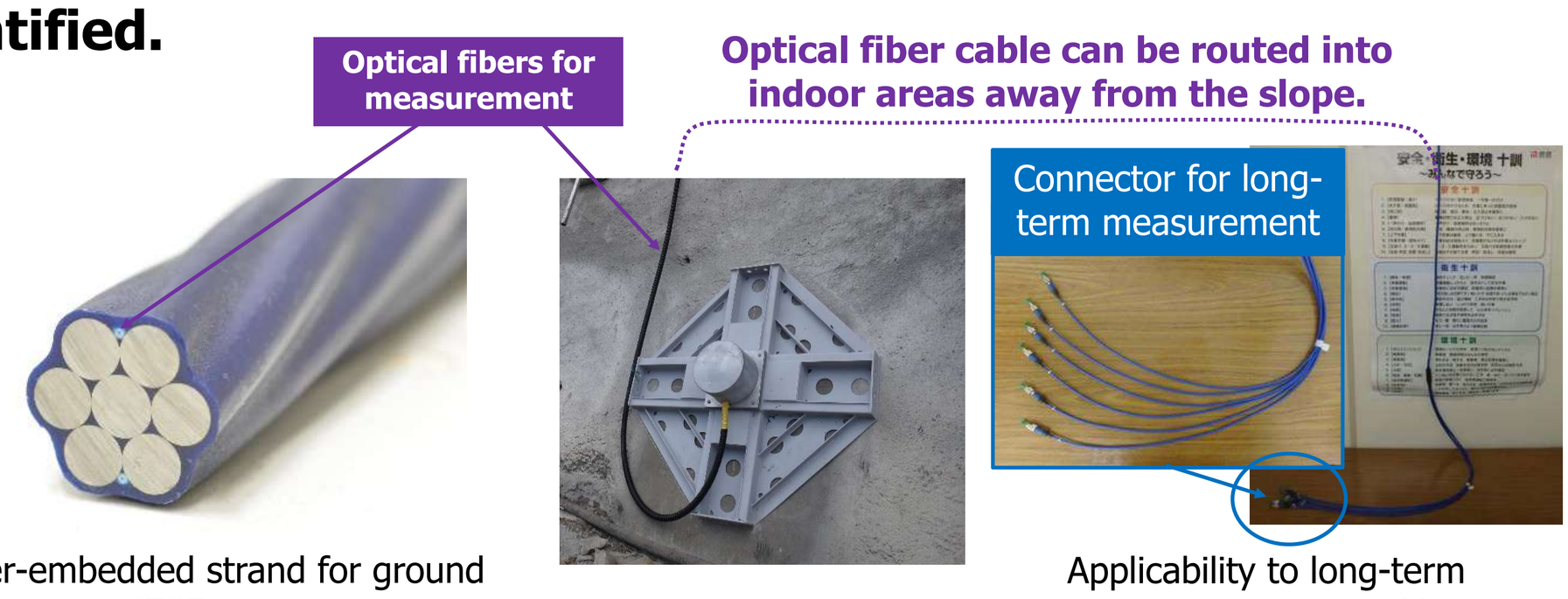
~ نظام مراقبة شد المرتكز الأرضي المزود بمستشعر الألياف البصرية ~

