ANNUAL REPORT 2017-2018

For the year ended March 31, 2018

Railway Technical Research Institute

Foreword

Norimichi KUMAGAI
President of the Railway Technical Research Institute

After celebrating its 30th anniversary in 2016, RTRI took one step forward in 2017. In the past 30 years, we have been exploring how to contribute to railway operation and businesses with our technical development and which technical fields we need to address and doing research in that direction. Being supported by the national government and rail-related companies, our researchers have been creating quality research outcomes and working to establish credibility.

In 2015, RTRI announced a new vision "RISING – We will develop innovative technologies to enhance the rail mode so that railways can contribute to the creation of a happier society," in order to meet the expectations from the railway world and Japanese society. As a mid-term plan to state concrete strategies to implement the vision, we publicized a five-year master plan starting in 2015, "RESEARCH 2020 - Aiming at Creation of Innovative Technologies -"

In fiscal 2017, the third year of the master plan, we focused on the research and development to enhance railways safety. We implemented projects to make railways more resilient when serious natural disasters such as major earthquakes and heavy rain and snow falls occurs, and projects to prevent derailment, accidents at level crossings and human errors. We have also promoted research and development to enhance convenience of train travels, to reduce maintenance cost and to build energy-saving railway systems as well as the research to raise Shinkansen's speed and to further enhance simulation technologies. For the purpose of increasing Shinkansen's speed, the high-speed pantograph testing machine and low-noise train model testing machine have been built.

RTRI has been seeking to use information and communication technology extensively in research and development. In June 2017, the ICT Innovation Project was started at RTRI to address the goals of "reducing natural disaster damage," "low-cost maintenance" and "energy saving." The most important challenge for the next 30 years is to combine IoT, big data analysis and simulation by supercomputers and to integrate it with AI. In this process, it will be important to keep in mind man-machine role sharing.

In order to keep providing quality research outcomes to enhance railway values and to be relied upon by railway users, continued support and advice from all the rail-related people will be most appreciated.

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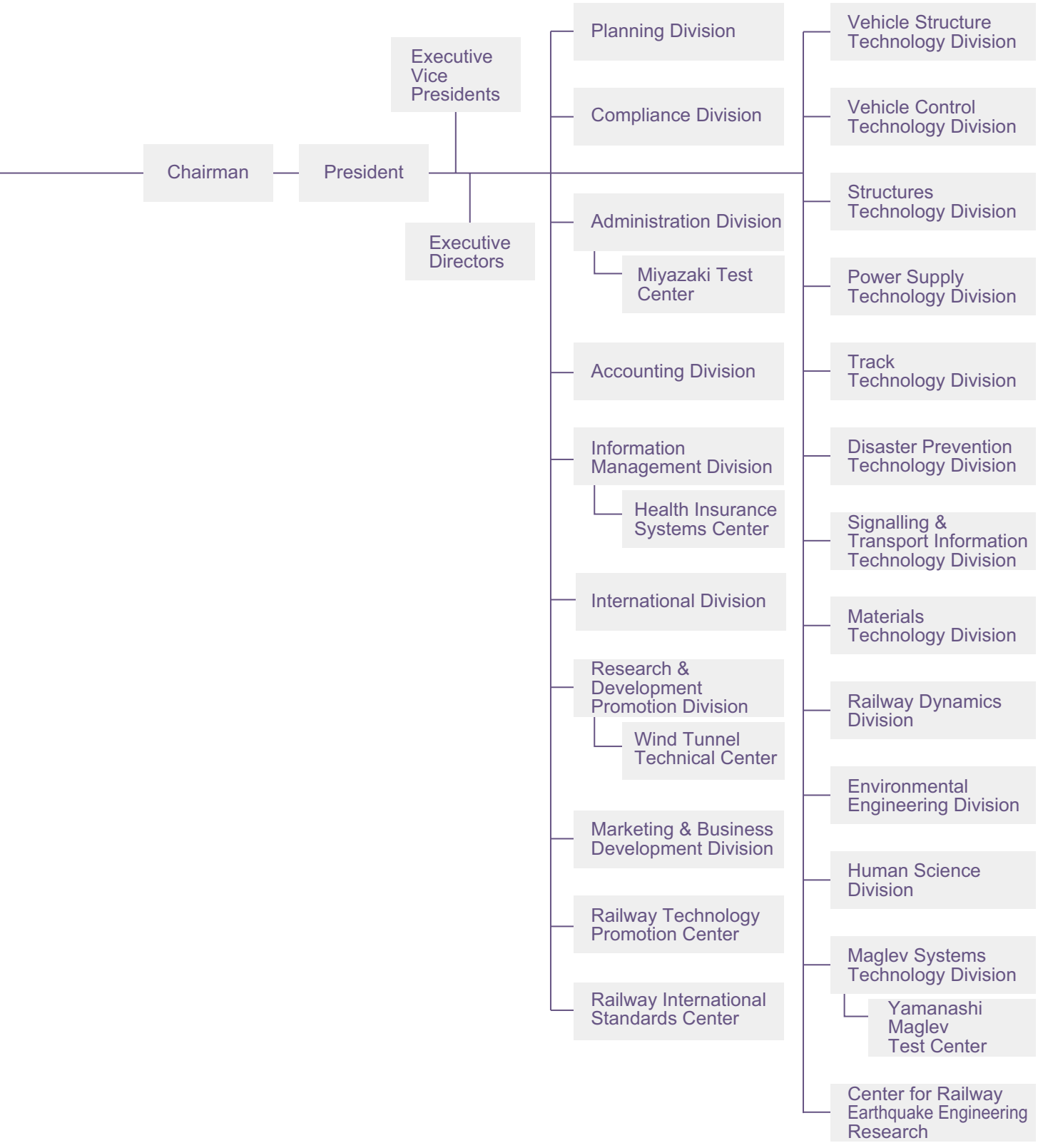


(As of April 1, 2018)

Major Results of Research and Development

IMPROVEMENT OF SAFETY

1. Earthquake damage simulator for railways with self-correcting function

- A simulator was built to be able to estimate the behavior of railway structures, electric poles and railway vehicles during earthquakes.
- A self-correcting function for input parameters corresponding to observed ground motions and railway damage data was added.
- A simulator makes it possible to reduce the time required to resume railway services after an earthquake by ranking structures in order of priority for inspection.

Rapid recovery of railway operations following an earthquake depends on being able to quickly obtain data about damage that has occurred. Until now, damage was estimated on the basis of seismic intensity observed through trackside seismographs and seismic damage nomographs, using the natural period and the yield acceleration of structures as parameters. This meant that obtaining more detailed damage estimation using local ground and structural characteristics, was difficult. This abstract introduces an earthquake damage simulator with a self-correcting function (Fig. 1). Simulation begins automatically when an Earthquake Early Warning is received. The simulator processes the information available at that moment (epicenter, seismic observation records, etc.) and predicts trackside seismic waveforms in real time. The simulator can estimate damage through detailed dynamic analyses of the behavior of structures, electric poles and railway vehicles using the seismic waveforms.

Using the simulator, damage can be estimated within several minutes to several tens of minutes taking into account the difference of in characteristics of deep soil structures, the surface ground and vibration characteristics of each railway structure. An algorithm automatically updates the parameters in the simulator used for estimating damage by adding information, such as boring survey data and structural design sheets, and observed ground motion. As a result, damage estimation can automatically improve with as damage and earthquake data is collected and accumulated.

Generally, increasing simulation accuracy requires longer calculation time. This simulator however, manages to combine high precision and immediacy thanks to the self-correction function and ranking of structures in order of priority for inspection, thereby allowing operations to resume more quickly following an earthquake.

This research was financially supported by the Ministry of Land, Infrastructure, Transport and Tourism.

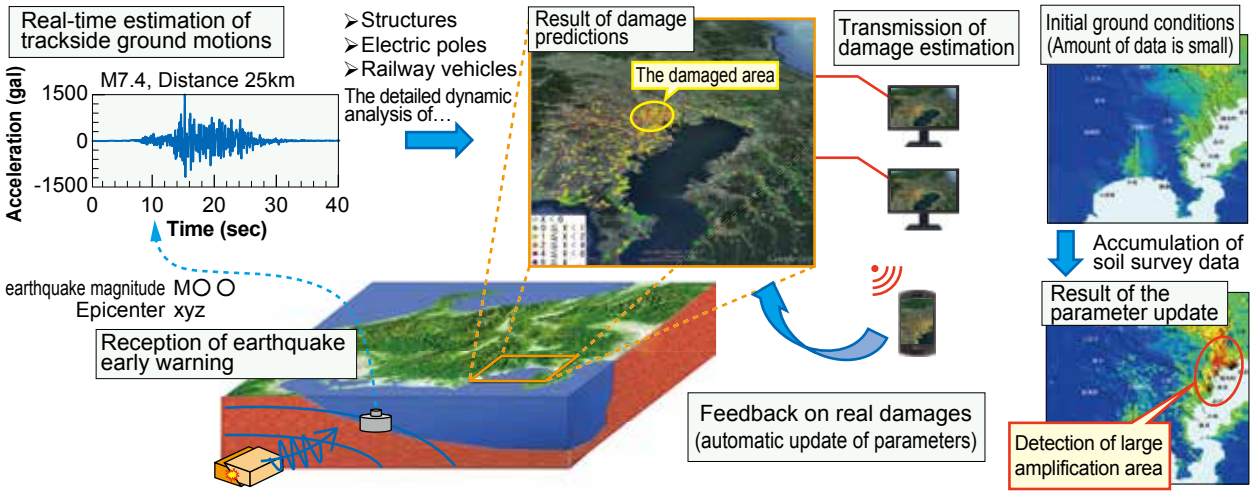


Fig. 1 Outline of earthquake damage simulator for railways

2. Practical application of early earthquake warning method using ocean bottom seismometer data

- An earthquake early warning method utilizing ocean bottom seismometer data was developed, to which observation data was applied to investigate the suitability of the specified values used in the method and its effectiveness in preventing false alerts.
- This method is expected to be able to generate warnings 10 secs earlier than with the previous method for subduction-zone earthquake.

An early earthquake warning system was developed that uses ocean bottom seismometer (OBS) data from public agencies. After completion of OBS installation, data could be collected and applied to previously proposed warning methods in order to verify them in practice. After adding a processing method to prevent false alerts, an early earthquake warning system for practical use on the railways was proposed.

Data for 137 earthquakes recorded in the S-net system maintained by the National Research Institute for Earth Science and Disaster Resilience was employed first, to extract the attenuation relationship and amplification characteristics for the target regions (Fig. 1). The first observation was that the peak ground acceleration extracted from the S-net data agreed well with the attenuation relationships found in data collected on land, secondly, compared to on-land data, the tendency of the amplitude to become amplified, was confirmed.

The data showed the same tendencies as results obtained from the small ocean bottom seismometer network used for studying the method. This demonstrates the adaptability of the new method to an early warning system which can consider the attenuation relationship and ocean bottom amplification characteristics.

Following on, ordinary noise characteristics were clarified, and it was found that preventing false alerts by processing data from one seismometer was a problem. In order to reduce the risk of erroneous warnings, a multiple-site processing method was proposed, where a warning is sent out if the observed data in one site exceeds the warning threshold level (Fig. 2, Red) and the detection threshold level is exceeded in another site at the same time (Fig. 2, Blue).

The new system based on multiple sites was not slower in generating warnings, than the existing system which sends out warnings when a fixed threshold level is exceeded in only one site, whereas it can reduce the risk of erroneous warnings being sent out.

It is expected that employing data collected from ocean bottom seismometers in early earthquake warning systems in addition to on-land seismic data will make it possible to generate warnings 10 secs earlier than the previous system which used solely on-land data.

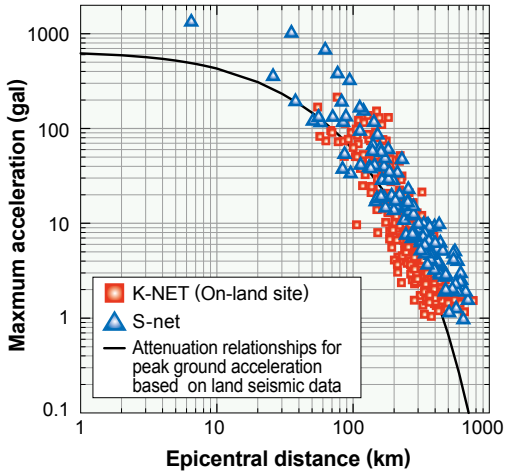


Fig. 1 Comparison of observation data with attenuation relationships

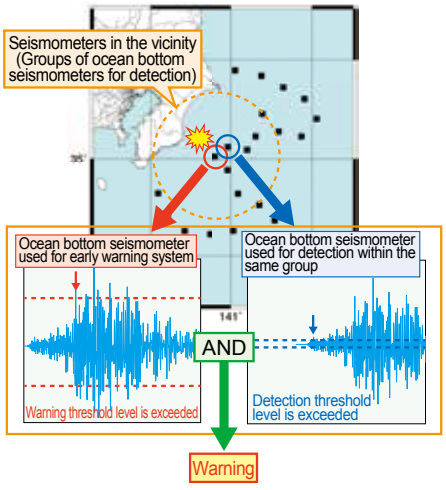


Fig. 2 Warning processing method using multiple sites

3. Countermeasures to prevent subsidence of abutment backfill and track buckling during earthquakes

- The mechanisms of ballasted track buckling during earthquakes resulting from subsidence of abutment backfill , were clarified.
- A countermeasure to prevent buckling was proposed, consisting of an integrated ballast retaining wall and contiguous pile wall for reinforcing the abutment backfill.

The mechanisms leading to buckling of ballasted track with continuous welded rail due to the decrease of lateral resistance force by the subsidence of abutment backfill, were clarified. Based on the insight gained, a countermeasure was proposed to prevent the fall in lateral resistance force, consisting of a contiguous pile wall to reinforce the abutment backfill, buckling prevention plates added to sleeper ends, and installation of a ballast retaining wall fixed to the pile wall (Fig.1).

A large scale shaking table test was performed on an integrated embankment / track model (scale of 1/9) with heated rails to raised axial forces, to reproduce abutment backfill subsidence and track buckling, and to investigate the effectiveness of the proposed anti-buckling countermeasure.

For tests carried out with the unreinforced abutment backfill, significant subsidence occurred without track buckling when a 400gal sinusoidal wave was input (Fig. 2). In the case where the embankment was reinforced with a contiguous pile wall, subsidence was reduced to about a third of the case where no contiguous pile wall was added. However, when only the abutment backfill was reinforced (without track reinforcement) and the sinusoidal wave was increased to 600gal, to simulate a very large earthquake, exceeding the force of an L2 earthquake, track buckling occurred. When anti-buckling plates were added to each end of each sleeper, and a ballast retaining wall fixed to the contiguous pile wall, no buckling occurred when sinusoidal waves of 600gal and even 700 gal were input, confirming that this countermeasure is effective for the prevention of track buckling (Fig. 3).

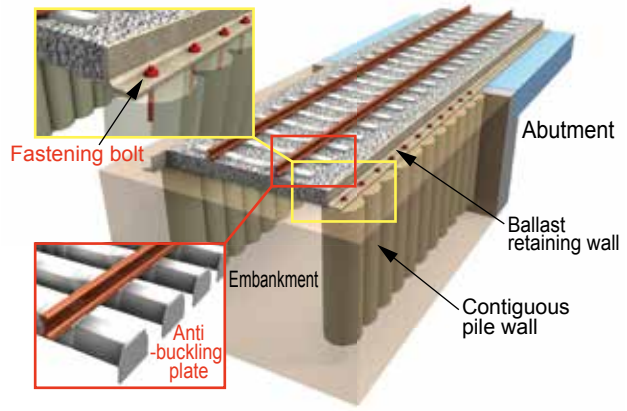


Fig. 1 Integrated ballast retaining wall and contiguous pile wall

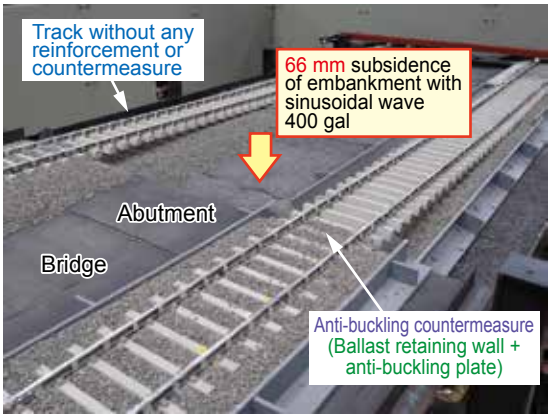


Fig. 2 Subsidence of abutment backfill without countermeasure

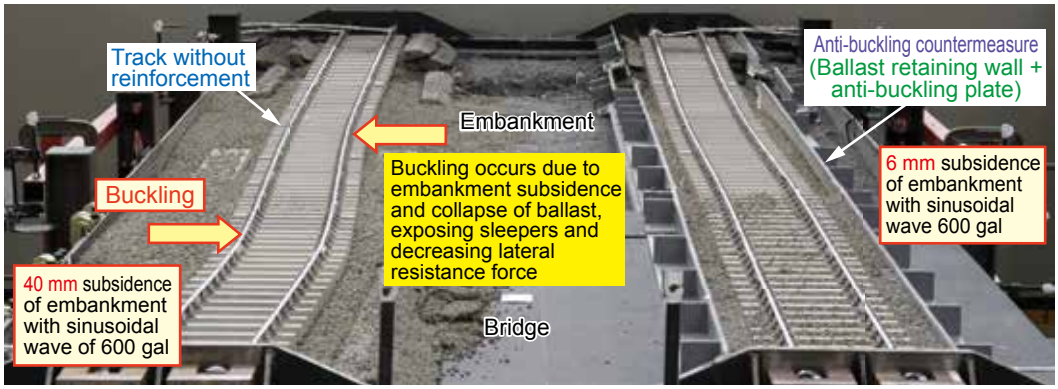


Fig. 3 Track buckling on track without reinforcement (left) and with reinforcement (right) (with reinforced embankment)

4.Ground surface layer response evaluation method for very large earthquakes

- A method for testing soil deformation characteristics was developed for conducting dynamic ground response analyses.
- A hybrid ground response testing device was developed in order to take into account ground including unusual soil.
- The proposed method can contribute to seismic design for railway structures and assessing soil liquefaction potential.

Structural safety during earthquakes depends heavily on the behavior of the surface ground. It is therefore essential to have correctly modeled soil deformation characteristics in order to conduct ground response analyses, to obtain estimated response values and soil liquefaction potential of the surface ground on construction sites.

To do this, a deformation characteristics test is carried out to calculated soil stiffness. However, the conventional method (existing method) for doing this places excessive emphasis on the rise in water pressure between soil particles caused by repeated cyclic loading, generating results that underestimate the stiffness of the soil. Consequently, a proposal was made for an alternative method (proposed method) which eliminates the influence of interstitial water pressure to calculate soil stiffness as much as possible.

By using the results obtained with the proposed method to conduct the ground response analysis, it was confirmed that ground deformation estimates (Fig. 1) and soil liquefaction potentials (Table 1) corresponded with results obtained in model tests.

Table 1

Assessment of soil liquefaction	Loose sand	Dense sand
Existing method or ordinary method	×	×
Proposed method	×	○
Model test（≒correct）	×	○

○ : Non liquefaction　× : Liquefaction

In the case of ground containing unusual soil, such as soil with friable particles or of volcanic origin, producing the correct model for analysis based on the results obtained from the proposed method was found to be sometimes impossible. Therefore, a hybrid ground response test device was developed, which reproduces special soil characteristics through shear tests on the one hand, and those of ordinary soil through simulation (Fig. 2). Adopting this hybrid approach has made it possible to evaluate the surface ground response even in cases including unusual soils.

The results from this method can contribute to seismic design, and to improving the seismic safety of structures.

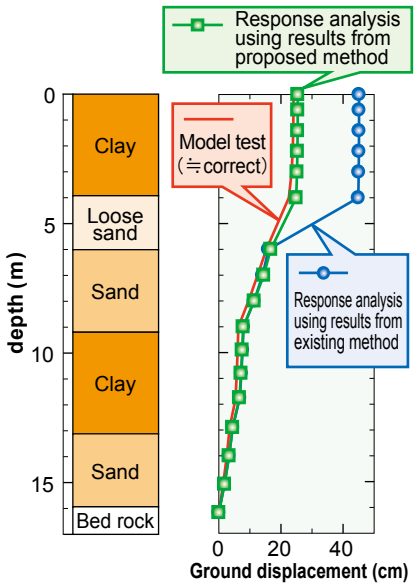
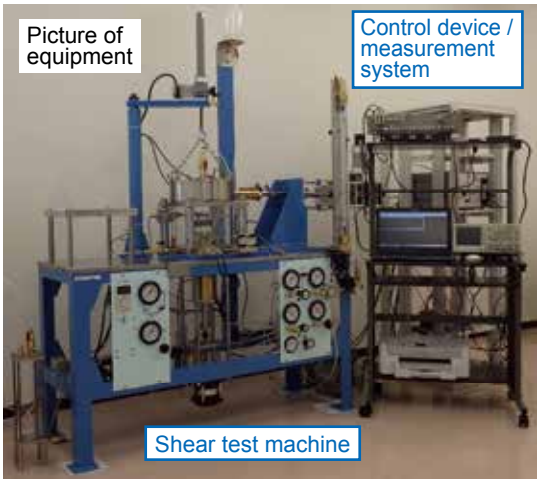


Fig. 1 Comparison of estimated response values



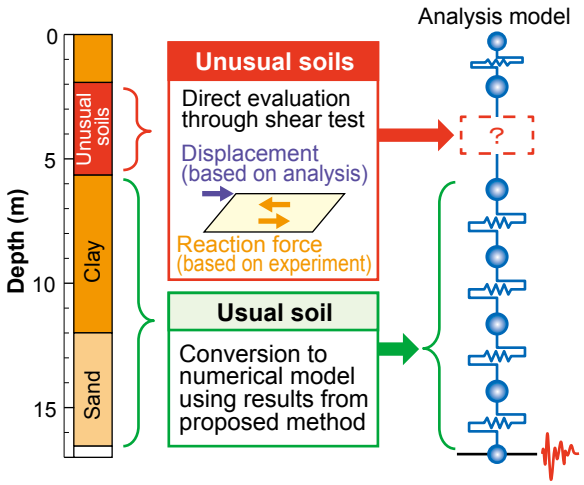


Fig. 2 Hybrid ground response test equipment and schematic overview

5. Anti-seismic reinforcement method for suspended-ceilings with small cavities at stations

- An anti-seismic reinforcement method was developed for suspended ceilings with small spaces at stations, using square pipes.
- Structural tests demonstrated the strong anti-seismic reinforcement performance of this method.
- This technique could reduce costs to less than half of that for existing methods.

In stations built beneath low viaducts, the cavity between the viaduct bottom and the suspended ceiling over the station is small. At the same time, a minimum amount of space must be kept free inside the suspended ceiling for passing plumbing and other pipes etc. As such, installing the usual anti-seismic braces used for reinforcement is difficult, since they would take up this space that needs to be kept free. Other reinforcement methods for replacing ceiling components such as hanging bolts etc. with channel steels exist, however, these types of constructions are complex and costly. In addition, vibration isolating rubber elements that are usually used as a noise abatement method, weaken this type of structure's anti-seismic reinforcement performance (Fig. 1).

As such, a less costly, more practical seismic reinforcement method was developed, where the ceiling cavity is not obstructed: a hanging bolt is combined with an ordinary square pipe which is secured at the bottom by a nut (Fig. 1). Structural cyclic loading tests using more than the largest design load were carried out to evaluate the anti-seismic performance of this method, and demonstrated that it had a strong anti-seismic performance (Fig. 2).

Acoustic tests were performed to evaluate the noise attenuating packing materials and rubber edges used to close gaps in the ceiling. Results confirmed that the noise abatement performance of these materials was just as effective as the previously used vibration isolating rubber elements.

Based on these outcomes, a new anti-seismic method for suspended ceilings with small-cavities in stations, was proposed (Fig. 3). In addition, it was shown that the proposed method cuts construction cost to less than half, compared to the existing construction method employing channel steels and vibration isolating rubber elements.

