Newsletter on the Latest Technologies Developed by RTRI

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Railway Technology Newsletter

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R&D and International Activities at RTRI

Shunichi KUBO
Director, Research and Development Promotion Division

RTRI has been engaged in research and development based on its vision and the five-year project plan (Master Plan RESEARCH 2020) which started in FY 2015. To achieve the vision, one of the plan's missions is to pioneer cutting-edge technologies for Japanese railways and become a world leader by working to develop technologies that contribute to railway systems in the world. Our strategies to achieve this goal include the expansion of our international presence, the promotion of the international exchange of researchers, and the support of the overseas development of railway systems.

For the expansion of our international presence, we will expand our joint research projects with overseas universities and research institutes while preparing and operating the World Congress on Railway Research (WCRR). We will further increase the opportunities to announce the results of the RTRI's R&D efforts by holding international workshops and attending international conferences.

Our current joint research projects with overseas railway organizations include an electric power and railway track simulation project with France and a research project with Germany on micro-pressure waves in tunnels. Joint research with China and Korea, and projects with the U.K. are also under way. Furthermore, we are engaged in joint research with universities and research institutes in fields such as bogie control, passenger behavior in the event of a train crash, dynamic interactions between vehicles, tracks and structures, and the maintenance of earth structures.

For the promotion of the international exchange of researchers, we are planning to increase the opportunities for direct discussions with overseas researchers by dispatching our staff and accepting researchers in joint research projects with overseas institutions. In addition, we will support the efforts of building a global network of researchers by holding international workshops.

With regard to the support of the overseas development of railway systems, we set up a new department in July 2015 for the overseas promotion of the RTRI's R&D efforts.

The 15th China-Korea-Japan Railway Research Technical Meeting

RTRI, China Academy of Railway Sciences (CARS) and Korea Railroad Research Institute (KRRI) held the 15th China-Korea-Japan Railway Research Technical Meeting for three days from November 17 to 19, 2015 in Beijing, China. Since the signing of an agreement on joint research in 2000, RTRI, CARS and KRRI have been conducting joint research in various fields of railway technology. The 15th annual seminar in Beijing was attended by 45 participants—13 from RTRI, 14 from KRRI and 18 from CARS. The participants discussed various topics including the management systems of the organizations, the direction of research, the target and challenges of speeding up railways, how to secure vehicle running safety, and methods to prevent and mitigate disasters.

Signing ceremony for a joint research program with CARS and KRRI

Workshop on Seismic Design of Embankment

RTRI held a Workshop on Seismic Design of Embankment on December 2, 2015. It was attended by 43 participants from 15 companies including railway operators and railway design consulting firms.

At the workshop, Professor Hoe I. Ling from Columbia University gave a keynote speech and Professor Feng Zhang from Nagoya Institute of Technology made a special presentation. There were also general presentations on themes such as seismic countermeasures and the design of embankments and ground to withstand large earthquakes. The presentations were followed by practical discussions on the problems of the current design approaches and design philosophies for the future.

Keynote speech by Professor Hoe I. Ling

Meeting on Joint Research with the University of Cambridge

RTRI held a meeting on the nine-year joint research with the University of Cambridge on December 10, 2015 by inviting Professor Lord Robert Mair, Sir Kirby Laing Professor of Civil Engineering and Head of Civil Engineering at the University of Cambridge, and Professor Kenichi Soga, Professor of the Civil Engineering at the university.

Professor Mair gave a presentation on tunnel construction technology for reducing effects of tunneling on buildings and monitoring technology using optical fibers and wireless networks. Professor Soga reported on the outline of the joint research project between the University of Cambridge and RTRI, recent topics of interest at the R&D center at the University of Cambridge and the center's research projects.

Presentation by Professor Mair

Presentation by Professor Soga

Railway Technology Newsletter Relaunch

RTRI is now preparing to relaunch its newsletter. This No.54 is the final issue before relaunch. The most important feature of the new newsletter is its contents which is easy to understand for rail-related readers who are not technical experts. Please wait for upgraded RTRI Newsletter.

Monitoring System by Vibration Power Generation of Steel Railway Bridges

Yoshinori YOSHIDA
Assistant Senior Researcher, Steel and Hybrid Structures, Structures Technology Division

1. Introduction

Structural monitoring is a technology with potential to improve the efficiency of maintenance. However, there are problems with providing power to the monitoring systems. Since structures do not normally have a power source, the costs to install electrical power to a monitoring system are large. Although battery-powered monitoring systems have been developed in recent years, these systems incur running costs due to periodic battery replacement. To address these problems, we attempted to generate power for monitoring systems by utilizing the vibration of a steel railway bridge when trains pass.

