Newsletter on the Latest Technologies Developed by RTRI

Railway Technology Newsletter

March 28, 2014 No.46

Railway Technical Research Institute
2-8-38 Hikari-cho, Kokubunji-shi
Tokyo 185-8540, JAPAN
URL : http://www.rtri.or.jp
E-mail : iainfo@rtri.or.jp

Editorial Office: Ken-yusha, Inc.
URL: http://www.kenf.jp/en/

GENERAL INFORMATION

- Research and Development for the Future of Railways
  Kimitoshi ASHIYA 271
- Renewal of RTRI's Supercomputer 272
- A Taiwan Rail Technology Seminar Held at RTRI 272
- The 1st Workshop of Ballasted Track Maintenance between Japan and United Kingdom 272

ARTICLES

- Designing Railway Noise Barriers to Account for Resonance due to Train Draft Pressure *Munemasa TOKUNAGA* 273
- High-precision Prediction of Tunnel Micro-pressure Wave Based on Theoretical Analysis *Tokuzo MIYACHI* 274
- A Reflecting Back Support System for Train Driver Training
  Hiroharu ENDOH 275
- A Preliminary Study of Magnetic Fields on Railway Vehicles
  Yoshihito KATO 276

Research and Development for the Future of Railways

Kimitoshi ASHIYA
Director, Research and Development Promotion Division

Foreseeing the future five to ten years ahead, RTRI is now promoting research and development of wide-ranging subjects under the overall title of "Research and Development for the Future of Railways." Some subjects are expected to have far-reaching effects after commercialization. RTRI is also implementing basic studies to analyze various phenomena and constructing tools that will result in highly significant breakthroughs in railway research and development.

The five subjects currently under promotion are (1) improvement of safety and reliability of railway systems, (2) high-efficiency use of energy, (3) innovation of maintenance, (4) sustainability and development of railway networks and (5) construction of railway simulators. Among these subjects, those in (1) and (2) are specified as "subjects of particular importance" on the basis of the experience in The Great East Japan Earthquake Disaster in March, 2011.

Regarding the subject (1), RTRI is developing technology to predict the occurrence of natural disasters such as destructive earthquakes, tsunamis, strong winds and heavy rains as well as measures to prevent damage therefrom. To attain the target in (2), RTRI promotes development of high-efficiency induction motors to save energy consumed by rolling stock, improvement of power transmission efficiency in DC sections and development of superconductive cables to reduce energy consumption by power supply equipment. Additionally, RTRI is making efforts to develop basic technology to run trains on virtual permanent ways constructed in computers in order to reproduce various phenomena specific to railways and facilitate solutions through simulation.

The research and development programs referred to above are generally being promoted as scheduled, with their outcomes expected to contribute to the sustainability and development of railways, not only in Japan but also in other countries around the world.

Renewal of RTRI's Supercomputer

RTRI introduced a new computer system composed of two supercomputers XC30 and CS300 (Cray Inc., US) on September 1, 2013. This upgrading of computer power will enable RTRI to model the combined behaviors of railway system components in different fields to produce an upgraded high-performance railway simulator for use as a common tool for research and development. The general-purpose XC30 supercomputer, superior in economy and throughput, is customized for large-scale parallel calculations and features compatibility with a number of existing applications. The CS300 supercomputer performs multi-purpose calculations centering on applications for general-purpose analysis. The combination of these supercomputers claims a total throughput of 114.7 TFLOPS, approximately 10 times as high as that of the prior conventional simulation system. RTRI will use this system from now on for numerical simulations to analyze various phenomena related to railways.

President Kumagai (right) at the opening ceremony

A Taiwan Rail Technology Seminar Held at RTRI

RTRI held a seminar on Taiwanese Railway Technologies on November 5, 2013.

Since the inauguration of a high-speed railway in Taiwan in 2007, the number of users of the new railway has been increasing year after year. On conventional railways as well, remarkable developments can be seen with passengers increasing and stations are rapidly increasing.

Five presentations were made by the guests from Bureau of High Speed Rail, Taiwan High Speed Rail Corporation, and Taiwan Railway Administration, on the topics of those presentations were various, including passenger seat arrangement, adoption of LEDs for cab lighting, investigation of derailment accidents, development of stations and rail operation management.

Besides RTRI researchers, a number of guests from railway companies leading manufactures, consultants and other organizations in Japan attended the seminar and reception enjoyed active information exchange.

Taiwan Rail Technology Seminar at RTRI

The 1st Workshop of Ballasted Track Maintenance between Japan and United Kingdom

The 1st Workshop of Ballasted Track Maintenance between Japan and United Kingdom was held at RTRI on November 20 (Wed.) to 21 (Thur.) , 2013.

There are a number of common issues in the upkeep and maintenance of ballasted tracks between Japan and UK as the ground in these two countries is softer than that in continental countries. Under the circumstances, RTRI organized this Workshop with support from the British Embassy Tokyo and Scottish Development International.

