Newsletter on the Latest Technologies Developed by RTRI

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Special Issue: WCRR2011 in Lille

RTRI's International Activities

Masao UCHIDA
Vice President

RTRI's international activities are steadily developing. This can be seen in the positive presentation of research results at a number of international conferences, in the promotion of joint studies and exchanges of researchers with overseas railway research organizations, in the implementation of technological support and co-operation with foreign countries, in the dissemination of information through the Internet and publication of periodicals and in the enforcement of international standardization by the Railway International Standard Center as outlined below.

RTRI is now promoting joint research with organizations and universities in foreign countries such as French National Railways (SNCF), China Academy of Railway Sciences (CARS), Korea Railroad Research Institute (KRRI), Railway Safety and Standards Board (RSSB) in the UK and the University of Cambridge to utilize the excellent abilities of RTRI's counterparts to carry out research and development. In this way, RTRI is aiming at attaining new research achievements and disseminating and collecting information through staff exchanges, while simultaneously expecting these activities to give RTRI a greater presence in the field of railway technologies.

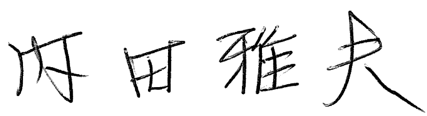
To disseminate the outcome from its research and development programmes to foreign countries, RTRI encourages its staff to positively contribute and present their theses at international conferences and to foreign academic societies. Promotion of international conferences also provides RTRI with valuable chances to make its presence widely known among railway engineers and operators across the world. To celebrate the 5th anniversary of its inauguration, RTRI held an international forum on railway research and development in 1992. The World Congress on Railway Research (WCRR), which originated from this forum, has now taken root as a full-fledged international congress. In 1999, RTRI hosted the 4th WCRR at the Kunitachi Head Office Laboratory as the main venue. The 10th International Workshop on Railway Noise (IWRN 10) was also held in Japan.

International action is being taken in unison by the public and private sectors to disseminate the highly-advanced technologies cultivated by Japan for many years in the field of high-speed railways and of urban transit systems through a number of projects in developed and developing countries. RTRI plays a major role in this work by documenting the bases for the standards of railway technologies in Japan and evaluating railway systems through tests and analyses.

While it contributes/presents theses to international conferences and foreign academic societies, RTRI periodically issues a Quarterly Report (QR), a publication of theses in English, News Letters to promptly release the topics and research results and an Annual Report summarizing its activities every year. The contents of these documents are also made available through the Internet.

To ensure its continued development in the future, it is essential for the matured railway industry in Japan to advance into overseas markets. To respond to the requirement of the railway industry as a whole, therefore, RTRI incorporated the Railway International Standard Center into its organization in 2010. This move represented a concerted effort in strategic terms to attain success in the international standardization programme for the whole railway industry. It is thought that participation in individual standardization activities contributes significantly to the enhancement of the research ability of researchers and simultaneously advances the performance of RTRI.

RTRI's international activities hitherto have effectively confirmed the significance of its presence throughout the world. As its activities now also encompass an international standardization programme, it has become an urgent requirement for RTRI to increase its human resources to cover this additional activity. However, this cannot be achieved overnight. RTRI will therefore address this problem systematically and strategically. To attain its due reputation in international circles, RTRI is now required to concentrate its corporate efforts on this demanding mission.



WCRR 2011: World Congress on Railway Research 2011 Successfully Completed

Koichi GOTO
Director, International Affairs Division

WCRR 2011 was successfully held from May 22 to 26 in Lille, France, attracting more than 800 participants from 35 countries (Fig. 1). About 300 papers were presented in oral or poster sessions, including 32 papers by RTRI's researchers. The congress also featured a technical exhibition, in which 32 railway-related organizations took part (Fig. 2). This is the 9th of the WCRR congresses, which were first started in Paris in 1994 and hosted by French National Railways. This year, the event returned to France. RTRI is very proud to have been a member of the WCRR Organizing Committee from the beginning of this significant event. In 1992, RTRI held an international seminar on railway research, commemorating the 5th anniversary of RTRI's inauguration. This seminar was considered to be one of the important activities which led to the launch of WCRR.

