Newsletter on the Latest Technologies Developed by RTRI

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Tokyo 185-8540, JAPAN
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GENERAL INFOMATION

■ Preface
Toshiyuki AOKI 197
■ IWRN10 (The 10th International Workshop on Railway Noise)
Tatsuo MAEDA 198
■ Co-operative Study with RSSB
Koichi GOTO 199
■ Activities of RTRI at UIC HIGHSPEED 2010
Koichi GOTO 200

ARTICLES

■ A Noise Reduction System Using Piezoelectric Materials
Katsuya YAMAMOTO 201
■ Development of a Train Simulator for Diesel-hybrid Railway Vehicles
Hideo NAKAMURA 202
■ Determining Priorities for Seismic Countermeasures on the Basis of Costs and Benefits *Kimitoshi SAKAI* 203
■ Simple Catenary Equipment Offering High Speed Operation and Maintainability *Satoshi HARADA* 204

Preface

Toshiyuki AOKI
Director, Information Management Division

On March 12, 2011, operations were launched on a new 130-km Shinkansen line on Kyushu Island, the southernmost of the four major islands that form the Japanese Archipelago. In December 2010, an 82-km extension of the existing Shinkansen line linking the capital of Japan, Tokyo, to the Tohoku region was put into service. Further construction work on this extension will take the line further north to Hokkaido Island, the northernmost of the four major islands of Japan, through an undersea tunnel which has been used by local trains for 20 years. Furthermore, extension work on another Shinkansen line is progressing satisfactorily on Honshu Island, Japan's largest island, so that it will run right across Honshu, northwestward from Tokyo. With work in progress on all these lines, in four or five years time Japan's Shinkansen network will have a total length of about 3,000 km (Figure).

The total length of railway in Japan amounts to 27,500 km, including all the conventional lines and Shinkansen lines. Together, they have a total traffic volume of 1,100 million passenger-kilometers and a total freight volume of 60 million tonne-kilometers.

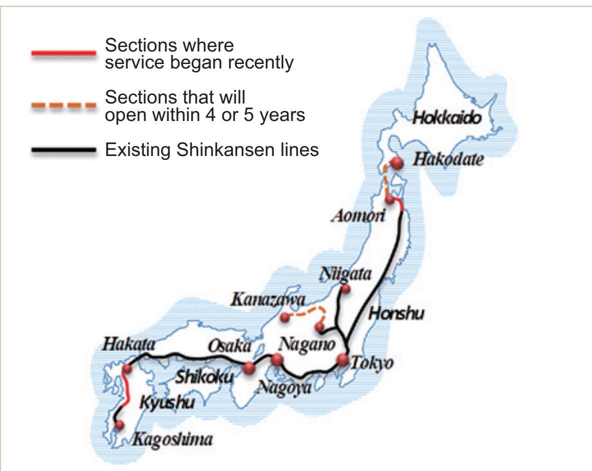

Figure The Shinkansen network in Japan

As indicated by these figures, Japan is one of the countries in the world where railways are very heavily used. And, it is research and development carried out by the Railway Technical Research Institute (RTRI) that supports Japan's railway sector in terms of safety, environmental performance, cost reduction, and user-friendliness. RTRI's mission includes the presentation to the world through various information channels of the results achieved by its R&D work. We issue Newsletters, the Quarterly Report of RTRI, and the Annual Report.

For the convenience of those who have yet to obtain our publications and periodicals, we have published these documents on our web site, http://www.rtri.or.jp/, where anybody can easily access and download the full texts of these documents in pdf format. Our home page also offers to the public a variety of content, such as the major results of research and development work.

On this home page, we are planning to upload and present more content which would be useful and interesting to all visitors. We welcome your access to our Web site.

青木 俊幸

IWRN10 (The 10th International Workshop on Railway Noise)

Tatsuo MAEDA
Principal Researcher, Research & Development Promotion Division

IWRN10 (The 10th International Workshop on Railway Noise) was held on October18 to 22, 2010 in Japan. This was the first time that the event had been staged in Asia. The workshop was organized by RTRI (Railway Technical Research Institute) and supported by the Ministry of Land, Infrastructure, Transport and Tourism and the Ministry of the Environment.

In total, there were 147 participants from 15 countries across the world: 73 from Japan, 11 from the UK, 11 from China, 11 from Sweden, 7 from Australia, 6 from France, 5 from the USA, 5 from Korea, 3 from Belgium, 2 from Denmark, 1 from Austria, 1 from Singapore and 1 from Spain.