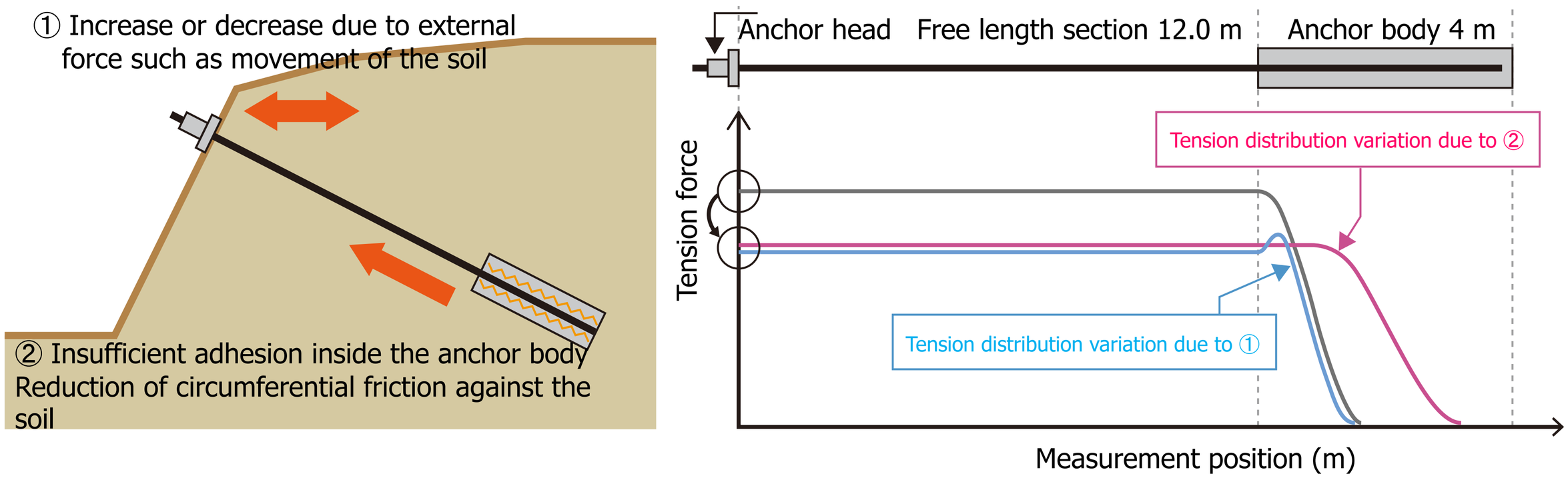
Optical fibers are embedded along the ground anchor for tension force distribution measurement. This technique is effective not only for tension force variation detection, but for identification of the cause of force variation. Thus, it is gratefully useful for maintenance of ground-anchor-reinforced-slope.

Tension force variation along the ground anchor can be detected, located and identified.



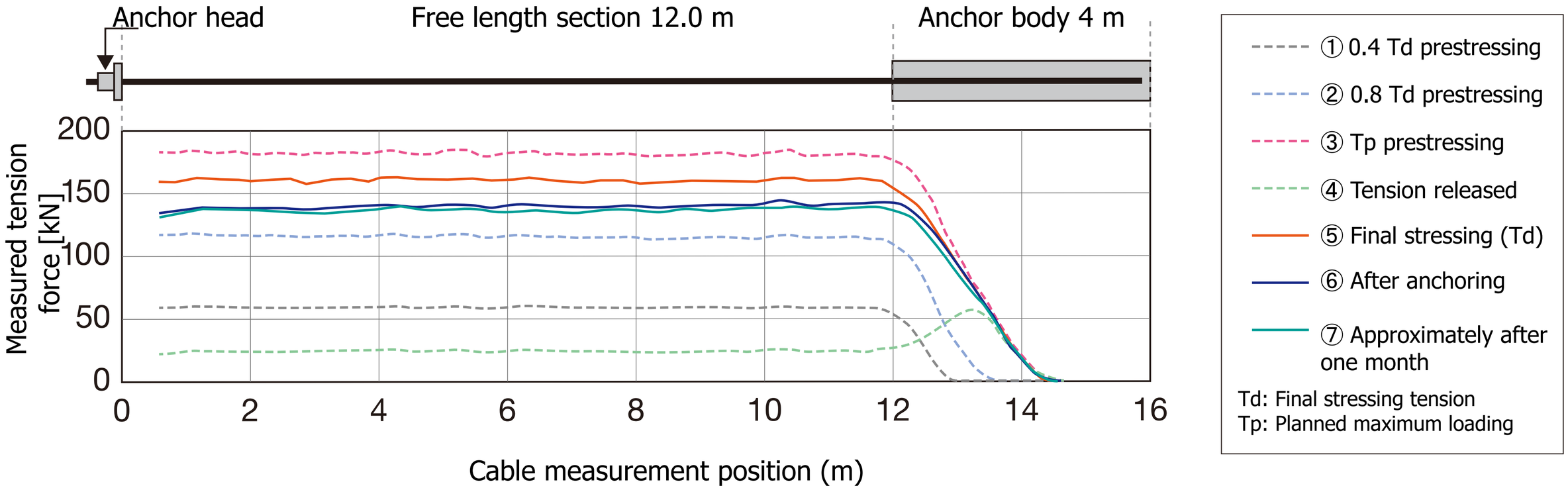
Optical fiber-embedded strand for ground anchor (ECF type)

Applicability to long-term measurement capability



■ Tension force distribution can be measured along the whole length of ground anchor including the inside of the anchor body.
■ Re-measurement can be made any time afterward, thus the technique is also helpful for maintenance. No need for elaborate measurement setup such as that for lift-off tests.
■ Use of durable optical fiber cabling allows us to monitor the slope any time from a safe location.

