Recent Research of Track Technology Division

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The Track Technology Division is engaged in railway track research and development to make their outcomes available for commercial use to enable "social implementation." This is to ensure that our technology is widely adopted in the operations of railway companies.

Our track development initiative starts with fundamental research. It brings our technology up to the level wherein test installation is performed in some commercial lines to introduce the technology to many railway operators.

The public does not directly use track-related technologies; however, many passengers indirectly use them via railway operators that use them. This paper describes track technologies that our division applied in developing and introducing certain technologies already in commercial use and implemented in society or in a transition phase from trial installation to social implementation, as well as the ones currently under development for future implementation.

Track technologies that have been implemented in society

Since ballasted tracks become deformed under the stress of train load over time, periodic repair work is required. To prevent this, slab track (*Slab track*) that does not considerably deform under stress was developed by the Research and Development Institute of the former Japanese National Railways (JNR), the predecessor of the Railway Technical Research Institute (RTRI).

A slab track consists of approximately 5-meter concrete slabs that directly support rails in the structure.

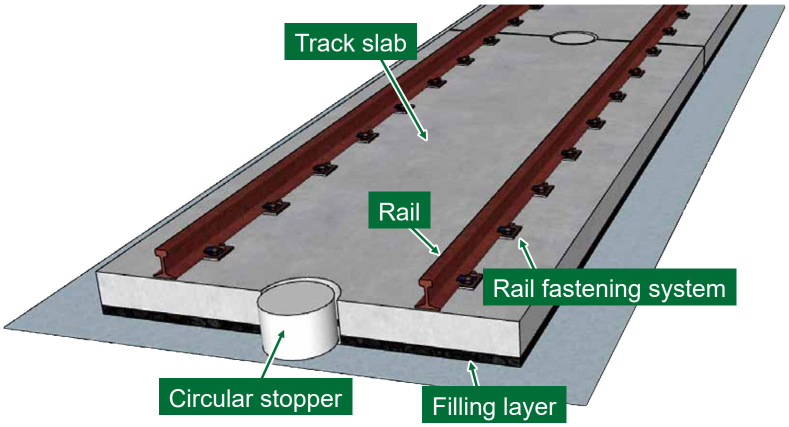
For the Tokaido Shinkansen line, a ballasted track system was used, but later, a slab track system was introduced in earnest for Shinkansen lines including Sanyo Shinkansen and the subsequent Shinkansen lines.

Slab tracks, however, have no tolerance for large subsidence, and this limited their use to only viaducts or tunnel sections until the 1980s.

Since the 1990s, the slab track structure has been laid on earth structures constructed with high-quality subgrade and concrete roadbed [1] (*Slab track on earth structure*) .

Furthermore, since the 2000s, an integrated RC roadbed has been developed, which combines the roadbeds of double tracks, making it possible for slab tracks to be laid on relatively soft ground [2] (*Integrated RC roadbed (Before a track slab is laid)*).

Commissioned by the Japan Railway Construction, Transport and Technology Agency, the RTRI was involved in a project for the technological development of slab



(a) Slab track structure

(b) Example of a slab track being laid

Slab track

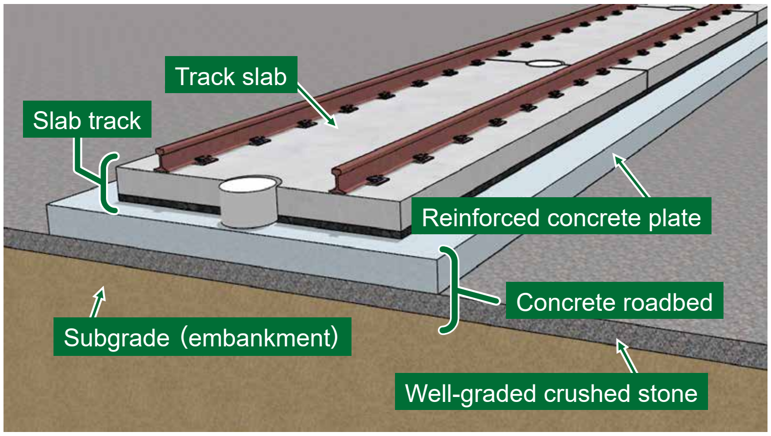
tracks applied to earth grounds and contributed to their implementation in society.