IWRN10 covered not only railway noise but also other environmental problems that affect railways. Sessions were classified into 7 categories: 1. Prospects, legal regulation and perception, 2. Wheel and rail noise, 3. Structure-borne noise and squeal noise, 4. Ground-borne vibration, 5. High speed trains (aerodynamic noise and micro-pressure waves from tunnel portals), 6. Interior noise and sound barriers and 7. Prediction, measurements and monitoring. As many as 50 papers were presented in oral sessions and 20 papers were given in poster sessions. Table 1 shows the number of papers and their main themes classified by category.

Papers submitted to IWRN10 from many countries showed that the understanding of environmental phenomena and their countermeasures are essential if railway networks are to prosper and high speed railways are to be developed around the world. The selected papers will be published in a special dedicated issue of "Notes of Numerical Fluid Mechanics and Multidisciplinary Design" from Springer Japan.

Figure 1 shows the participants at IWRN10.

During IWRN10, a technical tour to RTRI's Wind Tunnel Technical Center was arranged for the afternoon of October 22. Nearly 100 people joined the technical tour and inspected the large scale and low noise wind tunnel. The low aerodynamic noise from an improved pantograph and the low background noise of the wind tunnel were demonstrated. A technical exhibition was also held at IWRN10. 12 companies including RTRI and Japan Rail group took part in the exhibition.

The next IWRN11 is scheduled to be held in Europe in 2013.

Table 1 Categories, papers and main themes in IWRN10

Category		Number of papers and main themes	
1	Prospects, legal regulation and perception	5	Noise and vibration abatement, Annoyance caused by transportation noise, cognitive performance and sleep disturbance, Human response to ground-borne vibration in buildings
2	Wheel and rail noise	16	Wheel-rail contact forces, Simulation and abatement of wheel and rail noise
3	Structure-borne noise and squeal noise	9	Field measurements and numerical simulation of structure-borne vibration and noise, Model for wheel and rail interaction contributing to squeal noise
4	Ground-borne vibration	14	Field measurements and numerical simulation of ground-borne vibration
5	High speed trains (Aerodynamic noise and micro-pressure waves from tunnel portals	10	Numerical simulation and abatement of aerodynamic noise, Numerical simulation and model experiments of micro-pressure waves from tunnel portals
6	Interior noise and sound barriers	5	Estimation method and abatement of interior noise, Effect of noise barriers
7	Prediction, measurements and monitoring	11	Monitoring methods for railway noise, Measurements of rail roughness and irregularity

Fig.1 Participants at the closing ceremony of IWRN10 on October 22

Co-operative Study with RSSB

Koichi GOTO
Director, International Affairs Division

In October 2008, RTRI initiated a co-operative research agreement with RSSB (Rail Safety & Standards Board), a British organization actively engaged in advanced research and development concerning the performance, cost and safety of the railway system. In December 2008, studies on the themes shown in Table 1 were launched. On 12 November 2010, a meeting to confirm co-operative research results was held at RSSB in London.

RTRI sent to this meeting Mr. Takai, Director of the Research & Development Promotion Division, Mr. Shigemori, Senior Researcher in the Human Science Division and Dr. Goto, Director of the International Affairs Division. On the RSSB side, Dr. Ann Mills and Mr. Huw Gibson, in charge of the theme related to human factors, participated in the meeting, together with Mr. Anson Jack, Director of Policy, Research and Risk, Mr. Guy Woodroffe, Head of Research and Development, Mr. Michael Woods, Head of Operations and Management Research and Dr. Tanya McCallum, Senior Research Strategy Manager, in charge of research partnerships. Mr. Len Porter, Chief Executive of RSSB, was also present at the meeting.

It should be also noted that Mr. Woods visited Tokyo in September 2010 to attend a symposium on level crossings held by the International Union of Railways (UIC). On that occasion he also visited RTRI for discussions about joint research activities and delivered a lecture on the activities of RSSB (Fig. 1). Figure 2 shows Mr. Woodroffe and Dr. McCallum with Mr. Takai and Dr. Goto in the meeting held at RSSB.

In the meeting, Dr. Mills, Principal Human Factors Specialist, made a presentation on RSSB's activities relating to human factors. During her presentation there was a lively discussion about an aptitude test for train drivers, as RTRI had also recently developed a new test method. Following Dr. Mills, Mr. Shigemori reported on the theme which was completed in September. His report was related to results from an analysis of RTRI's data where RSSB's analysis method had been applied. This was followed by discussions about how to collect data, how to classify errors and a model for human error. The participants finished the session on the theme while checking the results from their study. The researchers from both parties agreed to continue exchanging information and opinions as required.

Subsequently, the meeting proceeded to a discussion about new themes, and the participants decided to pursue the two themes shown in Table 2 during the term between April 2011 and March 2014. Researchers in charge will start discussions about these themes, exchanging their knowledge, experience and information on technical matters and opinions about the direction in which to move. In this scheme, we expect that researchers will further promote their activities so as to yield fruitful results through their collaboration.