Example of ground anchor measurement result



This system has been jointly developed by Sumitomo Electric Industries, Hien Electric Industries, SE and Kajima Corporation.

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Road maintenance and management improvement technique

~ UHPFRC Deck Slab for Highway Bridge ~

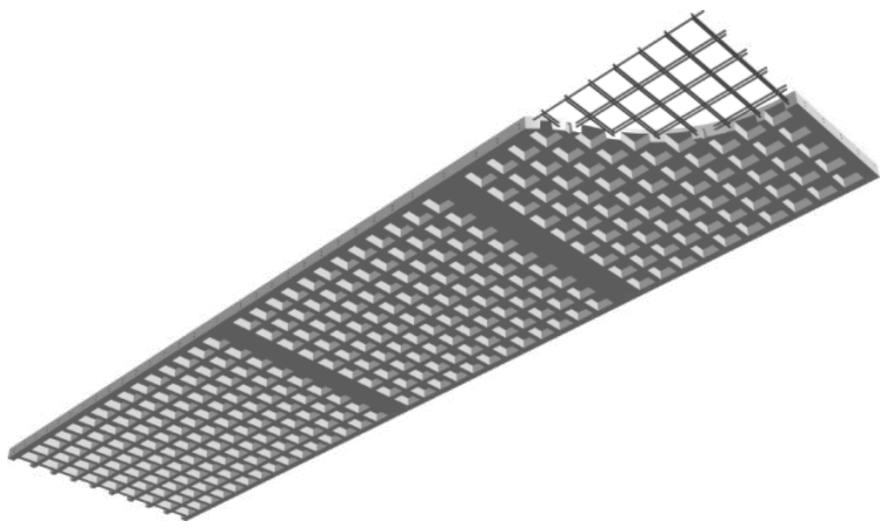
تكنولوجيا تجديد إدارة صيانة الطرق

~ لوحة سطح UHPFRC لجسر الطريق السريع ~

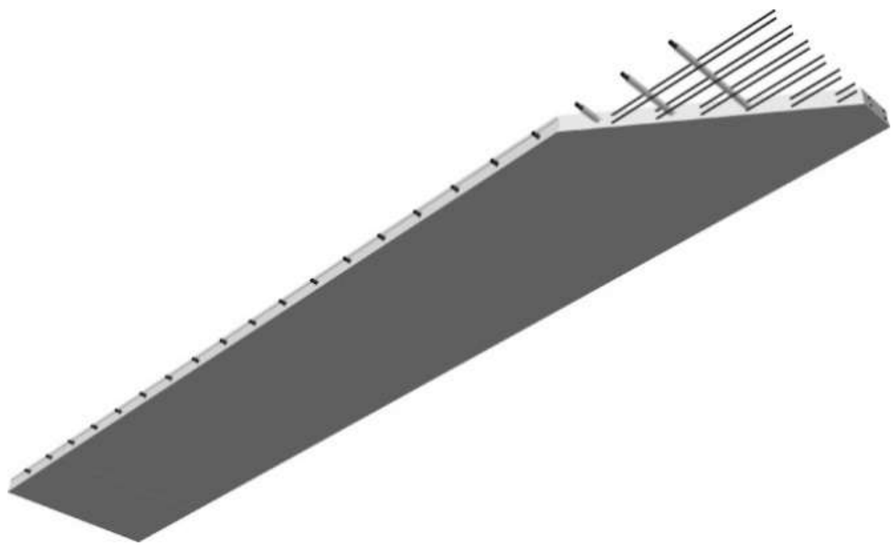
Development of UHPFRC Deck Slab

Kajima Corporation has partnered with Hanshin Expressway to jointly develop a deck slab for highway bridges made of ultra-high-performance fiber-reinforced concrete, namely, "UHPFRC Deck Slab".
UHPFRC Deck Slab has a thin and lightweight structure yet provides excellent durability and fatigue resistance.
The UHPFRC Deck Slab can be produced in two types, "waffle type" and "flat type". The ultra-lightweight waffle type has been developed mainly as a substitute for steel orthotropic deck slab. The flat type has been developed to replace aged concrete deck slab.
With established performance through various testing and analysis, the technology has been certified by the Japan Society of Civil Engineers Technology Assessment System in 2015.

