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Structures Technology Division is engaged in research and development of railway structure technologies covering fundamental and applied research up to further solutions for commercial use.

We focus on three core objectives: “effective maintenance technology” aiming for higher labor efficiency of existing railway facility maintenance, “disaster countermeasures and early recovery technology” to help enhance the safety and expedite restoration of facilities, “construction and improvement technology” for higher productivity and cost reduction of a new construction or existing facility reinforcement.

This paper introduces some of our recent research and development projects.

Structures Technology Division

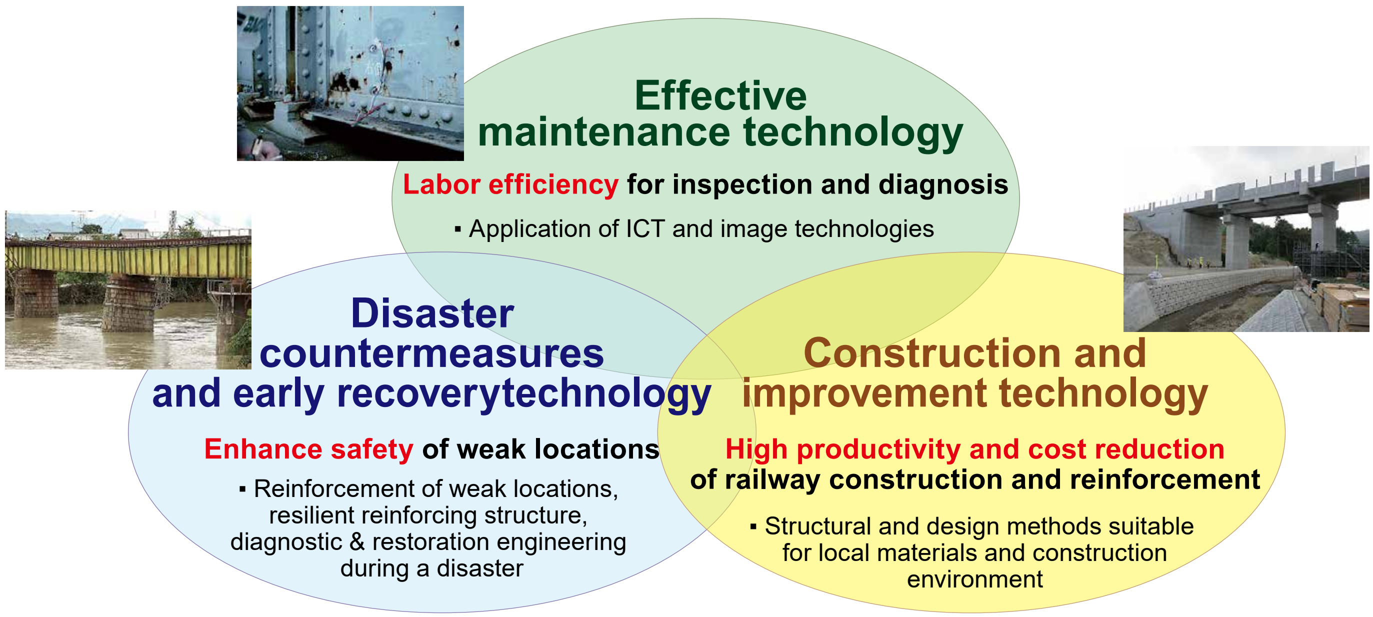
Introduction

There are growing concerns about the importance of railway structure maintenance services to ensure safe and stable railway operations. Meanwhile, serious facility damage cases are reported due to severe natural disasters, which disrupt train operations. Furthermore, as we move toward a post-pandemic society, digital strategies must be incorporated into the research and development of railway structure maintenance operations to streamline railway management.

As such, the technical field surrounding railway structures faces extensive challenges that must be addressed, from labor efficiency for maintenance works and anti-disaster measures up to early recovery.

Our division consists of five labs: Concrete Structures, Steel & Hybrid Structures, Foundation & Geotechnical Engineering, Tunnel Engineering, and Architecture Engineering, pursuing engineering excellence as a specialist team that can offer swift and diverse solutions through our fundamental and applied research for commercial use focusing on three objectives: “effective maintenance technology,” “disaster countermeasures and early recovery technology,” and “construction and improvement technology” (*Core objectives for research and development*).