Finally, Mr. Takai and Mr. Woodroffe signed a memorandum on the information exchange between the two organizations as proposed by RSSB and agreed by RTRI (Fig. 3). We hope that RTRI and RSSB will further deepen the friendly ties and contribute to development of railways in the world by leveraging the knowledge and experience that the two organizations have developed and accumulated.

Table 1 Co-operative themes: Phase I

Theme	Period
The influence of the human factor in risk assessment and the classification method of human action	2008.12 – 2010.9
Research and survey on design, manufacturing and maintenance of axles and wheelsets	2008.12 – 2009.12

Table 2 Co-operative themes: Phase II

Theme	Period
New materials to improve railway performance	2011.4 – 2014.3
Increasing railway network capacity, focusing particularly on "nodes" or "bottlenecks" in the rail network	2011.4 – 2014.3

Fig.2 Meeting at RSSB

Fig.1 Mr. Woods at RTRI

Fig.3 Signing of memorandum

Activities of RTRI at UIC HIGHSPEED 2010

Koichi GOTO
Director, International Affairs Division

The 7th World Congress on High Speed Rail (UIC HIGHSPEED 2010) took place in Beijing from 7 to 9 December 2010. This was a big event hosted by the International Union of Railways (UIC) and co-sponsored by the Ministry of Railways of the People's Republic of China. The name of the Congress had previously been Eurailspeed, but it was changed to HIGHSPEED from the previous holding in Amsterdam. This was the first time it had been held outside Europe. From the early days of this event, RTRI has always sent speakers, mainly consisting of executives, and it has also taken part in exhibitions as a member of a Japanese group. On this occasion we will summarize the Congress and introduce the activities of RTRI. Prior to the opening of HIGHSPEED 2010, UIC held its General Assembly and Regional Assembly Asia.

The total number of participants was about 2,700, including more than 100 attendees from Japan. The Japanese participants consisted of officials from the Ministry of Land, Infrastructure, Transport and Tourism (MLITT), executives from the JR Group companies (East Japan Railway Company, Central Japan Railway Company, West Japan Railway Company and Kyushu Railway Company), manufacturers, and other related bodies. From the Chinese Government, Mr. ZHANG Dejiang, Vice-Premier of the State Council, and other senior officials attended the opening ceremony, delivering speeches on how Chinese high-speed railway systems are rapidly growing. Three days before the Congress, their CRH380A type of high-speed train had attained a speed of 486.1 km/h on a test section between Beijing and Shanghai. Mr. Yoshio Ishida, UIC chairman (vice chairman of East Japan Railway Company), and other speakers from various countries, such as Thailand, Spain, Germany and the U.S.A., described the situation in their respective countries. Mr. Akira Yonezawa, Deputy Director General for Engineering Affairs of Railway Bureau, MLITT, made a presentation on railway technology that had been developed and accumulated over many years in Japan, the first country that launched a high-speed train system.

In this Congress there were two Round Tables. In the Round Table called "High Speed Rail Towards the Future" held on 8 December, Mr. Masaki Ogata, Vice President of East Japan Railway Company, took part in a discussion on services and systems. In the Table "Innovation in High Speed Rail" held on 9 December, technological development was discussed, and Dr. Norimichi Kumagai, Executive Director of RTRI, attended the Round Table (Fig. 1), demonstrating results from our research and study on seismic counter-measures (Fig. 2), the economic effect of possible operation of the Superconducting Magnetically Levitated Vehicle (MAGLEV) between Tokyo and Osaka, etc. RTRI also contributed to the presentation of research papers with two entries: "The Study on Seismic-Isolation Railway Structures — Consideration of Running Safety during Earthquakes" presented by Chief Researcher Mr. Luo in the field of anti-seismic structures and "Modeling of CWR (Continuous Welded Rail) for Installation under Various Track and Infrastructures" by Researcher Mr. Nishinomiya who specializes in track structures.

As China hosts an event called "Modern Railways" every year, the Chinese decided to stage this exhibition in conjunction with HIGHSPEED 2010. RTRI, in cooperation with MLITT, JR Group Companies and Japanese manufactures, worked on an exhibition of research results on the Japan stand which was managed by the Japan Overseas Rolling Stock Association (Fig. 3). On the afternoon of the last day of the Congress, many participants visited Beijing South Railway Station and enjoyed a technical tour that included travelling on a super-express train running at 350 km/h between Beijing and Tianjin.