The main theme of WCRR 2011 was "Meeting the challenges for future mobility." In addition, eight challenges to be targeted for the improvement and development of future railways were set to promote discussions: Challenge A: A more and more energy efficient railway, B: An environmentally friendly railway, C: Increasing freight capacity and services, D: A world of services for passengers, E: Bringing the territories closer together at higher speeds, F: Even more trains even more on time, G: An even more competitive and cost efficient railway and H: For an even safer and more secure railway. For each challenge, one best paper was selected and Dr. Chen from RTRI was given the best paper award for Challenge E (Fig. 3).

Apart from the paper presentation sessions, three Plenary Sessions (1: More services, more trains, 2: Economics and environments, 3: Meeting the challenges for future transport needs) were organized, to which notable railway experts from around the world were invited. From RTRI, Vice President Uchida made a presentation at Plenary Session 2 as a member of the Organizing Committee to solicit discussions of panelists, and President Tarumi joined Plenary Session 3 as one of the panelists (Fig. 4).

The next WCRR will be held in Sydney from 25th to 27th November 2013. RTRI would like to provide full support for organizing the congress. Please visit the homepage of WCRR 2013 (http://www.wcrr2013.org/).

Fig. 1 Opening Session

Fig. 2 RTRI's booth

Fig. 3 Dr. Chen (center)

Fig. 4 President Tarumi in Plenary Session 3

Measurement of Velocity and Pressure Fluctuations around High-speed Trains Running in Tunnel

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The flow-induced vibration of high-speed trains travelling in tunnel has been studied in Japan for more than 20 years as this is one of the issues affecting ride quality. It is known that flow-induced vibrations of cars featuring a cross-sectional variation such as tail-end cars or cars equipped with large pantograph shields are caused by separation of the air flows arising from the difference in cross-section. In addition, flow-induced vibrations of intermediate cars have been observed even when they do not feature a variation in cross-section. Some work has shown that the aerodynamic forces acting on the intermediate cars of the trains stem from large-scale coherent structures existing in the flow along the sides of the trains.

In this study, air velocity and pressure fluctuations around a high-speed train running in a tunnel were measured simultaneously to investigate the details of the large-scale coherent structures as well as their distribution around the circumference of the cross-section of the train (Fig. 1). In particular, a two-component hot-film probe was placed on the right and left bodysides of the 3rd car from the head end of the 16-car outbound train, i.e., the 14th car of the inbound train, to measure two velocity components in the directions parallel to the rail and perpendicular to the bodysides. Twenty pressure gauges were attached to the right and left sides of the car and additionally to the roof and the underside of the car. It was shown that the large-scale coherent structures spread along the train not only on the left-hand side of the train but also on the roof and on the underside of the cars (Fig. 2). In addition, even on the right-hand side of the train, the large-scale coherent structures could be observed, although these were in antiphase with those on the left-hand side of the train. Correlations between velocity and pressure fluctuations demonstrate that the large-scale coherent structures are composed of rotating air flows. Finally, new car-body designs are being introduced to reduce the effects of the large-scale coherent structures and thus improve ride comfort.

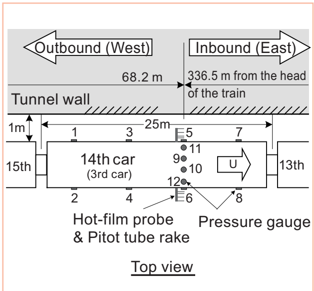

Fig. 1 Layout of equipment on the train travelling through a double-track tunnel

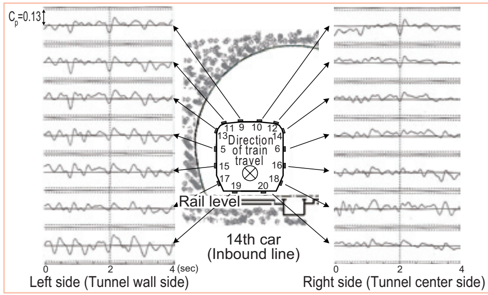

Fig. 2 Time histories of dimensionless pressure fluctuations around the cross-section of the 14th car from the head end of the train

Development of a Mobile Broadband Telecommunications System for Railways Using Laser Technology

Shingo NAKAGAWA
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Having an eye to the laser communications technology that is already proven in the field of fixed section-to-section communications, we have carried out research and development work for a high capacity optical communication system offering practical application of this technology as a means of ground-to-train communication.

