Newsletter on the Latest Technologies Developed by RTRI

Railway Technology Avalanche

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GENERAL INFOMATION

ARTICLES

The Information Infrastructure in RTRI

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Director, Information Management Division

The basic service of our group, the Information Management Division, includes provision and operation of the information infrastructure in RTRI. In recent years, RTRI has restructured the in-house office automation systems to expand our support of the information system for research activities and various types of administrative work for staff members. We have specifically pursued enhancement of the ability to refer to previous research topics and published papers, to carry out searches and to reuse a variety of references for writing research papers, as well as enhancement of other functions and similar activities.

Further, RTRI has been operating computers capable of high speed and parallel calculations (supercomputers) since 1993, and these can be shared for sophisticated analyses and simulations. We update the computers with new models every three or four years to take account of the increasing computation demands and to keep pace with progress in computer technology. We upgraded the system last year to a much faster one with greater capacity. In terms of throughput, the new model has remarkably increased capacity with about sixteen times as much capacity as the former model and about 5,000 times more capacity than the system used in 1993.

As the situation surrounding the railway industry has changed, the demands placed on the railway have become more diverse. Not only are there demands for improvements in reliability, safety, convenience, and similar fields, but also for improvements in the environment along railway lines, for a contribution to global environmental issues, and more besides. Future expectations call for us to take advantage of computing power in a wide range of applications, including the definition and assessment of aerodynamic sound and other noise generation mechanisms when a train is running, the development of measures to reduce noise, to clarify the complex dynamic movement of rolling stock, to simulate structures and the behaviour of trains during an earthquake, to calculate the forces exerted on passengers during accidents, and to analyse the flow of passengers in stations and larger areas. RTRI owns a wide variety of test facilities. We are keen to contribute to research and development work to achieve superior research outcomes by combining data obtained from experiments conducted at our facilities, data measured in the live railway environment and the results of theoretical calculation and simulation using the supercomputers.

Micky Tanaka

Report of the China-Korea-Japan Railway Research Technical Meeting

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The China Academy of Railway Sciences hosted the 9th China-Korea-Japan Railway Research Technical Meeting (hereinafter, 9th CKJ Meeting) in Beijing, on December 14th - 15th, 2009. The CKJ Meeting has been held annually since 2001 by the railway research organizations of the three countries: the China Academy of Railway Sciences (CARS), the Korea Railroad Research Institute (KRRI) and the Railway Technical Research Institute (RTRI).

Approximately 60 participants attended the 9th CKJ Meeting, including Vice President Mr. Wang and 30 members from CARS, President Mr. Choi and 17 members from KRRI and Executive Director Mr. Uchida and nine members from RTRI (Fig. 1).

On December 14th, we held the summit meeting, the preparatory meeting and the researchers' meetings on technical issues. In the summit meeting, discussions were made on mutual utilization of the test facilities owned by each organization, on personnel exchanges among the three institutes, and on similar topics.

On December 15th, the annual meeting was conducted as follows.

(1) Representative Addresses: a representative from each of the three organizations gave an address.

(2) Keynote Lectures: the three institutes gave the following keynote lectures.

- "Construction of National Science & Technology Innovation Platform" by CARS
- "Green Growth and Railway Technology R&D" by KRRI
- "R&D of the Railway Technical Research Institute" by RTRI

(3) Introduction of Test Facilities: an introduction was given to the major test facilities of each organization.

(4) Accomplishment Report Session: the achievements of joint research projects were presented with eleven presentations in total (four from CARS, four from KRRI and three from RTRI), followed by a question and answer session.

(5) Introduction of New Topics: each institute presented the outlines of research topics that had recently commenced (three from CARS, five from KRRI and one from RTRI).

(6) Signature on Minutes: the secretarial officers of the three organizations signed the minutes of the 9th CKJ Meeting.

As of January 2010, there are 17 ongoing joint research projects being undertaken by China, Korea and Japan. Among them, RTRI is taking part in the following six research topics, four of which are newly established.