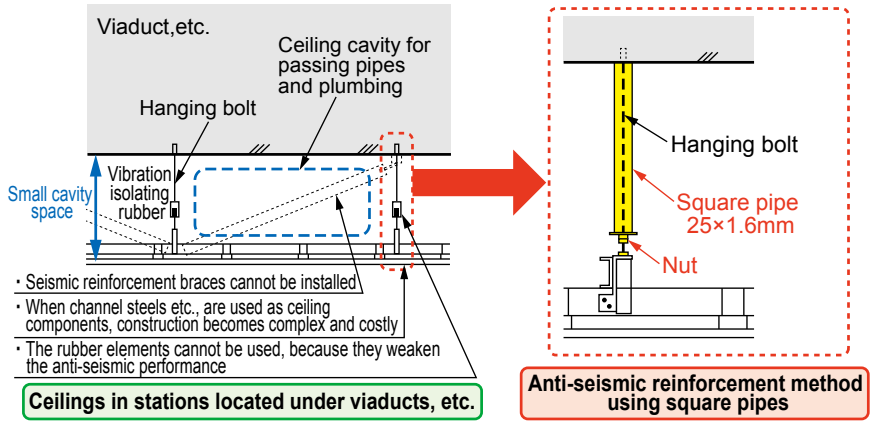


Fig. 1 Seismic reinforcement problems in station ceilings, and anti-seismic reinforcement solution using square pipe

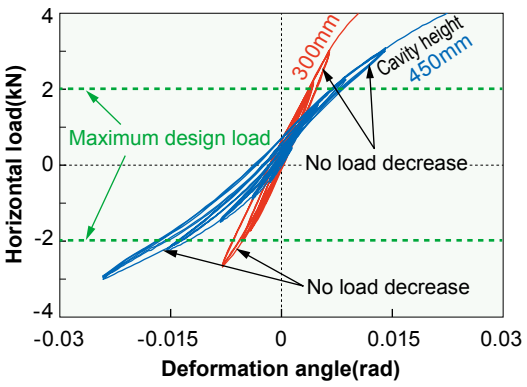


Fig. 2 Results of cyclic loading tests

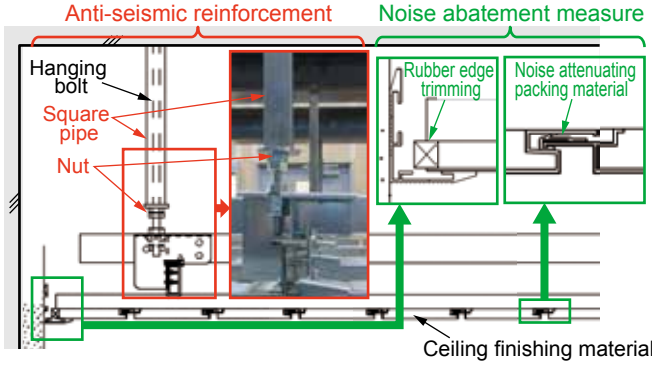


Fig. 3 Anti-seismic reinforcement method considering noise abatement

6. Algorithm to estimate strong wind locations due to such as gusts.

- An algorithm has been created to estimate strong wind areas due to gusts etc., based on meteorological radars.
- The algorithm can predict strong wind areas due to gusts up to 10 minutes ahead, at 5 minute intervals.

Gusts such as downbursts, gust fronts and tornados can affect zones covering several hundred meters to several kilometers in area. The anemometers used for train operation control however are spaced at 20 km intervals, on average, which means there is a possibility that they will not accurately detect these gusts. Consequently, an algorithm was created to predict locations likely to be affected by strong wind at ground level on the basis of wind and rain-cloud conditions in the upper air, from data collected from meteorological radars and the results of numerical calculations.

The first step in the algorithm detects areas (gust area in the upper air) of divergence, convergence, and strong vorticities formed by air streams that appear noticeably, by using the wind speed difference between two adjoining points obtained from wind velocity information observed by meteorological radars (XRAIN). After detecting their area, direction and speed of gust areas in the upper air, an estimation is made of strong wind locations at ground level due to these gusts. The relational expression between the wind speeds of gust areas in the upper air and at ground level for each altitude was set on the basis of difference in wind speed per unit of distance at different altitudes (Fig. 2), based on the results of numerical calculations for previous gust cases. In Figure 2, the warmer color indicates the larger localized wind speed difference. The algorithm can be used to predict strong wind areas up to 10 minutes ahead, at 5 minute intervals.

As such, this algorithm can be applied as a support tool for safer and more prompt train operation management for preventing natural disasters due to localized and short-term phenomena such as gusts.

The DIAS dataset is archived and provided under the framework of the Data Integration and Analysis System (DIAS) funded by Ministry of Education, Culture, Sports, Science and Technology (MEXT).

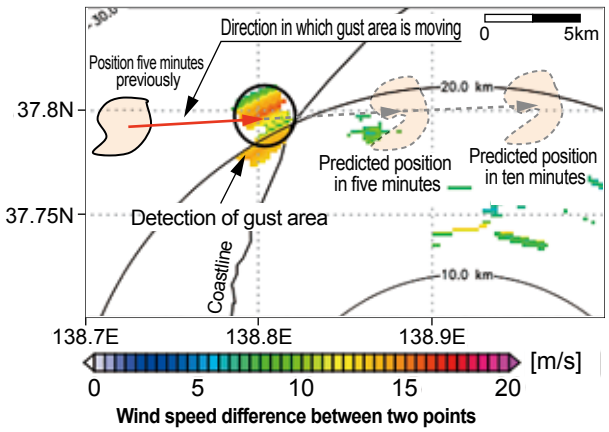


Fig. 1 Detection of gust area in the upper air from meteorological radar readings

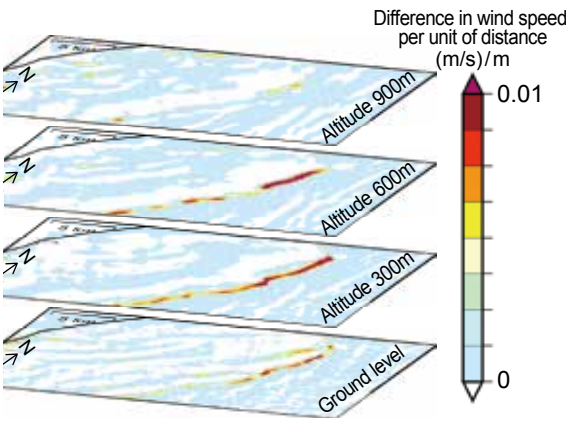


Fig. 2 Example of wind speed difference between two points about 1 km apart at each altitude whilst gusts are blowing

7. Flowchart to determine possibility of reusing bridge following scouring damage

- A decision-making flowchart was proposed for determining if a bridge can be reused after scouring damage.
- This method shortens traffic downtime and contributes to improving the resilience of the railways.

The increase of flooding over recent years in short but localized intense downpours and typhoons has led to more frequent small to medium scale damage to old-design river bridges, such as subsidence, tilting of piers or deformation of steel girder bearing seats in some cases, due to bridge scour and subsequent weakening of the supporting ground (Fig. 1).

In order to reopen bridges as soon as possible after this type of small to medium-scale damage, the priority is to be able to reuse the bridge by carrying out minimum repair to remaining piers and girders, rather than rebuild it. There are cases where the bridge's residual resistance may stay the same even after substantial bridge scour, and so model tests (Fig. 2) were carried out to confirm this possibility.

There are cases nevertheless, where the resistance of the bridge's foundation has been severely damaged, and the safety level at the time of construction can no longer be guaranteed. Using the subsidence measured in the course of a test vehicle run as a quantitative evaluation criterion to resume operation, a method was proposed to evaluate whether the residual resistance, estimated from the measured subsidence value, was well enough within the safety margin to allow emergency repair. This was followed by a proposed for a decision-making flow chart to help determine whether a bridge can be reused or not (Fig. 3).

The present research was conducted with financial support from the Ministry of Land, Transport, Infrastructure and Tourism.

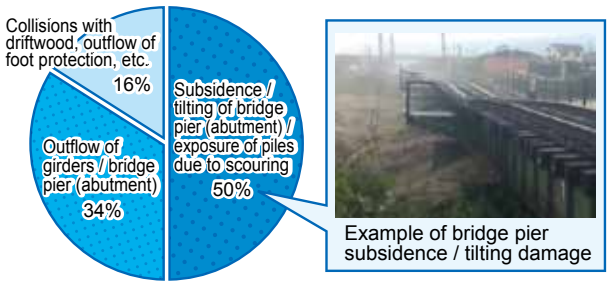


Fig. 1 Results of analysis of damage to bridge from flooding

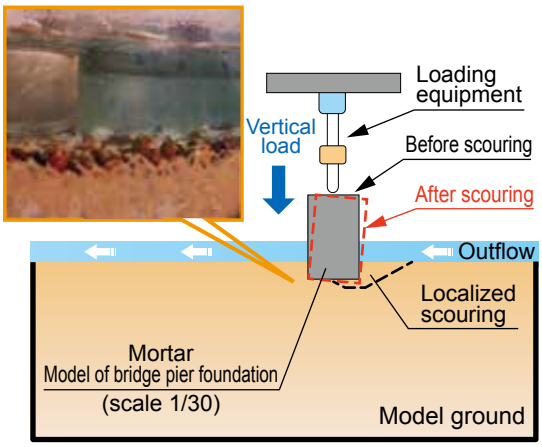


Fig. 2 Scouring test on foundations of model bridge pier

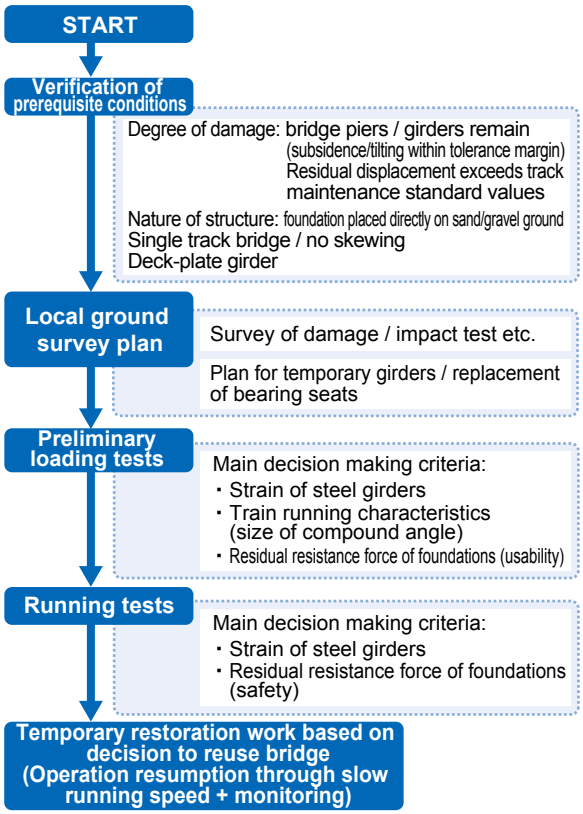


Fig. 3 Outline of flowchart supporting decision to reuse or not reuse bridge

8. Increase in accuracy of bogie hunting stability evaluation

- It has been clarified that bogie hunting is caused by a combination of running speed and lateral displacement of the wheelset.
- It is now possible to accurately evaluate running stability through a test method.

It is possible to evaluate the running stability of bogies, or the critical speed of hunting, through rotation tests on a roller using the rolling stock test bench at RTRI (Fig. 1). However, there may be cases where the critical speed of the hunting differs depending on the external trigger used to generate the hunting (excitation conditions applied to the roller), which causes variance in the evaluation results. If the result of an evaluation indicates a sufficiently large safety margin at the in-service running speed, then variance is of no great consequence, however, clarification of the exact conditions that cause hunting, would contribute to making stability evaluations more accurate, so work was done to achieve this.

When the roller speed is gradually increased without any excitation, hunting occurs when a certain speed is reached (hereinafter, 'generation speed'). Inversely, when the roller is gradually slowed down, hunting will eventually cease at a given speed (hereinafter, 'disappearance speed'). When the roller is at the speed between the generation and disappearance speeds, whether or not bogie hunting occurs depends on excitation conditions. Various excitation conditions were tried and the behaviors at which hunting actually occurs were clarified experimentally (Fig. 2).

Results revealed that the amplitude value of lateral displacement immediately after excitation ceases (hereinafter, 'initial amplitude'), has an upper limit within which vibration disappears. Vibrations disappear after excitation stops if the initial amplitude has not reached the peak value ("○" in Fig.2). If the initial amplitude does exceed the peak value ("x" in Fig2.), then vibrations diverge and hunting occurs, and the amplitude of the vibration increases up to the flange contact boundary. The peak value in question decreases monotonically as the roller speed increases from stopping speed to the generation speed.

Conventionally, to compare running stability, excitation conditions were fixed while bogie parameters were varied. Based on the findings of this research, adjusting the input excitation conditions to maintain a constant initial amplitude would prevent variance in the critical speed evaluation values, making comparison possible.

Progress now needs to be made to develop an analytical method that will make it possible to accurately estimate the correlation between running speed and the initial amplitude peak value, with the aim of building an easy-to-use running stability evaluation method that does not require complex fixed rotation tests.

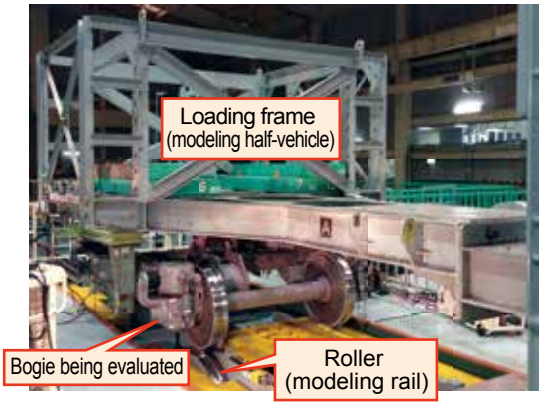


Fig. 1 Hunting tests on rolling stock test stand

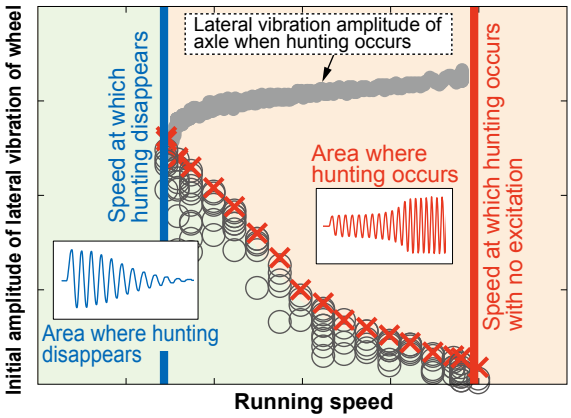


Fig. 2 Conditions generating hunting motion

9. Driver visual recognition support method using image processing

- A method has been developed for projecting images onto a monitor of outside views a driver cannot see from the driving cab due to lines of vision obstructed by parts of the driving cab, in a way which appears natural to the driver.
- This equipment will alleviate driver load as a visual support.

The presence of large members in the driver's cab or in gangways can narrow a driver's field of vision (Fig. 1). In order to reduce these blind spots, new image processing technology has been employed in a method to project the external obstructed viewpoint onto a display, such as a monitor, so that the driver can see through the blind spot as naturally as possible. Generally, it is not possible to install a camera on the back of the member blocking the extension of the line of vision of the driver. Consequently, as shown in Fig. 2, a forward facing camera is used, positioned at a different angle to capture the obstructed view. A virtual screen is inserted into the camera image to reflect the projected view. A method was then developed that makes it possible to project the image on the virtual screen onto a display: the 3-D coordinates in the four corners of the virtual screen are converted to 2-D coordinates and a projection conversion program was built and used to project the coordinates of the four corners onto the projection display.

A prototype set of equipment was built where the blind spot image, processed in about 10ms, was projected onto a monitor located to the side of the driver's seat. This in-situ test confirmed that the driver's natural line of vision could be reproduced (Fig. 3). Applying this equipment as a visual support to the driver can eliminate blind spots that prevent the driver from seeing some stop-position signs, etc. which alleviates driver load.

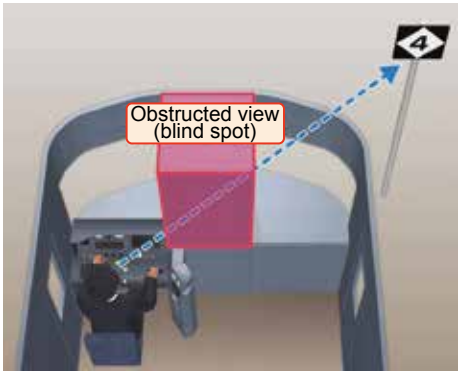


Fig. 1 Blind spot created by members in the driver's cab

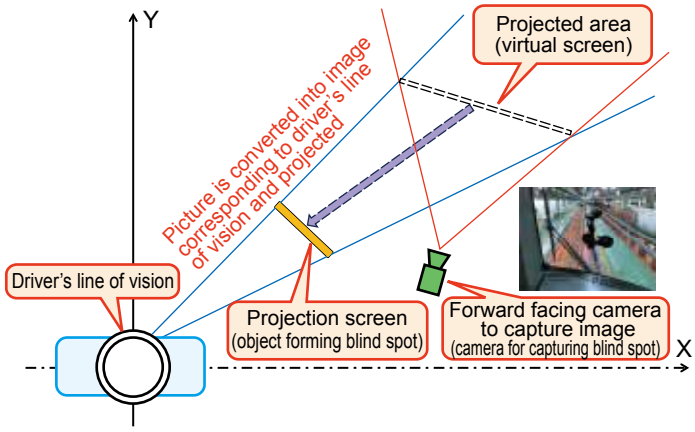


Fig. 2 Method for converting view point, by projection conversion

Fig. 3 In-cab functional verification test

10. Health monitoring of very large structures using long-range U-Doppler

- Using an invisible ray laser Doppler vibrometer, it is possible to determine the overall health of an entire structure from a distance of 300m.
- The laser's automatically controlled scanner allows the device to detect the points on the target surface which can offer the highest level of measurement accuracy.
- Using simultaneous measurements made from two devices it is possible to measure the natural frequency of a continuous viaduct remotely.

A "long-range U-Doppler" has been developed (Fig. 1) which has made it possible to investigate changes in the behavior of railway bridges due to failing health, and even detect deformation in ancillary structures, without the need to access elevated positions.

The long-range U-Doppler, which is a laser Doppler vibrometer installed on a custom-built horizontally and vertically adjustable rotating base permits long-range remote stable measurements, has extended the conventional remote measuring distance from 30 to 300m, even when the target structure does not have a reflecting plate.

The laser's automatic scanning function allows it to identify the points on the target structure within the measurement zone that offer the highest reflection intensity (Fig. 2). This algorithm now makes it possible to efficiently make measurements from large distances and of structures that were difficult to measure until now, for example, measurements that have to be made from far away, of cables with curved surfaces or structures with dirty surfaces.

For example, measurement of the tensile force of 44 cables on a cable stayed bridge with a span of about 130m, would require four night shifts using the conventional method, whereas the present contactless method can achieve the same result with equal accuracy in just one hour during the day time (Fig. 3).

In addition, an algorithm was created to enable measurement of individual vibration components of viaducts with complex 3-D vibrations, using simultaneous measurements from two Long-range U-Doppler devices.

This has made it possible to measure the natural frequency of each span on the viaduct remotely, in a single visit from a single spot.

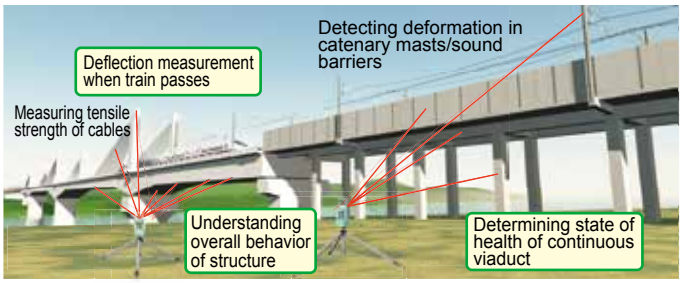


Fig. 1 Applications for long-range U-Doppler

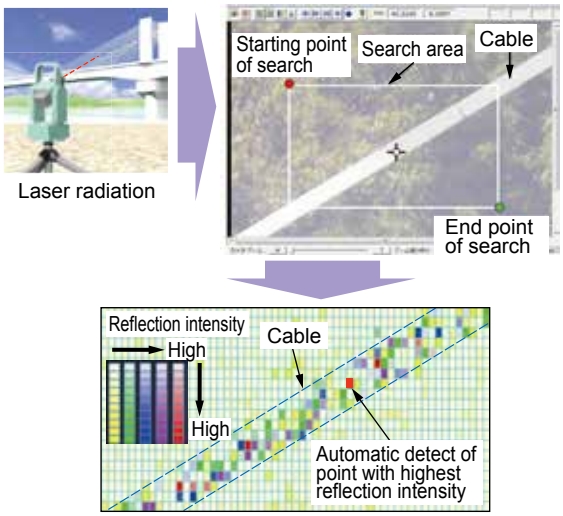


Fig. 2 Measurement cable and automatic collimation

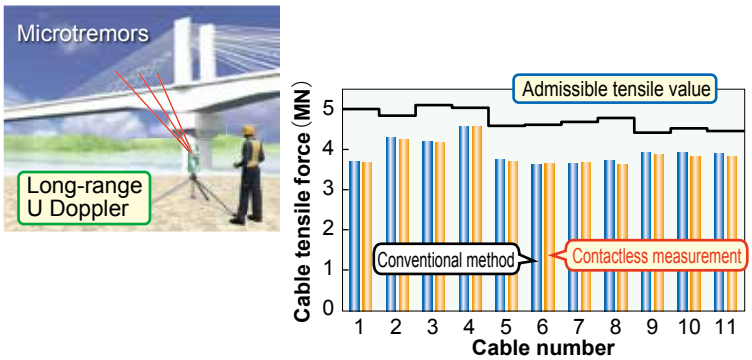


Fig. 3 Example of measurement of tensile force of cables on cable stayed bridge

11. Influence of pinion shaft bearing endplay (axial clearance) on its seizure initiation

- The change in pinion bearing endplay due to the temperature variations of the pinion and its peripheral parts was clarified.
- Assembly methods capable of not reducing the endplay to near 0 mm during the shaft rotation, and structures capable of eliminating the adjustment of the endplay, were found to be effective in preventing pinion bearing seizure.

In order to prevent pinion bearing seizure and increase the reliability of gear units, it is important to ensure that sufficient endplay is maintained with the pinion bearings during rotation (Fig. 1). Bench rotation tests were conducted to measure changes in endplay, variations in endplay caused by changes in temperature of the pinion bearings and the peripheral parts were estimated through calculation.

Results showed that the lower the temperature of the gear oil, the greater the reduction in endplay immediately after the rotation start of the shaft. In addition, the difference between measured and calculated endplay was 0.02 mm at most, confirming that the tendency of their variations were almost the same (Fig. 2).

The rotational torque of the pinion bearings and the temperature of each component were also measured. It was found revealed that, when the (calculated) endplay reduced to near 0mm due to changes in temperature of the pinion bearings and its peripheral parts during rotation, seizure occurred, and the bearing shaft torque and temperature suddenly rose (Fig. 3).

From these results, it can be concluded that assembly methods capable of not reducing the endplay to near 0 mm during the shaft rotation, and structures capable of eliminating the adjustment of the endplay, were found to be effective in preventing pinion bearing seizure.

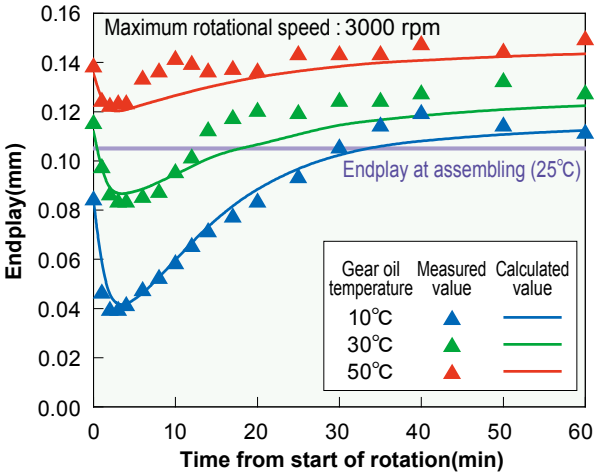


Fig. 2 Variation in end play after rotation begins

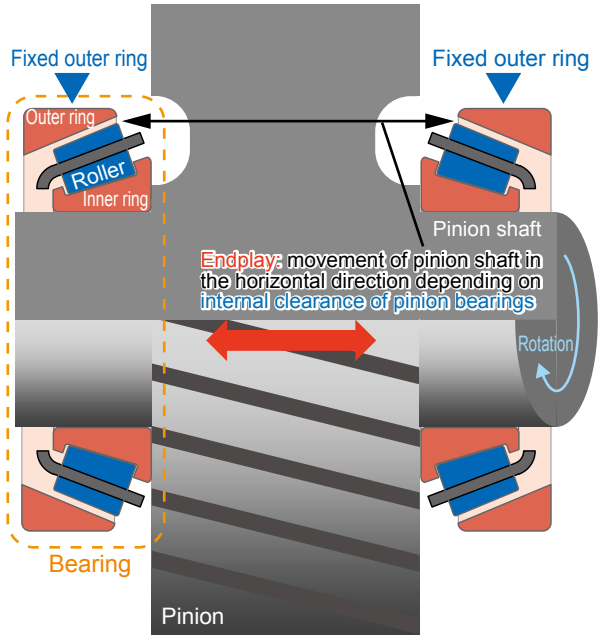


Fig.1 Pinion shaft bearing endplay

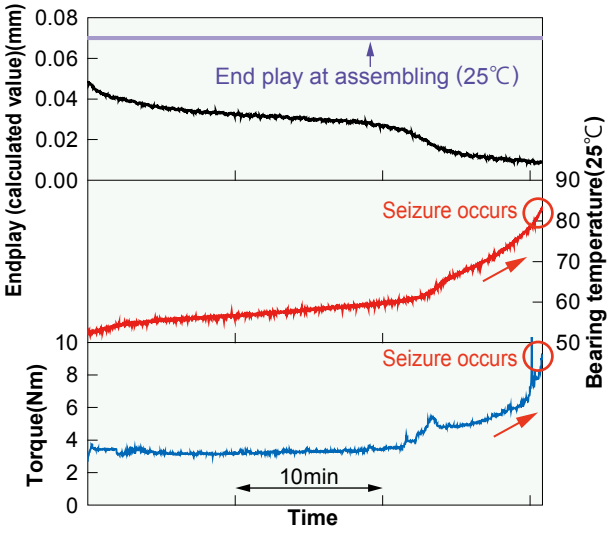


Fig. 3 Variation in bearing temperature, torque and endplay until burn-off seizure occurs

12. Development of early restoration and reinforcement technologies for embankments damaged by natural disasters

- A effective method for rapidly restoring and reinforcing embankments damaged by severe weather events, using a combination of earth bank reinforcing materials, gabions and drainage pipes has been developed, and an accompanying design and work manual has been drafted.
- The proposed restoration method increases resistance to rain damage 1.7 times and 1.5 times to earthquakes.
- The proposed method can reduce work time by approximately 30%.