In the 1980s, the slab track system was constructed in conventional lines. However, railway noise became an issue in urban areas, as the noise levels were higher when a train ran on slab tracks than when it ran on ballasted tracks. To address this issue, the former JNR's research institute developed a track system equipped with resilient sleepers (sleepers fitted with under sleeper pads). This system reduces noise via an elastic rubber material installed underneath the sleeper, which is supported by a concrete track bed.

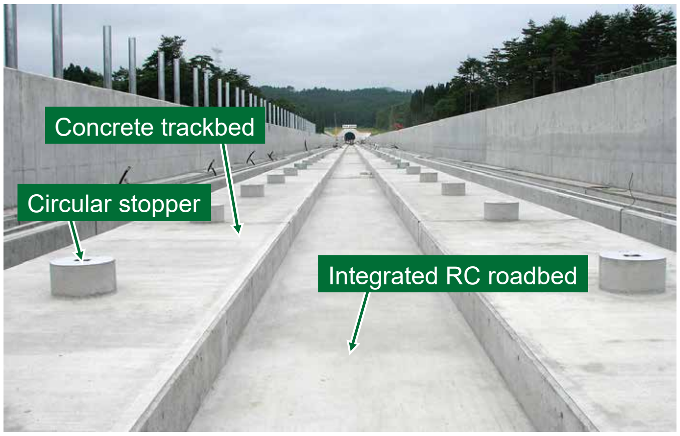
A structure called B-type solid-bed track equipped with resilient sleepers [3] is laid as the track structure for the Shinkansen line between the sections of Ueno to Omiya station. In the 1990s, RTRI developed a D-type track system, wherein the elastic material beneath the sleepers is replaceable [4].

Various railway operators in Japan and overseas have widely used the D-type track system. In the latter half of the 2010s, further improvements were made to streamline the concrete track bed as a cost-cutting effort, and it was upgraded to an S-type version [5] (*Solid-bed track equipped with resilient sleepers using the shear-key*). The S-type track system has been adopted for public work projects launched in the vicinity of the Nagasaki or Matsuyama stations, where multiple existing level crossings were replaced with overhead crossings. This is another practical case, and we believe this technology is a step closer to being implemented in society.

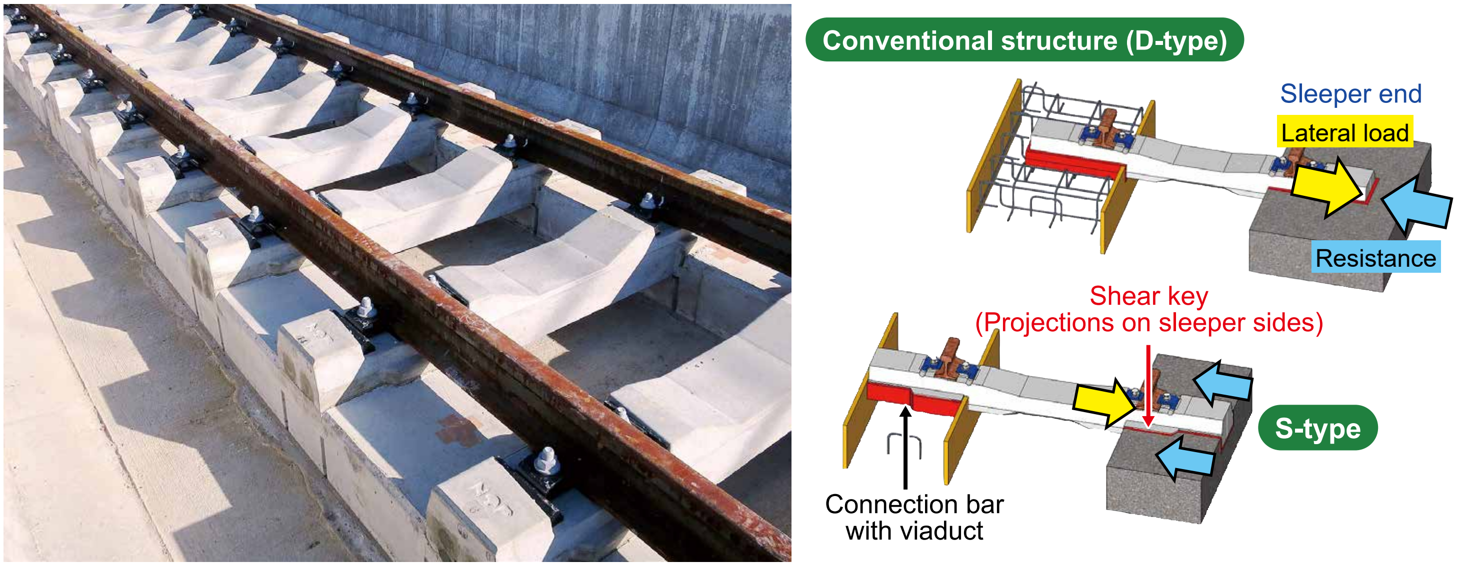
Meanwhile, in a track management field, a waveform data processing tool called LABOCS [6] was developed by the former JNR's research institute. LABOCS has since