2. Vibration power generation

Our vibration power generation system consists of attaching piezoelectric devices to bridge members whose vibration induces stress on the piezoelectric devices to generate power. Since piezoelectric devices are capable of generating power almost permanently, there is no need to replace batteries. Another advantage is easy installation, which means the system can be installed at low cost.

Since the power generated by vibration is very small, we studied a method which efficiently generates power by changing the conditions of actual bridge members and piezoelectric devices. As a result, we found that the bridge member that causes continuously high-frequency vibrations generates power more easily (Fig. 1).

3. Monitoring system using power generated by vibration

We developed two types of monitoring systems operated by power generated by vibration, and conducted a field test that simulates actual operation. One system type is designed to detect a defect of a bridge and report the result. The other type monitors changes in conditions of bridges. The former detects defects in the bridge by a sensor and transmits the result of the sensing to the train passing on the bridge by wireless, so that the transmitted data can be obtained on-board (Fig. 2). The latter system measures at constant time intervals and dynamic response when trains pass to monitor changes in the bridge conditions over time by storing the power generated by vibration.

Figure 3 is an example of the monitoring results for the bridge temperature and the displacement of the bearing which have been continuously measured for more than two years by a system using only power generated by vibration. Such results can be effectively utilized to detect changes in bridge conditions by monitoring the response to temperature.

Part of this research has been conducted using a subsidy for railway technology development granted by the Ministry of Land, Infrastructure, Transport and Tourism.

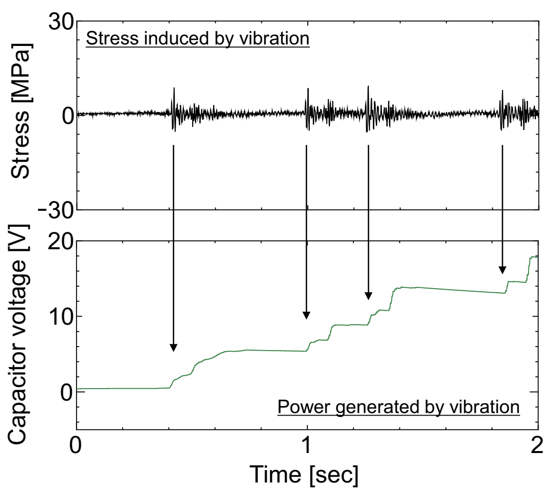

Fig. 1 Power generated by vibration

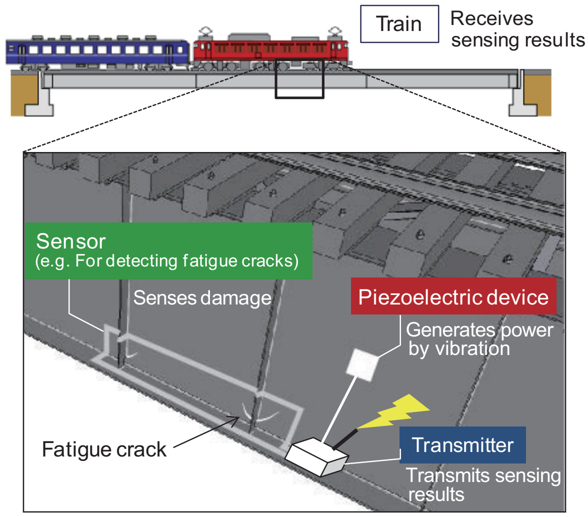

Fig. 2 Concept of monitoring system

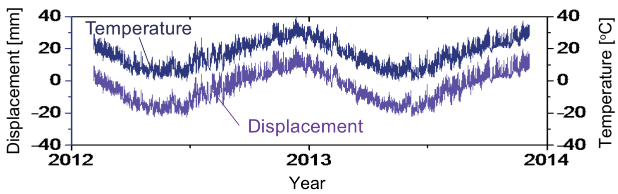

Fig. 3 Data from bridge monitored by developed system

Preventing Excessive Temperatures of the Overhead Contact Wire When Rapidly Recharging Battery-Powered Trains

Takamasa HAYASAKA
Senior Researcher, Contact Line Structures, Power Supply Technology Division

1. Introduction

A battery-powered electric train is recharged while it is in electrified sections, and then runs in non-electrified sections by consuming the power stored in the batteries. Recharging is carried out while the train is stopped at a station or other facility by use of the contact wire and pantograph. However, the re-charging process creates heat and when the contact wire temperature reaches 90 °C, it begins to soften. Since the catenary wire is under tension, wire breakage can occur in the worst case. The thickness of the film on the contact wire at the contact point between it and the pantograph has a significant influence on the temperature rise of the contact wire. However, the relationships between the film growth rate, the film thickness and the contact resistance have not been quantified sufficiently.