- A Comparison of the Environmental Performance of Railway Systems
- A Study on the Research and Sharing Mechanism of Railway Scientific Technological Literature Resources
- Research on the Management Arrangements for Mutual Use of Research or Testing Facilities Among CARS, KRRI and RTRI Laboratories (New)
- Research on Evaluation Methods and Criteria for the Derailment Safety of High Speed Train-Track Systems (New)
- A Study on the Remediation of Contaminated Soil on Railways (New)
- Measurement methods for the pantograph and catenary system and their application to maintenance works (New)

The next CKJ Meeting will be held in Seoul, Korea, in September 2010. As we shall be celebrating the tenth anniversary, we anticipate even more eclat, and we shall be inviting participants from outside of the three organizations.

Fig. 1 Participants at the 9th China-Korea-Japan Joint Research Seminar

A Model of Two Types of Leveling Valve

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The automatic leveling valve (LV) is one of the components of the air spring system which automatically maintains the floor height of a railway vehicle at a certain level. Two types of leveling valves, called LV-4 and LV-7, are used in Japan. The LV-4 has the neutral zone and a time lag. The LV-7 has a throttled air flow around the neutral position. In order to investigate the dynamics of a vehicle passing through a curve at low speed, it is necessary to consider a model of the leveling valve.

To create a model, the functions of the mechanical structure and the air flow have to be separated. A spring with the initial load and a single action damper featuring a time lag are built into the LV-4. Using the indicator, the mechanical structure of the LV-4 is as shown in Fig. 1. When the indicator moves away from the neutral position, the damper takes effect. The delay time is defined as the time from the air spring exceeding the neutral zone to the moment when the leveling valve starts to work. When the air spring moves slowly, the delay time is about 10 msec without the initial load. But there is no delay time when the initial load is applied. On the other hand, if the air spring moves quickly and the displacement of the air spring is the same as the height when the time lag is measured, the delay time converges towards the time lag. However, if the displacement of the air spring is shorter than the height when the time lag is measured, the delay time is longer than the time lag. The mechanical structure of the LV-7 is a simple model as shown in Fig. 2, because there is no time lag.

It is assumed that the characteristic of the air flow rate through the leveling valve is the same as the orifice. After the end of the time lag and when the indicator has passed the neutral zone, the characteristic of the flow rate of the LV-4 rises sharply, forming a step shape. Thinking about the pressure condition when the leveling valve works, the flow rate through the LV-4 is proportional to the pressure of the upstream air flow. The characteristic of the flow rate of the LV-7 is proportional to the displacement of the air spring, because it has a throttled air flow and no time lag.

Using two models of these leveling valves, a simulation of the vehicle running through a sharp curve at low speed was carried out. The roll angle of the vehicle on the curve became constant, because the LV-4 worked only in the start of the transition curve. And on the straight section of line after the train had passed through the curve, the vehicle tilted by an angle of a few degrees because of the neutral zone. The roll angle of the vehicle on the curve changed, because the LV-7 worked when the train was traversing the curve. Moreover, on the straight section of line after the curve the roll angle of the vehicle decreased gradually, because the LV-7 works continuously.