The system we have developed, as shown in Fig.1, utilizes a laser beam tracking method. Both the on-train communication device (mobile station) and its ground counterparts (base stations) emit infrared beacon lights as their identifying signals and transmit data between them by sending out a laser beam to each other with their beacon signals as the targets. Even in a situation where the relative positions of the ground and the on-train communication units are changing rapidly, they can keep track of each other through adjustment of their internal movable mirrors. Also, the system contains a handover function to switch rapidly and dynamically from one base station to another in response to the running speed of the train, which enables continuous communication.

As a result of the performance test using a commercial train on a conventional line (Fig. 2), we were able to obtain a transmission rate ranging from approximately 500 to 700 Mbps at a train speed of approximately 130 km/h. The handover took approximately 0.4 seconds due to vibrations of the train. In a bidirectional transmission test with high-definition video, however, little disturbance was observed in the pictures, and by using some protocol, we could see the video without observing any effect caused by the handover. In similar communication tests conducted on a Shinkansen line, the two devices were able to track each other for a maximum of approximately 0.7 seconds at train speeds up to 270 km/h.

By conducting these tests, we were able to verify the applicability of the system we had developed to railway environments. At the same time, problems that will need to be solved in the future were identified, such as the handover time and the influence of glass in train windows. We intend to continue our efforts to bring the system to perfection in pursuit of its practical application.

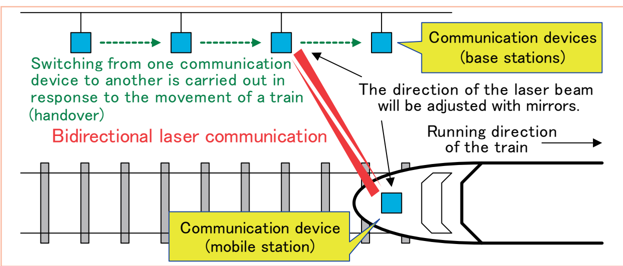


Fig. 1 The concept of the laser beam tracking communication system on a railway line

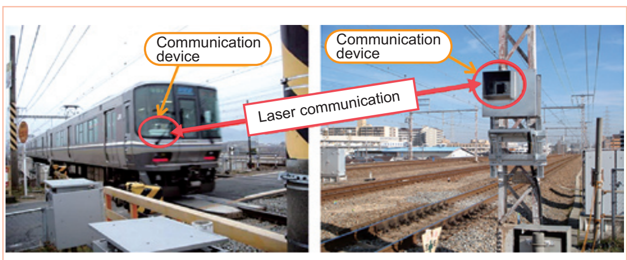
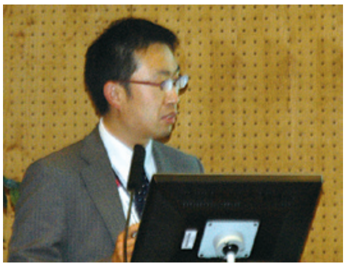


Fig. 2 View of the field test on a conventional line

Prediction of Contact Wire Wear on High-speed Railways

Takayuki USUDA
Senior Researcher, Current Collection, Railway Dynamics Division



Although wear of contact wire is one of the most important problems in maintaining the catenary system, there are many unsolved questions. This is due to the mechanism of the wear progress of contact wire being very complicated. So far, various studies in this field have been carried out using a test bench. However, there has been no study to develop a prediction model of contact wire wear, because of the difficulty of using test equipment to simulate wear phenomena in the field, which includes the effect of oxidation of the contact wire surface, etc.
The authors have started to research the quantitative effects on contact wire wear caused by the contact force of the pantograph and arcing due to contact loss in order to clarify the mechanism, by which contact wire wear progresses. For this purpose, the contact force of pantographs, the arc due to contact loss and the collected current of all the trains, which pass through two measurement sections on a commercial Shinkansen line, must be measured, because several types of pantographs are involved, and trains run at different speeds. The authors have developed a contact force measurement method by equipping a catenary with sensors as well as arc measurement equipment which detects the UV ray emitted from an arc at the wayside. The contact force of pantographs, the arc due to contact loss and the collected current of all the trains which pass through the two measurement sections of the commercial Shinkansen line have been measured regularly. The wear of contact wire on these sections has also been measured regularly. We have compared this data in order to build a wear prediction model for the contact wire.
In the measurement section where high current is drawn, the progression of wear of the contact wire is greatly affected by the arcing, which has a high probability of occurring. On the other hand, in the measurement section where low current is drawn, the progression of wear of the contact wire is greatly affected by the high contact force. One set of results is shown in Fig. 1.
From these measurement results, we have developed a prediction model for contact wire wear. An example of the wear prediction result is shown in Fig. 2. Finally, we have reported the results of the case study on evaluation indexes of current collection performance.