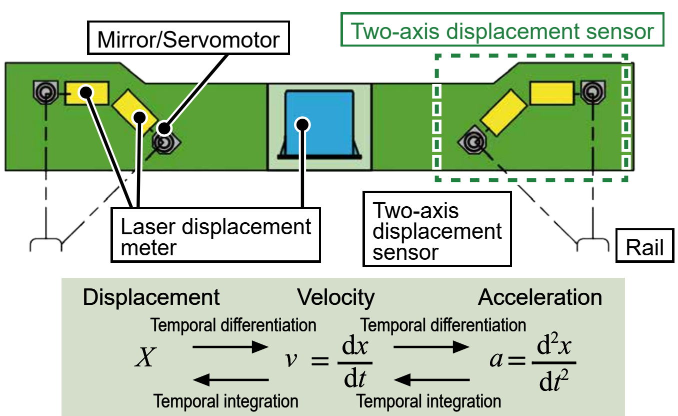
Slab track on earth structure



Integrated RC roadbed (Before a track slab is laid)



Solid-bed track equipped with resilient sleepers using the shear-key



(a) Measuring principle of inertial mid-chord offset method

(b) Installation example of track measuring device using inertial mid-chord offset method

Track measuring device with the inertial mid-chord offset method

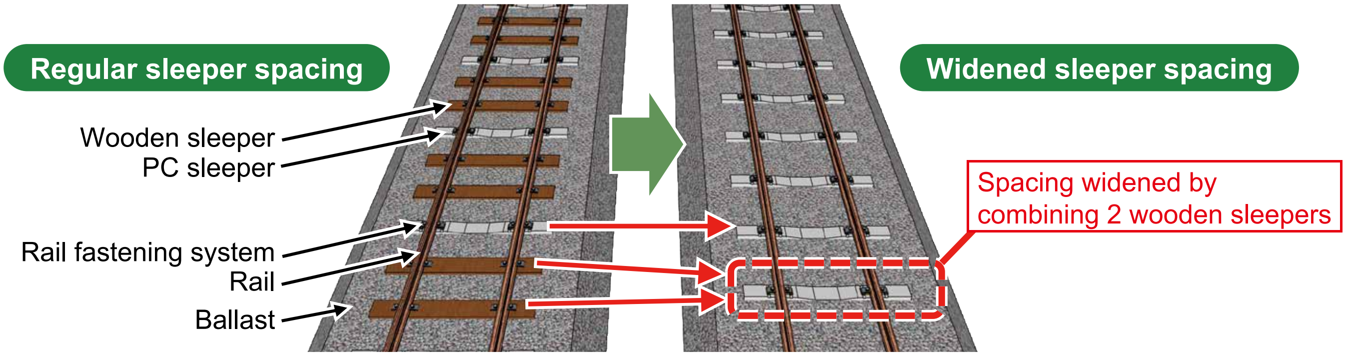
evolved, focusing on track irregularity management, and since the 1990s, it has been adopted by many railway operators. In recent times, upgrading effort with new technologies is underway to incorporate features such as correcting the distance discrepancy of the data measured by a track recording vehicle using cross-correlation methods or predicting the displacement amount of floating sleepers.

As for track measurement research, we have been developing the inertial mid-chord offset method since the 1990s [7] (*Track measuring device with the inertial mid-chord offset method*). This method enables the downsizing of a track measuring device such that it can be mounted on commercial railway vehicles. This technology enables track irregularity monitoring at high frequency by commercial vehicles. Thus, a more flexible track maintenance management is achieved according to track conditions.

Track technologies shifting from test installation in commercial lines to social Implementation

One technology moving toward social implementation is a scheme of widening sleeper spacing, which some railway operators have adopted [8].