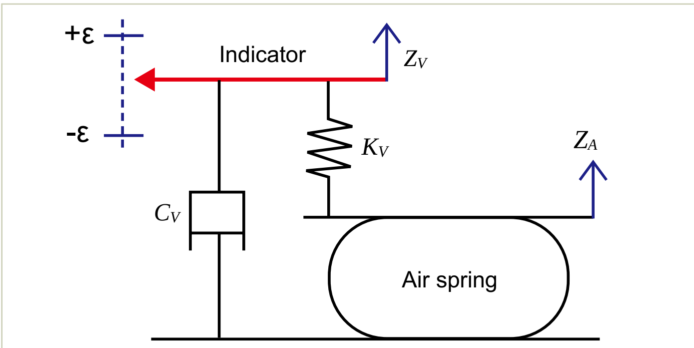

Fig. 1 The mechanical structure of LV-4

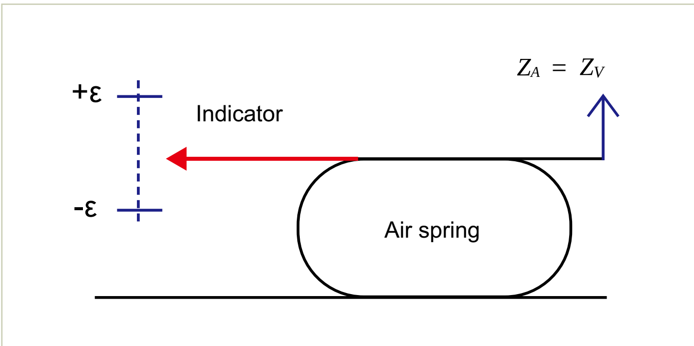

Fig. 2 The mechanical structure of LV-7

The Restraint Effect of a Scoring Phenomenon in an Abrasive Block Used for Cleaning Wheel Treads Using Changed Control Techniques

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1. Introduction

Wheel tread cleaners are installed on high-speed vehicles to press adhesion-intensifying abrasive blocks onto the wheel tread for the purpose of improving adhesion. The abrasive block plays various roles: to clean the wheel tread, to prevent wheel slip and skid, to improve sensitivity for operating track circuits and to reduce running noise. Recently, however, abnormal noise has been generated by scoring fragments adhering to the abrasive block or by concave wear which is caused by the scoring phenomenon on the wheel tread. These problems have been observed on vehicles of a certain type running on lines where single-step-brakes are applied. A vehicle running test was conducted using a control technique developed in the course of tests for reproducing scoring fragments. The next part of this description introduces the results of a comparison between the developed control technique and the present control technique with respect to the restraint effect of the scoring phenomenon which reduces the formation of scoring fragments.

2. Scoring fragments in present circumstances

Figure 1 illustrates the abrasive block of an actual vehicle and some scoring fragments. The scoring fragments to the portion corresponding to the rolling width of the wheel tread can be observed (Fig. 1(a)). From this Fig., the formation of scoring fragments is assumed to be related to a certain substance intervening between the wheel and the rail in different rolling conditions. Wedge-like cut metal pieces can be observed on the surface, with a melting mark or high-temperature oxidation visible on the reverse surface (Fig. 1(b)). The scoring fragments are assumed to have been formed after the surface layer of the wheel tread starts to peel in the high-temperature environment.

3. Reproduction test on a test stand

Figure 2 illustrates a dynamo test stand. Dry and wet conditions are combined with the presence/absence of sample sprinkling to simulate the conditions of the actual vehicle running environment. Powdered materials such as cement, rail rust, vehicle sludge, alumina, quartz sand and white sand were used as samples to be sprinkled onto the wheel tread to provide the same conditions, in tunnels, on open sections and on new lines, an adhesion-intensifying injection device is operated on certain sections, for examples. Both single-step-brakes and conventional multi-step-brakes were used to generate different braking patterns.

In the single-step-brakes test to reproduce the actual vehicle condition, scoring fragments were observed both in wet conditions and in wet conditions when samples of powdered material were sprinkled on the wheel. In particular, when quartz sand was being sprinkled on to the wheel surface, scoring fragments similar to those observed in the actual vehicle were formed (Fig. 3(a)). In the multi-step-brakes test conducted under the same conditions, scoring fragments smaller than those observed in the previous condition were formed (Fig. 3(b)). The intermittent operation of the abrasive block, which occurs when the multi-step-brakes is used, is assumed to provide the restraint effect. Then the single-step-brakes was subjected to both continuous control, as currently used, and intermittent control with a combination of 20-second operation and 10-second release. A comparison between the two types of control was made with respect to the wheel tread roughness contributing to the adhesion coefficient. Comparison of the results shows the same wheel tread roughness arising from intermittent control as from continuous control.