Up until now, when embankments collapsed due to earthquakes or torrential rain, temporary measures, such as application of large sandbags, were used to reconstitute the earthwork's profile, then, whilst trains continued to run, repair work was carried out on the embankment. This approach requires the erection of temporary earth retaining walls, on-site inspections and implementation of speed restrictions.

As such, a rapid restoration and reinforcement method to improve embankment performance was developed which splits the work: a stock of gabions is kept on standby in order to quickly restore the earth bank, whilst earth bank reinforcing materials and drainage pipes can be added later while trains are running (Fig. 1). The proposed method requires 30% more time than it takes for completion of the first phase of immediate emergency repairs under the existing method, however, the total completion time of the new method is 30% shorter. In addition, the new method can lower costs by approximately 30-60%.

With a view to verifying the long-term stability of the proposed construction, cyclic loading tests of repeated train loads and FEM analyses were conducted over 3 years on a class-4 line (max. axle load 14t, max speed 85km/h). The residual subsidence after this period was 8 mm, validating the design as an alternative to an earth embankment as a supporting structure for ballasted track. In the functional tests conducted on the proposed structure shown in Fig. 2, the high draining capacity of the gabions meant that resilience to circular slip in torrential rain was 1.7 times higher than the existing construction method, validating the improvement in rainfall resistance.

In addition, the combined use of gabions and soil reinforcement meant that acceleration before collapse was 1.5 higher than before, which confirmed the consolidating performance of the gabions and earthquake-resistance of the proposed construction method. The insights from these results were used to compile an accompanying user manual.

Fig.1 Proposed construction work flow

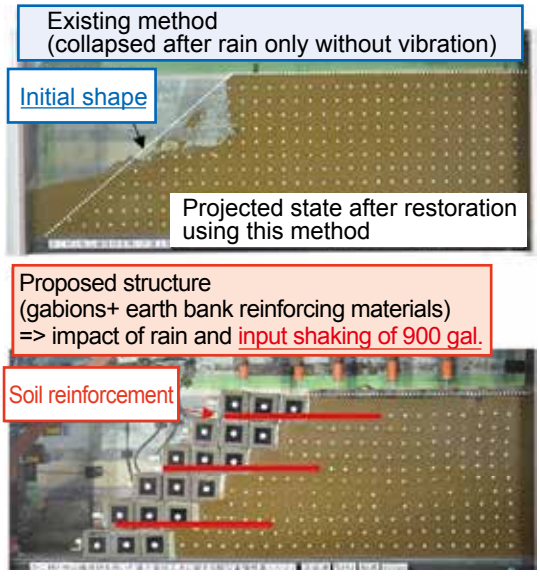


Fig. 2 Functional verification testing increased resistance to rain fall and earthquakes

13. Tunnel reinforcement method using improved performance ground reinforcement rock bolts

- An improved performance rock bolt was developed that is effective even in loosened ground.
- Test work confirmed that the new design was workable and maintained axial force over the long term.
- Compared to existing rock bolts, the new design can reduce work related costs by about 40%.

Reinforcement work on tunnels subject to earth pressure is usually carried out using rock bolts, however, in cases where the ground continues to weaken, the effectiveness of this type of measure is limited because it is not possible to maintain fixing strength. Consequently, improved performance rock bolts were developed, which can be just as effective on softened ground.

The problems encountered with existing rock bolts, included absence of filler mortar around the tip of the rock bolt, and lack of fixing strength when inserted into softened ground around the tunnel. The new rock bolts have additional packers and expansion mortar injected around the tip of the rock bolt, which maintains fixing strength of the tip. Permanent grouting is also injected into the weakened surrounding ground, which is the source of the pressure, bringing the loosening ground problem under control (Fig.1).

Based on the results of calculations performed on a single track tunnel, the effectiveness of the performance improved rock bolts in preventing deformation, is 2.6 times greater than the existing bolts, compared to the case where three times as many existing rock bolts were used (Fig. 2). Given that about three times as many existing rock bolts are required, using the newly developed bolts can reduce costs by approximately 40%. A test using the newly developed bolts was carried out on a tunnel on a disused line in Hokkaido.

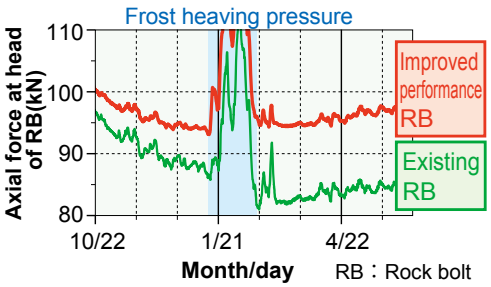


Fig. 3 Change in axial force after test work

Results of a trial on a tunnel subjected to pre-stress of 100 kN over one winter, confirmed that the newly developed rock bolts were able to retain axial force more effectively than the existing type (Fig. 3).

In addition, an accompanying design / work manual was drafted.

This research was financially supported by the Japanese Ministry of Land, Transport, Infrastructure and Tourism.

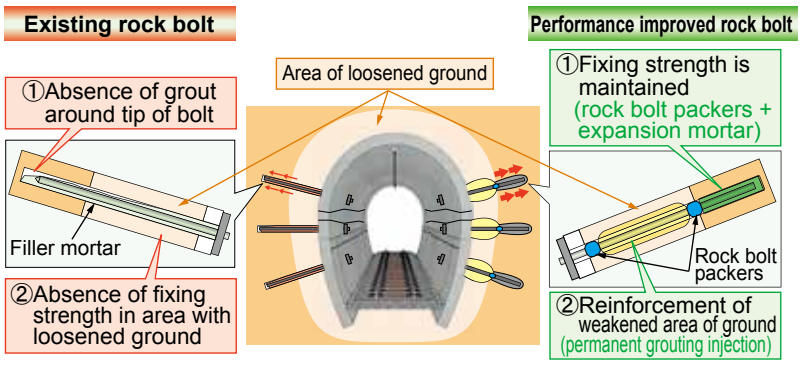


Fig. 1 Comparison with existing type of rock bolt

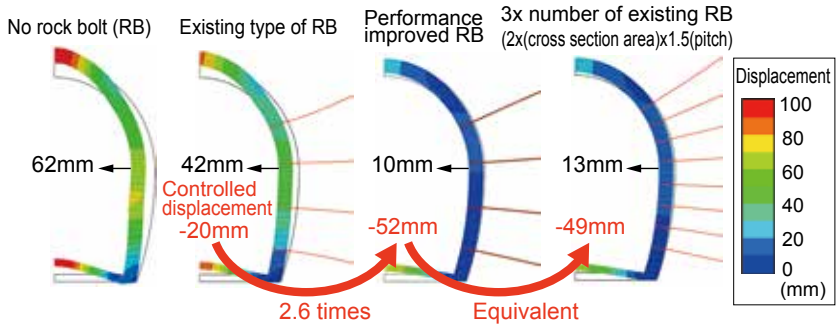


Fig. 2 Evaluation of effectiveness of displacement control through numerical analysis

14. Simple catenary designed for running speeds of over 300 km/h

- A simple catenary has been developed with fewer components and good maintainability for lines with running speeds of over 300km/h.
- Tests on a revenue line confirmed that the contact loss ratio and contact wire uplift were both within admissible limits, and that the new design posed no problem for the current collecting function of the new system.

Auxiliary messenger wires on Japan's Shinkansen line heavy compound catenary systems are gradually coming the time having to be replaced on a large scale. This is being used as an opportunity to replace incumbent installations with simple catenary systems on lines with running speeds below 300 km/h. Interest has been growing in the meantime, to have simple catenary systems introduced on lines with running speeds of over 300 km/h. Consequently, two types of simple catenary system designed for operating speeds over 300 km/h were developed (Table 1).

Compared to heavy compound catenary systems, the problem with simple systems was that at speeds of over 300 km/h there is a risk for vertical pantograph vibrations to increase in the intervals between masts, which hinders current collection. As such, the overall tension of the catenary was increased above the normal simple catenary system level in order to increase the spring constant of the contact wire in the middle of the span between masts, thereby controlling the vertical vibration of the pantograph. Two simple catenary designs were developed, one for running speeds of 320/km/h and the other for 360 km/h (Fig.1).

For the 320 km/h design, in order to ensure that the wave propagation speed in the contact wire allows stable current collection at 1.4 times the standard speed, the selected contact wire had a cross sectional area of 170mm2 and was tensioned to 22.54kN.

For use at 360km/h, the cross sectional area of the selected wire was 130mm2 even though this reduces the maintenance margin against frictional wear, which was tensioned to 24.5kN.

The two designs were tested on a revenue line to verify their current collection performance. Results confirmed that the contact loss ratio and contact wire uplift were both within target values, and that the new design did not pose a problem for current collection. In addition, tests demonstrated that the state of frictional wear and workability of the new design were also satisfactory (Fig. 2).

Table 1 Overview of high speed catenary systems on Shinkansen lines

Type of catenary system	In the region of 250 km/h	285km/h	320km/h	360km/h
Compound catenary system	Heavy compound catenary system	High-tensile force heavy compound catenary		With proposed※ catenary system
Simple catenary system	High speed use simple catenary for new Shinkansen bullet-train projects (total tensile force 39.2 kN)	Large current capacity high speed simple catenary (total tensile force 49.0 kN)	320 km/h use 170 mm² cross-section contact wire (total tensile force 53.9 kN)	360 km/h use 130 mm² cross-section contact wire (total tensile force 53.9 kN)

Existing catenary wire

※ after completion of functional performance verification in high speed running tests

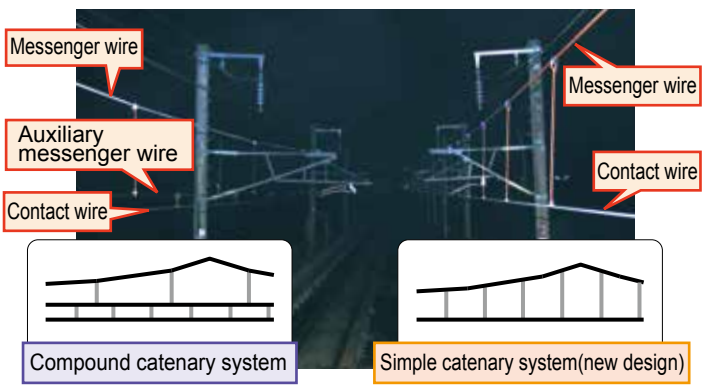


Fig. 1 Schematic and image of developed catenary system

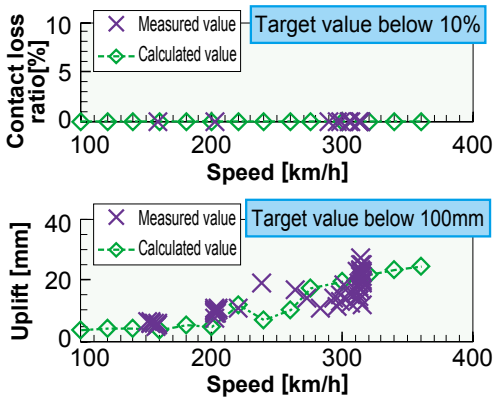


Fig. 2 In-line tests (360 km/h)

15. Decision making system for economical mid-term track maintenance plans

- A system has been developed to optimize five-year maintenance plans for track irregularity and ballast replacement.
- This system makes it possible to decide track irregularity maintenance and ballast replacement plans that reduce the total cost of maintaining tracks to a satisfactory level over the medium term.

In order for track maintenance and management to be more efficient, it is important to make the, “inspection, diagnosis (level of deterioration), maintenance plan preparation, maintenance implementation” cycle as functionally efficient as possible. Consequently, discussions began on how to effectively exploit track irregularity data etc. collected by either track inspection cars or commercial trains in order to develop a system that would propose maintenance plans for short to medium and long term periods.

As a result, a medium term maintenance planning system was developed to plan both ballast replacement and maintenance for track irregularity for 5-year periods.

Figure 1 shows how a yearly maintenance planning system functions according to the 5-year maintenance plan decided by this system, upgrading track maintenance and management more efficient.

In the developed medium-term maintenance planning system, the state of deterioration of the track is diagnosed on the basis of past maintenance and track irregularity data, from which sections of ballast that require replacement are extracted. Ballast replacement prioritization is calculated on the basis of savings to be made on the cost of track irregularity maintenance by replacing the ballast.

If the maximum possible maintenance for each year for ballast replacement and track irregularity maintenance is attributed, then the plan decided by this system will ensure that the track is in best condition after five years (annual ballast replacement and track irregularity maintenance). Then, since the relationship between the amount of maintenance and track condition can be analyzed (Fig. 2), it is possible to decide the maintenance plan to maintain the track to a satisfactory level at a lower cost. Apart from determining the sections requiring maintenance to manage track irregularities over a year, use of the collected data allows the plan to be reviewed etc., and can be connected to the newly developed management and maintenance planning system to update annual plans, in order to continuously improve the efficiency of the management cycle.

The new system was introduced into the track maintenance planning systems being developed by railway operators, and brought into service in 2018.

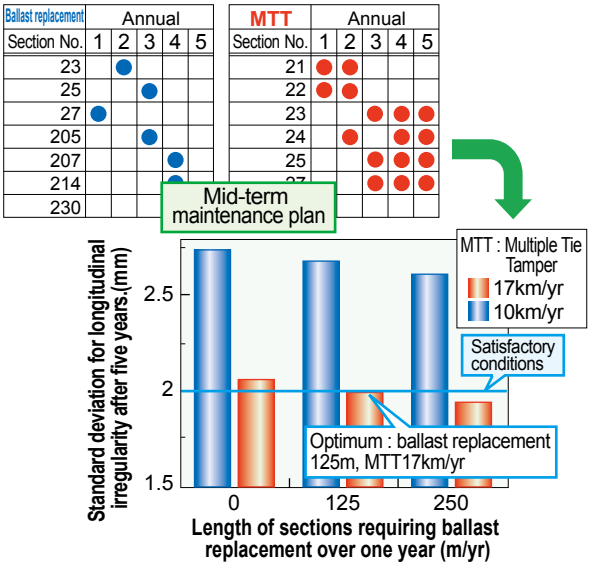


Fig. 2 Example of mid-term maintenance plan trial

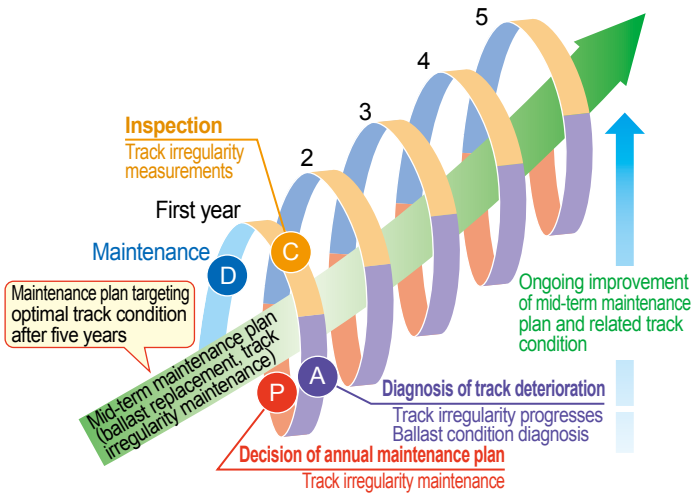


Fig. 1 Image of mid-term maintenance planning system

16. Rail head defect repair method with reduced work time

- An automatically controlled hot rail correcting machine was developed as a rail head defect repair method.
- The new machine can reduce working time by 2/3 compared to existing methods, to within three hours.
- In order to generalize the use of this method, a “Working handbook” was compiled.

The method used for repairing rail head defects involves localized removal of the damaged part of the rail head, and filling the gap with molten steel. It is an inexpensive repair for the rail damage method and railway companies have tested the method and have now begun to use it in earnest.

In this method, heat is only applied to the affected part of the rail head, therefore, because of thermal contraction, the rail will dip after cooling (Fig. 1). Consequently, after pouring the molten steel on the rail to mend the defect, the repaired part of the rail is bent upwards whilst it is still hot (hot rail correction), in anticipation of the dipping in the rail, preventing the thermal contraction effect (Fig. 2).

Nevertheless, the following issues have arisen with this hot rail correcting process so far, which will form an obstacle to the method being adopted generally:

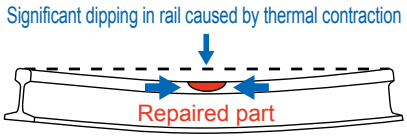


Fig. 1 Thermal contraction of repaired part

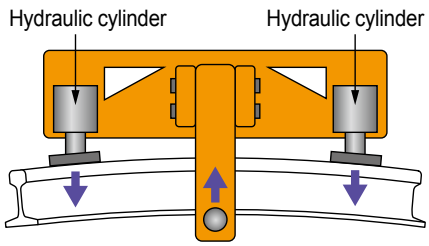
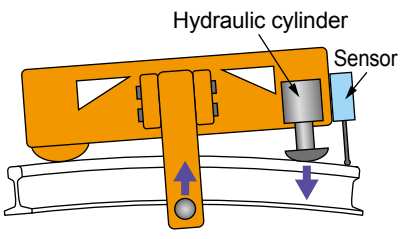
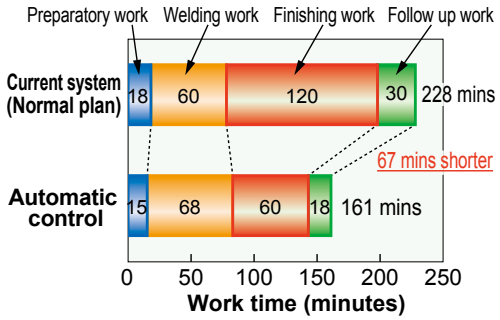


Fig. 2 Bending upwards the repaired part of the rail by hot correcting



correcting possible with single hydraulic cylinder

Fig. 3 Outline of automatically controlled hot rail correcting machine



Reduction by half of finishing work time

Fig. 4 Resulting shorter work time

(1) The operator must visually measure rail deformation using a custom-designed special ruler whilst operating a hydraulic pump, which requires a high degree of skill and experience.

(2) There are cases where the rail is bent upwards too far, which increases the time required for rail grinding work, while it is necessary to keep work time to around 4 hours.

In order to deskill the rail head repair process, an automatically controlled hot rail correcting machine was developed (Fig.3).

With the new machine it is possible for an ordinary operator (without the specialist skills) to accurately and quickly carry out the hot rail correction work. The machine is also simpler with only one hydraulic cylinder, in order to make it lighter and less expensive. Trials where the machine was used on actual in-service railway lines confirmed that repairs could be completed in approximately 160 minutes. Removing the risk of bending the rail upwards too far makes the new method 60 mins shorter than the existing method (Fig. 4).

In addition, in order to support the creation of a qualification system for operators using this method which is essential if it is to be used by operating companies throughout Japan, a “work manual” was compiled containing the key points on how to apply the rail head repair method.

17. Wireless train control systems designed for regional railways

- A train control system has been developed, designed for regional railways using wireless communication which does not require track circuits and wayside signals in station yards.
- Trains are protected when running from one station to the next by an onboard device installed with a database.
- Since a generic wireless LAN is used, and IP telephone connection can be used for ground facility-train communication

Current train control systems designed for regional railways includes electronic blocking systems, and train control systems using area-specific radio communications developed by RTRI, which both still require track circuits and wayside signaling equipment. In the proposed newly developed system, the train position recognized by the onboard system is transmitted by radio to a central management device, which determines the section within which the train can operate and transmits this information back to the train, which does not require track circuits and wayside signaling equipment. The train position in the developed system is recognized using the ATS-Dx function of the onboard database, developed by RTRI.

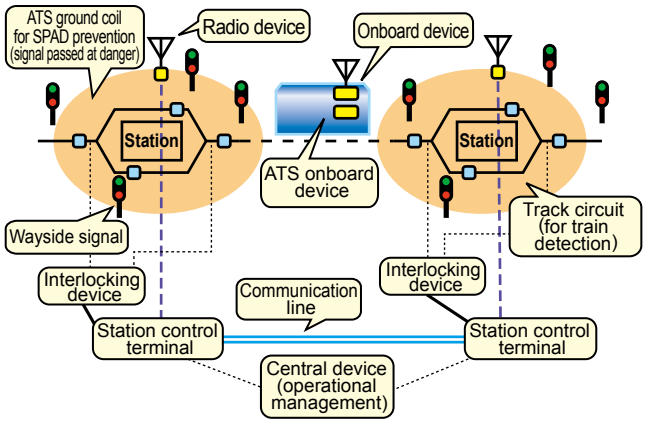


Fig. 1 Schematic of existing system (with radio communications in specific areas)

Wayside equipment is composed of ATS ground coils for absolute position detection, radio devices, and the station control terminal which interfaces with points machines and level crossing equipment (Fig. 1). Within station premises, a generic 5.6GHz wireless LAN is used which does not require a radio station license and has the advantage of providing track-train radio communication by IP telephone connection, even for sections not equipped with train radio. The bandwidth of control information to be transmitted is sufficiently small for wireless networks to function, therefore, if the radio is adequately designed, it is possible to ensure stability.

A special feature of this system is that the section between the departure signal in the departure station and the platform in the destination station is occupied as one block, therefore, even if there is a problem in the onboard or ground equipment on route, the train is protected up to the destination platform.

The specifications of the system were defined and based on these findings and tests were conducted with a prototype system to check basic functions such as block control, control of passing and turning at stations, voice communication and emergency response. It was confirmed that even when the radio was unstable, safety was ensured. In the future, tests on commercial lines are to be conducted.

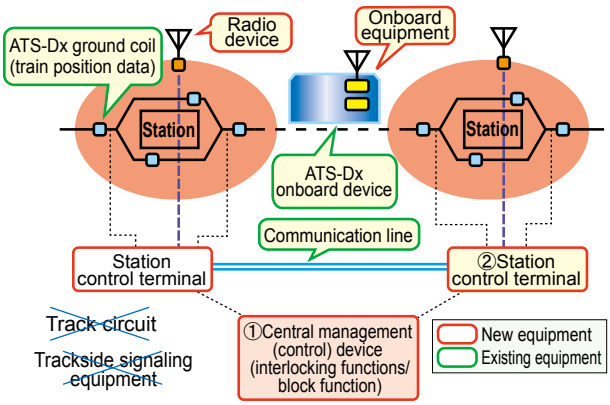


Fig. 2 Schematic of proposed new wireless train control system for regional railways

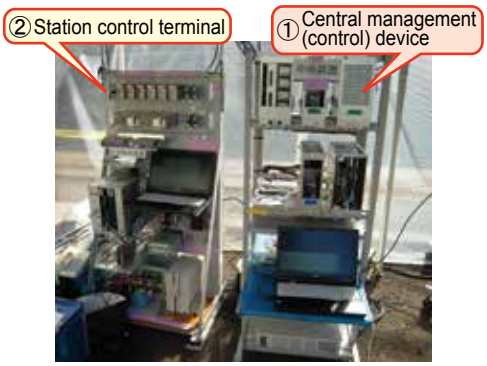


Fig. 3 Station terminal device and central management device

18. Concrete deterioration control using hydrogen-ion type geopolymer

- A method to synthesize hydrogen-ion type geopolymer with a high-performance concrete deterioration inhibitory effect has been developed.
- The new compound is as effective against ASR concrete deterioration as existing lithium based products, for one-fifth of the material cost.