The following is an outline of research examples based on the three abovemen-



Core objectives for research and development

tioned objectives, including another project case "development of railway technical standards" in which we worked together with the Railway Bureau of the Ministry of Land, Infrastructure, Transport and Tourism (hereinafter MLIT) and railway operators.

Structural Visual Inspection Support System using 3-Dimensional Images【Effective maintenance technology】

"Structural visual inspection support system using 3-dimensional images" has been developed to improve the labor efficiency of the railway facility's general inspection and enhance inspection accuracy by accumulating a digital database, and to foster skilled engineers (*Structural visual inspection support system using 3-dimensional images and its applications*) [1), 2)].

Using 3D image processing technology, photos obtained from video shooting during site inspection are processed into a 3D-image structure and saved as digital data on a PC.

This 3D-image structure comprises point data (location data) processed by combining the structure image and image data using a computer system, enabling workers to check and view structures at all angles or different distances on the PC. This system can also support workers so they can compare the structure at a site with the past 3D data shown on a mobile tablet brought to the site. Workers are also no longer required to go to the facility site for rechecking, if something is found unchecked, as they can perform a visual inspection with 3D structure images stored on the PC. This system also helps skilled workers to review inspection results, and to educate junior workers. A trial run of the system is underway, and technical working group for how to use is being held with the support of railway operators and co-developers.

We consider this to be one of our research outcomes leading to an innovative solution for maintenance work for existing railway facilities.

Seismic Reinforcement Technology for Steel Railway Bridges【Disaster countermeasure technology】

Seismic reinforcement work needs to be performed for some old-type steel bridges which were constructed before the 1970s. However, some works may require building a temporal track line and bridge by securing land to keep train operations running, or railway service must be suspended during reinforcement work, or a bridge needs to be replaced.

In any case, it is high-cost time-consuming work, especially in an urban area where it is difficult to secure land. Furthermore, deterioration issues must be addressed to repair or reinforce damages like corrosion or cracks in steel girders and support parts.

To extend the life and strengthen the earthquake resistance of old-type bridges without replacing, securing land for a temporary line, or disrupting railway operations, we have developed a reinforcing technique by integrating abutment and backfill with ground reinforcing nails, connecting abutments and steel girder, so called "Seismic reinforcement method for steel railway bridges (Integration of bridge girder, abutment, and embankment) (*Seismic reinforcement technology of steel railway bridges(Integration of bridge girder, abutment, and embankment)*)[2),3)].