4. Running test

A comparison was made between continuous control and intermittent control applied to the leading vehicle (Car No.1) on each of the train set which is likely to generate more scoring fragments. These train sets had been subjected to running tests using single-step-brakes in the winter or during the season when scoring fragments are most often observed (Fig. 4). Under the intermittent control conducted in the test, both the operation period and the release period were corrected to 17seconds to take account of the operational characteristics of the abrasive block used on the actual vehicle. The test result shows that the intermittent control effectively suppresses formation of scoring fragments while keeping the equivalent adhesion-intensifying effect (Fig. 4(b)).

5. Conclusion

Based on the results of the running tests, intermittent control is considered as one of the optimum techniques to suppress the scoring phenomenon while keeping the adhesion-intensifying effect. Application of the control technique to other types of vehicle will be further examined by evaluating adhesion and the restraint effect throughout the year.

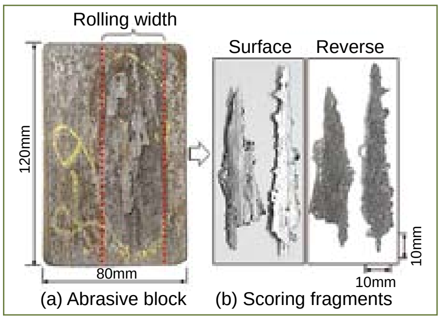

Fig. 1 Abrasive block and scoring fragments of a vehicle

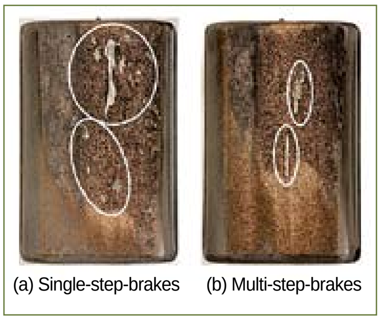

Fig. 3 Scoring fragments formed during laboratory tests

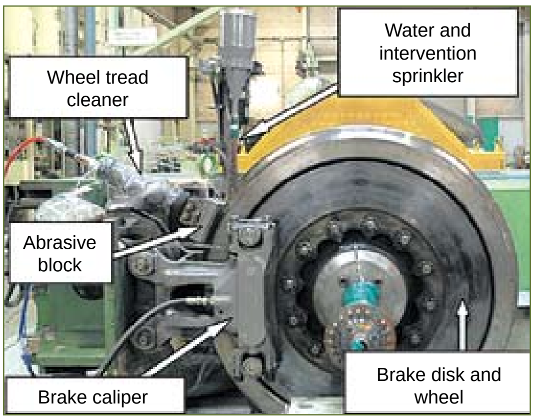

Fig. 2 Dynamo test stand in a laboratory

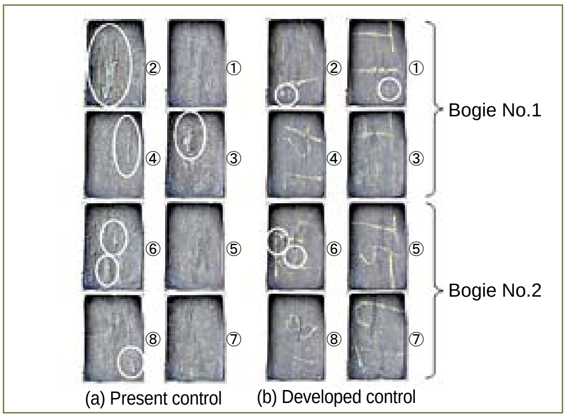

Fig. 4 Scoring fragments formed in a running test

A Non-Destructive Inspection Method for Concrete Elements in Tunnel Linings Using Remote Laser Sensing

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1. Introduction

To ensure that trains run safely, the performance of railway civil engineering structures is checked by periodic inspections. Table 1 shows a summary of different general inspection methods for tunnel linings, such as impact acoustics, infrared and ultrasonic methods. Each method has merits and demerits, but none of them offers the combination of high accuracy and quick inspection.