Ballasted track sleepers are generally laid at a space of approximately 60 cm. Increasing this space as wide as 1 m would help reduce the number of sleepers installed,



Widening of sleeper spacing

Low-strength stabilization method

contributing to cost reduction efforts (*Widening of sleeper spacing*).

Widening sleeper spacing has been achieved after carefully verifying factors such as track subsidence property, track lateral stability, and track material safety during our research.

Meanwhile, ballasted tracks have a limitation wherein crashed or refined ballast particles may cause the bearing capacity of ballast to decrease during rainfall, resulting in a large subsidence. For a general resolution, those deteriorated ballasts must be replaced. However, because ballast replacement entails a relatively high cost, an alternative method has been sought to prevent ballasted track subsidence at a lower cost.

A low-strength stabilization method [9] has been developed to stabilize ballasts. In this method, repair material comprising of ultrarapid hardening cement and polymeric material is mixed with deteriorated ballasts and tamped at the repair work site (*Low-strength stabilization method*).

A pilot run of this method has been conducted on several commercial lines, and we are now working to expand the applications aimed at social implementation.

We have also developed a technology to help improve labor efficiency in ballasted track maintenance and management. In this "Ballastless track with super-fine particle cement [10]," track subsidence can be mitigated by grouting a super-fine particle cement (SFC) fluid into the ballasted track. Some railway operators are also adopting this technology, and it is expected to be socially implemented soon.

Moreover, we have several other developments that are a step closer to being implemented in society, including the railhead crack repair method using the thermit welding technology [11], a dynamic track measuring device for gauge and twist that costs less than the inertial mid-chord offset track measurement device [12] (*Dynamic track measuring device for gauge and twist*) or an image analysis system for detecting obstacles within a structure gauge of railroad track [13].

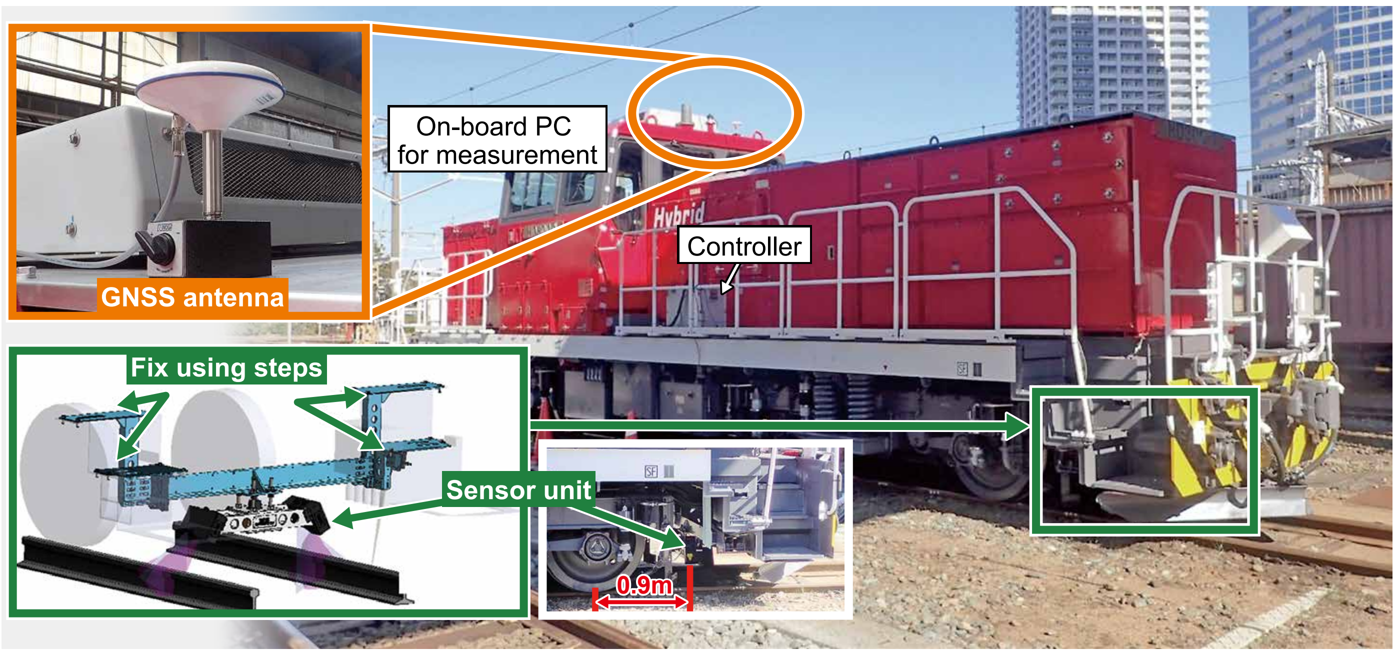
Track technologies under development aimed at future social implementation

An intelligent turnout is an example of a product under development for future social implementation (*Intelligent turnout*).