In response to the commonly occurring Alkali-silica reaction (ASR) deterioration to concrete, RTRI developed a protective lithium (Li+) type zeolite material based on a compound using zeolite and lithium ion (Li+), known for their effectiveness against ASR, which is now used in practice. The issue with this compound is that the ingredient Lithium is expensive, limiting possible cost reduction of the product.

Investigations were therefore made with geopolymer which has the same properties as zeolite and combines easily with hydrogen ions (H+), focusing on cheap industrial by-product and mineral admixture geopolymer technology, and developing a hydrogen-ion geopolymer synthesizing method which uses materials that are 1/5 to 1/10 the cost of the existing lithium-ion zeolite combination.

In tests with a mortar to reproduce grout injection into cracks, a cement paste containing the developed Hydrogen-ion geopolymer was injected into holes (Fig. 1) and the expansion rate was measured. Results showed that even though the developed Hydrogen-ion geopolymer contained materials the cost of which was less than 20%, it was just as effective in suppressing expansion as the Lithium-ion zeolite (Fig. 2).

The target now is to develop the new grout for crack injection to suppress ASR, for practical use within three years, which should contribute to improving concrete structure maintenance.

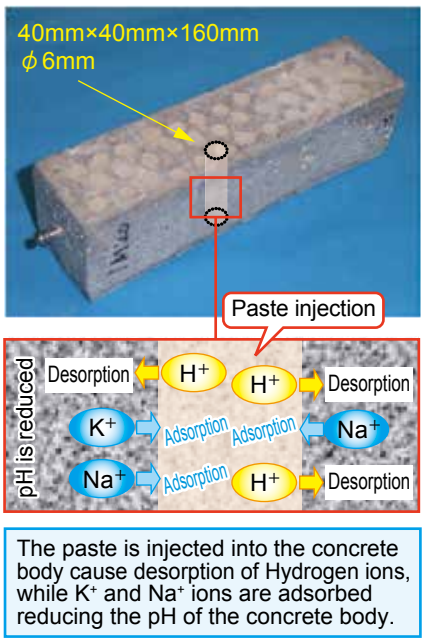


Fig. 1 Specimen reproducing grout injection into cracks and schematic showing how ASR process is suppressed

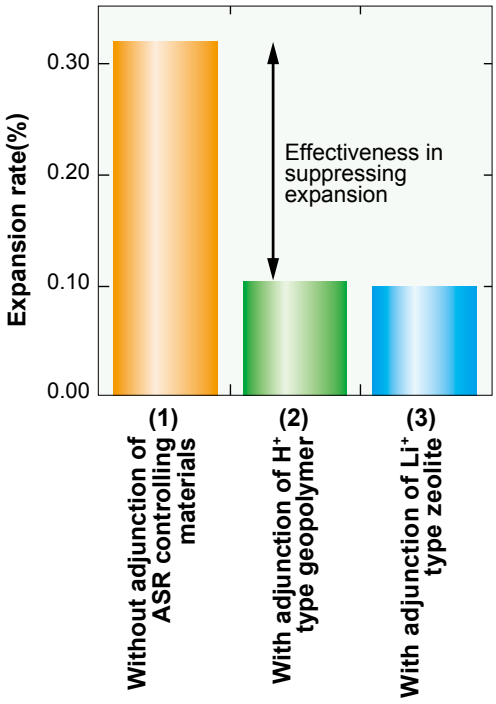


Fig. 2 Effectiveness in suppressing expansion due to ASR

19. Voltage control method for DC electric traction system with variable inductor

- A DC feeding voltage control technology has been developed to allow more efficient use of regenerative electric power.
- With the new technique, voltage can be controlled to within approximately 25% of the rated value, whilst the cost is about 20% of the latest existing technology.

Optimized control of feeding voltage supplying DC electrified railway lines should generate energy savings and result in higher efficiency of power supply.

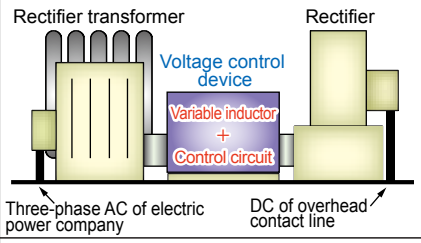
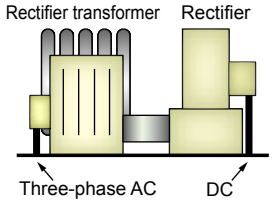
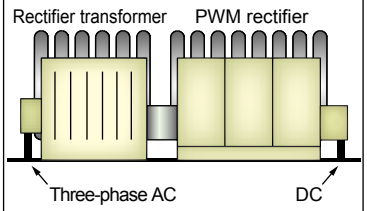
Robust and inexpensive diode rectifiers (middle of Table 1) widely used today cannot control their output voltage, and although the newest PWM rectifiers (right side of Table 1) that are able to control voltage are being used in practice as well, they are approximately ten times more expensive than diode rectifiers.

Consequently, a new voltage control method has been designed (left side of Table 1), composed of a voltage control device built with a voltage control circuit and a variable inductor (Fig. 1) connected to a rectifier transformer with a rectifier installed on both sides. This variable inductor type method is based on a technology patented by the Tohoku Electric Power Co., Inc. The equipment configuration and design method were then adapted for use on the railways.

Contrary to PWM rectifiers, the new method has some constraints, for example it does not allow reverse power flow (so regenerated power cannot be reused as a power source in stations etc.), however, it can reduce costs to approximately 20% of the latest existing method (about 1.5 to 2 times the cost of diode rectifier).

A prototype with a small capacity of rated current (500 A) was built (Fig. 1), to validate the function and effectiveness of the new method. Results confirmed that the rated voltage (1500 V) could be controlled to approximately within a maximum of 25% (approx. 400V) (Fig. 2). ICT is used to exchange data in real time between rolling stock and substations, which should allow energy savings to be made across the whole DC railway network. The new method can also be used as a measure against voltage drops in the DC electric traction system.

Table 1 Composition and position of new control method equipment

Type	New control method	Diode rectifier	PWM rectifier
Equipment configuration			
Voltage control	Available	Not available	Available
Reverse power flow	Not available	Not available	Available
Relative price	1.5～2	1 (baseline)	10
Position	Newly developed voltage control technology	Widely used	Latest technology used in practice

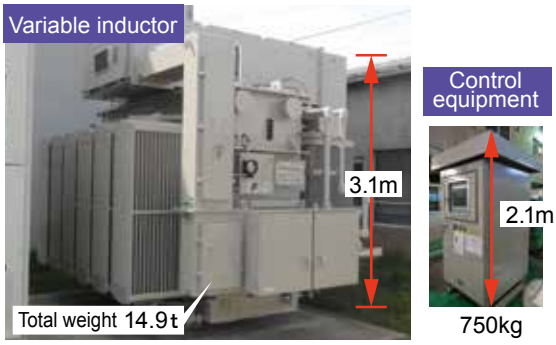


Fig. 1 Prototype voltage control equipment

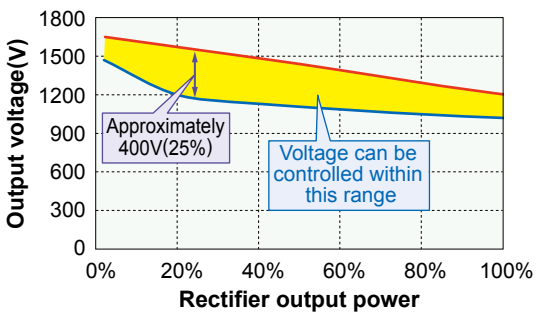


Fig. 2 Voltage control characteristics of new control method

20. Model for predicting wayside noise considering sound reflection from structures close to the railway track

- A model for predicting wayside noise has been designed which takes into account the influence of sound reflected or shielded by cut slopes, overpasses and other buildings.
- This model can be applied for investigating noise control for complex situations, for example if a new building or overpass has been constructed adjacent to railway tracks.

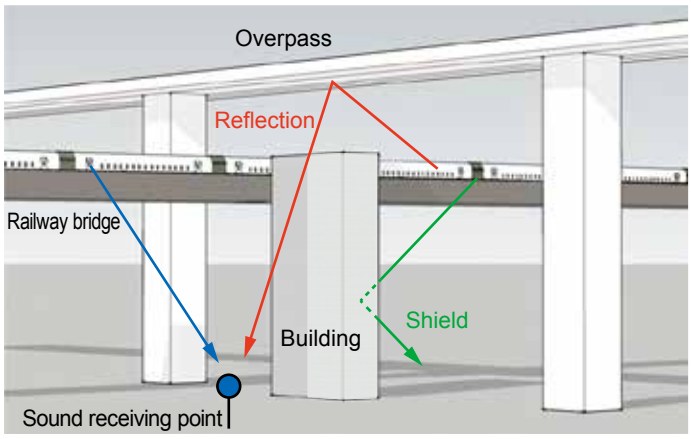
In order to evaluate environmental impact assessments and countermeasures to reduce noise, it is necessary to have a model for predicting wayside noise which can be applied to various situations, whereas existing prediction models were mainly designed to estimate the noise from trains passing over viaducts.

Consequently, in order to extend the scope of application of these existing models, the influence of wayside structures such as cut slopes, overpasses and buildings, etc. on noise propagation was evaluated through model acoustic tests and actual running tests, and the results of these tests were used to build a new model.

A noise source model to be applied to cut sections was constructed, taking into account the noise reflecting and shielding effects of noise barriers, slopes and carbodies. Similarly, the model was applied to complex situations with overpasses and buildings, taking into account the noise reflection and shielding effects of the underside of overpasses and building fronts (Fig. 1).

Using a spread sheet software the influence of reflected sound was calculated as a reflection correction of a finite flat surface, and the influence of sound shielding was calculated as a shielding correction of multiple walls and rectangular barriers. The difference between resulting predictions made using this new model and results of actual model tests on the influence of an overpass and a building, were within 1.5dB, confirming the validity of the new model (Fig. 2).

The present model will make it possible to estimate noise even in complex conditions, with adjacent overpasses and buildings. It should also contribute to evaluation of countermeasures against noise when new overpasses or buildings are constructed in the vicinity of railway tracks.



Evaluation of sum power of noise from different passes

Fig. 1 New model for predicting wayside noise

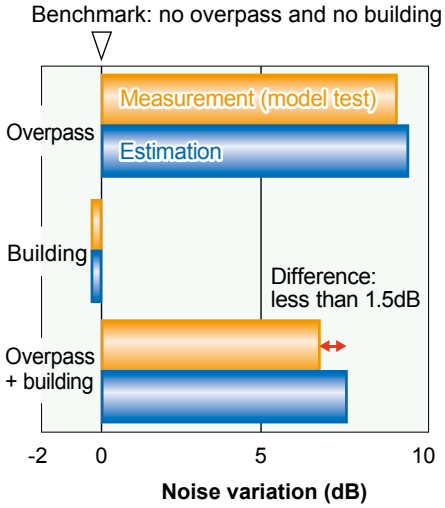


Fig. 2 Example of evaluated influence of building and overpass

IMPROVEMENT OF CONVENIENCE

21. Active bogie angle steering system ensuring both running stability and reduced lateral force

- An active bogie angle steering system has been developed which can reduce the yawing moment of a bogie by 77% and the average lateral force by 56% in curved sections.
- The new system includes a robust failsafe function, and can be fitted onto existing vehicles.

A new active bogie angle steering system has been developed, which not only reduces the lateral force in curved sections by controlling the bogie angle of vehicles, but also ensures the running stability in straight sections by acting as a yaw damper. Unlike the existing system, the present system does not require linking devices to be installed under the primary suspension, avoiding the problem of added weight to the bogie.

The developed steering system is composed of three parts: a steering controller which detects curves and generates the steering command, steering actuators that can be activated to act as yaw dampers to maintain the running stability if necessary, and a mechanical device which detects the bogie angle to prevent reverse steering and wrong steering on straight sections (Fig.1).

In simulation bogie rotational resistance tests conducted on a commercial railway line, it was demonstrated that the steering control system was able to reduce the yawing moment of the bogie by 77% (Fig. 2). The results of hunting stability tests confirmed that the new steering actuator was capable of maintaining the same level of running stability as the current yaw dampers. Trial running tests conducted on the RTRI test line on curves with a radius of 160m confirmed that the average lateral force can be reduced by 56% in curved sections (Fig. 3).

This system is suitable for express trains that are subject to very high lateral forces when running through sharp curves or when running speeds on curved sections are increased. The system can also be fitted to existing vehicles equipped with yaw dampers.

Fig. 1 Active bogie angle steering system

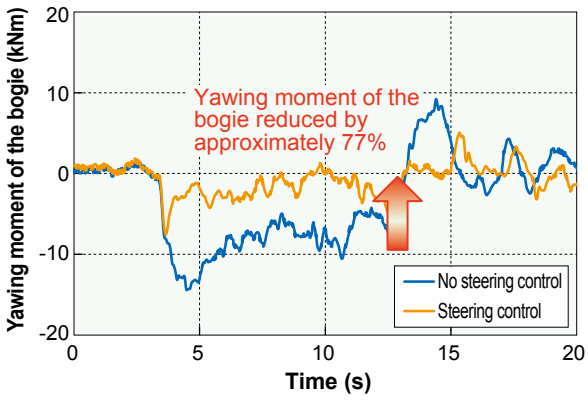


Fig. 2 Effective reduction in the yawing moment of the bogie demonstrated in bogie rotational resistance tests simulating on a curve section.

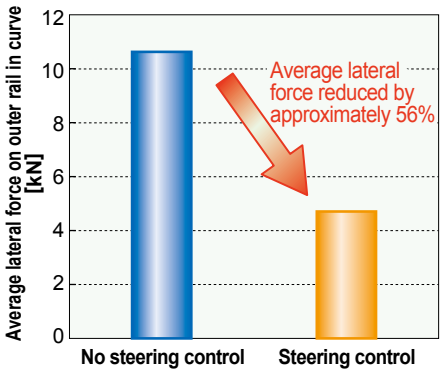


Fig. 3 Effective reduction in the average lateral force in the running tests at RTRI.

22. Improvement of the effectiveness of tunnel entrance hoods by enlargement of their cross-sectional area to reduce micro-pressure waves

- A cross-sectional area ratio of the tunnel entrance hood to the main tunnel has been proposed which is effective in reducing micro-pressure waves.
- It has been found that if the tunnel-entrance-hood-to-main-tunnel cross-section ratio is increased to 2.5, the hood will still be effective in reducing micro-pressure waves even if all side-wall openings are closed, and the hood is less than 40m. It was also found that for cases where the extension is over 40m, a graduated increase in the cross-sectional area ratio of the tunnel entrance hood to the main tunnel is also effective.

As Shinkansen running speeds increase, solutions have to be found to reduce micro-pressure waves emitted from tunnel portals. One approach is to install a tunnel entrance hoods on tunnel portals at the point of trains entry. As running speeds exceed 320 km/h however, the tunnel hood that would have to be added for these measures to be effective, would be longer than the 30-50m currently applied. This limitation added to the extra cost of extra work, and in certain cases, these countermeasures would not be feasible.

Consequently, model tests were carried out on new proposed designs (Figs. 1 and 2) that could be more effective unconcerned about the existing specifications (currently, the cross-sectional area ratio of the hood to the main tunnel are between 1.4-1.6, and openings are added to the side wall of these extensions).

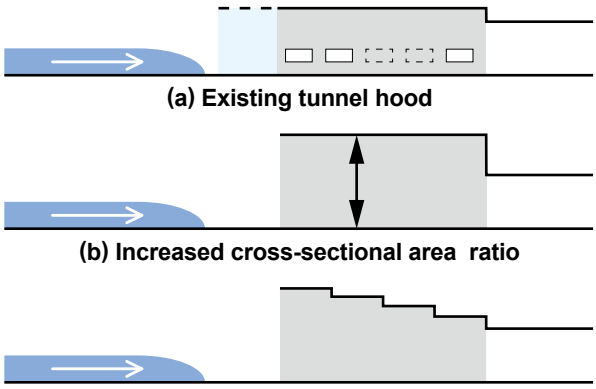


Fig. 1 Tested attenuation methods

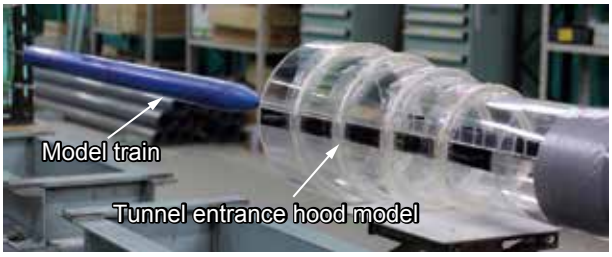


Fig. 2 Image of experiment set up for model test of tunnel hood with graduated increase in cross-section ratio

Results of these trials showed that on hoods under 40 m in length, raising the tunnel-hood-to-extension cross-sectional area ratio to 2.5 increased the reduction effect compared to the existing design, even if side wall openings were closed (Figs. 3 and 4). For hoods of over 40 m in length, a graduated increase in this ratio over the length of the hood was even more effective (Fig. 4). The two proposed solutions with larger and graduated cross-section ratios offer the added advantage of not requiring side openings along the tunnel hoods.

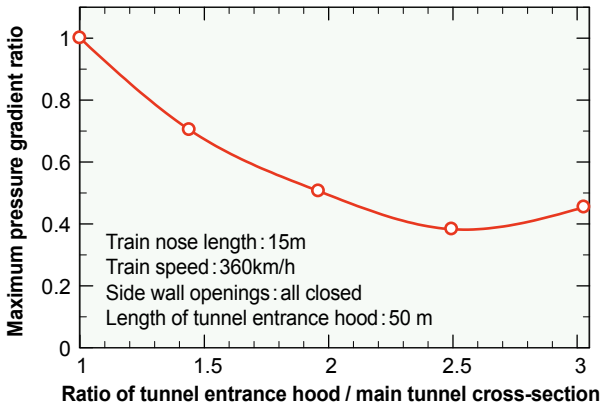


Fig. 3 Relation between tunnel entrance hood cross-section and effectiveness

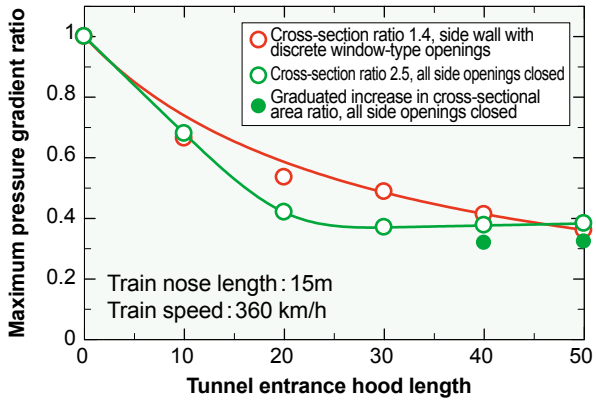


Fig. 4 Relation between tunnel entrance hood length and effectiveness

23. Communication network and train operation simulator for designing train control system using radio communication

- A simulator was developed to evaluate train delays and stability of the train control system using radio communication.
- The simulator will help to reduce the cost of designing radio communication networks and also satisfy the requirement of ensuring transmission quality and recovery from train delays.

In train control systems using radio communication , a section is predefined as a “zone” by each base station and the base stations communicate with multiple trains located in their zone at the same time. Each base station allocates “timeslots” which are brief windows of time given to each train to be able to communicate in real time. When traffic density is very high and there are not enough timeslots for each train, trains without allocated timeslots are forced to stop. Therefore, when radio communication networks are designed, it is necessary to take into account both transmission quality and the need to avoid train delays due to lack of timeslots. Up until now, radio communication network design focused solely on transmission quality, which meant that excessive communication capacities were provided to endure stable transportation service.

Consequently, RTRI developed a “Telecommunications and train operation simulator for train control systems using radio communication” which evaluates transmission quality taking into account train operations. This method combined the “Train communications network simulator for train control systems using radio communication” for evaluating the stability of transmission quality of the train control systems using radio communication with “Train operation and passenger flow simulator,” both previously developed by RTRI (Fig.1). It is now possible to quantitatively evaluate the load on radio communication networks, and train delays not only for ordinary but also for disrupted situations which represent severe operating conditions for train control systems using radio communication. A method was also devised to detect sections vulnerable to deadlocks which force trains to stop due to lack of timeslots.

In addition, a flow chart was produced for designing radio communication networks using the developed simulator, etc. (Fig. 2). When new train control systems using radio communication are introduced, this flow chart will make it possible to ensure that the designs satisfy the need for transmission quality and capacity to recover from train delays. It can also ensure the lowest cost design for radio communication networks.

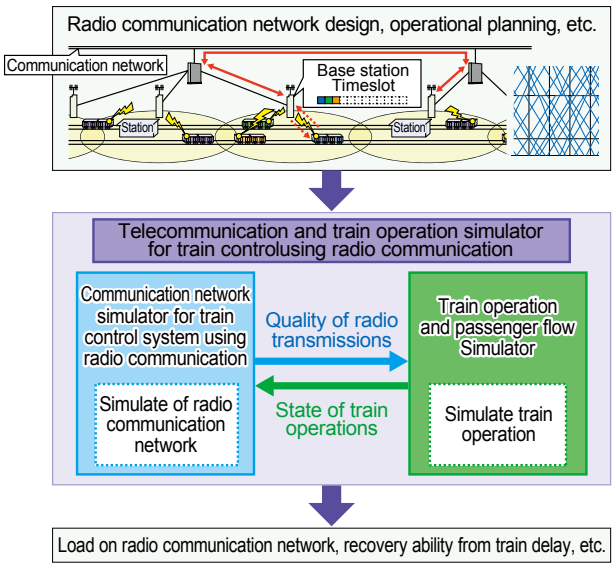


Fig. 1 Telecommunication and train operation simulator for train control using radio communication

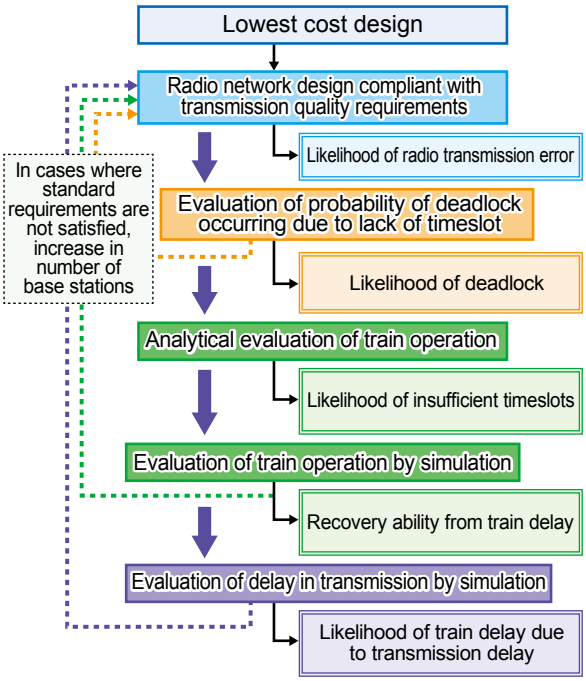


Fig. 2 Flow chart for system design

24. Method for supporting decisions on planning Shinkansen transport services based on forecast demand fluctuations

- A method to forecast half-hourly demand fluctuations on a daily basis was developed based on past actual Shinkansen ridership records, calendar arrays and large events scheduled to be held near stations.
- With the developed decision-making support system for planning Shinkansen transport services, it is possible to determine the need to operate or not daily pre-planned extra trains based on the result of demand fluctuation forecasts.

In order to formulate Shinkansen transport planning with high passengers' convenience, it is necessary to accurately forecast Shinkansen demand which constantly fluctuate. However, it was difficult to forecast such detailed passenger demand with conventional approach because it targets demand of average day.

Consequently, a method to forecast half-hourly fluctuations in Shinkansen passenger demand was developed using actual ridership records, calendar arrays, and information about scheduled large local events (Fig. 1).

First of all, daily demand fluctuations were calculated from collected ridership records. Using a statistical method, these fluctuations were separated into several 'basic fluctuations' which were constant regardless of day, and 'weights' of each basic fluctuations were estimated. Then, based on the relationship between the weights, calendar arrays and information about large scheduled events, an equation was formulated to forecast future weights. By combining forecast weights with the basic fluctuations, future daily demand fluctuations were forecast. Comparison of forecast results with actual data, confirmed a high level of accuracy (correlation coefficient of over 0.8) for over 90% of the examined period of 172 days (Fig. 2).

The developed Shinkansen transport planning support system which incorporates the demand forecasting method can be used to calculate the load factor between all stations along the route of all scheduled trains, based on the forecast demand fluctuations. By using this system, it is therefore possible to determine whether pre-planned extra trains need to be operated.