Waffle type UHPFRC Deck Slab



Flat type UHPFRC Deck Slab

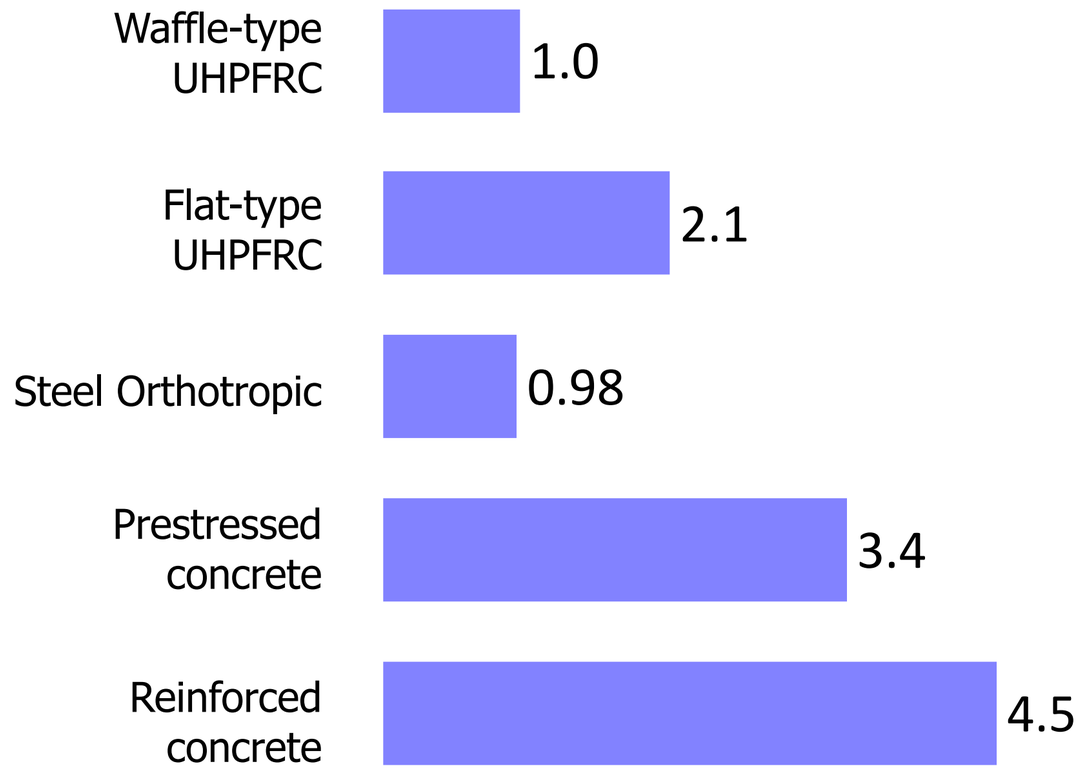


Wheel Running Fatigue Test

Wheel running fatigue tests have proven that UHPFRC Deck Slab has a fatigue resistance of far longer than 100 years.
Flat-type UHPFRC Deck Slab did not exhibit any fracture-triggering damage even after the number of loading cycles where ordinary prestressed concrete deck slabs would collapse has been exceeded, giving evidence to a superior fatigue resistance to that of prestressed concrete deck slab.

Weight Reduction of Deck Slab

The waffle-type UHPFRC Deck Slab can be made equally lightweight as steel orthotropic deck slab.
The weight of a flat-type UHPFRC Deck Slab can be reduced to approximately 60% of prestressed concrete deck slab.
In the past, concrete deck slabs have often been designed and built for the vehicle load which was lighter than that of recent vehicles and without sufficient consideration for fatigue. Many such aged deck slabs are now rapidly deteriorating. The flat-type UHPFRC Deck Slab can successfully replace such concrete deck slabs with weight reduction benefit.