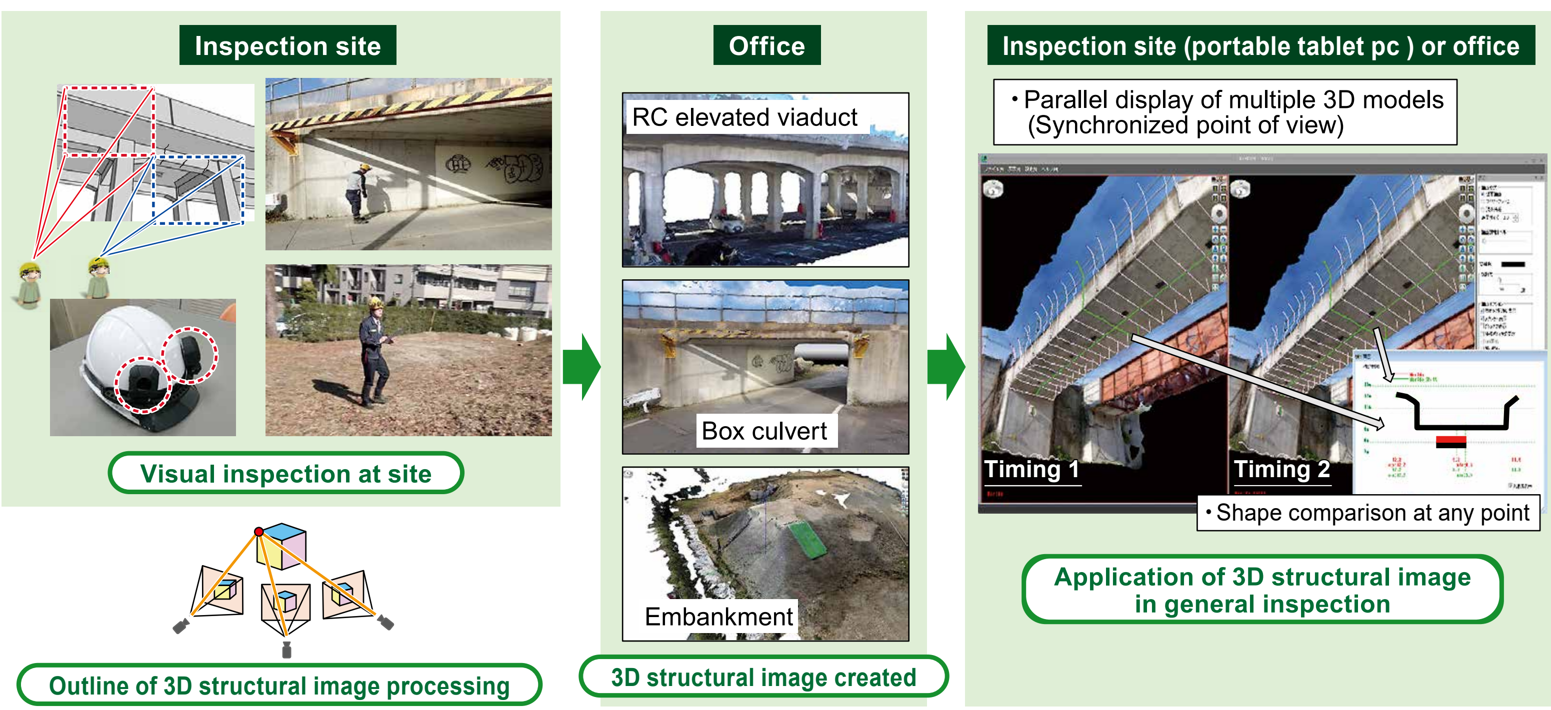
This approach increases earthquake resistance and helps reduce steel girder issues like warping or distortion by half. As the maintenance work for support parts is not required, the new structure has contribute to labor efficiency efforts for maintenance services.

This reinforcement technology brought a novel structure concept, moving from a steel girder and abutment-type bridge to an integrated one, and achieving a higher seismic resilient performance and longer service life of existing bridges.

Application Method of Mechanical Anchorage Method for the Beam-to-Column Joint of RC Viaducts 【Construction and improvement technology】

The application mechanical anchorage method for longitudinal steel bars could be a countermeasure for dense rebar at the beam-to-column joint of RC viaducts (*Mechanical anchorage method for the beam-to-column joint of RC viaducts*).

Beam-to-column joint sections can get congested with beam rebars being arranged from 3 to 4 directions beside column rebars. Furthermore, they require more space owing to being folded at their edge to be secured firmly.