Fig.1 Dr. Kumagai at round table

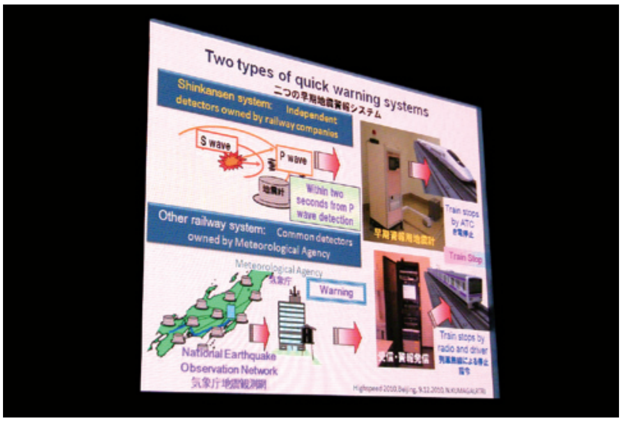

Fig.2 Research on seismic counter-measures

Fig.3 Exhibition

A Noise Reduction System Using Piezoelectric Materials

Katsuya YAMAMOTO
Senior Researcher, Vehicle Noise & Vibration, Vehicle Structure Technology Division

1. Foreword

Acoustic noise penetrating the interior of rolling stock is a critical issue that may affect passenger comfort. To date, against a "transmitted noise" that is emitted from noise sources such as bogies and car bodies and that penetrates car body structures or interior walls, "passive countermeasures" such as sound insulation material or vibration-insulators have often been adopted. In many cases, such passive countermeasures may not be sufficient to reduce the unwanted noise in the low-frequency range and, specifically, noise below 500 Hz may remain without attenuation.

The Railway Technical Research Institute has thus been developing a noise reduction system that introduces a new method using piezoelectric materials that is applicable to the low-frequency range.

2. Outline of noise reduction system of an array type noise insulation panel

Figure 1 shows a cross section of the noise reduction system attached to a target wall surface (called the "target plate"). The noise reduction system comprises: a panel (called the "noise reduction panel") on which small, flat plates (called the "noise insulation panel") to which piezoelectric material is bonded, are arranged in a planar manner; and a control circuit.

The control circuit is an analog inductance circuit using an operational amplifier. Since the piezoelectric material generally includes capacitance, it forms a resonant circuit when connected to the inductance circuit. In this state, when the noise insulation panel vibrates due to incident noise, the piezoelectric material generates a voltage. The generated voltage is amplified in the vicinity of the resonance frequency to be applied to the piezoelectric material. This further amplified voltage has a phase opposite to that of the voltage generated by the incident noise, and consequently an antiphase force can be applied to the noise insulation panel, resulting in the effect of reducing the vibration of the plate. The target frequency can be set in a low-band range of several hundred Hz or below, and thus it is possible to freely adjust the inductance value by adjusting the resistance in the control circuit.

When the noise reduction panel is attached to the target plate, directly attaching the panel to the plate may not necessarily exhibit sufficient control of the vibration of the target plate, and hence a sealed layer of air is provided between the panel and the plate. The vibration of the noise insulation panel is restrained, and therefore the acoustic energy within the air layer also decreases. As a result, the acoustic energy incident on the target plate shrinks, thereby reducing the transmitted noise regardless of the vibration mode of the target plate. Figure 2 shows how this control mechanism works.

3. Result of noise reduction tests in railway vehicles

In a railway vehicle verification test, several noise reduction panels were applied to the ceiling of a Shinkansen vehicle. Since it had been proven beforehand that a dominant acoustic noise penetrating the ceiling exists at a frequency close to 200 Hz, prototype panels for 200 Hz, as shown in Fig. 3, were fabricated; these were installed behind the ceiling interior and tested under actual running conditions. As the result, as shown in Fig. 4, the noise in the cabin decreased by a maximum of 4 dB with its peak in the vicinity of 200 Hz with control, at a point 1,200 mm above the floor immediately below the panel.

4. Afterword

The noise reduction system using an array type noise insulation panel introduced in this paper is now being developed as a new method to combat acoustic noise. This development programme will now be applied to a variety of fields, and at the same time performance will be improved, including enhancement of the frequency range to be controlled.