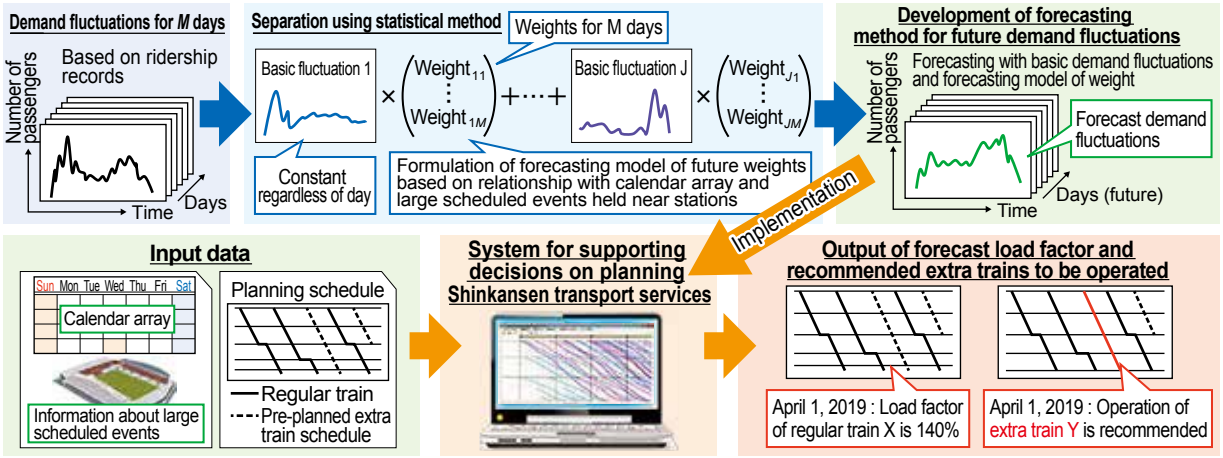


Fig. 1 Outline of the developed method for forecasting demand fluctuations and system for supporting decisions on planning transport services

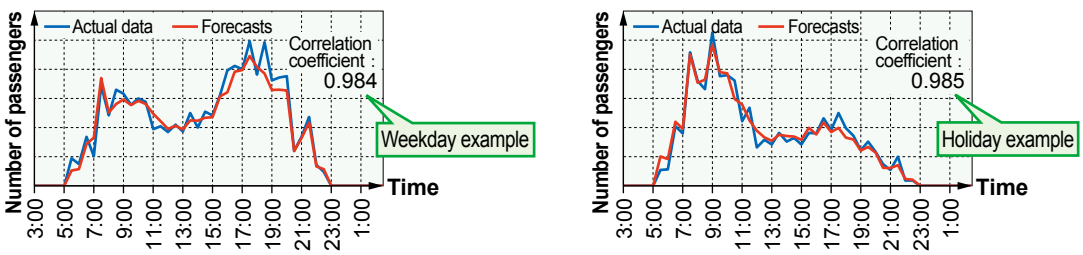


Fig. 2 Example of accuracy verification for forecasting half-hourly fluctuations in Shinkansen passenger demand (for same section (route))

25. Method for measuring dynamic deformation of brake disc

- A method has been proposed for measuring dynamic deformation on the friction surface of brake discs heated to high temperature during high speed rotation, which up until now has been difficult to do.
- Better understanding of the dynamic deformation of the disc and the pad can be used for verifying their design and examining relevant mechanisms.

The high speed vehicles that are the trademark of Shinkansen lines use disc braking. This type of braking method involves the brake pad being pressed onto the brake disc generating frictional force. Consequently, the faster the speed, the greater the heat produced by this rubbing, which in some cases leads to lower braking performance. Observations made of the disc in this mechanism using a thermal-camera show that the spots where heat is generated constantly vary over time. However, there is no insight, including from other industries, about the mechanisms underlying the dynamic deformation of discs, which is another factor thought to contribute to lower performance. This lack of knowledge is one of the obstacles to making progress in brake device assembly research and development (discs, pads, calipers).

The method described here was therefore proposed to measure the dynamic deformation of the brake disc in operation using a vibration-absorbing table and electrostatic capacitance type sensors capable of measuring displacement without contact (Fig. 1).

Through in-depth dynamic deformation analysis of the disc in operation from different rotation angles, it is possible to visualize dynamic deformation (Fig. 2). Through these investigations, it was possible to clarify: the cyclic appearance of deformation on the friction surface, the differing aspects of dynamic deformation depending on the disc/pad configuration and microscopic deformation related to the distance between disc lock (fastening) bolts.

The proposed measurement method will be useful not only for design verification of the shape and mechanical structure of brake pads and discs, but may also contribute to clarifying frictional mechanisms and evaluating braking noise.

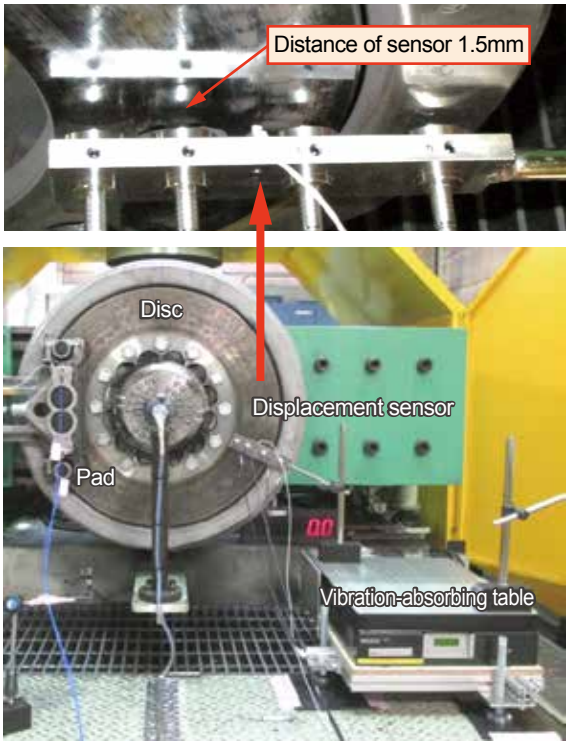


Fig. 1 External view of measuring device

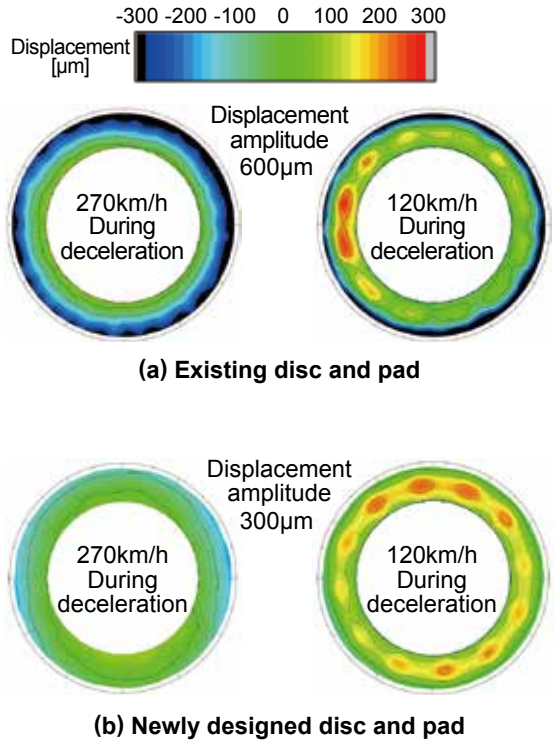


Fig. 2 Example of visualization of dynamic deformation

26. Current collection HILS system enabling simulated running tests

- A current collection HILS system was developed which enables simulated running tests to be conducted using stationary pantographs to examine the interaction between pantographs and overhead contact lines.
- Verifications were made to check that the system was able to reproduce OCL vibrations up to 20 Hz generated at running speeds of 300 km/h by the span length between support points and distance between droppers.
- The HILS system could reduce the time required to develop new pantograph designs.

In the process for developing pantographs, before actual vehicle tests are conducted, each component of the new pantograph has to be tested on test rigs for resilience of structural members and ability to comply to the vibrating overhead contact line (OCL). Existing test rigs however, are unable to fully reproduce the vibrations generated by the swaying movement of the OCL as a pantograph moves along it, as in real running conditions. This means that in actual vehicle tests, some pantographs may not produce the same performance as verified in preliminary functional bench tests, and until now, the only way to resolve design problems was to carry out repeated adjustments and tests.

Consequently, a current collection HILS (Hardware In the Loop Simulation) system was developed which enables simulated running tests with stationary pantographs to examine the interaction between pantographs and overhead contact lines (Fig. 1). The system calculates the OCL vibration that would be generated by a passing pantograph during running in real time, which controls the vibrating equipment, reproducing the vibration conditions of a pantograph running under an OCL.

A comparison of the results obtained from the test equipment reproducing running conditions at 300 km/h with target values (set by simulation of the overhead line / pantograph system) showed that the frequency response up to 20Hz correlated well, and confirmed that the simulated running test of a pantograph was able to reproduce conditions which could examine the influence of OCL vibration due to the periodicity in OCL structure and wave propagation generated by the pantograph under running conditions for speeds up to 300 km/h (Fig. 2). Given that the conditions reproduced in these stationary tests are very close to real train tests, the newly developed system should be able to reduce the time required to develop new pantograph designs.

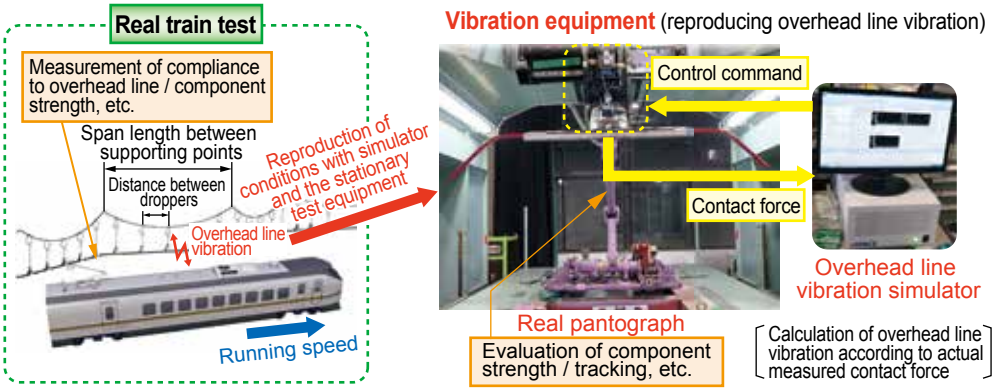


Fig. 1 Outline of current collection HILS system

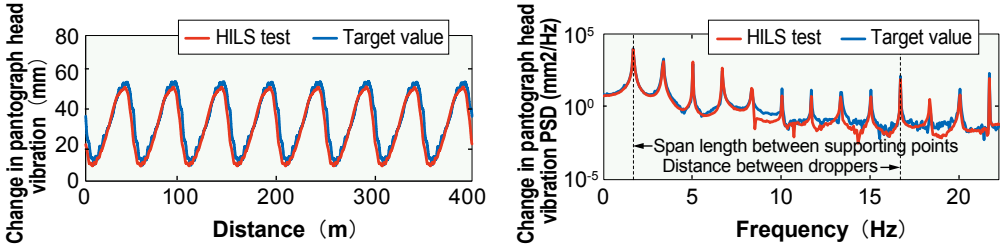


Fig. 2 Results of mock running test using HILS system (change in pantograph head vibration)

27. Reproduction of meandering airflows under the carbody through numerical simulation

- Based on an analysis of airflows around a railway vehicle including the bogie, it was possible to reproduce the meandering airflows occurring underneath the carbody.
- Comparison of calculated airflows and wind tunnel test results showed that the tendencies in power spectra for lateral airflow velocity fluctuations between the two were almost identical.
- The results of this work can be used to examine measures for reducing train oscillation in tunnels.

It has been shown using numerical simulations of airflows around a simple shaped train model, that train oscillation in tunnels is induced by meandering airflows under the carbody floor. So far however, no quantitative comparisons have been made using detailed investigations, or actual tests that also take into account the influence of bogies.

Consequently, a numerical simulation of airflows beneath a carbody floor was carried out on a coupled train model that included bogies (Fig. 1). The output of this simulation was compared with the results of wind tunnel tests (using a 1/8.4 scale train model on a moving belt) which revealed that the power spectra of lateral airflow velocity fluctuations showed the same tendencies, which confirmed that it was possible to reproduce the meandering airflows generated in wind tunnel tests (Fig. 2).

Investigations into the impact of modifying the bogie shape confirmed that a completely smooth bogie generated no meandering airflows, demonstrating that smoothing the bogie was an effective measure to reduce meandering airflows.

Numerical simulation of the airflows beneath the vehicle floors in a coupled train not only contributes to the development of carbody shapes that can reduce train oscillation in tunnels, it can also be used as a tool to estimate airflows around bogies, and to develop measures to reduce air resistance of vehicles, snow accretion on bogies and aerodynamic noise from bogie parts.

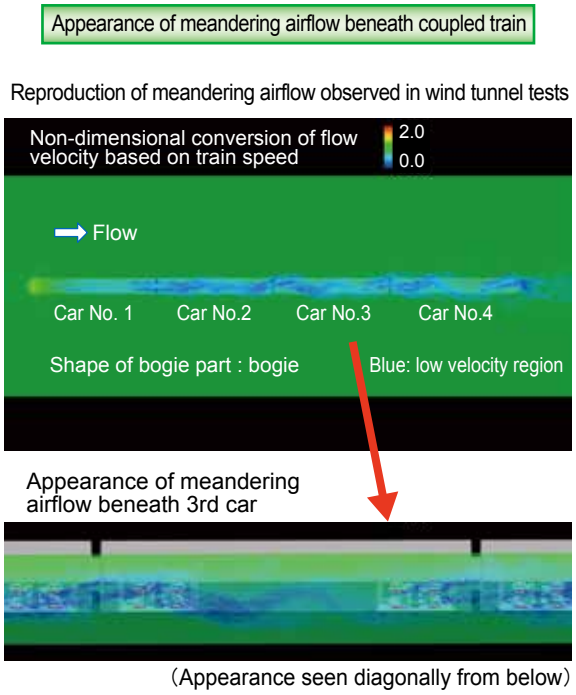


Fig. 1 Fluid analysis considering bogie

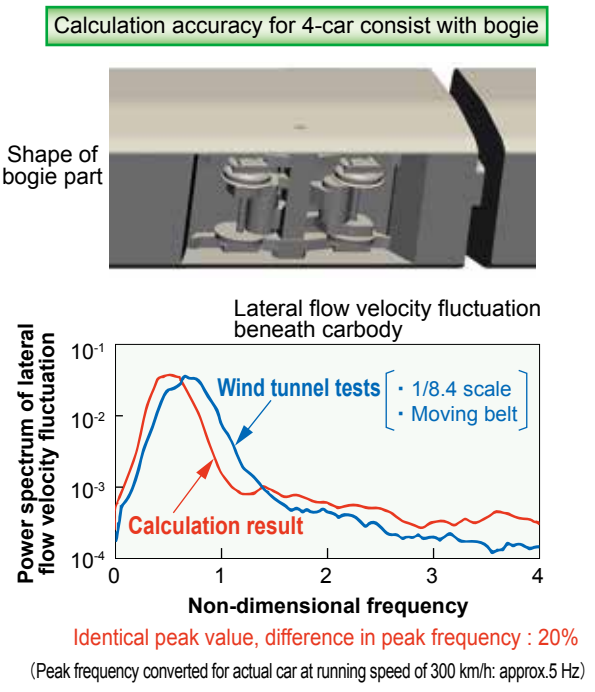


Fig. 2 Comparison of fluid analysis and wind tunnel test

28. Wind tunnel tests reproducing the wind force resulting from natural wind and vehicle velocity to evaluate aerodynamic forces acting on railway vehicles

- In order to evaluate the effect of wind force resulting from natural wind and vehicle velocity, a wind tunnel test method was developed to evaluate the aerodynamic forces exerted on a moving vehicle model.
- It was found that on flat ground and on top of embankments, the influence of running on the side force coefficient is small, and it is therefore possible to evaluate the performance of a railway vehicle in resistance to overturning in windy conditions by using a static train model.

Aerodynamic force evaluations are required to assess running safety in high wind conditions, and in general they are made using wind tunnel tests. In these tests a static model of a railway vehicle is placed on a piece of railway infrastructure, and the influence of the shape of the vehicle and the infrastructure, as well as aerodynamic characteristics for the wind direction etc. are investigated.

This method however does not take into account another very important factor in aerodynamic force evaluation of a running vehicle, which is the influence of wind force resulting from natural wind and moving velocity. Therefore, with the purpose of validating the suitability of using a static train model in wind tunnel tests, a moving model rig for reproducing the wind flows around a railway vehicle was installed in a wind tunnel, and a wind tunnel test method was developed which can evaluate the aerodynamic forces acting on a running vehicle under natural wind conditions using a vehicle-mounted system (Fig. 1).

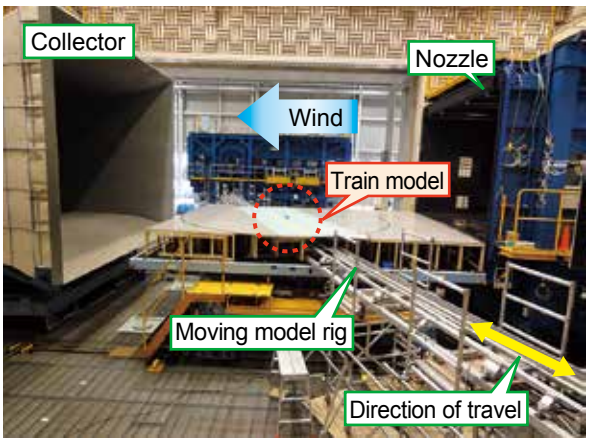


Fig. 1 View of Wind tunnel test set up
(RTRI's large-scale low-noise wind tunnel)

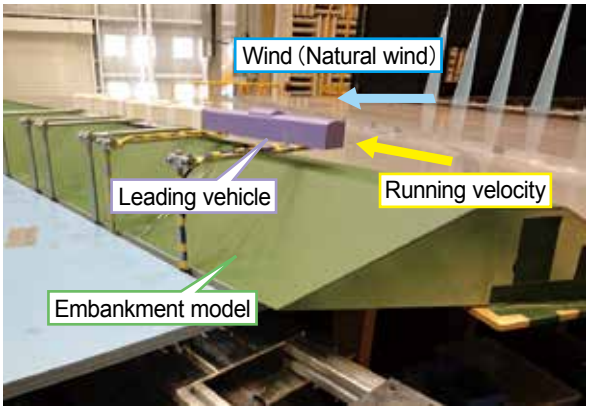


Fig. 2 Vehicle and infrastructure model

The wind tunnel test was conducted whilst varying the following conditions: running speed (of the train model), wind speed in the wind tunnel and angle between the travel direction and that of the natural wind. Wind-pressure taps suitably distributed across the surface of the carbody were used to measure pressure distribution. The side force, which has the largest influence on overturning in all aerodynamic forces acting on a vehicle (the side force contributes up to 70% of the overturning moment in critical conditions), was evaluated.

The scale of the model was 1/60th, and its carbody shape was the same as that of an ordinary commuter train. The test was carried out both for flat ground and embankment conditions (Fig. 2).

The side force coefficients were estimated from the pressure coefficients measured on the model of the commuter train. The maximum difference in side force coefficient between the moving model tests and the static model tests was a relatively small 0.04 (9%) on the flat ground and the embankments (Fig. 3). This demonstrated that it is possible to evaluate the performance of a railway vehicle in resistance to overturning in windy conditions by using a static train model in wind tunnel tests.

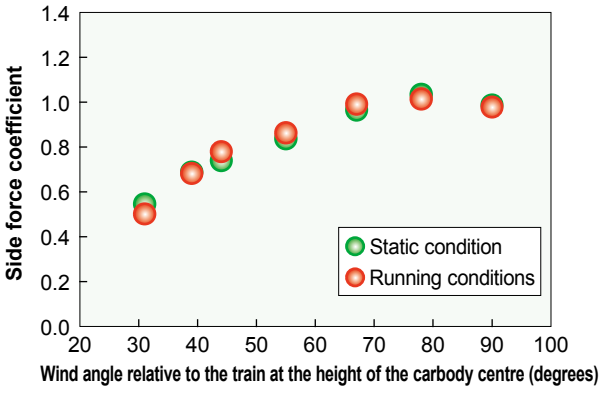


Fig. 3 Comparison of side force coefficients on leading vehicle on embankment (1/60th scale model of commuter train)

29. Wind tunnel tests for detailed detection of sources of aerodynamic noise from bogies

- A measuring method for detecting the sources of aerodynamic noise from bogies was developed using a “sound transmission plate”
- It was found that the main sources of aerodynamic noise were the traction motor and the gear unit.
- This method will now allow the reduction of the aerodynamic bogie noise more efficiently.

The main sources of aerodynamic noise from a railway vehicles running at high speed are the head car, pantographs and bogies. Work is ongoing using RTRI’s large-scale low-noise wind tunnel facility to find ways to reduce aerodynamic noise generated by bogies, however, it has not been possible so far to clearly detect the exact location of aerodynamic noise sources in a bogie through lateral acoustic investigations because the bogie is fully covered.

Therefore, the ground plate beneath the bogie was replaced with a sound transmission board, which allows sound waves to pass through but blocks air flow, and a microphone array was installed beneath the board. The proximity of the microphone array to the bogie made it possible to accurately distinguish the sources of aerodynamic bogie noise (Fig. 1).

The results from tests using this method identified the main sources of aerodynamic bogie noise to be the traction motor and the gear unit among others (Fig. 2). An acoustic test using a speaker confirmed that the influence of the sound transmission board on measuring the location of sound source was sufficiently small.

By using the developed measurement method, it will be possible to locate various sources of aerodynamic noise, and contribute to the reduction of aerodynamic bogie noise.

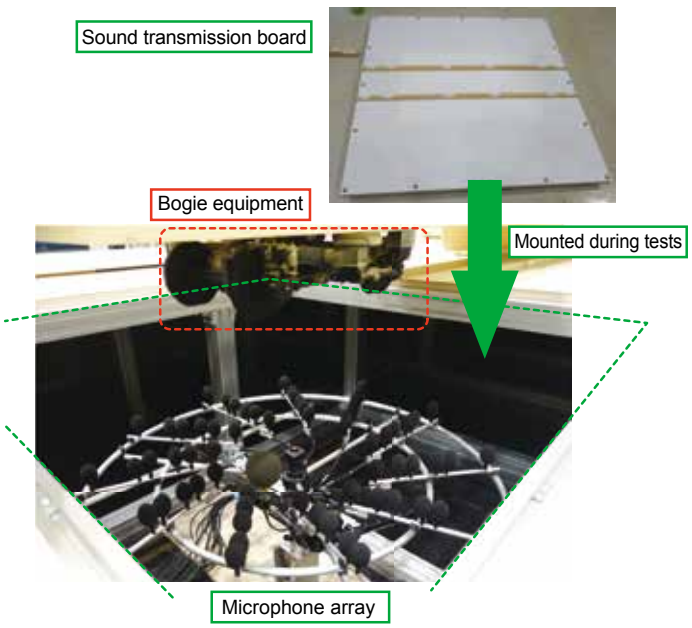
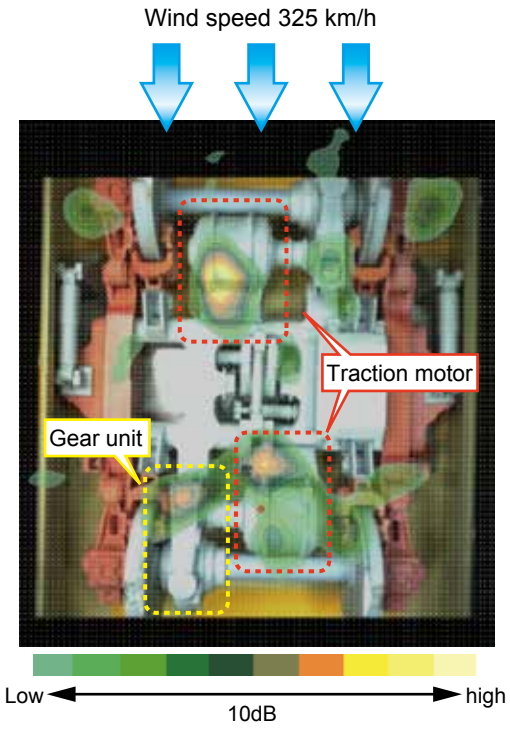


Fig. 1 Acoustic source investigation using sound



Bogie equipment seen from the bottom up

Fig. 2 Sources of aerodynamic bogie noise

30. Assessment of driver state based on physiological indices

- It is now possible to objectively monitor changes in the physiological state of drivers as they carry out their driving tasks, based on simultaneous measurement of various physiological indices using high performance multipoint electroencephalographs etc.
- By combining various physiological indices, it is possible to detect moments of concentration or psychological upset.