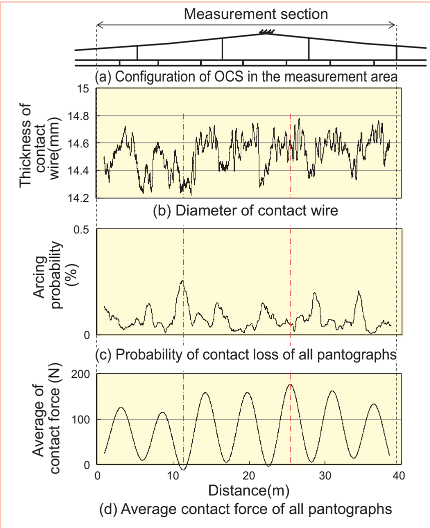


Fig. 1 Measurement results

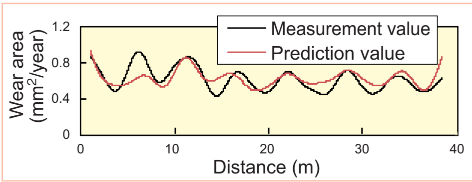
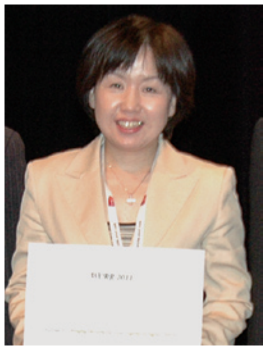


Fig. 2 Prediction results of the area of contact wire wear

Influential Factors on Adhesion between Wheel and Rail under Wet Conditions

Hua CHEN
Senior Researcher, Track Dynamics, Railway Dynamics Division



It is empirically common knowledge that the adhesion coefficient between wheel and rail is low under wet conditions due to rain or snow-fall, compared with the dry conditions experienced during sunny weather. With a low adhesion coefficient, it is not only hard to achieve a desired higher running speed, but also to minimize the distance for bringing a train to a halt. Moreover, some damage on the top surface of rails and on wheel treads is likely to occur due to wheels slipping during acceleration and/or sliding during deceleration. This damage will cause noise and vibration of the vehicle and hence a deterioration in ride quality.
This paper describes a study of the adhesion coefficient between wheel and rail under wet conditions using both theoretical and experimental approaches. The purpose of the study was to achieve a good understanding of the mechanism of a low adhesion coefficient when a film of water exists on the rail surface. Theoretical analysis was based on a numerical model (Fig. 1) applying a Mixed Lubrication theory. A laboratory experiment was conducted with a twin-disc rolling contact machine and a water spray system (Fig. 2). In order to clarify how the adhesion coefficient was affected by the contact parameter, the author focused on several factors such as running speed, slip ratio, axle load, water temperature and the surface roughness of wheel and rail, as they play important roles in the lubrication behaviour of the water film. The analysis results and the experimental results indicated approximately the same tendencies showing that, among the factors mentioned above, rolling speed, water temperature and surface roughness have significant effects on the adhesion coefficient. Therefore, the author presented a proposal to improve the adhesion coefficient between wheel and rail under wet conditions by raising the water temperature or by increasing the surface roughness.

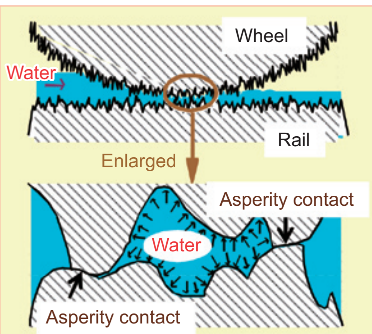


Fig. 1 Numerical model of wheel/rail contact under wet condition

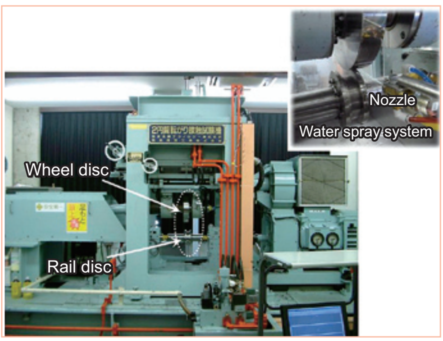


Fig. 2 Twin-disc rolling contact machine with a water spray system

Indoor Air Quality at Stations: Development of a Methodology for Quantifying Railway Customers' Perception of Odor at Stations