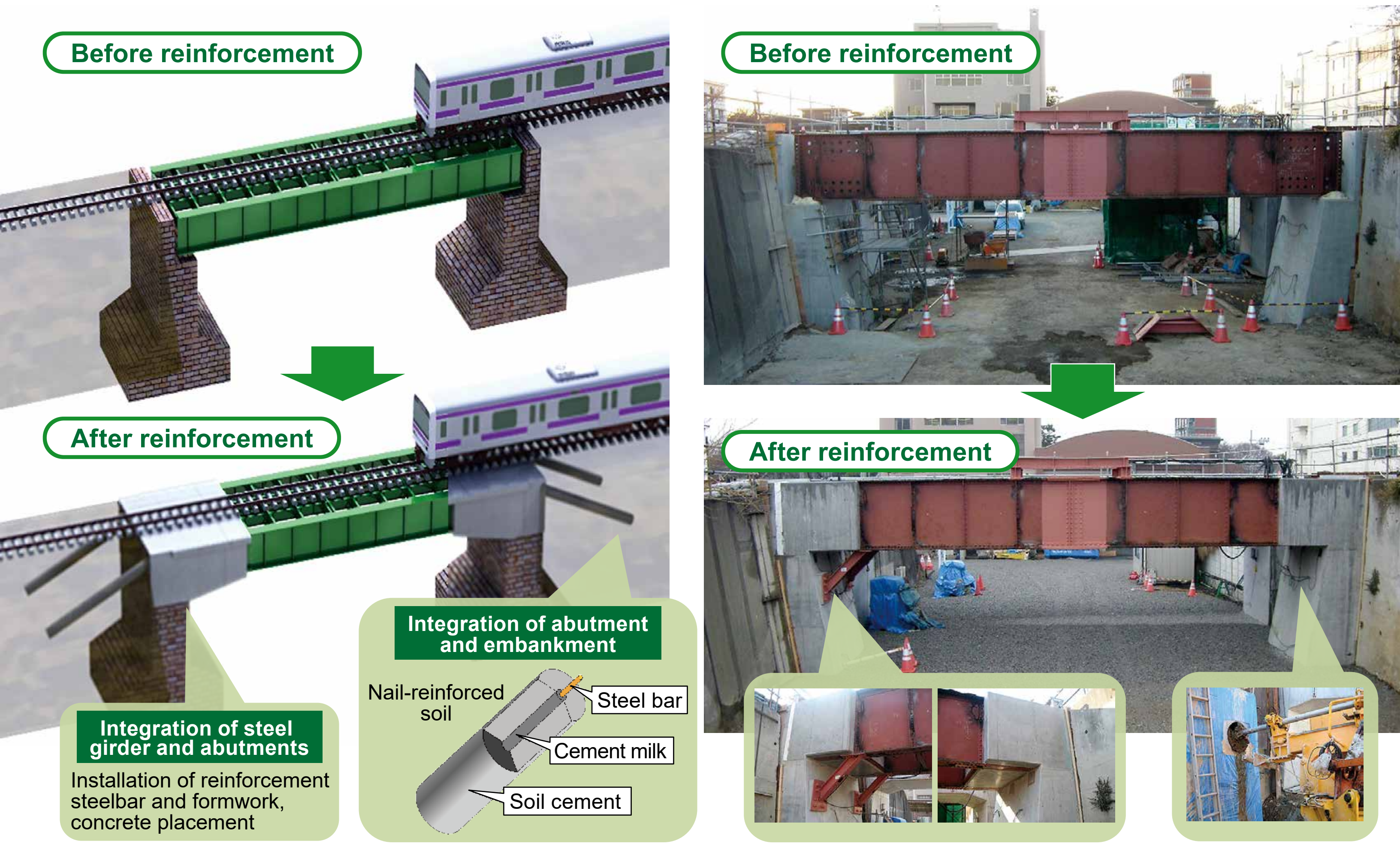
Structural visual inspection support system using 3-dimensional images and its applications

To save space, the mechanical anchorage method is applied, as shown in the photos. As productivity will be improved with this method, using the method is recommended by MLIT under the program called “i-Construction”. However, the behavior of the anchorage has not been clarified at the parts where constraint by concrete is weak, such as the beam-to-column joints. Therefore, load tests and finite element analysis were performed to clarify its behavior when applying mechanical anchorages to longitudinal steel bars at the beam-to-column joint and proposed conditions under which the mechanical anchorage method can be applied to the beam-to-column joint (*Mechanical anchorage method for the beam-to-column joint of RC viaducts*) [4].