With a view to supporting drivers to prevent human-error induced accidents, an experimental environment (physiological indices measurement system) was designed incorporating various cutting edge measurement technologies, which makes it possible to measure variations in the physiological state of drivers when carryout driving tasks.

The physiological indices measurement system combines high-resolution multipoint encephalographs with other simultaneously measured physiological factors such as pupil diameter, electrocardiography, respiratory waves and perspiration. In addition, the system also uses motion capture and eye tracking technology which can then be applied to convert attention point data based on the subject's degree of movement in space, into digital form (Fig. 1).

A basic tests were conducted using the measurement system on a normal adult as subject placed in a driving simulator, which suggested that it is possible to pick up changes in state of mind of the participant in abnormal situations using the multiple physiological indices.

The experiments involved confronting the subject with an accident scenario, or asking them to drive under pressure to meet tight timetabling requirements. Results confirmed that concentration and decrease in alertness during driving tasks, and the level of stress due to an accident could be objectively evaluated based on brain activity (Fig. 2).

Given the disparity in physiological indices obtained from person to person, it has been difficult up until now to use indices quantitatively. However, it has been suggested that there appears to be a way to reproduce typical variation patterns based on a combination of certain common indices found in individuals. Based on variation patterns of physiological indices found in certain individuals, this method should make it possible to objectively assess changes in state of concentration or psychological upset.

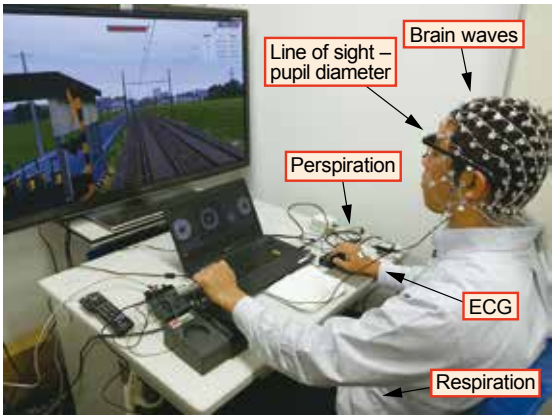


Fig. 1 Physiological index measurement system and mock driving experiment setup

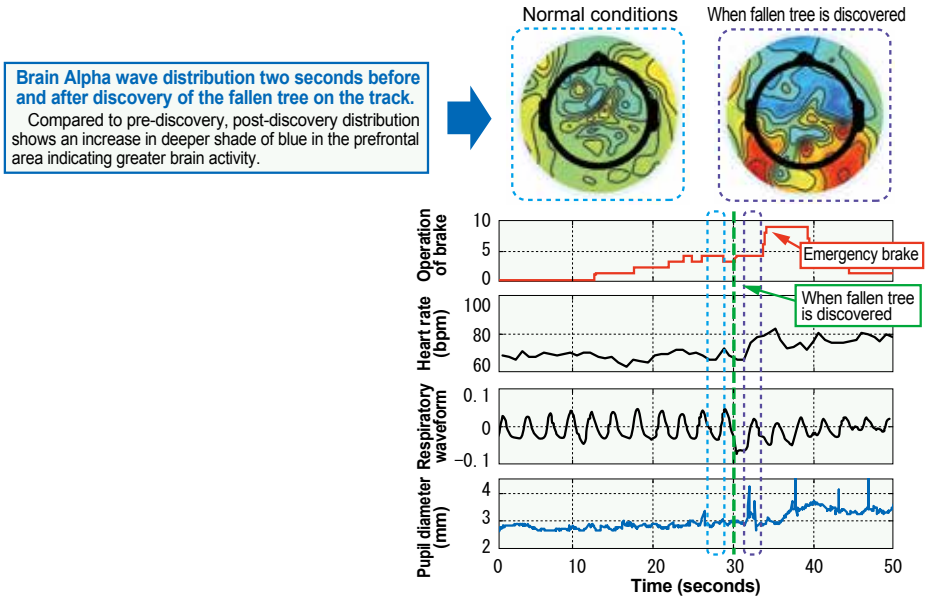


Fig. 2 Change in physiological indices in abnormal situation

31.Multi-segment pantograph head with high compliance to contact wire fluctuation.

- A multi-segment pantograph head has been proposed which not only produces less noise but also offers high compliance to contact wire fluctuation .
- Compared to a conventional type pantograph head fitted with flexible contact strip support, tests confirmed that the multi-segment panhead had ten times more compliance and a 50% lower contact loss ratio.

Giving the cross-section of a pantograph head a curved surface is an effective measure to reduce aerodynamic noise. This type of conventional pantograph head however needs to be fitted with a flexible contact strip support in order to follow to the unevenness of the contact wire (the whole contact strip moves vertically against the cross-section of the pantograph head). In doing so in this type of pantograph head, the vertical movement of the contact strip makes the lift force susceptible to change, which can at high speeds induce unwanted vibration in the pantograph head.

For solving this problem a multi-segment pantograph head was proposed. In order to guarantee both low noise and lift force stability, the shape of the pantograph head cross-section was made to be curved, and to be used only in one travel direction. In addition, the pantograph head itself was divided into segments, so that each segment of the pantograph head was capable of vertical movement whilst maintaining the same cross-section shape, in order to follow to the contact wire. In order to keep the weight of each moving part as low as possible, a carbon composite contact strip was adapted to the multi-segment pantograph head and a prototype was built (Fig. 1) and compared to a conventional type pantograph head with flexible contact strip support for current collection performance (Fig. 2). Compared to the conventional pantograph head, the compliance performance of the multi-segment pantograph head to contact wire unevenness corresponding to the frequency band of dropper intervals at a running speed of 300-400 km/h was ten times higher (Fig. 3). In addition, it was confirmed that the contact loss ratio was reduced by about 50% at a running speed of 300km/h with a current of 400A (Fig. 4).

This prototype will contribute to further improving pantograph design.

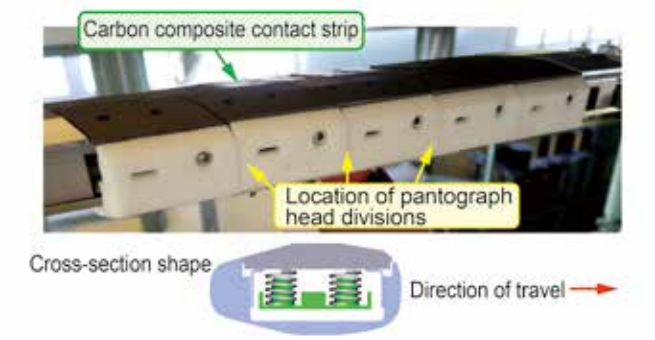


Fig. 1 Prototype of multi-segment pantograph head and cross-section shape

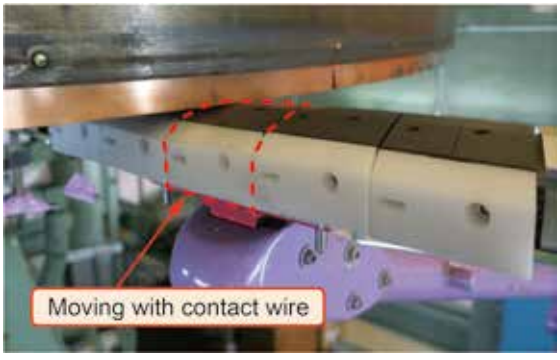


Fig. 2 Current collection performance verification tests using pantograph testing equipment

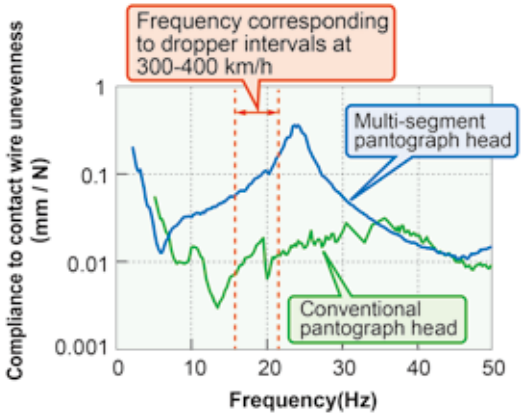


Fig. 3 Compliance characteristics of multi-segment pantograph head and conventional pantograph head

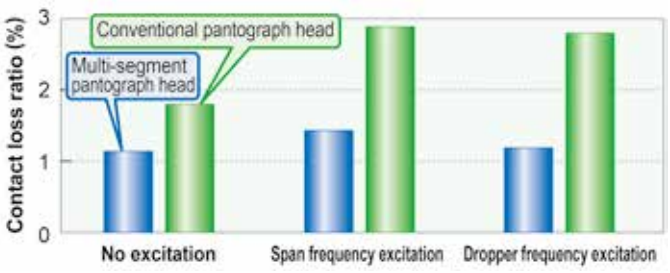


Fig. 4 Comparison of contact loss ratio between multi-segment pantograph head and conventional pantograph head

1. RTRI Co-Hosts France-Japan Railway Technology Symposium 2017

On April 23, RTRI co-hosted “France-Japan Railway Technology Symposium – Urban Railways of the Near Future –“ with the Maison Franco-Japonaise. The main hosts of this symposium are la Société Franco-Japonaise des Techniques Industrielles (SFJTI) and French Embassy in Japan.

The first France-Japan Railway Technology Symposium was held in 2007, followed by the second one in 2012 and the third this year. This year’s symposium was organized under the theme ”Urban Railways of the Near Future” and experts of Régie Autonome des Transports Parisiens (RATP), Alstom and Institut Français des Sciences et Technologies des Transports de l’ Aménagement et des Réseaux (IFSTTAR).

RTRI has maintained a collaborative research agreement with IFSTTAR and co-hosted this symposium in order to share information with French rail-related organizations regarding state-of-the-art technologies such as autonomous driving, artificial intelligence and Internet of Things.

From Japan, engineers and researchers of East Japan Railway Company, Tokyo Metro Co., Ltd., Bureau of Transportation of the Tokyo Metropolitan Government, and RTRI participated. The following seven presentations were delivered by these French and Japanese and shared issues in both countries’ urban railway systems were described and solutions toward the near future were suggested. Representing RTRI, President Kumagai gave a welcome speech and Executive Director Watanabe made a presentation.

About 110 persons from Japan and other countries joined this symposium and discussions were made regarding the current situation and issues of urban railways.

Details of the Symposium

1. Date and time: April 23, 2017 13:30 - 18:00
2. Venue: Maison Franco-Japonaise
3. Host organizations
Main hosts :
La Société Franco-Japonaise des Techniques Industrielles, Japan (SFJTI)
French Embassy in Japan
Co-hosts : Maison Franco-Japonaise in Ebisu (MFJE)
Railway Technical Research Institute, Japan (RTRI)
Patronage:
Ministry of Land, Infrastructure, Transport and Tourism, Japan (MLIT)
Régie Autonome des Transports Parisiens, France (RATP)
Tokyo Metro Co., Ltd.
Sponsors:
Japan Railway Engineers’ Association (JREA)
Japan Subway Association (JSA)
4. Program
Opening remark by Mr. Yutaka Takahashi, President of SFJTI
Welcome by Mr. Yuki Yokoyama, Vice President, MFJE
Welcome by Mr. Norimichi Kumagai, President, RTRI
Greetings by:
Mr. Shunya Shiozaki, Deputy Director-General for Engineering Affairs, Railway Bureau, MLIT
Mr. Takao Nishiyama, Executive director, East Japan Railway Company

Presentations

(1) “Mobility Revolution by the East Japan Railway Company with IoT and AI”
Mr. Atsushi Yokoyama
Executive Officer
Director, Technology Planning Department
Director General, Research and Development Center of JR East Group
East Japan Railway Company
(2) “Parisian Metro Network Modernization, Energy Saving and Automation””
Mr. Jean-Marc Charoud, Director of the Engineering Department, RATP
Mr. Claude Andlauer, Head of Railway Transportation Systems, RATP

(3) “Railway Innovation Based on Network and Simulation”
Mr. Ikuo Watanabe, Executive Director, RTRI
(4) “Technological Development of Tokyo Metro”
Mr. Akihiro Kosaka, Director, Corporate Value Enhancing Department, Tokyo Metro Co., Ltd.
(5) “Light Transit System in Tokyo Metropolitan Area”
Mr. Masaru Furuta, Former Bureau of Transportation, Tokyo Metropolitan Government
(6) “Alstom Business with Japanese Urban Transport”
Mr. Gérald Kowalski, Customer Director for International Business, Alstom
(7) “R&D on Railway Infrastructures and Systems at IFSTTAR”
Mr. Bruno Godart, Deputy Director of Materials and Structures Department, Institut Français des Sciences et Technologies des Transports de l’ Aménagement et des Réseaux, France (IFSTTAR)

General review

Mr. Pierre Feuardant
Project Manager in Science and Technology, Embassy of France in Japan

Closing remark

Mr. Tatsuhiko Suga, Chairman of the Railway Transportation Committee
La Société Franco-Japonaise des Techniques Industrielles (SFJTI)

President Kumagai of RTRI

Executive Director Watanabe

2. RTRI Sets up ICT Promotion Team

On June 1, RTRI set up the ICT Promotion Team. The Team has been established in order to develop a strategy and plan to promote systematic use of information and communication technologies in RTRI's entire research and development activities and to increase their speed.

This team, lead by Mr. Hiraguri, Deputy Director of the Research and Development Promotion Division, consists of principal researchers, directors and general managers of concerning research laboratories. President Kumagai, Executive Director Ashiya and Mr. Furukawa, Director of the Research and Development Promotion Division, have also joined the team as supervisors. Under the team, three subgroups, sensing, information communications and control, data analysis, have been set up.

On June 9, the first joint meeting of the team and subgroups was held. At the meeting, following President Kumagai's greetings, topics for research and development using ICT have been listed. These are enhancing safety and stability, autonomous driving and energy saving in train operation and an advanced condition monitoring by automated monitoring technologies. Techniques to share and use data were also referred to at the meeting as important basic technologies. The members discussed what role RTRI should play in order to develop these technologies.

Fields and Topics to use ICT

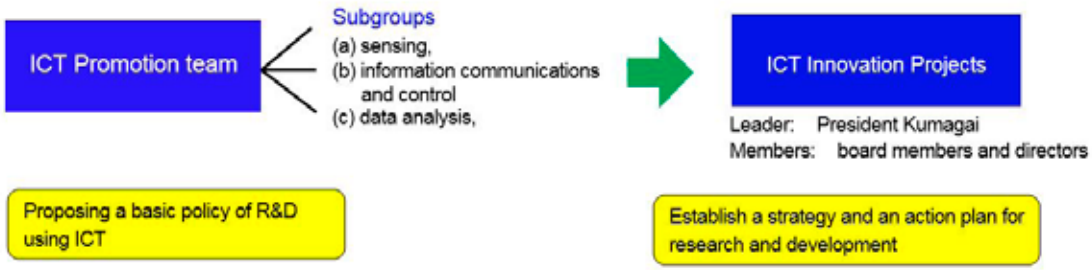
Field		Topic
Train operation	safety and stability	Real-time safety control Prevention of human errors
	Autonomous driving	Real-time operation control
	Energy saving	Ground-onboard-coordinated control
Facilities maintenance		Advanced condition monitoring
Basic technology		Decision making and prediction based on big data analysis and AI

ICT Promotion Team will propose a basic policy of research and development using ICT. At the next phase, after September this year, the team will set ICT Innovation Projects according to the proposal and establish a strategy and an action plan for research and development. The research and development will be promoted in cooperation with other organizations which have advanced technologies, including universities.

[President Kumagai's greetings]

RTRI has already been utilizing ICT in our research activities in specific technical fields and has been developing the knowhow. But now, we need to focus our accumulated knowhow on the newly-set research target which requires extensive and intensive use of ICT. Since railway systems are mainly based on conventional infrastructure, it is quite a challenge to apply innovative technologies to them, and just because of that, there is a possibility to be able to create a railway system surpassing current systems by using ICT. So, I would like to set out a reliable strategy and would like you all to actively implement research in order to build a new railway system.

Roles of ICT Promotion Team and ICT Innovation Projects



Members of ICT Promotion Team

Leader:

- •Deputy director of Research and Development Promotion Division

Members:

- •Principal researchers of Research and Development Promotion Division
- •Director of Power Supply Technology Division
- •Director of Track Technology Division
- •Director of Disaster Prevention Technology Division
- •Director of Signalling and Transport Information Technology Division
- •General Manager of Transport Operation Systems
- •Director of Railway Dynamics Division
- •Director of Human Science Division
- •Manager of Research and Development Promotion Division (secretariat)

Supervisors:

- •President
- •Executive director for research and development
- •Director of Research and Development Promotion Division

The 1st meeting of the team and subgroups

3. The Vertical Vibration Reduction Control System Mounted on the luxurious trains of JR East and JR West

Railway Technical Research Institute HITACHI Inspire the Next

The “vibration reduction control system using variable vertical damper,” what we call vertical vibration reduction control system, jointly developed by Hitachi Automotive Systems, Ltd. and Railway Technical Research Institute (RTRI) has been mounted to the luxurious trains newly launched by JR East and JR West, “Train Suite Shiki-Shima”, and “Twilight Express Mizukaze.”

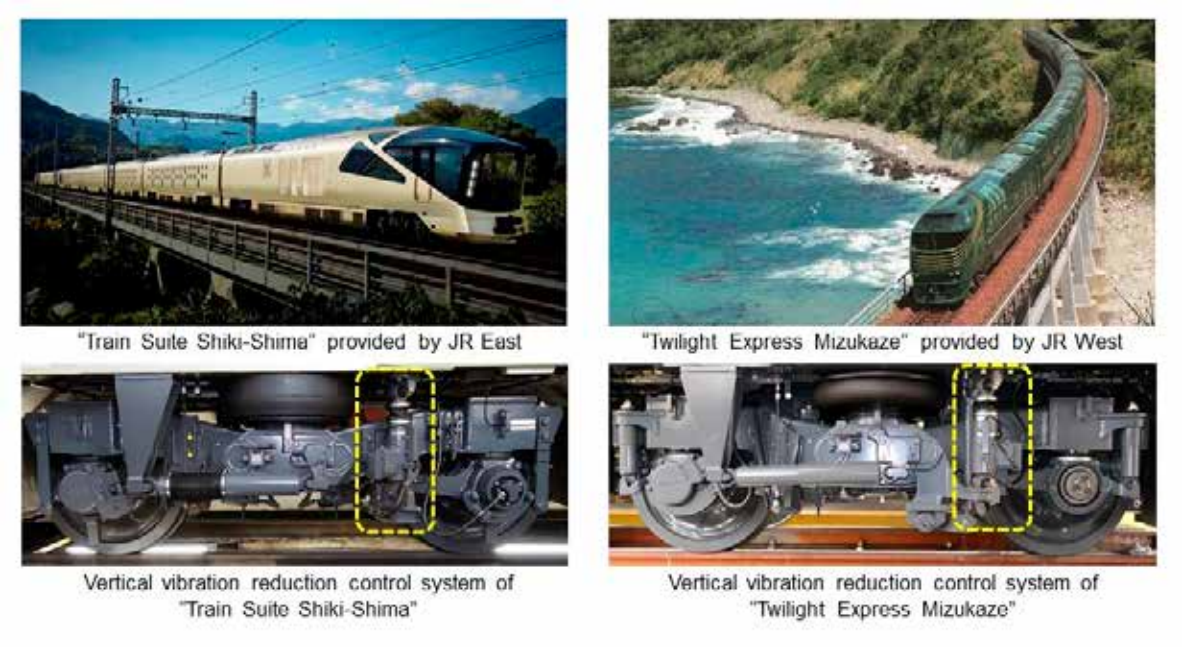


Fig Vertical vibration reduction control system mounted “Train Suite Shiki-Shima” and “Twilight Express Mizukaze”

The vertical vibration reduction control system was developed to reduce vertical vibration of running railway vehicles. This system has already been mounted on sight-seeing express trains of JR Kyushu including “Ibusuki no Tamatebako” and “Yufuin no Mori” and has contributed to improving the ride comfort on these trains by reducing vertical vibration by up to 50%. “Seven Stars in Kyushu,” a luxurious train of JR Kyushu which started operation in 2013 has also been equipped with this system.

On May 1 and June 17 this year, luxurious trains of JR East and West, “Train Suite Shiki-Shima” and “Twilight Express Mizukaze” started commercial services. Following “Seven Stars in Kyushu,” this system has also been mounted on these two trains. Now all the luxurious trains in Japan have this system and their ride comfort is much higher than conventional passenger vehicles.

Overview of Vertical Vibration Reduction Control System

In this system, variable vertical dampers (vertical-direction hydraulic dampers capable of controlling damping force) and the secondary pneumatic suspensions are mounted on bogies in parallel. The dampers reduce vertical vibration by controlling the damping force so as to cancel vibration of carbody based according to acceleration measured by on-board (Fig. 1 and Fig. 2).

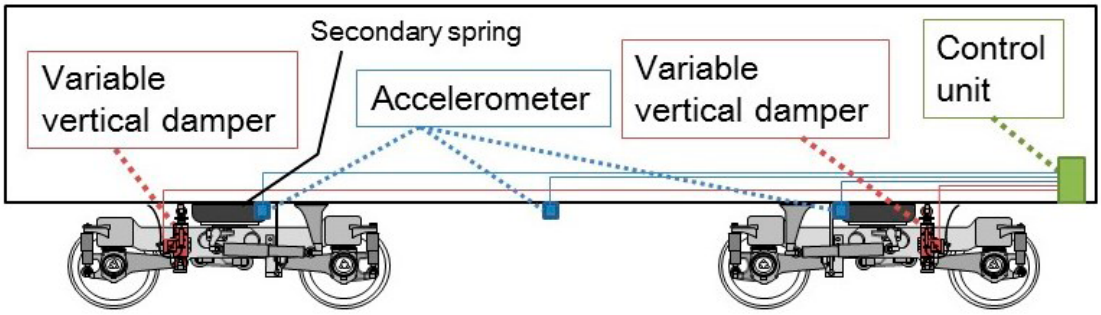


Fig.1 Structure of Vertical Vibration Reduction Control System

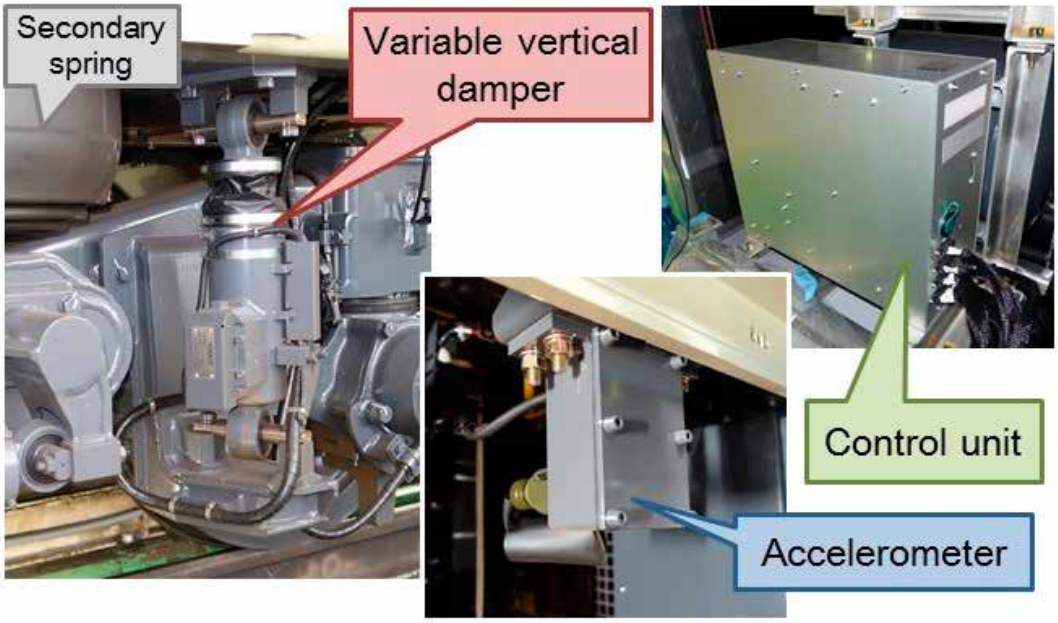


Fig.2 Variable vertical dampers mounted on vehicle, accelerometers and control unit

4. RTRI and Taiwan Railways Administration Co-Hosts Technical Exchange Seminar

RTRI concluded an agreement for technical cooperation with TRA and the experts of both organizations have been sharing information on railway technologies.

Participants from TRA and RTRI

On June 16 this year in Taipei, RTRI and TRA organized a technical exchange seminar on railway technologies. Seven people from RTRI including five experts and 70 people from TRA including four experts joined this seminar.

The participants exchanged information on the research and development of each organization regarding the following four topics proposed by TRA:

- The strategy of noise control for elevated railway system (ballasted and non-ballasted track) in metropolitan area
- Whole life cost analysis for rolling stock
- Positioning technology analysis on shortage points for overhead catenary system and early prediction method for material variation of the overhead catenary system
- The latest status of international standardization activities in railway field

The presentations were followed by lively Q & A sessions and discussions.