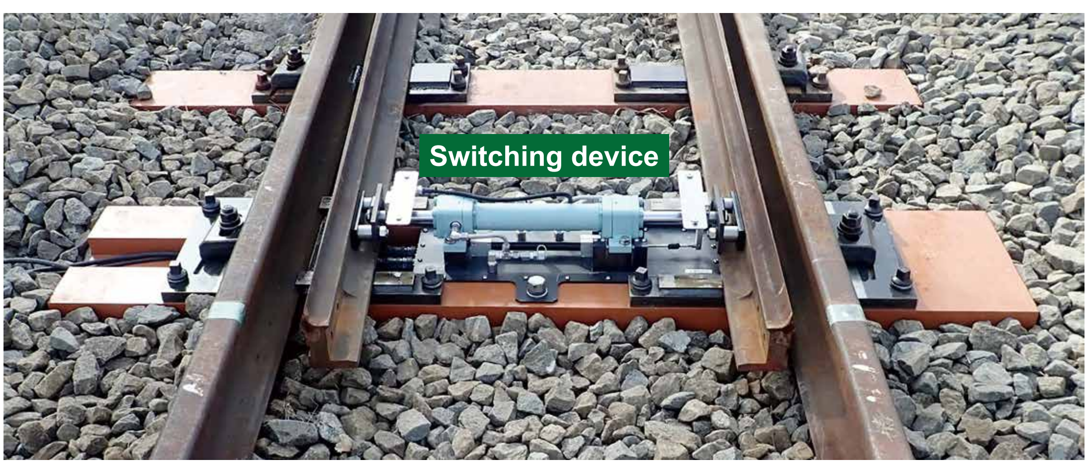
This turnout allows streamlining of the structure by incorporating the switching device into a sleeper. It also enables controlling and monitoring of the switching force at all times to eliminate the labor of the operator's inspection work.

In addition, we have developed a floating solid-bed track system equipped with resilient sleepers (*Anti-vibration slab track*).

In this track system, a concrete track bed equipped with resilient sleepers is supported by low-elastic antivibration materials such that the track support spring coefficient is significantly reduced, which would



Dynamic track measuring device for gauge and twist

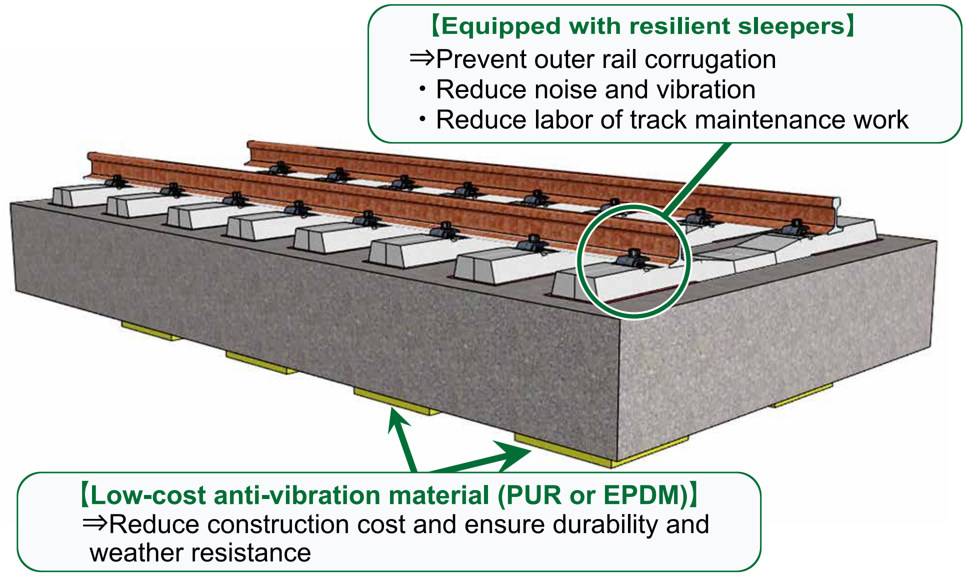


Intelligent turnout

help mitigate noise and ground vibration.