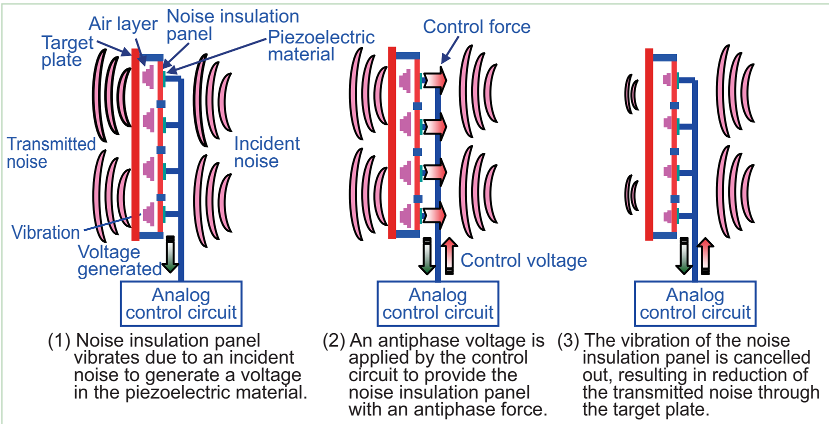

Fig. 2 Control mechanism

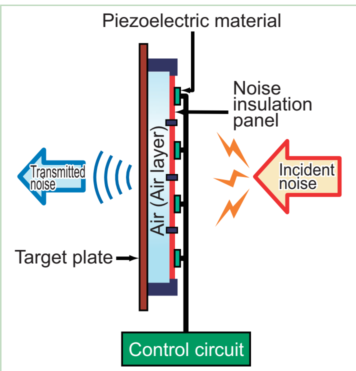

Fig. 1 Noise reduction system (a cross section)

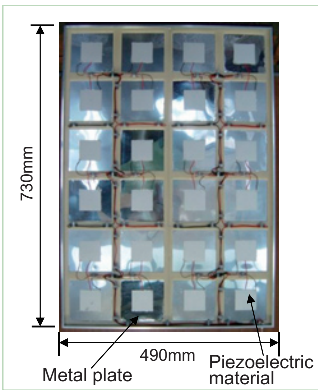

Fig. 3 Noise reduction panel

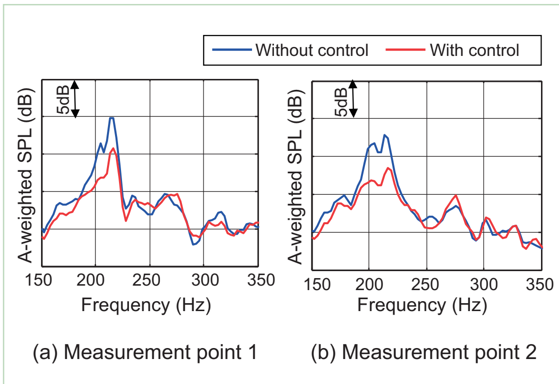

Fig. 4 Noise reduction effect in the Shinkansen vehicle

Development of a Train Simulator for Diesel-hybrid Railway Vehicles

Hideo NAKAMURA
Senior Researcher, Drive Systems, Vehicle Control Technology Division

For the purpose of energy saving, countermeasures for exhaust gas, etc. of diesel railway vehicles, development and introduction of Diesel-hybrid Railway Vehicles have been in progress. At the development of hybrid railway vehicles, it is necessary to precisely evaluate the running performance, energy-saving effect, exhaust gas reduction effect, etc. of railway vehicles for various equipment configurations and equipment specifications. As the evaluation method, RTRI developed the Train Simulator for Diesel-hybrid Railway Vehicles capable of drawing up train performance curves and calculation of energy consumption, a discharge amount of exhaust gas, etc. associated with running of hybrid railway vehicles.

The main features of the simulator are shown below.

(1) It can draw up train performance curves and calculate fuel consumption, the SOC (State of Charge), the discharge amount of exhaust gas (NOx, PM, CO, HC, and so on), etc. associated with running of railway vehicles.

(2) It has a high degree of versatility and is applicable to the equipment configuration of various hybrid railway vehicles in the series type and the parallel type.

(3) User interface functions are enhanced to enable setting of the equipment configuration and setting of the operating conditions (operating modes) of equipment which change depending on speed and the SOC.

The overall configuration of the simulator is shown in Fig. 1. The simulator includes the user interface, a calculation part for train performance curves, and a calculation part for vehicle models. The train performance curve preparation system "Speedy", which has been widely used in Japan, is adopted for the calculation part for train performance curves and the related user interface. The calculation part for vehicle models receives a notch, speed, etc. as information of the running condition from the calculation part for train performance curves, then determines operating modes of individual equipments such as an engine and motor, responding to the running condition, and returns tractive force as well as braking force after calculating them to the calculation part for train performance curves. The calculation part for train performance curves calculates the speed, notch, etc. at the next step using the tractive force and the braking force. A train performance curve is drawn up by repeating the calculation successively. At this time, the calculation part for vehicle models calculates the instantaneous fuel consumption successively, and it then calculates the total fuel consumption by integrating a summation of the instantaneous fuel consumption calculations.

When carrying out a simulation, it is necessary to input many pieces of data for setting the equipment configuration and operating modes of hybrid railway vehicles. Accordingly, user interface functions are enhanced to facilitate such works in the simulator. For example, setting of the equipment configuration can be easily performed by selecting the necessary equipment from the block diagram on the operating screen by click operation, as shown in Fig. 2.