Hence, we have worked to determine the relationships between the condition of the contact point and temperature rise by conducting simulations to examine the temperature rise under a variety of conditions. The research has resulted in the formulation of a proposal for maintenance work to alleviate the potential problem of excessive contact wire temperatures.

2. Test results and simulation schemes

Figure 1 shows the relationships between contact wire film thickness and number of exposure days. The data were obtained from a contact wire exposure test. The film is found to grow thicker with the number of exposure days. It was noted that the film thickness reached 4 μm in about one year and the contact resistance increased to 2.23 mΩ.

Figure 2 shows a simulation result about the relationships between collection current and contact wire temperature rise in the catenary wire. The recharging current for the present battery-powered train in the catenary wire section is 250 A. If it is recharged with this current value, the temperature of the contact wire exceeds 90 °C when the contact resistance is 2.23 mΩ. As discussed before, the elapsed time to reach the resistance of 2.23 mΩ was about one year, and thus, grinding the surface of contact wire is required every six months including a certain allowance for the maintenance servicing.

For the simulation, we apply an electric field and thermal conductivity analysis through a finite element method. With this approach, the study of temperature rise in various pantograph shapes and contact point conditions has been made feasible.

3. Conclusion

There is a concern that the rapid recharging of battery-powered trains by using the catenary wire and pantographs can potentially cause a sharp temperature rise of the contact wire, with consequent wire breakage depending on conditions. Notably, the adverse effect of the film on the wire as a cause of temperature rise had not been clarified sufficiently. Through this research, we are recommending that grinding the contact wire once every six months is an appropriate standard for maintenance planning.

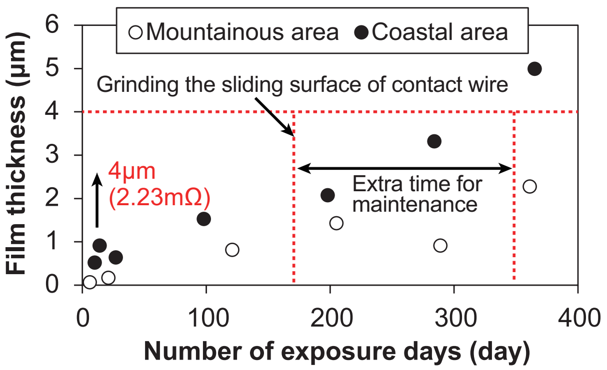

Fig. 1 Relationships between the number of exposure days and film thickness

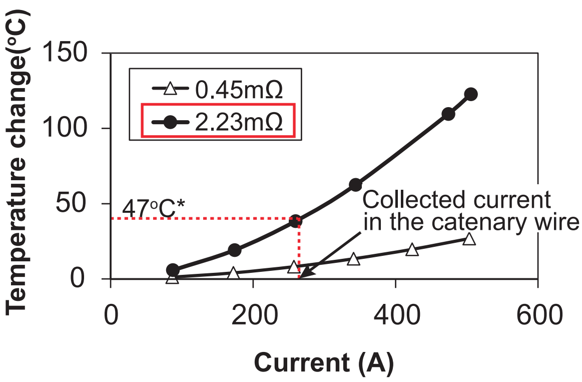

Fig. 2 Relationships between current and temperature rise
* Allowable temperature rise assuming the outdoor temperature to be 43 °C

Development of Portable Trolley for Continuous Measurement of Rail Surface Roughness

Hirofumi TANAKA
Assistant Senior Researcher, Track Maintenance & Geometry, Track Technology Division

1. Introduction

Rail corrugation that occurs mainly on rails in curved sections due to train passage typically consists of periodic and minute surface roughness of 1 mm or less amplitude. Since the corrugation causes noise and vibration, it needs to be controlled appropriately. Furthermore, the increase of operations of luxurious tourist trains in recent years requires closer control with a view of improving comfort on the train. To this end, we have developed a portable trolley for continuous measurement of rail surface roughness such as corrugation from the ground, as shown in Fig. 1.