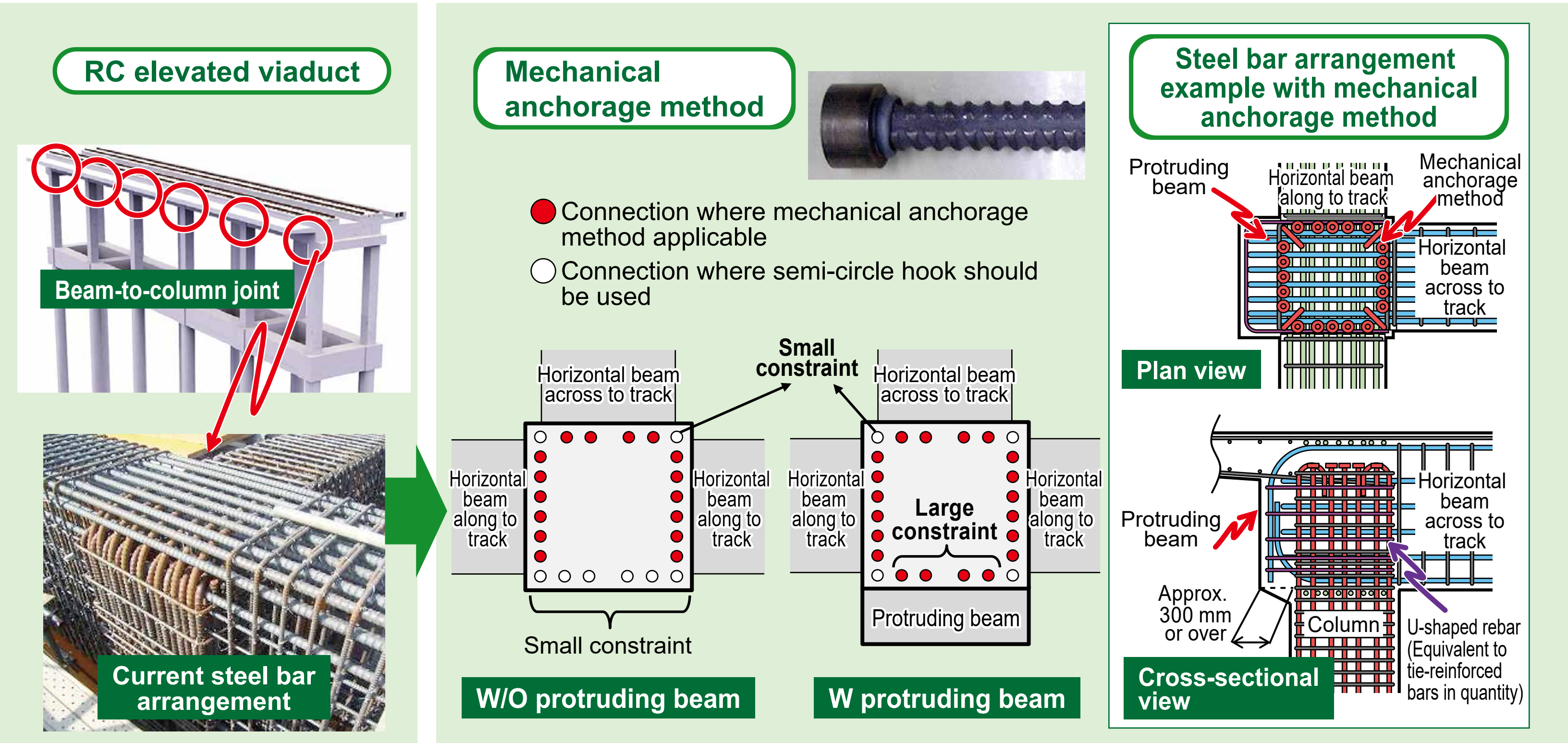
We consider it one of our research outcomes that contribute to higher productivity and labor efficiency of the rebar arrangement of railway construction work or improving the work of existing facilities.

Guideline on the design of support part for platform screen door【Development of technical standards】

Installing a platform screen door program has been promoted, aiming to prevent passengers from accidental falling off a platform or possible contact with trains. However, no reference standard was available to design the parts to support the platform screen door, and railway opera-



Seismic reinforcement technology of steel railway bridges (Integration of bridge girder, abutment, and embankment)



Mechanical anchorage method for the beam-to-column joint of RC viaducts

tors determined design loads or designing methods at their discretion based on RTRI's other guidelines set forth for the Transfer Overbridge Design Guideline.

To aid in making the design process more appropriate and efficient, the Railway Bureau of MLIT and RTRI served as secretariat, it held four technical committees in August 2020 to discuss the platform screen door design methodology with members from academics, research institutes, and associations led by Hidemasa Yoshimura, a specially appointed professor at the Osaka Institute of Technology. Discussions were conducted to determine a reasonable design method for the support part, taking into consideration the conditions under which the screen door is actually used.