An example of the simulation result using the simulator is shown in Fig. 3. Further, it has been already confirmed that simulation results and actual measured values on actual vehicle tests almost coincide to each other.

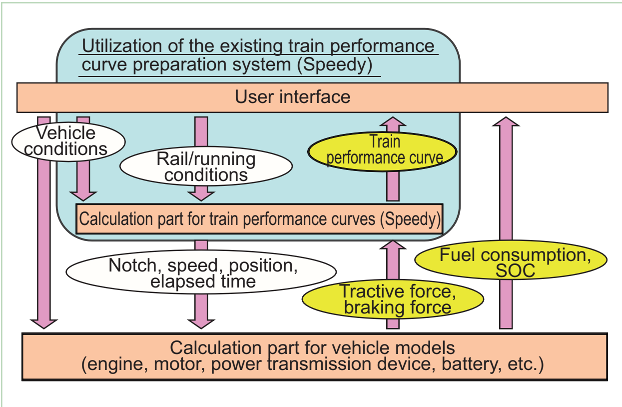

Fig. 1 Overall configuration of the simulator

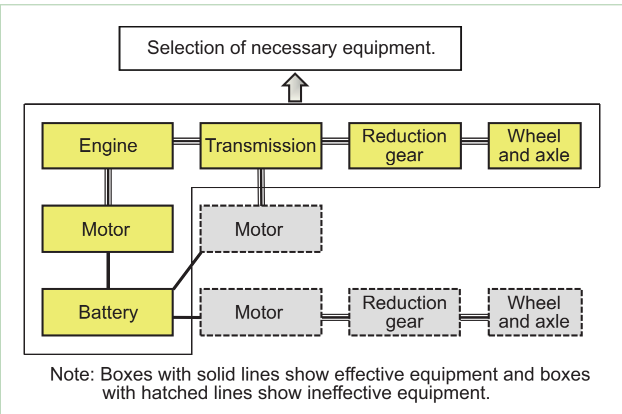

Fig. 2 Screen for setting the equipment configuration

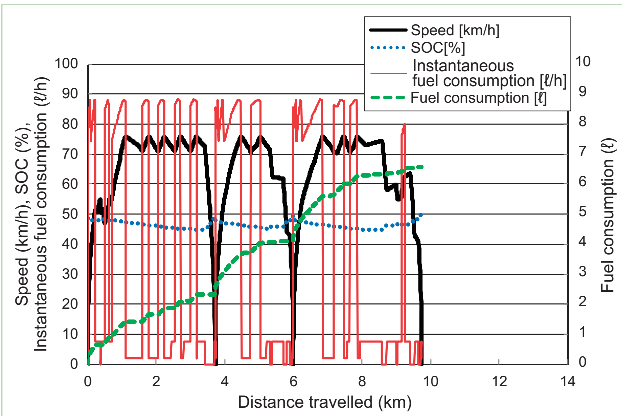

Fig. 3 Example of the results from simulation

Determining Priorities for Seismic Countermeasures on the Basis of Costs and Benefits

Kimitoshi SAKAI
Researcher, Earthquake & Stractural Engineering, Structures Technology Division

Railway systems include a variety of facilities and components such as railway structures, tracks, electrification masts, and vehicles. While measures against seismic disaster have been actively applied to various facilities and to prevent derailments since the Hyogo-Ken Nanbu Earthquake (1995) and the Niigata-Ken Chuetsu Earthquake (2004), they have actually been conducted independently from each other. The aseismic capability that individual equipment possesses may therefore vary.

To achieve the objective of an improvement in safety for the whole railway system against earthquakes, aseismic capability and the effect of seismic countermeasures for each facility have to be evaluated using a common standard. In addition, to put effective countermeasures into practice within a limited budget, priorities in reinforcement and the selection of construction methods have to be determined on the basis of a rational principle. Given these circumstances, we calculated the earthquake risk for each railway system, and we proposed an evaluation index to determine the required seismic countermeasures in terms of life-cycle cost derived from the earthquake risk (Fig. 1).

On the basis of the results of recent studies of major earthquakes and active faults, it is possible to stochastically evaluate earthquake motions estimated at a target location by means of a stochastic seismic hazard analysis. By dynamically simulating the ground motion based on the probability of an earthquake occurring and the ground condition of the target point, it is possible to evaluate a surface earthquake motion at a particular location. Further, the seismic risk and the life-cycle cost for each facility can be calculated to give an each facility the seismic vibrations assumed at the ground surface. Finally, the effectiveness of the measure is evaluated by calculating the difference in the life-cycle costs, or DLCC, on each condition before and after a seismic countermeasure has been implemented. Ranking of the effectiveness of each seismic countermeasure can be numerically determined by calculating the DLCC for each location and the construction method of the measure.