Program of the 2017 TRA & RTRI Technical Exchange Seminar

Opening remarks

LU Chieh-Shen, Director General, Taiwan Railways Administration, Ministry of Transportation and Communications

Toru MIYAUCHI, General Manager, International Development, International Division, RTRI

Session 1 The strategy of noise control for elevated railway system (ballasted and non-ballasted track) in metropolitan area

1. "Rail Corrugation Monitoring and Management"
   Hirofumi TANAKA, Assistant Senior Researcher, Track Geometry & Maintenance, Track Technology Division, RTRI
2. "Noise Control Measures for Elevated Track System in Urban Area (Tracks w/o Ballast)"
   LIN Yung-Chang, Manager of Bridge and Tunnel Division, Taiwan Railways Administration, MOTC

Session 2: Whole life cost analysis for rolling stock

1. "Whole Life Cost Analysis for Rolling Stock"
   Naoki AIHARA, Chief Manager, International Affairs, International Division, RTRI
2. "Life-cycle Costs Analysis for Rail Vehicles"
   HSIAO Chien-Ting, Manager of Motorcycle Section, Vehicle Division, Taiwan Railways Administration, MOTC

Session 3: Positioning technology analysis on shortage points for overhead catenary system
Early prediction method for material variation of the overhead catenary System

1. "Positioning Technology Analysis on Shortage Points for Overhead Catenary System"
   Masataka AKAGI, Senior Researcher, Power Supply Technology Division, RTRI
2. "Basic Study on Corrosion – Environment Evaluation in OCL"
   Tadanori USUKI, Assistant Senior Researcher, Current Collection Maintenance, Power Supply Technology Division, RTRI
3. "Early Prediction Method for Material Variation of the Overhead Catenary System"
   HUANG Li-Wu, Manager of Electricity Section, Taiwan Railways Administration, MOTC
4. "Positioning Technology Analysis on Shortage Points for Overhead Catenary System"
   HUANG Li-Wu, Manager of Electricity Section, Taiwan Railways Administration, MOTC

Session 4: The latest status of international standardization activities in railway field

1. "The Latest Status of International Standardization Activities in Railway Field"
   Hiroshi TANAKA, Director, Railway International Standards Center, RTRI
2. "Reflect on the Standardization of Taiwan Track Engineering"
   HSU Wei-Lun, Project Manager, Railway Engineering Department, Sinotech Engineering Consultants, LTD.

Closing remarks:

HSU Hui-Yuan, Deputy Chief Engineer, Taiwan Railways Administration, Ministry of Transportation and Communications

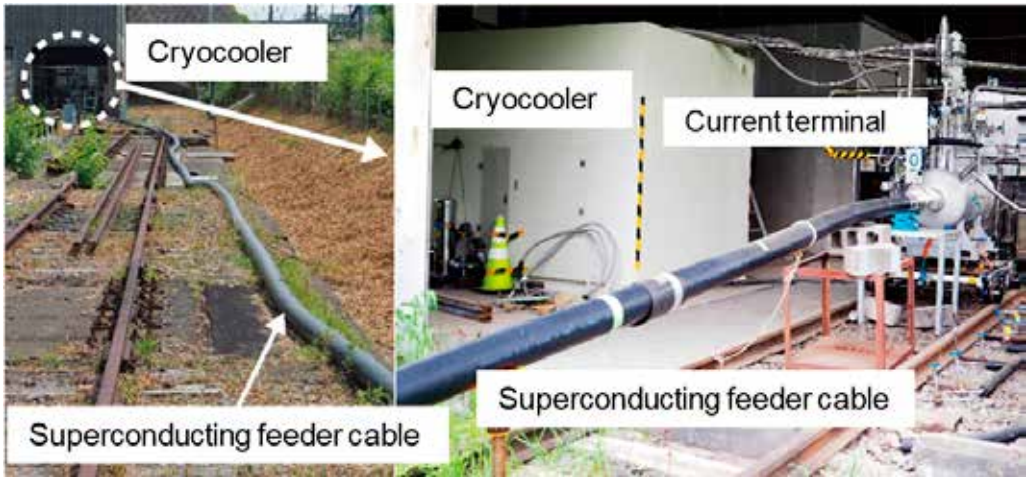
Toru MIYAUCHI, General Manager, International Development, International Division, RTRI

Director General LU of TRA (right) and General Manager MIYAUCHI of RTRI (left) exchanging gifts

Technical Exchange Seminar

5. RTRI Develops New Superconducting Power Cable System for Testing on Commercial Railway Line

RTRI has developed a new superconducting feeder cable system which is closer to practical use, and is planning to test the system on an urban commercial line.



New superconducting feeder cable system at RTRI's Hino Civil Engineering Testing Station

【New Superconducting Feeder Cable System】

By improving its cryocooler mechanism, RTRI has succeeded in developing this new superconducting feeder cable system that has stable enough performance to be tested on commercial lines. The superconducting layer of its cable is made of a material with high insulation performance in order to keep constant temperature inside the cable (Fig. 1), and the current terminal has a structure which prevents heat conduction. Furthermore, a Brayton-cycle-type cryocooler customized for the cable has been adopted. Due to these improvements, the new system has come a step closer to commercial application, with the following features.

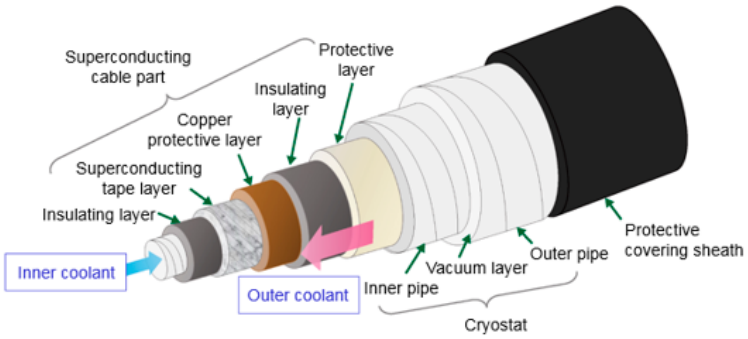


Fig. 1 Inside of Superconducting Feeder Cable

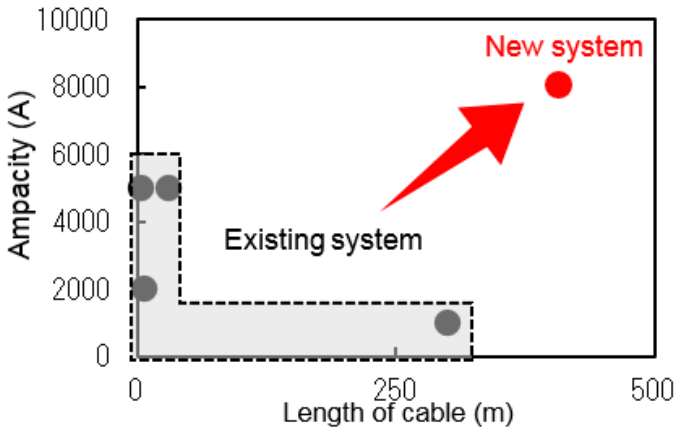


Fig.2: Ampacity of the New System

•The cable temperature can be set anywhere between 65 (-208℃), and 77K. Since the existing cable needs to be cooled down to 77K, it has been impossible to maintain superconducting state, when a cryocooler goes down due to any trouble. But this new system is capable of keeping the superconducting state for a few days even if its cryocooler is down. It means that we will be able to keep the superconducting state if we need to shut down the cryocooler for maintenance purpose.
•Due to the improvement on the cryocooler, this system does not need an auxiliary cryocooler which requires refilling of coolant.
•We have already tried 2-week continuous operation and confirmed that the system works normally.

This new system has thicker layer of superconducting material and its ampacity is 8,000 A or more for 408-meter-long cable. (Fig.2) This ampacity allows 2 or 3 trainsets of 10 cars running at a time in the same block between substations, a typical operation pattern on urban commuter lines.

We are planning to conduct power transmission tests with this system on a commercial track.

•Part of this project has been supported by the subsidy for railway technical development by the Ministry of Land, Infrastructure, Transport and Tourism.
•Part of this project has been implemented as the Program to Promote Strategic Innovation by the Japan Science and Technology Agency.

【Existing superconducting feeder cable system】

In the superconducting feeder cable system, the cable made of high-temperature superconducting material is cooled to extremely low temperatures which creates superconducting state and transmit electricity with zero electric resistance. This system requires a cooling system using -196℃(77K) liquid nitrogen as a coolant. We have installed the existing system to RTRI's test track and conducted running tests in order to seek the possibility of applying high-temperature superconducting material to railway systems. These running tests have been conducted with a trainset of 2 to 3 cars for a few days. The existing system has a sterling-type cryocooler and, in order to continue the running tests, it has been necessary to refill the auxiliary cooling device with coolant and cryocooler control by engineers has also been required. Therefore, development of high-performance, reliable cryocooler mechanism has been our top-priority issue in order to apply the superconducting feeder cable system to commercial operation.

6. S-Shaped-Sleeper Concrete-Bed Track with Resilient Pad

- Cost Reduced and Construction Time Shortened -

RTRI has developed S-shaped-sleeper concrete-bed track. This track is easier to construct and cheaper than existing concrete-bed track.

S-shaped-sleeper concrete-bed track with resilient pad

【Outline】

RTRI has developed s-shaped-sleeper concrete-bed track with rubber pad in order to reduce the construction cost of existing concrete-bed track. Major points of this development are as follows. (Fig. 1)

1. This track supports lateral load with shear key on the side of the rail and therefore the width of the concrete track bed is thinner and its material cost is lower than existing solid-bed track.

2. Since this track uses short-fiber-reinforced concrete and has a structure proper to unreinforced concrete track bed, additional reinforcing bars except the displacement guide have become unnecessary.

3. Its formwork placement and alignment has been made simpler so that accurate shapes of concrete track bed can be determined only by pressing the formwork to the end of sleepers and shear keys.

Since the workload to construct this S-shaped-sleeper track is smaller than that of D-shaped-sleeper track, its construction periods can be shortened by more than 40%. In addition, as its material cost can also be reduced , the construction cost of the concrete track bed and of the entire track can be cut by 60 % and 20% respectively.

【Commercial application】

This S-shaped-sleeper track was already introduced to commercial track of a rail operating company in the end of 2016. We will prepare a handbook for its design and construction in half a year, and will further promote its practical use.

【Background of development】

Concrete-bed track with rubber pad is one of ballastless tracks which supports sleepers with elastic materials such as rubber pad placed between track bed and sleepers.

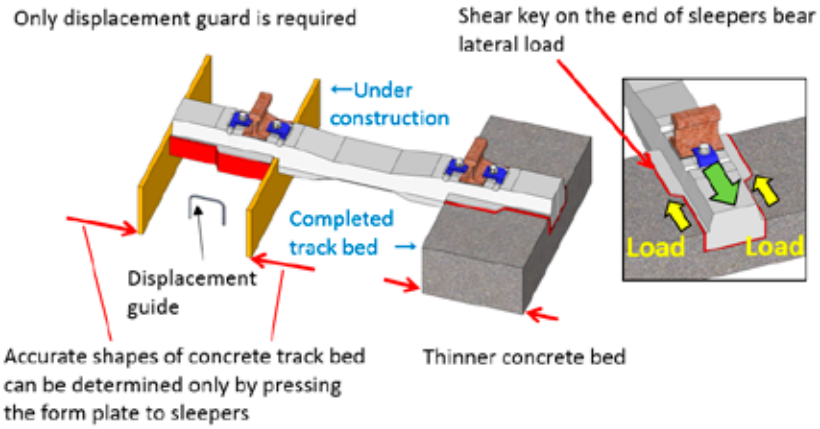


Fig.1 Newly-constructed concrete-bed track with s-shaped sleeper

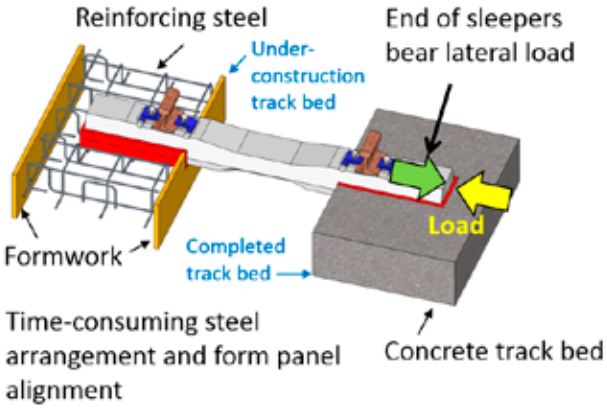


Fig.2 Existing D-shaped-sleeper concrete bed track

Since this type of track reduces noise and vibration generated by running trains, it has been used mainly on elevated tracks in urban areas.

The D-shaped-sleeper concrete-bed track that RTRI developed in 1998 has also been widely utilized on JR and other private railway lines and the total length of the D-shaped sleeper track has amounted to 60 km. But the complicated placement and precise alignment of reinforcing steel and formwork requires a lot of work when constructed. (Fig. 2) In order to reduce the construction cost and to expand the use of concrete-bed track, RTRI has developed the S-shaped-sleeper track which is easier to construct.

We have conducted real-vehicle-weight loading tests and non-linear FEM analysis in order to check its performance and confirmed that this track has sufficient strength to bear train load. Through running tests with motor cars, we have also confirmed that it has the same level of basic performance as the D-shaped sleeper track.

7.Tunnel Crack Detection with Deep Learning

RTRI has developed a new technique to detect cracks on tunnel lining using deep learning technology. This technique will enable more efficient tunnel maintenance.

【Outline】

With this technique, the cracks are automatically detected from the images of tunnel lining. (Fig. 1)

1.Using deep-learning technology, this technique is capable of detecting cracks as accurately as visual detections. (Fig. 1) With this technique, it is possible to clearly distinguish cracks with other similarly-looking objects such as signaling cables, contact wires and joints and exclude these noises.

2.It automatically processes, at one time, all the images of the entire tunnel lining surface taken by a laser-camera.

3.It is capable of detecting more than 83% of cracks wider than 0.5 mm.

4.It is capable of checking the images covering 1 km length of a tunnel in 15 minutes.

5.The images can be processed with a computer at offices near tunnels.

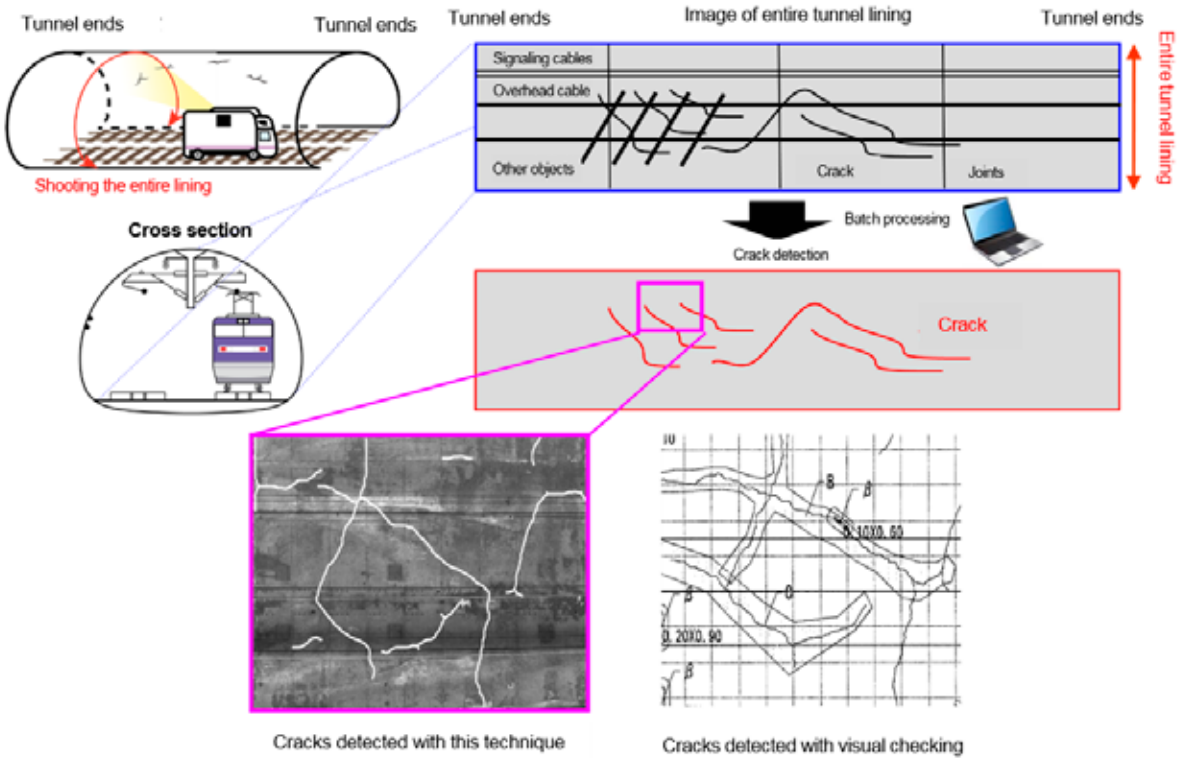


Fig.1 Cracks detected this technique

【Detection using deep learning】

This technique has applied deep learning technology to crack detection. It makes a computer to learn both images with and without cracks so that the computer will be able to recognize cracks accurately. (Fig. 2 left) Then the computer will examine the images of tunnel lining, detect cracks and process the images to display the detected cracks accurately. The results have succeeded in showing only cracks without other similar objects such as cables and joints. (Fig.2 right)

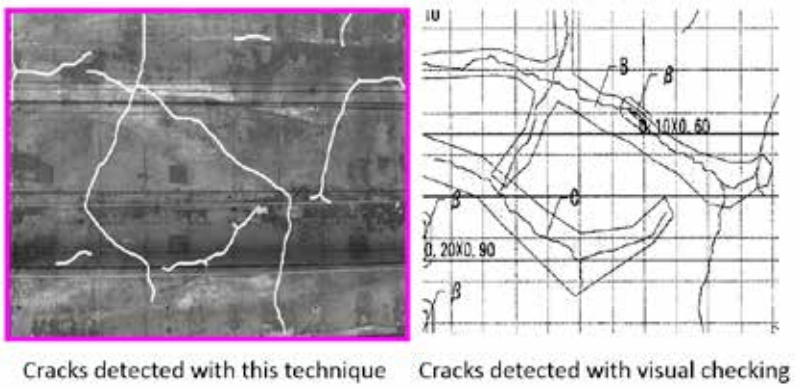


Fig. 2 Crack detection using deep learning technology

【Existing image processing technology】

In order to correctly detect troubles on tunnel lining surface such as cracks with existing image processing programs, it has been necessary to adjust parameters according to tunnel shapes and conditions of tunnel lining, using special know-how based upon experience. In addition, it takes a lot of work to correct detection errors caused by similar objects.

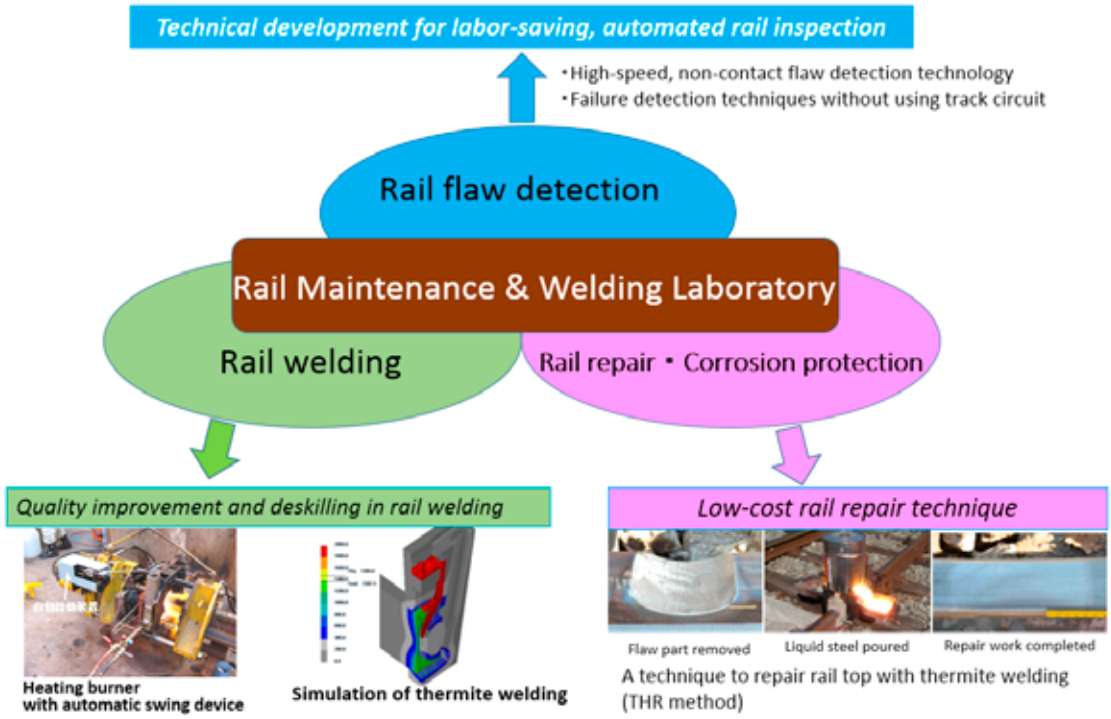
Deep learning is one of the analytical methods using machine learning. Its neural network algorithm which has imitated the human brain's neural system has multiple layers between the input and output layer in order to be able to solve complicated problems. We have made our computer learn the images with and without cracks repeatedly with the deep learning method so that it will be able to recognize the rules and patterns of the images, and to detect whether the tunnel lining has cracks or not as accurately as humans do.

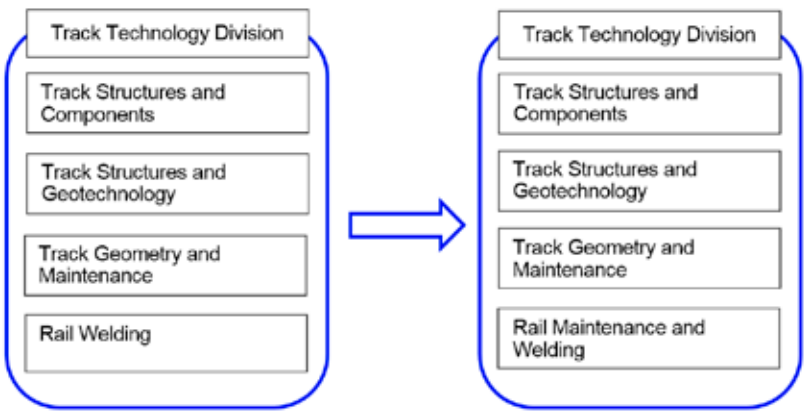
【Patent pending】

8. RTRI Launched Rail Maintenance & Welding Laboratory

On October 2, 2017, Rail Maintenance & Welding Laboratory was launched as a new laboratory in the Track Technology Division of RTRI. This laboratory will take the responsibilities of research and development and technical support on rail maintenance, and it will quickly meet the needs of railway operators.

RTRI has developed rail flaw detection technologies, rail repair techniques, anti-corrosion measures and rail welding techniques for continuous welded rail. The new laboratory will actively utilize ICT including AI and develop high-speed, non-contact rail flaw detection technologies and techniques to detect broken rails without using track circuit. This laboratory has also taken over the research work on rail welding from the former Rail Welding Laboratory.





9. RTRI and IFSTTAR Conclude Agreement on Collaborative Research

On October 24 this year, the French Institute of Science and Technology for Transport, Development and Networks (IFSTTAR) and RTRI signed an agreement on collaborative research in railway engineering.

1. The goal of the agreement

Both institutes concluded this agreement in order to collaborate together in advanced and practical railway research and in personnel exchange and training by utilizing their research resources. Their goal is to contribute to development of railways, science and technology through this collaborative relationship.

2. The background of the research collaboration

In fiscal 2014 and 2015, RTRI implemented collaborative research and exchanged researchers with IFSTTAR, and since then, both institutes have continued technical exchange in design, construction and technical development of geotechnical engineering.

Since it is highly likely that the research collaboration and personnel exchange will be continued, RTRI and IFSTTAR concluded the agreement in order to strengthen their collaborative relationship.

3. Form of collaboration and research topics

Under this agreement, IFSTTAR and RTRI will collaborate in the activities shown below.

(1) Collaborative research and information sharing projects with following three topics
- Analysis of scouring at river bridge base and soil erosion
- Comparison of Japanese and French technical standards for base and soil structures
- Information sharing on the methods to analyze ground-structure dynamic interaction

(2) Organizing joint research seminars

(3) Personnel exchange – sending researchers to each organization

4. Messages from RTRI and IFSTTAR

Norimichi Kumagai, President of RTRI

I am honored to implement collaborative research with IFSTTAR, a prominent research institute on advanced research and development in geotechnical engineering. In recent years, the Japanese government has been leading an effort to enhance the resilience of our national land. But, over the last 6 years, Japan has been hit by many natural disasters and suffered serious damage. We would like to continue technical development to reinforce railway systems, taking specifically defined steps.