In an effort to resolve this problem, the Institute for Laser Technology, the Tokyo Institute of Technology, the Railway Technical Research Institute and West Japan Railway Company jointly developed a remote laser sensing system as an alternative to the impact acoustics method for detecting defective concrete elements in tunnel linings. This report describes the principle of the proposed method, an algorithm to detect faulty concrete elements and a verification test with the proposed method.

2. Development of laser remote sensing

(1) Principle of remote laser sensing

Figure 1 shows the principle of the proposed remote laser sensing system. This system has two lasers, one to apply an impact to the concrete surface and the other to measure the vibration of the concrete generated by the impact laser. The impact laser is a high-energy pulse laser that induces vibration in the concrete. The detection laser has a signal beam and a reference beam. The signal beam reflects on the concrete surface and goes into the dynamic hologram crystal. The reference beam diffracts in the dynamic hologram and enters the detection sensor with the signal beam. The vibration of the concrete surface can be measured to detect the movement of an interference pattern.

(2) Prototype of remote laser sensing system

A prototype of the remote laser sensing system was developed. This uses the principle shown in Fig. 1, and the device is illustrated in Photo 1. The system is equipped so that it can stabilise an interference pattern, and this allows it to reduce the amount of movement in the interference pattern generated by a small external vibration between the detector and the surface of the concrete.

3. Development of a detection algorithm to show concrete defects

In this research, the time history of acceleration on the surface of the concrete after application of an impact force by hammering is adopted as the relevant data for the impact acoustics inspection. Figure 2 and 3 show representative Fourier spectrums measured from concrete specimens without and with defects, respectively. The performance of the concrete can be evaluated by using the ratio of the area of the Fourier spectrum that is lower than a given frequency tolerance to the whole area of the Fourier spectrum. The index of the above ratio can be calculated from the following formula.

$$R_S = A_1/(A_1 + A_2) \qquad (1)$$

where A_1 is the area of the Fourier spectrum lower than the frequency tolerance, A_2 is the area of the Fourier spectrum higher than the frequency tolerance and RS is the ratio of the Fourier spectrum area. This ratio is referred to as a spectrum score in this paper.

The proposed detection algorithm was verified against the result obtained from the impact acoustics inspection. Figure 4 shows the result obtained using the proposed detection algorithm. The evaluation by the detection algorithm agrees well with the result of the impact acoustics method using the tolerance of 2000 Hz and a spectrum score of 0.1.

4. Verification field test with an actual bridge

The proposed laser remote sensing system and the detection algorithm were verified with the help of field tests conducted at a bridge and in a tunnel on the Shinkansen. Photo 2 shows the tunnel used for the field tests. An impact test using hammering was applied to obtain the accurate response acceleration on the surface of the concrete before application of the proposed method. In both tests, the result obtained from the proposed method agreed well with that obtained from the impact test by hammering. Consequently, it is verified that the proposed method can be used as an alternative to the standard impact acoustics method.

5. Conclusions

The paper describes the proposed remote laser sensing system including the detection algorithm using an impact laser to induce vibration on the surface of the concrete and a detection laser to measure the vibration on the surface of the concrete. The following conclusions can be drawn and a proposal for future investigation put forward:

1. A prototype of the remote laser sensing system to detect defects in concrete elements was developed.
2. Verification of the proposed system was conducted using field tests.
3. It is possible to measure the performance of concrete by the proposed method.
4. To make the proposed method suitable for practical use, it will be necessary to develop a vibration canceling system on the maintenance vehicle and to increase the intensity of the detection and impact lasers.