Conclusions

This paper introduced the status of the social implementation of track technologies being developed by RTRI. To achieve this, accurately understanding the needs of railway operators and setting the direction of research and development are critical. The Track Technology Division will continue to develop technologies that contribute to the innovative operations of railway companies.



Anti-vibration slab track

References

1) Railway Technical Research Institute: "Design Standards For Railway Structures and Commentary," Earth Structures, 2007

2) Yoshitsugu Momoya, Etsuo Sekine, Takatada Takahashi, Osamu Maruyama: "Performance Evaluation of Reinforced Concrete Roadbed for Slab Track on Clay Subgrade," Quarterly Report of RTRI, Vol.50, No.2, pp.110-115, 2009

3) Yoshihiko Sato, Fujio Ohishi, Goto Hirata, Tamio Usami, Takaharu Nagafuji, Iwao Iwasaki: " Development of Danchoku Track of Type B. -Resilient tie track on solid bed filled with concrete," Quarterly Report of RTRI, Vol.23, No.2, pp.110-115, 1982

4) Katsutoshi Ando, Akira Mukai, Takahiro Horiike, You-ichi Sunaga, Ken-ichi Takao, Akihito Kito: "Development of Solid-Bed Track with Removable Resilient Ties," Quarterly Report of RTRI, Vol.43, No.3, pp.107-112, 2002

5) Hikaru Tanigawa, Shuhei Kikkawa, Takatada Takahashi, Yoshitsugu Momoya: "Development of New Solid-bed Track Equipped with Resilient Sleepers Using the Shear-key to Achieve Efficient Construction Work," Quarterly Report of RTRI, Vol.59, No.3, pp.107-112, 2018

6) Akiyoshi Yoshimura, Yasuo Yoshida, Masako Kamiyama: "Development of Database System for Railway Track Maintenance Management, Micro LABOCS for Windows and its Features," Quarterly Report of RTRI, Vol.38, No.2, pp.102-106, 1997

7) Yosuke Tsubokawa, Eiji Yazawa, Kiyotaka Ogiso, Toshiaki Nanmoku: "Development of the Car Body Mounted Track Measuring Device with the Inertial Mid-chord Offset Method," Quarterly Report of RTRI, Vol.53, No.4, pp.216-222, 2012

8) Tadashi Deshimaru, Daiki Yamaoka, Kazuki Ito, Saki Shimizu: "Design Method for Ballasted Track Applicable to Widening of Sleeper Spacing," RRR, Vol.36, No.3, pp.23-28, 2022 in Japanese

9) Takahiro Kageyama, Takahisa Nakamura, Ippei Kijiya, Yoshitsugu Momoya, Hirokazu Akagi, Ryuji Saito: "Development of low-strength stabilization method for fouled ballasted tracks," Transportation Geotechnics, Elsevier, Volume 34, 2022

10) Shota Fuchigami, Takatada Takahashi, Takahisa Nakamura, Yoshitsugu Momoya: "Ballastless Track with Super-fine Particle Cement," RTRI Report, Vol.30, No.10, pp.23-28, 2016 in Japanese

11) Hajime Ito, Ryuichi Yamamoto, Yoshihiro Terashita, Mitsumasa Tatsumi: "Extension of Application and Deskilling for Rail Head Repair Method," RTRI Report, Vol.33, No.2, pp.23-28, 2019 in Japanese

12) Yosuke Tsubokawa, Tomoyuki Ishikawa, Kousaku Shiono: "Development of a Dynamic Track Measuring Device for Gauge and Twist that can be mounted on a Motor," RTRI Report, Vol.31, No.12, pp.47-52, 2017 in Japanese

13) Atsushi Shimizu, Masashi Miwa: "Development of Risk-based Railway Track Maintenance Method Using Image Analysis Technology," Quarterly Report of RTRI, Vol.60, No.4, pp.262-267, 2019

14) Shota Fuchigami, Tsutomu Watanabe, Takatada Takahashi: "Development of floating solid-bed track equipped with resilient sleepers," JSCE Annual Meeting, 2023 in Japanese