Hélène Jacquot-Guimbal, Director General of IFSTTAR

Researchers of RTRI and IFSTTAR have had meetings and shared their expertise at every phase,in particular, on the topics of railway infrastructure and the risks of earthquake and other natural disasters. Through this process, we have forged a close relationship by the visits of executives to each other and exchange of geotechnical engineers. I am very much pleased that we have been seeing each other very frequently in spite of the distance between Japan and France. I hope to focus our efforts on this 5-year collaborative research and to intensify various fields of rail and transport research.

5. Signing ceremony

Date and time:October 24, 2017 14:00 – 15:00
Venue:IFSTTAR head office (Marne-la-vallée)
Participants:

IFSTTAR

Ms. Hélène Jacquot-Guimbal
Director General
Dr. Éric Gaume
Head of Geotechnical Engineering, Environment, Natural Hazards and Earth Sciences Department
Dr. Christophe Chevalier
Head of Soils, Rocks and Geotechnical Structures Laboratory
Geotechnical Engineering, Environment, Natural Hazards and Earth Sciences Department
Dr. Jean-François Semblat
Deputy Head of Geotechnical Engineering
Head of Earthquakes and Vibrations Laboratory
Geotechnical Engineering, Environment, Natural Hazards and Earth Sciences Department
Mr. Fabien Szymkiewicz
Soils, Rocks and Geotechnical Structures Laboratory
Geotechnical Engineering, Environment, Natural Hazards and Earth Sciences Department
Mr. Bruno Godart

Head of Materials and Structure Department
Dr. Claude Marin-Lamellet
Deputy Head of European and International Affairs
Ms. Christelle Fongue
Manager of Bilateral and Multilateral Cooperation Projects

RTRI

Norimichi Kumagai
President
Ikuo Watanabe
Executive Director
Atsushi Furukawa
Director
Research and Development Promotion Division
Naoyuki Ota
Director
Disaster Prevention Technology Division
Kenji Watanabe
Laboratory Head
Foundation and Geotechnical Engineering
Osamu Nunokawa
Laboratory Head
Geo-hazard and Risk Mitigation
Shuichi Myojo
Manager International Division

6. IFSTTAR

A national research institute of France, IFSTTAR, was formed in 2011 by the merger of the French National Institute for Transport and Safety Research (INRETS) with the French Central Laboratory of Roads and Bridges (LCPC). Its head office is located in Marne-la-vallée and 1,200 people works for IFSTTAR. Its research work covers wide ranging fields including urban and civil engineering, natural disaster mitigation measures, transport efficiency and safety. In particular, it has been promoting civil engineering research and development from basic to practical on an impartial footing and has been involved in the work to set French domestic standards and Euro Code.

President Kumagai and Director General Jacquot-Guimbal at signing ceremony

10.RTRI Launched Image Analysis and IT Laboratory

On December 1, 2017, Image Analysis and IT Laboratory was launched as a new laboratory in the Signalling and Transport Information Technology Division of RTRI.

RTRI will promote the research and development regarding information technologies, specifically, image analysis technologies, big data analysis and deep learning, in order to meet the needs of railway operators more quickly and to propose new technologies of these fields. For these purposes, a new laboratory "Image Analysis and IT" was set up in Signalling and Transport Information Technology Division. RTRI will actively utilize image-processing technologies and IT that the researchers have already accumulated and used in different technical fields.

This laboratory will seek to apply image analysis technologies to constant condition-monitoring for railway facilities and train driving safety and to use IT in maintenance and operation control.

At the inauguration of this laboratory RTRI's president Dr. Kumagai expressed his expectations for the new members, and Dr. Masato Ukai, the head of the laboratory, also expressed his wishes.

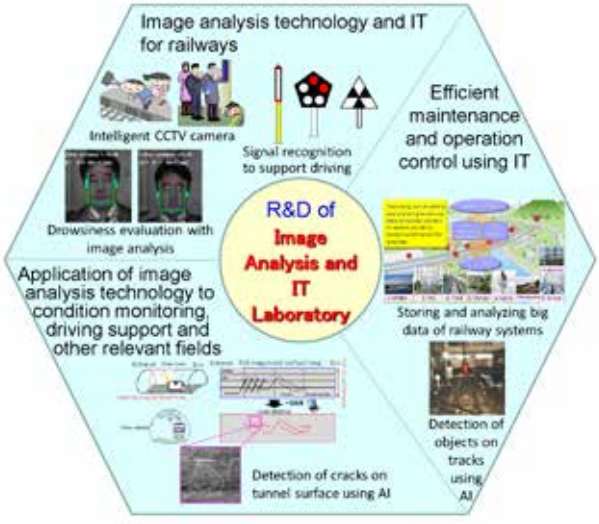
President Kumagai's statement

There are two purposes for the newly-established Image Analysis and IT Laboratory. First one is to quickly and actively implement the research into IT for railways utilizing the expertise of different fields of researchers. For this purpose, the members of the new laboratory have been chosen from among every research field at RTRI. In order to introduce IT to railway operations, high-performance low-cost systems need to be established. I hope that the researchers will integrate their research results and expertise and that synergy will be generated. The second purpose is to create a place where the researchers interested in image-related technologies and IT and hoping to get involved will be able to have discussions openly and freely and to absorb scientific knowledge. Every researchers active involvement is highly anticipated.

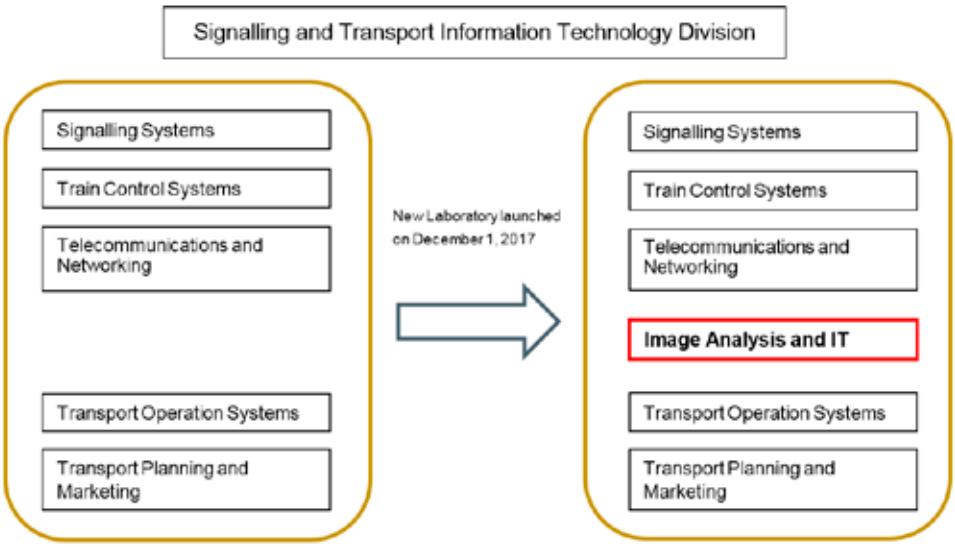
Greetings from Dr. Ukai, Laboratory Head of Image Analysis and IT Laboratory

The Image Analysis and IT Laboratory is unique in that researchers from different research fields have gathered here. It is essential to make the best use of RTRI's technical resources in order to generate effective results as early as possible. Now, its stage has been set. By sharing the expertise of each researcher, I believe we will be able to have synergy effects that is impossible without sharing and cooperation. We might have to start without a chart, but we will keep close communication among the members and dedicate our efforts in order to create innovative results.

Image Analysis and IT Laboratory is launched with Laboratory Head and 12 researchers.



President Kumagai (second left, front row) and the team of the new laboratory



11. RTRI and DLR conclude LoI and Collaboration Agreement

On March 1, 2018, at the German Embassy, Railway Technical Research Institute (RTRI) and the German Aerospace Center (DLR), concluded a Letter of Intent to build a close relationship and a collaboration agreement on research in the field of large-scale 3D model experiments on micro-pressure waves .

1. The goal of the LoI and collaboration agreement

Under these LoI and agreement, RTRI and DLR will explore possible scientific fields suitable for their collaborative research and information sharing and promote collaborative projects utilizing the research resources and expertise of both organizations. They concluded the agreement on 3D model experiments regarding micro-pressure waves based on the LoI.

2. Background of the collaboration with DLR

RTRI and DLR have been sharing information on railway technologies so far. In 1997, one of RTRI's researchers stayed at DLR and conducted collaborative research on the measurement of aerodynamic noise at a wind tunnel. Since both organizations have strongly recognized the necessity to conduct collaborative research and personnel exchange, they concluded the LoI to deepen their tie for the future.

3. Main points of the LoI

(1) To implement collaborative research
(2) To hold management meetings in order to further strengthen the RTRI-DLR relationship
(3) To share views for the future research collaboration

4. Greetings by President of RTRI and Chair of DLR

Dr. Norimichi Kumagai, President of RTRI

Thank you so much for setting today's signing ceremony. I am so pleased that so many people are attending this ceremony, in particular, Dr. Wolfgang Sheremet, Director-General of Industrial Policy Bureau of the Federal Ministry for Economic Affairs and Energy.

It is great honor for me to conclude the collaborative research agreement with DLR, the most influential research institute in Germany which has abundant expertise and resources. It was also my pleasure to meet Prof. Pascale Ehrenfreund yesterday, and to have a significant discussion in order to build the RTRI-DLR collaborative relationship. First, RTRI and DLR will start a collaborative project related to aerodynamic issues for railway vehicles, and continue to strengthen our relationship in other fields of scientific research.

Prof. Dr. Pascale Ehrenfreund, Chair of Executive Board of DLR

It is a great honor for DLR to conclude the agreement for collaborative research with RTRI. I am so pleased to be able to intensify cooperation with our Japanese partner, RTRI, in the field of transport. With this agreement, we will start collaborative research in the field of aerodynamics, and I am also very happy that our researchers have already been cooperating since quite some time. Yesterday, we visited RTRI, joined a very interesting tour to test facilities and had a really great discussion. I would like add this agreement is very much supported by the Federal Ministry for Economic Affairs and Energy.

5. Signing ceremony

Date and time: March 1, 2018 18:30 – 19:00
Venue: German Embassy in Japan

Participants:

RTRI

Dr. Norimichi Kumagai President
Dr. Ikuo Watanabe Executive Director
Dr. Kimitoshi Ashiya Executive Director
Mr. Ryuji Tsuchya Director, International Division
Dr. Atsushi Furukawa Director, Research and Development Promotion Division
Dr. Kiyoshi Nagakura Director, Environmental Engineering Division

German side

Dr. Wolfgang Scheremet Director-General Industrial Policy Bureau of the Federal Ministry for Economic Affairs and Energy, Germany
Prof. Dr. Pascale Ehrenfreund Chair of Executive Board

of DLR
Mr. Siegfried Loose Institute of Aerodynamics and Flow Technology, DLR
Mr. Nicolas Peter Director International Relations, DLR
Dr. Niklas Reinke Director Tokyo Office DLR

6. Overview of DLR

DLR, headquartered in Cologne, is a national agency of the Federal Republic of Germany responsible for development of aeronautical technology and space research. It has approximately 8000 employees and 40 research institutes, and it has been implementing a broad range of research and development covering aeronautics, space, energy, land and ocean transport.

The Institute of Aerodynamics and Flow Technology of DLR, the counterpart institute for the collaborative research, is located in Goettingen and Braunschweig in Niedersachsen and has been dedicated to the research into tunnel micro-pressure wave, aeronautical dynamics, dynamics of helicopters, aerodynamic noise, supersonic technologies and other relevant fields.

Prof. Dr. Ehrenfreund, and Dr. Kumagai at the signing ceremony

Dr. Scheremet Prof. Dr. Ehrenfreund Dr. Kumagai

1 Basic policies

To contribute to the advancement of railways and help bring about an affluent society, RTRI actively promotes R&D activities geared towards railway innovation, delivering high-quality results by fully deploying its comprehensive capabilities.

In addition, to fulfil its social responsibilities as a public interest incorporated foundation, RTRI is active in promoting engineering and legal compliance and carrying out neutral activities, such as providing technical support in the event of a disaster or an accident, based on technical knowledge and experience. Moreover, in order to be the leader in global railway technologies, RTRI helps with the effective deployment of Japanese railway technology in foreign countries, simultaneously increasing its presence in the global market.

To achieve these goals, RTRI adopts the following basic policies:

(1) Dynamic R&D to encourage railway innovation

RTRI should respond to the changing times and the various needs of society and carry out innovative technical development as a matter of urgency. It should strongly promote advanced R&D and R&D in new fields, including enhancement of simulation technology and active use of information and communications technology, by allocating more resources to such activities. Also, it should steadily pursue basic research that can be a source of innovative technology.

(2) Achieving high-quality results by fully demonstrating its comprehensive capabilities

RTRI should rigorously accumulate know-how and pursue the development of human resources in preparation for solving various problems in the railway industry and developing innovative technology, and at the same time combine the strength of researchers and experts in different fields. Together with these actions, the organization's original facilities and equipment for research should be rebuilt or revamped.

Building on these measures, RTRI should achieve high-quality results and disseminate them widely around the world.

(3) Trusted activities based on technical knowledge and experience

RTRI should accumulate deep insights across the railway industry and carry out investigations into the causes of accidents and the damage caused by disasters, presenting methods to guard against their reoccurrence, and formulating technical standards based on its technical knowledge and experience as an independent third-party specialist organization.

(4) Support for overseas deployment and enhancement of the Japanese presence in the international railway sector

To become a leader in the field of railway technologies, RTRI should effectively support the overseas deployment of Japanese railway technology and simultaneously enhance its global presence by disseminating information and building close relationships with foreign railway operators and research institutes. It should also actively propose the adoption of international standards from Japan.

(5) Ensuring that the working environment allows all employees to be highly motivated

RTRI should foster an environment where free-minded researchers and experts can perform to their full potential and produce results that will bring a sense of accomplishment. It should also promote a pleasant workplace culture that allows unfettered discussions while respecting diversity in terms of age, sex, culture differences and other considerations.

2 Business Activities

(1) Research and development

(a) Basic principles of R&D

RTRI pursues the improvement of safety by developing better measures to prevent or mitigate the effects of major natural disasters and implementing derailment prevention measures. It also seeks to reduce the cost of maintenance and other elements of the rail business, to attain harmony with the environment by using energy more efficiently, and to enhance the convenience of rail travel thanks to further increases in train speeds. Drawing on these activities, RTRI will create innovative technologies that can contribute to railway advancement while solving various problems confronting the railway industry today. These challenges constitute the four "R&D Objectives" that RTRI should follow.

R&D Objectives

- Improvement of safety
- Cost reduction
- Harmony with the environment
- Improvement of travelling convenience

In order to promote R&D, resources should be augmented in leading-edge technical fields such as advanced simulation and information and communication technologies, as well as in specific technical fields relating to safety, energy, and faster running, and in other new areas.

In addition, in order to deliver high-quality results, original facilities and equipment for research and testing should be enhanced; studies should be carried out across various specific areas; accumulated know-how and data should be actively used; and the ability to offer a comprehensive service should be leveraged through networks with railway operators and domestic and overseas universities and research organizations.

Furthermore, aiming at reaching a balanced distribution of resources and achieving effective R&D, the following three agendas are adopted as the "Pillars of R&D" (Figure 2-1-1).

Pillars of R&D

- R&D toward the future of railways
- Development of practical technologies
- Basic research for railways

(b) Research and development toward the future of railways

With the objective in mind of achieving practical applications in 10 to 20 years' time, research topics should be carefully selected according to the following principles:

- ○ Respond to the needs of the JR companies and other railway operators, and respond to social trends
- ○ Point to advanced R&D and the future of railways
- ○ Leverage RTRI's expertise in fields and areas where RTRI has higher R&D capability and unique features
- ○ Pave the way for practical R&D and solve critical problems in practical R&D, and encourage research staff to make academic contributions.
- ○ Pursue challenges that will have a large spin-off effect when put to practical use

In FY2015, RTRI will start to implement the four major challenges: "Pursuit of Safer Railway Systems," "Revolutionizing Railway Systems with Information Networks," "Speed-up of the Shinkansen," and "Construction of Railway Simulators." In each major challenge, two or three individual R&D projects have been set. Within each of these there are two or more detailed R&D projects. There will be links between the individual R&D projects so that they are implemented in a logical and systematic way (Figure 2-1-2).

(c) Development of practical technologies

Research issues affecting the railway business that will yield rapid results should be tackled so as to achieve a practical outcome in a timely and satisfactory way.

(i) R&D designated by JR companies

R&D that can contribute to the on-site solution of problems should be carried out, in response to various requests from JR companies and for which they have specific requirements. In R&D,

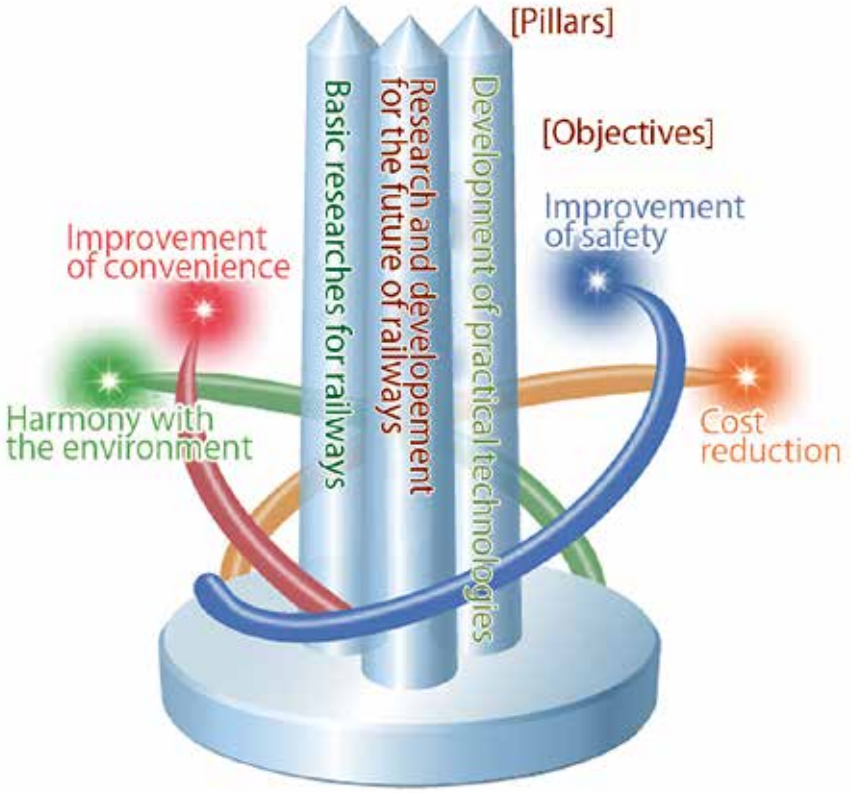


Figure 2-1-1

sufficient resources should be mobilized so as to meet the needs of the railway business and to ensure that results are provided promptly.

(ii) R&D initiated by RTRI to investigate technology for practical use

R&D into novel technology should be pursued, taking fully into account the needs of railway operators, leveraging RTRI's specialist facilities and analysis technology, and aiming at practical application in actual fields of the railway business.

In addition, for dealing with issues that require an immediate response, such as accidents or disasters, an organization should be formed to manage two or more issues so that it has an overview of the situation, and solutions should be proposed quickly.

(iii) R&D commissioned by the Government or the public sector

R&D commissioned by the Government or the public sector should be undertaken in order to put results to practical use and make them widely available.

(d) Basic research for railways

In order to solve various railway problems and address challenges related to sources of innovative technologies, basic research for railways should have high-level backing and support. It should include the following objectives: clarification of mechanisms and phenomena; establishment of analytical, experimental, and evaluation methods; development of sophisticated simulation technology; and the development of new technologies, new materials and of different approaches to research.

In the process of promoting research, the following five items should be allocated higher priority, while research in new areas such as brain science is pursued.

- Prediction, detection, and prevention of phenomena that cause disasters
- Clarification of dynamic phenomena caused by rail travel
- Elucidation of deterioration/damage mechanisms
- Improvement of the environment along railway

Figure 2-1-2

lines and the global environment

- Improvement of safety with a focus on human factors

(e) Facilities and equipment for research and testing

Original facilities and equipment for research should be replaced where necessary; the selected facilities should be directly connected to R&D activities in fields where RTRI intends to introduce innovative technologies. In addition, where the performance of test facilities has declined over time so that they no longer meet R&D needs, they should be improved or renewed, in addition to construction of new buildings for experiments.

(2) Investigation of railway technologies and science

RTRI should grasp social, economic and technological changes, and then collect and analyze various types of information generated in Japan and foreign countries that is needed in order to contribute to the technical development of the railway business. Once this has been completed, the results of such activities should be transmitted to the parties concerned. RTRI should also predict the future status of railways and conduct investigations necessary to choose technical issues for its R&D objectives.

(3) Preparation of drafts of railway technology standards

In accordance with the rising importance of the management and maintenance of society's infrastructure and the Japanese Government's movement towards performance specification of technology standards, RTRI should promote the formulation and arrangement of design standards, maintenance management standards, and design calculation examples of infrastructure. Technical fields, such as vehicles, where new technical standards should be formulated, and therefore where systematization is needed, should be clarified. This should ensure that tasks such as the formulation of design standards in these fields can proceed smoothly.

(4) Collection and release of railway-related documents, materials and statistics

RTRI should collect and collate information on Japanese and foreign railway technologies. It should also leverage various channels, such as mass media and the Internet, and transmit R&D results and activity status in a planned and timely manner. It should play a role as a source to send timely and precise railway technical information to the public.

(5) Publications and lectures to raise the profile of railway technologies and science

RTRI should expand the contents of its periodicals, such as the RTRI Report and RRR, lecture presentations, and technical forums. Through these instruments, the results of RTRI's R&D work should be offered widely to the public. The courses of lectures on railway technology and other lecture presentations should be systematic, and designed to meet the needs of all, from beginners to experts.

(6) Diagnosis, advice and guidance on railway technologies and science

RTRI should respond precisely to requests from railway operators to continuously and positively carry out its mission. Especially in offering a consulting service in response to a disaster or an equipment failure, a quick response should be agreed in a tie-up with the railway businesses or operators involved. Furthermore, consulting services for local railway companies should be enhanced by making site visits and giving technical advice.

(7) Drafting of original plans and proposals for standardization with regard to international railway standards

RTRI should promote, in a strategic way, activities related to the International Electrotechnical Commission (IEC) and the International Organization for Standardization (ISO). In particular, RTRI should actively participate in the operation of TC 269 (Railway Applications), newly established in ISO in April 2012. It should also strengthen its resources, and press on with projects such as "rail project planning" which Japan proposes. At the same time, RTRI should exercise leadership in standardization activities in the fields of operations and services where Japan has technical predominance.

(8) Authorization of qualifications with respect to railway-related science and technology

With a focus on accreditation tests for Professional Railway Design Engineers, RTRI should build up and arrange improvements in examination opportunities for applicants through overall verification of the tests, thereby contributing to the enhancement and maintenance of the level of technical expertise of railway engineers.

(9) Railway Technology Promotion Center

RTRI should contribute to an improvement in the level of technical expertise in the railway industry by promoting related business while taking, as pillars, systematization of technologies and problem solving, enhancement and maintenance of technical capabilities, and technical information services. For this purpose, it should tackle new research and study topics that are useful for systematization of vehicle technology, and simultaneously offer technical support to local railways and encourage technology succession by positively applying the knowledge of "Rail Advisers." In addition, the contents of the safety database should be enriched through intensified research and analysis activities in the human factors field.

(10) Railway International Standards Center

RTRI should promote strategic activities aimed at introducing Japanese technical specifications and concepts into international standards. It should actively exchange information with European and Asian standardization bodies and intensify its partnerships with them, and also boost educational activities on international standards for the parties concerned and human resource development activities.

(11) International activities

For the purpose of further improving the technical capabilities and presence of RTRI, joint research programmes with foreign universities and research bodies should be expanded. Exchange of researchers should be promoted by sending more RTRI researchers abroad and receiving more foreign experts in Japan. RTRI should actively take part in the World Congress on Railway Research (WCRR) as a member of the Organizing Committee, going ahead with preparation and management of the WCRR meeting to be held in Tokyo in 2019. RTRI should also aspire to organize international workshops and join various types of international conferences to exchange information on the latest railway technologies. RTRI researchers should be sent overseas to investigate global railway conditions and technologies.

RTRI should contribute to the wider application of Japanese railway technologies across the world by providing active support for railway operators and related businesses, assisting overseas deployment of intellectual property, and offering guidance to engineers in foreign countries.

YEAR 2017-2018: April 1, 2017 - March 31, 2018

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