Tamami KAWASAKI
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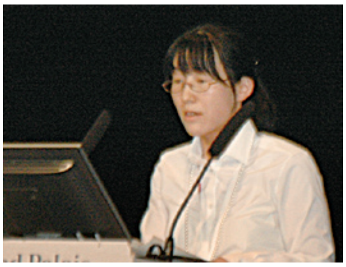


From the customer's point of view, providing a more comfortable station environment is important. From the railway's point of view, it is also essential for retaining railway customers. As a result of surveys addressing the comfort and cleanliness of railway stations and airports, approximately 90% of customers answered that airports are more comfortable and cleaner than railway stations. Customers have also shown a keen interest in the indoor air quality and odor in stations. Therefore, the authors began to carry out surveys to evaluate the indoor air quality of railway stations by trying to relate customers' views to investigations of airborne microorganisms.

Airborne microorganisms in 200 L of air were collected on to agar plates using an air sampling device. After cultivation of the plates, the number of microorganism colonies on each agar plate was counted. To study customers' views with respect to the indoor air quality of stations, surveys of 278 customers were also conducted at the same stations where the surveys of microorganisms had been carried out.

The number of airborne fungi in underground areas was greater than that in locations on the surface. There was a strong correlation (r = 0.72) between the degree of unpleasant odor judged by the customers and the number of airborne fungi (Fig. 1), and a weak correlation (r = 0.29) between the degree of unpleasant odor judged by the customers and the number of airborne bacteria. This result suggests that airborne fungi are an effective index in the evaluation of station air quality. Approximately 10% of the customers experienced strong sensations of odor in the station where the amount of airborne fungi was 500 cfu/m^3 (colony-forming units per cubic meter). We can predict how customers would sense and evaluate the odor in stations by measuring the amount of airborne fungi, using the results shown in Fig. 1.

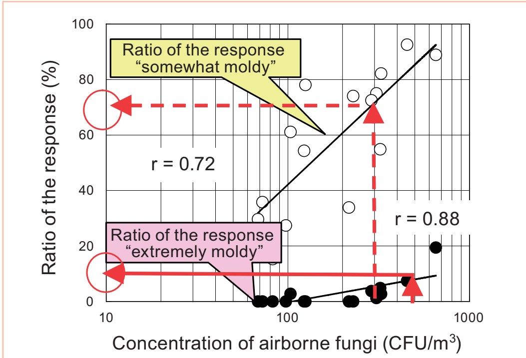
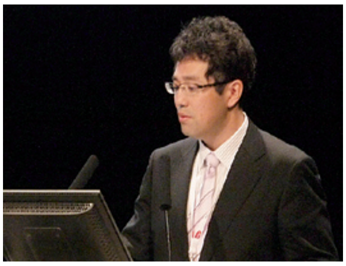


Fig. 1 Correlation between the ratio of the response "moldiness noticed" and the concentration of airborne fungi in stations

Improving the Running Safety of Railway Vehicles against an Earthquake

Kohei IIDA
Assistant Senior Researcher, Vehicle Mechanics, Railway Dynamics Division



In October 2004, a Shinkansen train was derailed in Japan as a result of the Mid Niigata Prefecture Earthquake. This was the first ever earthquake-related derailment of a Shinkansen train running at high speed. Following the accident, there were calls for safety measures to counter the problem of earthquakes. To respond to these needs, we calculated how the safe running performance can be improved by modifying the parameters of the bogie, and we determined that running safety against earthquakes could be effectively improved by increasing the damping force of lateral dampers.

In this paper, we describe how we developed a lateral damper to improve the running safety of railway vehicles against an earthquake (Fig. 1). The damper we developed has the same damping force characteristics as those of a conventional lateral damper in the usual piston speed region to avoid deterioration of either ride quality or running stability under normal conditions. However, it has larger damping force characteristics than those of a conventional damper when the piston operates at unusually high speed.