With the base of waffle-type UHPFRC Deck Slab weight as 1.0

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Road maintenance and management improvement technique

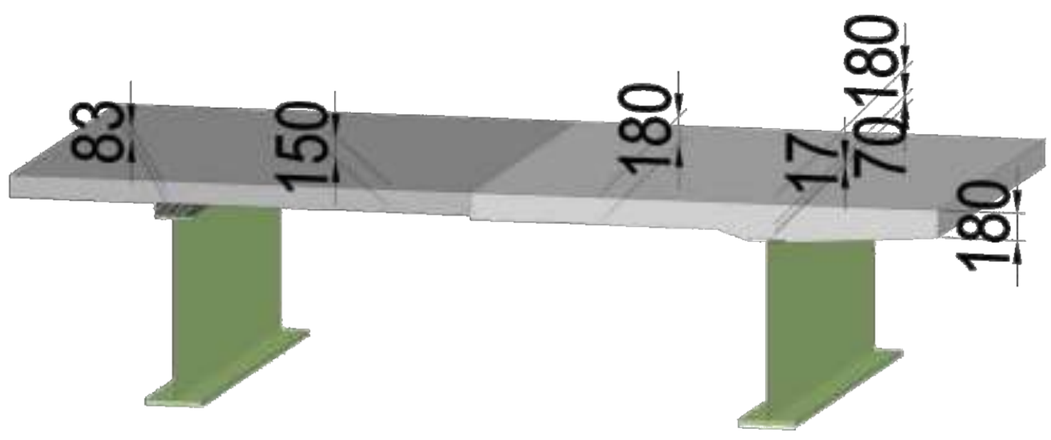
~ Replacement of aged reinforced concrete floor base with flat-type UFC floor base ~

تكنولوجيا تجديد إدارة صيانة الطرق

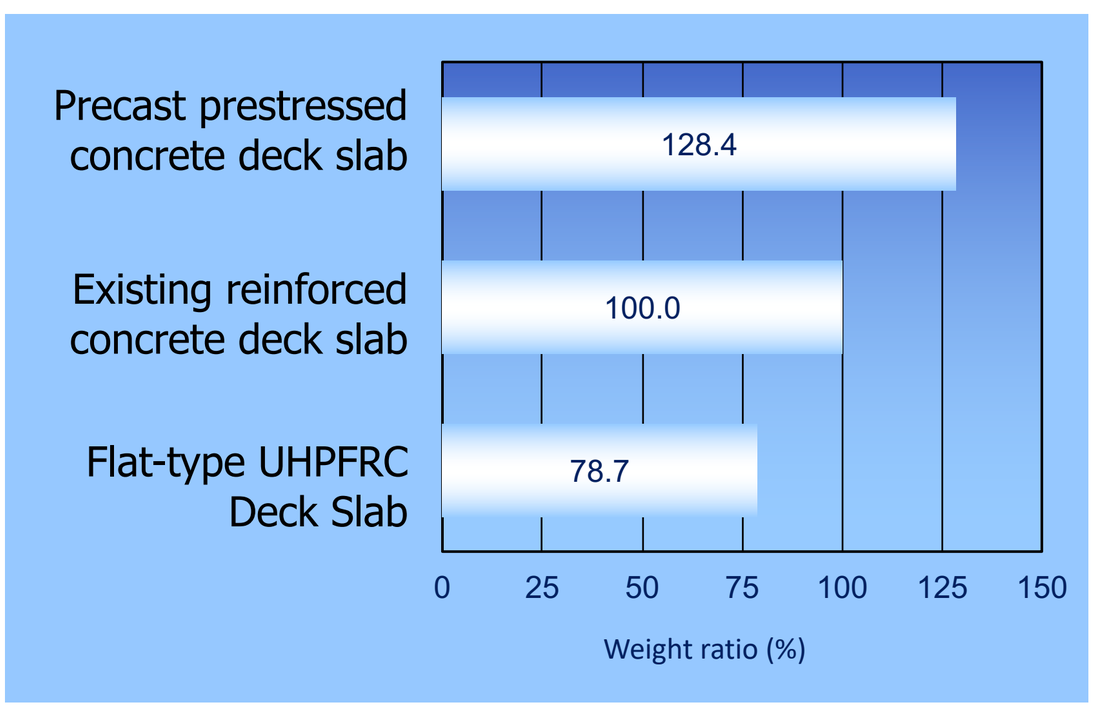
~ تجديد ألواح أرضيات RC المتقادمة باستخدام ألواح أرضيات UFC المستوية ~