2. Overview of portable trolley for continuous measurement of rail surface roughness

The features of the developed trolley include: 1) a trolley can be easily carried to the measurement site, 2) capability of continuous measurement of rail surface roughness by manually pushing the trolley after it is mounted on the rails, 3) a non-contact laser displacement sensor that allows measurement that is independent of the travel speed of the trolley, 4) a sensor that is movable in the cross sectional direction of the rail allows surface roughness measurement in gauge corners, and 5) a PC with special software that allows measurement results to be assessed and analyzed on the spot. The trolley uses the asymmetrical chord offset method for sensor layout, which allows high-precision measurement of rail surface roughness with a wavelength of approximately 26 to 700 mm.

3. Applications and future development

Figure 2 shows an example of rail corrugation. Since the occurrence of corrugations cannot be eliminated, the surface roughness is usually controlled by grinding the rail using a rail grinding car after the corrugations occur. We measure rail surface roughness(RSR) using the trolley before and after grinding the rails, and example measurement results are presented in Fig. 3. Since the presence of rail surface roughness can be checked on the spot, it is possible to decide the grinding range and working pass in advance for efficient rail grinding work by conducting measurements before grinding the rails. By conducting measurements after grinding the rails, the user can check for surface finish conditions.

Since the trolley allows the occurrence of rail corrugation to be accurately checked, we expect it will help in understanding the mechanism that causes rail corrugation as well. We are also tackling the challenge of understanding this mechanism by using simulation technologies.

Fig. 2 Examples of rail corrugation (left: low rail on ballasted track; right: high rail on ballastless track)

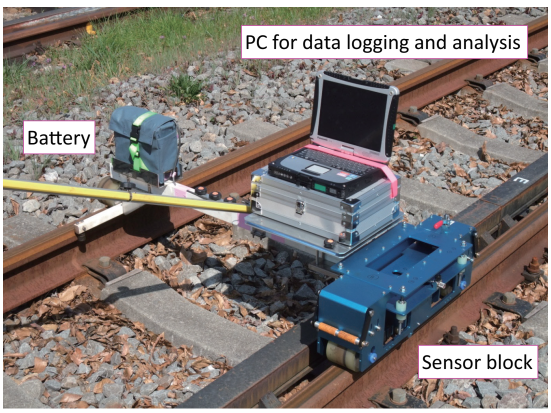

Fig. 1 External view of developed trolley

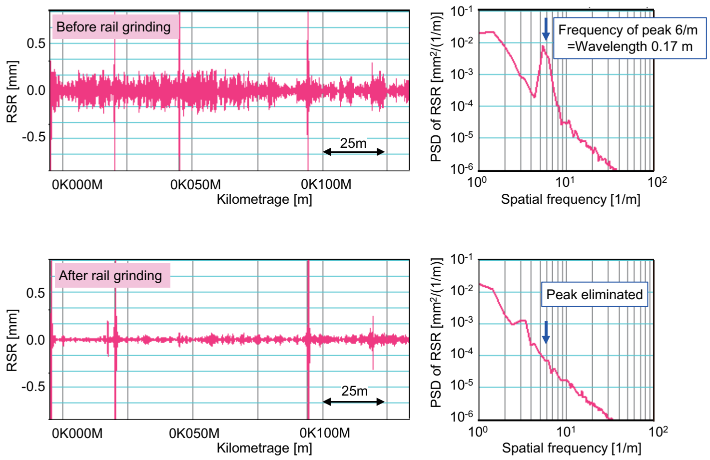

Fig. 3 Example of continuous measurements of rail surface roughness before and after rail grinding

Approach for Estimating the Outflow of Snowmelt Water from the Bottom of Snowpack

Ryota SATO
Researcher, Meteorological Disaster Prevention, Disaster Prevention Technology Division

1. Introduction

In early spring, snowpack begins to melt and snowmelt water flows from surface down to the bottom of the snowpack. The snowmelt volume that flows out from the bottom of the snowpack has an influence on the generation of full-depth avalanches and slope collapses during the snowmelt period. Accordingly, in order to evaluate the risk of these disasters, quantifying the rates of outflow from the bottom of snowpack is important. However, measuring the outflow from the bottom of the snowpack at a great number of locations along the railway lines is not realistic in regard to cost and maintenance efforts. Therefore, estimating the outflow from the bottom of a snowpack utilizing meteorological data and relevant information is desirable. As a result of this study, an approach to estimate the outflow from the bottom of the snowpack has been developed using the observation data from the Japan Meteorological Agency, referring to the observation results of weather and snowmelt, and using past study results.