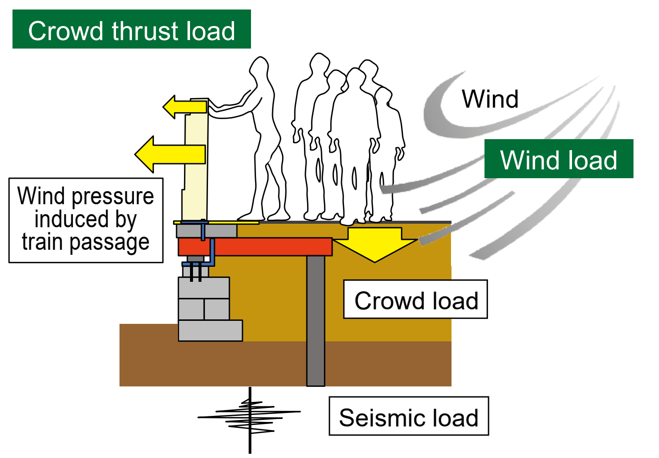
RTRI's research outcomes of wind load or crowd thrust load to the gate system under the condition of the presence or absence of hindering objects nearby were used in preparing the "Guideline of platform door support design" to aid designers in engineering (*Guideline of platform screen door support design*) [5].

The guideline has three key features, including 1) applying performance-based design with allowable stress design, 2) categorizing two different platform conditions: daily condition (normal) and other conditions (abnormal), and 3) indicating characteristic values of wind load and crowd thrust load.

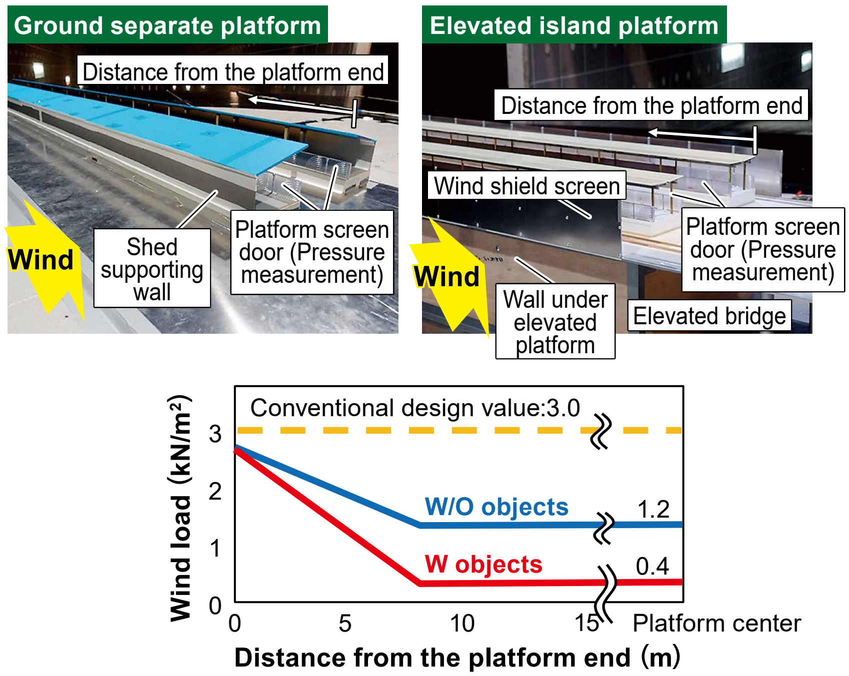
This guideline became available after the Railway Bureau of MLIT shared it with other transportation bureaus in December 2021, and we consider this another case of our research projects contributing to standardizing the design of platform screen door support where safety is secured and operating conditions are considered.

Conclusion

This paper introduced some of our recent research, including "structural visual inspection support system using 3-dimensional images," "seismic reinforcement technology for steel railway bridges（Integration of bridge girder, abutment, and embankment）," "application method of mechanical anchorage method for the beam-to-column joint of RC viaducts," and "guideline on the design of support part for platform screen door." However, our division has



Load or pressure need to be considered in design (Platform screen door support)



Wind tunnel test using miniature model and wind load

Guideline of platform screen door support design

many more research outcomes that have already been applied for commercial operations.

For more details, please visit our website at **https://www.rtri.or.jp/eng/rd/division/rd43/**

"Structures Technology Division, Railway Technical Research Institute"

Our division continues pursuing research and development based on the following objectives: "effective maintenance technology," "disaster countermeasures and early recovery technology," and "construction and improvement technology," contributing to better railway management.

References

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