Replacement with flat-type UHPFRC Deck Slab

The reinforced concrete deck slab of an old highway bridge which was constructed in 1970 has been replaced with our flat-type UHPFRC Deck Slab.
Without adequate technical knowledge at the time of construction, the bridge has been planned and built with little consideration for fatigue.
In addition, the deck slab was designed for the weight of vehicles at the time, which was much lighter than that of recent vehicles. As a result, the deck slab was only 180 mm thick, which would not satisfy the current design standards.
The thickness of the UHPFRC deck slab that replaced the old concrete slab is 150 mm, thus successfully reducing the slab weight by approximately 20%.
With the lighter deck slab, the total bridge girder loading did not increase even with the greater weight of recent vehicles taken into consideration.



Flat-type UHPFRC Deck Slab **Existing reinforced concrete deck slab**



Durability improvement by eliminating cast-in-situ portion

The flat-type UHPFRC Deck Slab is longitudinally prestressed by post-tensioning.
Longitudinal post-tensioning work normally requires a jack operation space to be provided at the end of the deck slab, which must then be cast in place after tensioning. With this, the deck slab end portion cannot be prestressed longitudinally.
On the other hand, our flat-type UHPFRC Deck Slab technology and its superior material characteristics allow downsizing the anchors of post-tensioning tendons, enabling the jack to be placed and operated under the deck slab at the center of the span and thus realizing a fully precast deck slab construction through to the ends.
With the entire deck slab prestressed longitudinally, durability has further drastically improved.

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Road maintenance and management improvement technique

~ Replacement of aged reinforced concrete floor base with flat-type UFC floor base ~

تكنولوجيا تجديد إدارة صيانة الطرق

~ تجديد ألواح أرضيات RC المتقادمة باستخدام ألواح أرضيات UFC المستوية ~

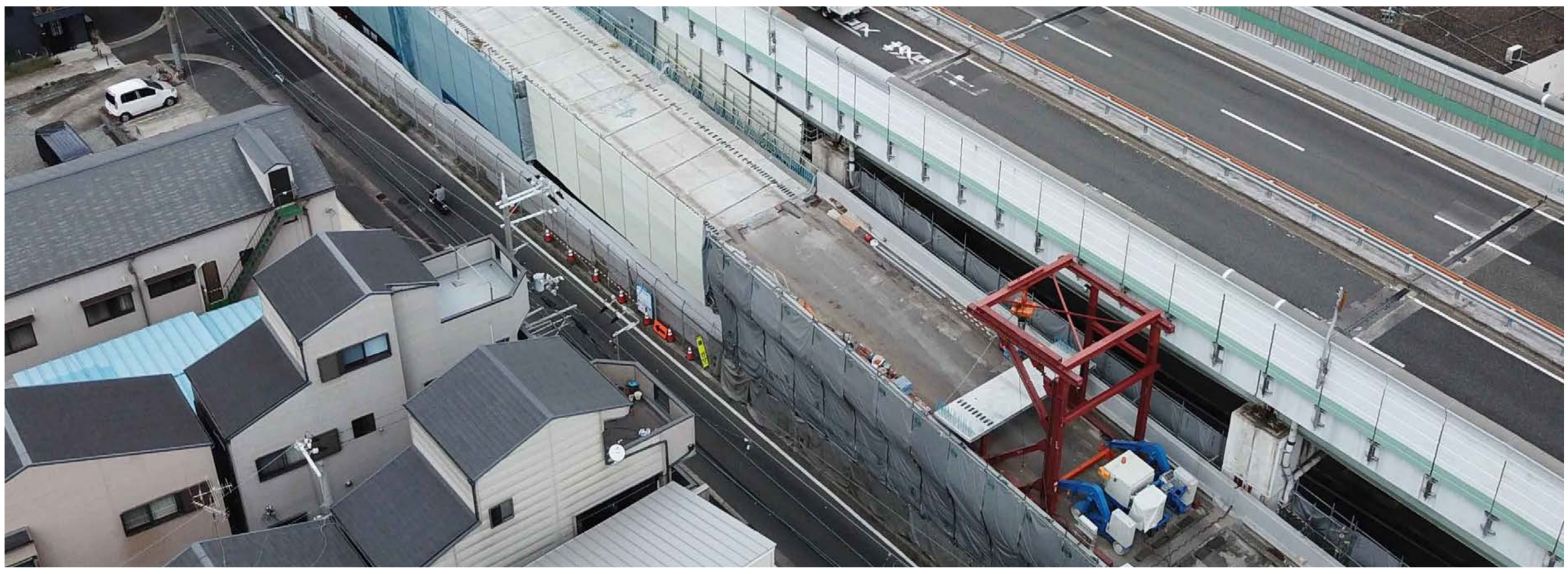
Fabrication of flat-type UHPFRC Deck Slab components in exiting production plants