Figure 2 shows an outline of how priority is determined for application of seismic countermeasures using this proposed method. Suppose that the DLCC for each location is calculated for each of the three locations A, B and C (for example, embankment, viaduct, and mast). Since location B in the figure shows the highest DLCC resulting from the seismic countermeasure, it was selected as the measure to be taken with the highest priority.

The studies also clarified that the priority varies depending on the seismic activity. In other words, this method allows the most appropriate countermeasures to be chosen for each target line by taking into account the seismicity, ground condition, structural conditions, and the level of traffic at that point.

This method is also applicable for determining the priorities for measures to be taken on different routes, and it is thus expected to be widely utilized when considering the priorities for implementation of seismic countermeasures.

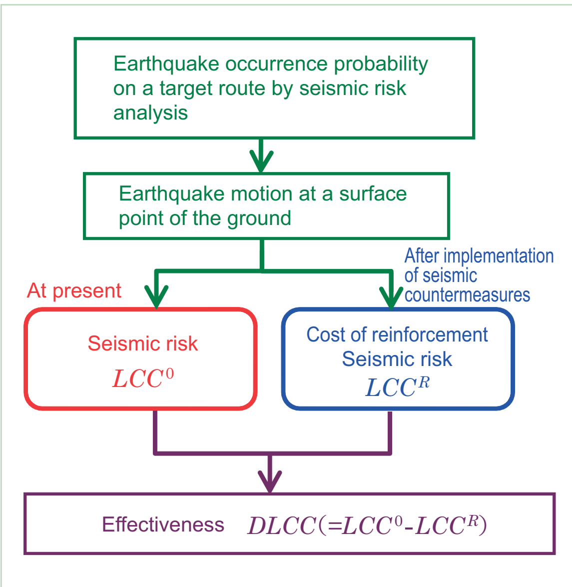

Fig. 1 Flow chart for estimating DLCC

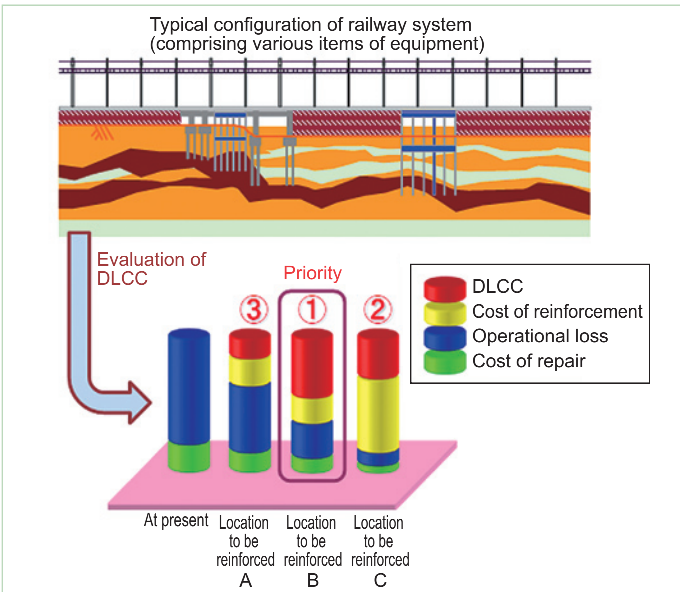

Fig. 2 Outline of determination of priorities for implementing seismic countermeasures

Simple Catenary Equipment Offering High Speed Operation and Maintainability

Satoshi HARADA
Senior Researcher, Contact Line Structures, Power Supply Technology Division

On the Shinkansen lines of this country, heavy-compound catenary equipment is used for those routes with a large volume of traffic, while simple catenary equipment is used for routes with lower transport capacity such as the new Shinkansen lines. While simple catenary equipment using a copper-steel (CS) contact wire has been traditionally put into service on the new Shinkansen lines, precipitation-hardened copper (PHC) alloy has recently been adopted more frequently because of the characteristics of this material. PHC is a copper alloy based oxygen free copper, containing tiny amounts of chromium, zirconium, and silicone, which has excellent durability against wear and recyclability.

A trial calculation shows that the CO_2 discharge of the PHC contact wire during the life-cycle decreases by 10 % as compared with that of the CS contact wire. Accordingly, this paper first briefly describes an overview of the PHC simple catenary equipment, and then reports on the wear rate of the contact wire exhibited during a period of four years in operational service and its current collection characteristics measured by a Shinkansen high-speed test train.

Figure 1 shows the structure of the PHC simple catenary equipment. This type of equipment comprises a contact wire having a cross section of 110 mm^2 stretched by a force of 19.6 kN and a stranded messenger wire of hard drawn copper with a cross section of 150 mm^2, also tensioned by a force of 19.6 kN. The standard specified hanger interval is 5 m.