2. Overview of the estimating method for outflow from the bottom of snowpack

The method we have developed is an approach to 1) estimate snowmelt at the snow surface and 2) estimate the outflow from the bottom of snowpack by taking into consideration the outflow delay time as a consequence of the infiltration of snowmelt water from the surface through the snowpack. The methodology utilizes input data corresponding to the four elements of weather (air temperature, rainfall, sunshine duration and wind velocity) obtained from the observation points of the Japan Meteorological Agency (Fig. 1). The snowmelt at the snow surface was estimated by calculating the heat balance on the surface of the snowpack by using the meteorological data, and the outflow delay time was calculated by using the infiltration coefficients obtained from observation.

3. Accuracy verification of the estimating method for outflow from the bottom of snowpack

The values of outflow from the bottom of the snowpack estimated through this approach have been compared with the results of one hour interval measurements based on the lysimeter method (a method for directly measuring the outflow from the bottom of snowpack) (Fig. 2). The data revealed that the data trends at one hour intervals for both methods generally coincide. Also, by examining the relationships of the two methods, it was found that the regression coefficient of both is 1.12, and while the estimated value somewhat exceeded the observed value, the determination coefficient R^2 is 0.74, suggesting that there is a good correlation between them (Fig. 3).

As described above, since outflow from the bottom of snowpack can be estimated utilizing the meteorological data obtainable from observation points of the Japan Meteorological Agency, estimating outflow from the bottom of the snowpack at an arbitrary point along the railway lines is possible. Thus, this approach is useful for determining the necessity of patrolling and guarding against probable disasters (full-depth avalanches and landslides) in the snowmelt period.

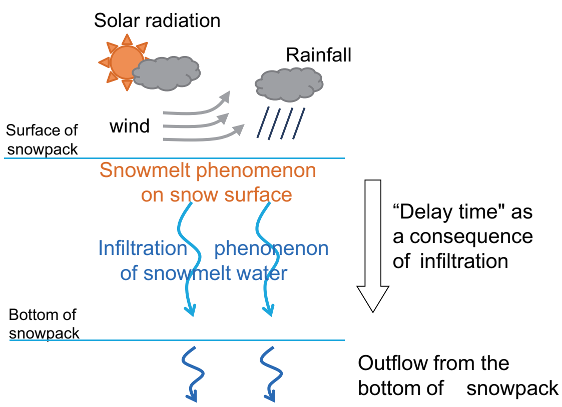

Fig. 1 Conceptual diagram of snowmelt phenomenon

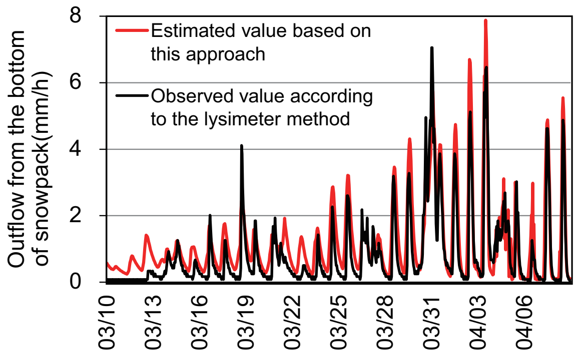

Fig. 2 Estimated results of outflow from the bottom of snowpack

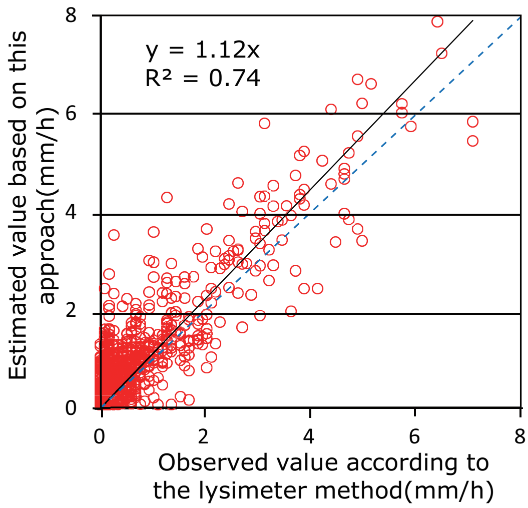

Fig. 3 Correlation between observed values and estimated values (The broken lines indicate one-to-one relationship)