The flat-type UHPFRC Deck Slab is prestressed transversally by the pre-tensioning. Therefore, the flat-type UHPFRC Deck Slab components can be fabricated using existing plant equipment for prestressed concrete products.
The flat-type UHPFRC Deck Slab has a simple, constant-thickness geometry and therefore can be produced with simple formwork. In addition, absence of reinforcement steel inside the concrete reduces work steps in production.

Internal structure of a flat-type UHPFRC Deck Slab without reinforcement steel

Use of an exclusive erection machine to allow installation work to be completed within the width of the road

We have developed and implemented an exclusive lightweight erection machine for the handling of the lightweight flat-type UHPFRC Deck Slab components. The special machine weighs only approximately 1/3 of a mobile crane unit commonly used for precast deck slab installation. With this, the installation of flat-type UHPFRC Deck Slab can be started with minimum amount of bridge girder strengthening.
The lightweight special machine can travel over the installed deck slab section and carry deck slab components right up to the intended installation position. It has been demonstrated that all installation work can be done within the width of the road, indicating the feasibility of single-lane deck slab replacements in the future.



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Road maintenance and management improvement technique

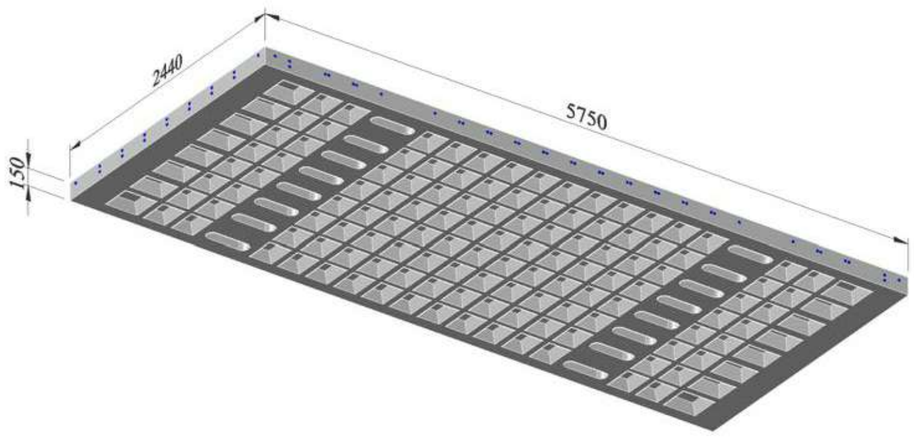
~ Waffle-type UFC floor base for new ramp bridge construction ~

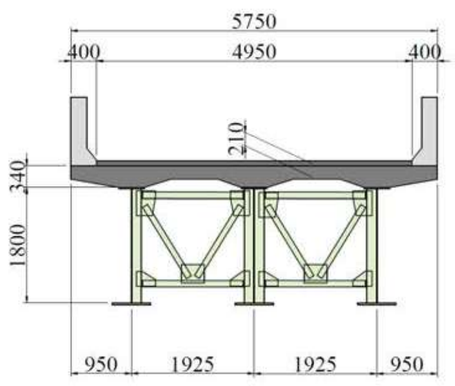
تكنولوجيا تجديد إدارة صيانة الطرق

~ استعمال ألواح أرضيات UFC المنقوشة في جسور الطرق الجديدة ~

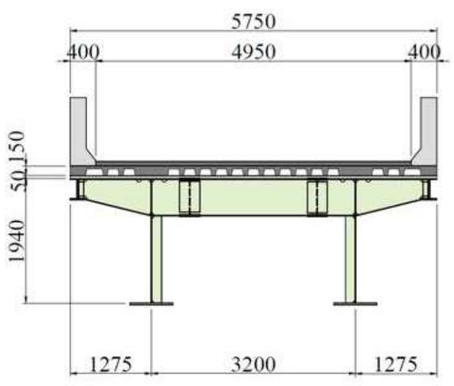
Weight reduction achieved with the use of waffle-type UHPFRC Deck Slab