Figure 2 shows the development of the wear process of the contact wire at a location where the PHC simple catenary equipment was actually used in service for four years. Furthermore, for comparison, the development of the wear process at a location where CS simple catenary equipment was constructed at the same location is also plotted in Fig. 2. Figure 2 shows that the wear rate of the PHC wire is 0.054 mm^2 per ten-thousand pantographs which is 70 % of that exhibited by the CS wire.

Finally, the result of high-speed running tests on a section of PHC simple catenary equipment is reported. The test comprises a Shinkansen high-speed test train with one pantograph running at a maximum speed of about 340 km/h. The test result shows that the maximum uplift of the contact wire is about 45 mm, which is below 100 mm, a standard value for high-speed running on a section of catenary equipment. Meanwhile, the maximum strain of the contact wire is 710×10^{-6}, which is also below the value allowed for the PHC contact wire, and thus running at a speed over 300 km/h is considered to be practicable enough.

Figure 3 then shows a graph depicting the values of the contact loss ratio of the test vehicle running through the PHC simple catenary equipment. This test gives the contact loss ratio as below 1 %, consequently showing sufficient current collection performance.

As stated above, the PHC simple catenary equipment provides a smaller environmental load during the life-cycle than the CS simple equipment, proving sufficient current collection capability even at a velocity exceeding 300 km/h. This PHC equipment was employed on the Tohoku Shinkansen (between Hachinohe and Shin-aomori) and on the Kyushu Shinkansen (between Hakata and Shin-yatsushiro).

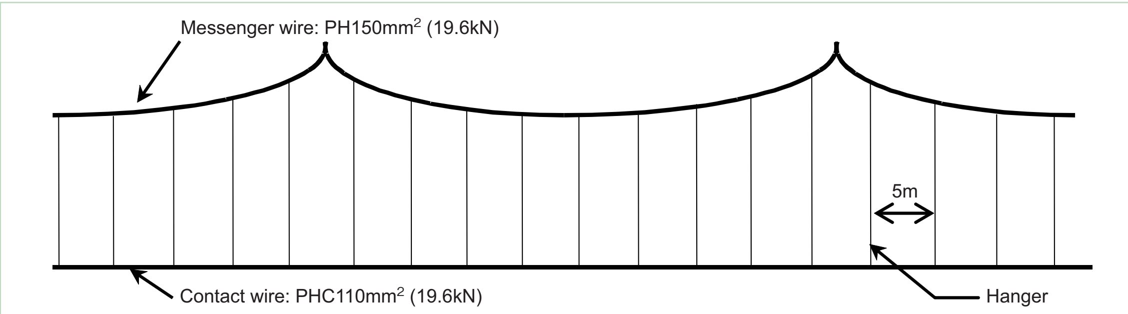

Fig. 1 Structure of PHC simple catenary equipment

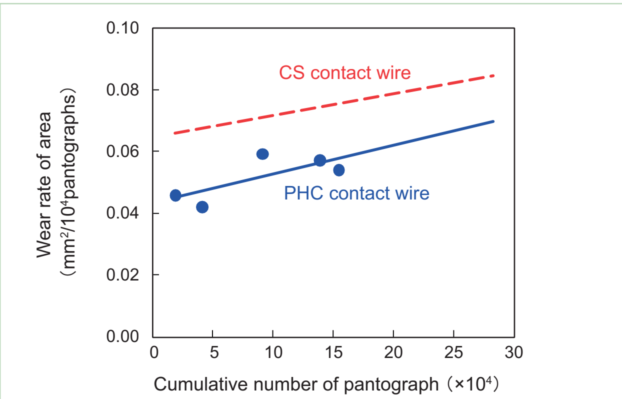

Fig. 2 Wear process of PHC contact wire

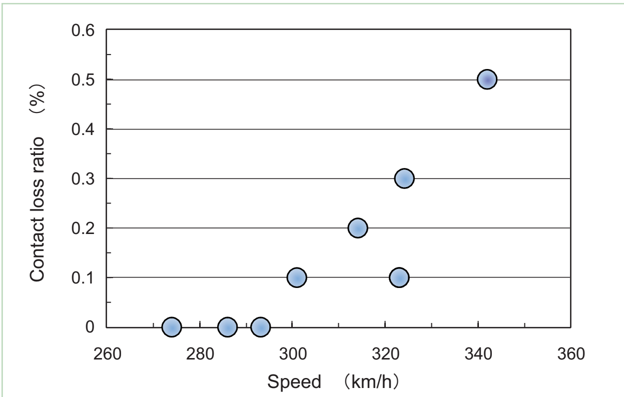

Fig. 3 Contact loss ratio during high-speed running tests