We experimentally tested the damper using a full-scale vehicle model consisting of one bogie and a half carbody on our own large shaking test facilities. The damper we developed increases the oscillation amplitude as the wheel load becomes zero by approximately 8%. We also numerically verified the safety performance of the damper against an earthquake. Figure 2 shows the results calculated for the increased running safety limit in comparison with a conventional damper; the result is shown as a ratio between the two types. From Fig. 2, it can be said that the running safety limit with the damper we developed is higher than or equal to that of a conventional damper in all frequency regions from 0.3 Hz to 3.0 Hz. In particular, the increasing ratio in the frequency region from 1.2 Hz to 2.2 Hz is so large that the developed lateral damper can suppress the upper center rolling vibration of a vehicle more effectively. Finally, we carried out on-track running tests and confirmed that the lateral damper that we developed behaved like a conventional damper when running under normal conditions.

We collaborated with East Japan Railway Company in carrying out this research.

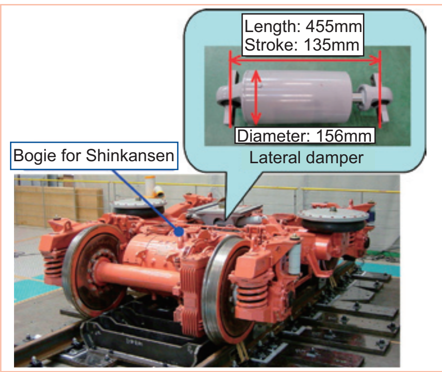


Fig. 1 Lateral damper developed to improve running safety during an earthquake

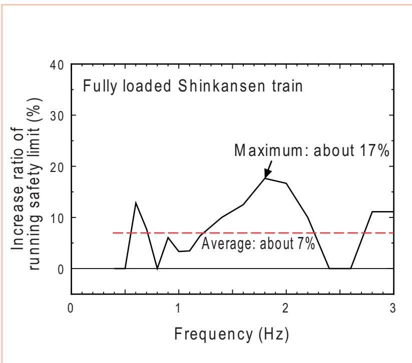


Fig. 2 Increase ratio of running safety limit of Shinkansen obtained by simulations

Practical Use of the Earthquake Early Warning (EEW) System for the Shinkansen

Shinji SATO
Senior Researcher, Earthquake Disaster Prevention, Disaster Prevention Technology Division

RTRI has carried out various research and development work to ensure the safety of train operations when earthquakes occur. Our EEW system, which stops trains as rapidly as possible by analyzing the P-wave forming the initial phase of seismic motion, is our major achievement in this field, and UrEDAS was developed as the first practical EEW system in the world. Our EEW system has the following two characteristics:

(1) Trains are stopped when a single seismograph detects an earthquake

Substations provided with seismographs exclusively for railways have been installed along the track at intervals of approximately 20 km. In order to stop trains immediately even when electric power and communication lines are cut during an earthquake, the decision to stop trains is based on data observed at a single seismograph.

(2) Coastline seismograph for earthquake detection in subduction zones

Seismographs also have been set up along the coast at intervals of approximately 100 km to detect in advance any earthquakes occurring in a subduction zones. This is termed a coastline seismograph, whereas the device described in (1), is called a railway-track seismograph. During the "2011 Earthquake off the Pacific Coast of Tohoku (Mw 9.0)" that occurred on 11th March, 2011, one of the coastline seismographs detected seismic waves and sent warning information that safely brought Shinkansen services to a halt.

Since 2000, we have developed a new algorithm for the EEW system in co-operation with the Japan Meteorological Agency with the aim of improving the system reliability. Based on the above achievements, we completed an update of the system for the entire Shinkansen network in 2007. The following three points describe the improvements made to the new EEW system for the Shinkansen.

(1) New earthquake detection algorithm

The significant point of the new EEW system for the Shinkansen is new algorithm to detect earthquakes. As a result, the accuracy of estimating the location of the hypocenter within a few seconds by detecting the P-wave improves by approximately 20%. A flow chart depicting the process is shown in Fig. 1.

(2) Standard communication telegram format

The communication telegram format that is used for communication between seismographs was standardized by RTRI. By using this standardized format, it became feasible to construct a large-scale EEW system with different seismographs produced by different manufacturers.