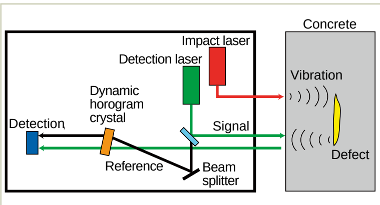


Fig. 1 Principle of the remote laser sensing system

Photo 1 Prototype of the remote laser sensing system

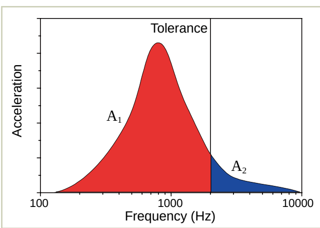


Fig. 2 Representative Fourier spectrum measured from the concrete specimen without defects

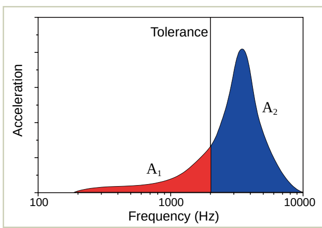


Fig. 3 Representative Fourier spectrum measured from the concrete specimen with defects

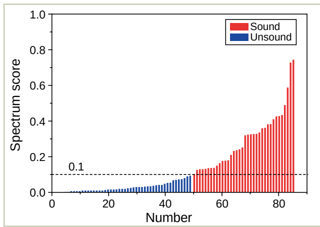


Fig. 4 Inspection result by spectrum score

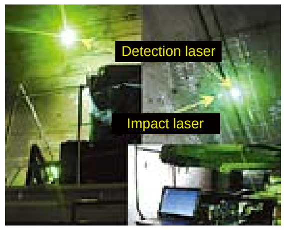
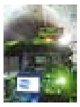
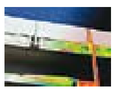
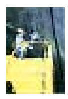


Photo 2 Field test of a tunnel lining

Table 1 Comparison of the proposed method with different general non-destructive inspection test methods for concrete elements in tunnel linings

	Proposed method	General methods		
	Laser ultrasonic method	Impact acoustics method	Infrared method	Ultrasonic method
Situation				
Advantage	• Non-contact • Quick detection • High accuracy • Can be used on curved surfaces	• Many previous records • Simple to use • Unsound concrete can be removed with a hammer	• Non-contact and remote sensing • Detection of damaged area	• Small apparatus • High accuracy
Disadvantage	• Decrease of accuracy due to external disturbance • Large apparatus	• Long inspection time in total • Need for many engineers • Elevated working position	• Low accuracy • Need to heat the concrete surface	• Long inspection time in total • Cannot be used on curved surfaces • Elevated working position

Mitigating the Low Frequency Magnetic Field Generated by Substations on Electric Railways

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Among many environmental issues, electric and magnetic fields (EMF) generated by power facilities have attracted some concern in society. The World Health Organization (WHO) has carried out an assessment of the effects on a human body of exposure to EMF, and in response to this, the ICNIRP (International Commission on Non-Ionizing Radiation Protection) and the IEEE have established international EMF exposure guidelines/standards. We are carrying out four operations (Simulation, Measurement, Mitigation measures, and Participation in the development of international standards) related to low frequency EMF generated by railway substations, as illustrated in Fig. 1. In the low frequency area, investigation of a magnetic field is particularly important, and our specific research work will be introduced in the following part of this article.

We have examined the characteristics of the magnetic field generated by the substation based on theoretical analysis and measurement/investigation in actual substations, and this enabled us to clarify that a cable through which a large current flows is a main source of magnetic field. As part of this process, we have developed software to simulate the magnetic field generated by a substation, something which was considered to be difficult, and we have confirmed the validity of the calculation method based on comparison/verification with measurements in actual substations. Thanks to simulation, it is possible to investigate the amount of magnetic fields generated at the design phase of the substation. Figure 2 shows an example (the strength of the magnetic field is illustrated with colours in the figure) of the result of a simulation of an AC magnetic field emitted from a DC electrified railway substation.