Our waffle-type UHPFRC Deck Slab has been used as the deck slab of a new bridge as part of the Hanshin Expressway Nishisemba Junction Renovation Project.
The original plan had a cast-in-situ reinforced concrete deck slab which has later been replaced with our waffle-type UHPFRC Deck Slab. This design change resulted in more than 50% reduction in the deck slab weight, reducing the number of girders from three to two. The total bridge weight has been reduced by more than 40%.





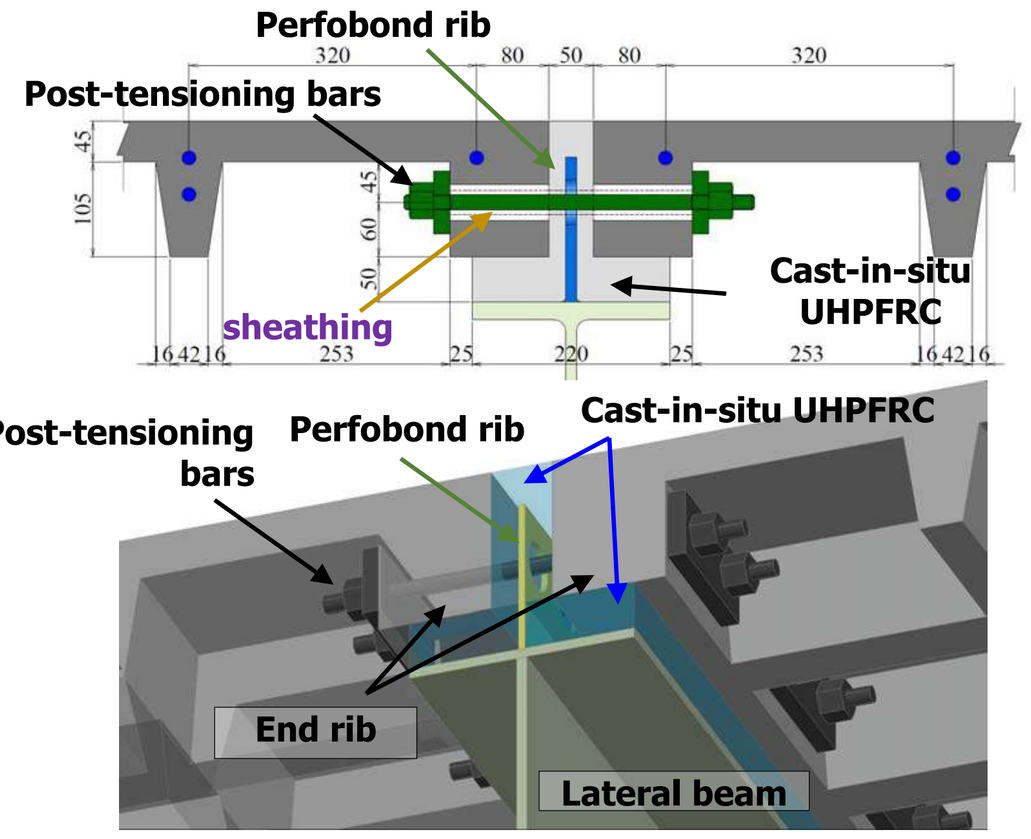
Girder section with reinforced concrete floor base



Girder section with UFC floor base

Deck slab component jointing for easy replacement

In this project, adjacent waffle-type UHPFRC Deck Slab components were secured and joined by post-tensioning bars.
The jointing feature has been designed and built for consideration for easy removal and repositioning of post-tensioning bars after the start of bridge service. With this, single deck slab panels can be swiftly replaced should it become damaged due to heavy objects dropped.



High-strength fiber-reinforced mortar for gap filling

A fluidity-enhanced UHPFRC has been used to fill gaps between the waffle-type UHPFRC Deck Slab and the steel girder for composite. Gap filling with UHPFRC has improved the horizontal shear resistance of the structure by approximately 40%, making it a highly hopeful technique to be applied to long span bridges in the future.

Gap filling test with fluidity-enhanced UHPFRC

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