(3) Complete two-way communication between seismographs

Two-way communication of warning information about the P-wave and S-wave was added following the experience of the Mid-Niigata Prefecture Earthquake in 2004, which had less lead time. We assume that this function will be very effective because the warning information that will stop the trains is transmitted to the region not yet reached by the P-wave and S-wave (see Fig. 2).

Simulation of operation of the new EEW system has been carried out based on the data recorded during the Mid-Niigata Prefecture Earthquake (2004) and the lead-time after the warning has been examined. As the result, it is found that the lead-time is estimated to be almost three seconds in the vicinity of the epicenter. It is obvious that the benefit of the lead-time is limited for the trains running in the vicinity of the epicenter because Shinkansen trains need a few minutes to be stopped completely. However, it is considered that the benefit of the lead-time is higher for the trains that are approaching the epicentral area.

With the increasing speed of trains, it is imperative to improve the reliability of the EEW system by updating algorithms as well as by evaluating the performance of the system.

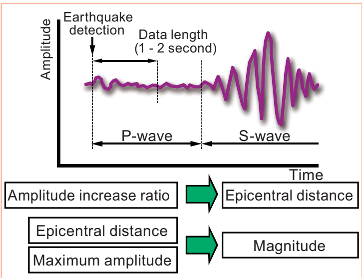


Fig. 1 Flow chart showing the process after detection of the P-wave

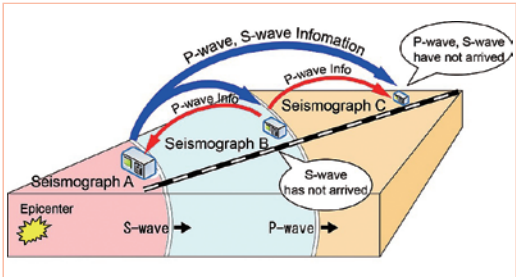


Fig. 2 Seismograph two-way communication

Identification of Thermal Cracking Criteria on Wheel Treads for Optimized Brake System Design

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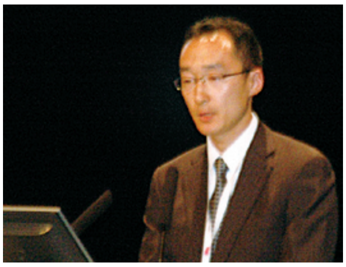

Thermal cracking of wheel treads is one of serious problems affecting wheel maintenance. However, systematic measures to deal with the problem have not been established because the mechanism of wheel cracking and the conditions, in which it occurs, are unclear. The authors reported successful reproduction of cracks by use of a full-scale apparatus at the previous WCRR (2007), which enabled a systematic approach to this phenomenon. The present study has been concentrated on the verification of a hypothesis about the crack-generating mechanism. This was formed on the basis of estimating the temperature/stress fields from the residual stress measured, on the microstructure observed by a high-resolution scanning electron microscope and on elastic-plastic FE-analysis. The predominant factor in the thermal cracking is considered to be the wheel/rail tangential force applied under a circumferential tensile residual stress field. The practical factors influencing this phenomenon are the maximum wheel temperature, the axle load and the acceleration/deceleration of the vehicle. Since these factors depend on the vehicle specification, applying the findings of the present study as guidelines for vehicle design will enable the total optimization of the brake system design including life-cycle manufacturing/maintenance costs, as well as safer operation of rolling stock.

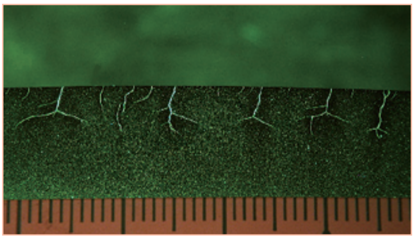

Fig. 1 Longitudinal cross section of thermal cracks in the wheel tread

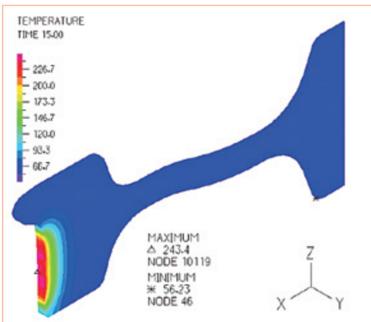

Fig. 2 Wheel temperature distribution during tread braking estimated by FEM analysis