As well as conducting the simulations, we have carried out many measurements of EMF in actual substations. The objectives are to verify the result of the simulation, to continue environmental research related to power facilities, and to assess compliance with the above-mentioned guidelines, etc. The magnetic field generated by a railway substation includes, in addition to a commercial frequency component, particular frequency components such as a DC component, and the level of the field also changes significantly over time according to variations in the load. Therefore, while using a suitable measurement instrument in accordance with a target frequency domain, we also measure currents of power circuits related to the magnetic field together with measurement of the actual magnetic field. Figure 3 shows a picture of the magnetic field measurement in the vicinity of a rectifier in a DC electrified railway substation. With regard to procedures for measuring magnetic fields in a railway environment, while the European Standard EN 50500 has been issued and development of an IEC standard based on this is now underway, this matter is also important for Japanese railways. For this reason, we are playing a positive role in the development work.

It is possible to mitigate the emissions from a magnetic field by optimizing the arrangement of the power cabling, including overhead lines, bus bars etc., in the substation. Using different examples, we have computed the optimal cabling applicable to the power cables of a railway substation, and proposed examples of a design for a substation which includes measures to mitigate the magnetic field. By combining this with the above-mentioned simulation technology, it is possible to carry out verification with respect to measures and effects in the design phase. Figure 4 shows an example of the mitigation measure in DC bus lines of a DC electrified railway substation, and by changing the normal cabling (left-hand side) to an optimum cabling (right-hand side) in which the return cables are sandwiched between two positive cables, it is possible to reduce considerably the amount of EMF generated (illustrated with colours in the figure). Optimising the arrangement of the cables is particularly effective as it has a low cost and is simple to implement. We have already started to introduce this arrangement in several new substations.

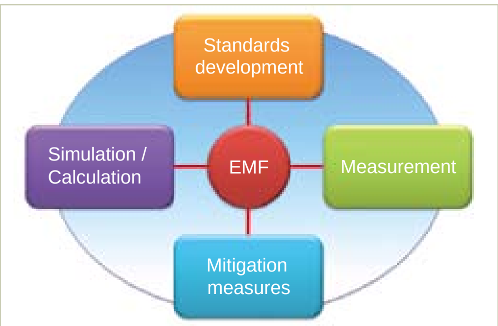

Fig. 1 Areas for investigation at the power supply systems laboratory concerning the problems of EMF generated by railway substations

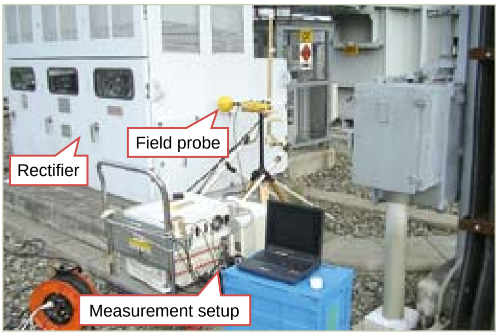

Fig. 3 A picture of magnetic field measurement in progress at an operational substation

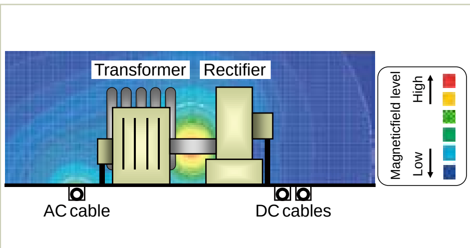

Fig. 2 The result of a simulation of an AC magnetic field emitted from a DC electrified railway substation

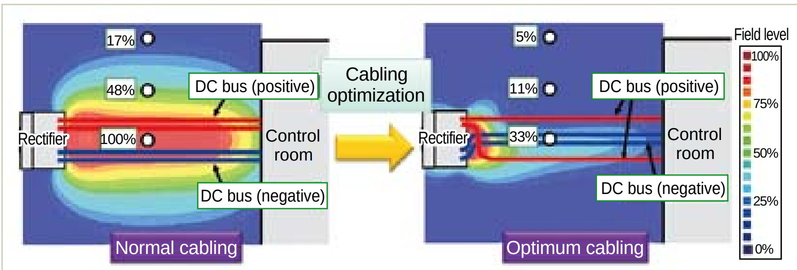

Fig. 4 A magnetic field mitigation measure using cabling optimization for a DC bus