We planned to meet on a regular basis to exchange information between the ballasted track researchers in Japan and UK and seek themes for a joint project to improve the efficiency of ballasted track maintenance.

The 1st Workshop was attended by 45 researchers from RTRI, Japan Railway Companies, universities in Japan and those in UK, with 10 presentations, seven from RTRI and three from UK. The 2nd Workshop will be held in autumn 2014 in the UK.

Prof. William Powrie (University of Southampton)

Prof. Peter Woodward (Heriot-Watt University)

Designing Railway Noise Barriers to Account for Resonance due to Train Draft Pressure

Munemasa TOKUNAGA
Researcher, Structural Mechanics, Railway Dynamic Division

1. Purpose and Background

To guarantee the environment-friendly performance of high-speed trains and to help protect them from snow in some circumstances, noise barriers are becoming increasingly taller to more than rail level +3.0m as new barriers are installed and existing low-rise ones are remodeled. Noise barriers for railways have been designed so far based on a simple static check to withstand a design wind load of 3.0kN/m^2 in strong winds (wind speed 50m/s). For tall noise barriers, however, there are concerns about resonance of the barriers due to decreases in rigidity and the emergence of other unsolved phenomena. Thus we investigated the response mechanism of these barriers at higher train speeds in order to compile reasonable technical design standards.

2. Understanding the response mechanism of noise barriers

(1) Measurement at site

The typical tall noise barrier has concrete panels trapped between H-shaped steel struts that are embedded in the RC bridge railing as shown in Fig. 1. Through measurements made at the site we identified the natural vibration mode of this noise barrier, quantified the train draft pressure formed at the head and tail of passing trains and assessed the phenomenon of subsequent resonance amplification of the strain at the bottom of the H-shaped struts.

(2) Analysis of dynamic interaction between trains and structures

We constructed a model to analyze the dynamic interaction between trains, tracks, structures and noise barriers. The model reproduced the results of impulse excitation recorded during the train running tests and allowed us to analyze and extract response-governing factors through numerical simulation. As a result, we were able to clarify that the response of tall noise barriers to train passage is (a) governed by the resonance between the noise barriers vibrating at the natural frequency and train draft pressure formed at the head of the train and (b) amplified by the overlapping effect of the tail pressure pulses (Fig. 1).

3. Generalization of dynamic response of noise barriers

As there are a great number of noise barriers and railway structures existing in combination, we extracted factors governing the resonance phenomenon based on the knowledge acquired above and developed a multi-body model that links springs, masses and dampers. The model allows us to express the behavior of noise barriers in simple terms (Fig. 2). By using this generalized model, we implemented a large-scale parametric analysis and proposed a design train wind pressure load for noise barriers based on their natural frequency and train speed. As an example, Fig. 3 indicates that, for a train speed of 260 km/h, the design train pressure load exceeds the value specified for strong winds in the existing standards when the natural frequency of the barrier is lower than 3Hz.

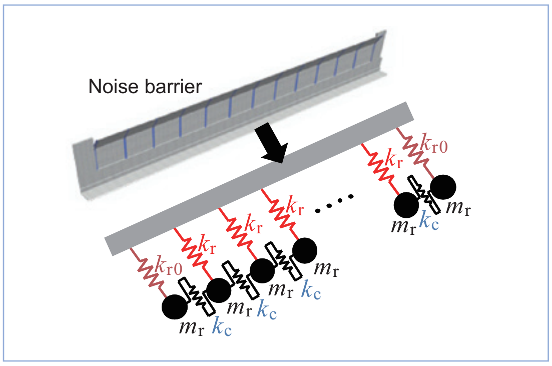

Fig. 2 A noise barrier generalization model

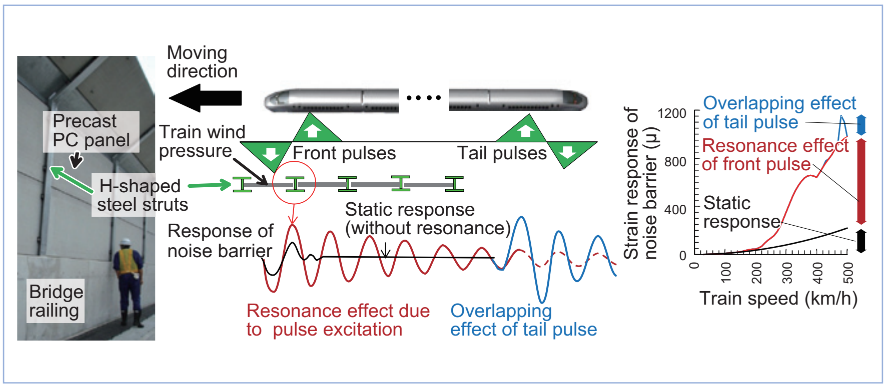

Fig. 1 A typical tall noise barrier and mechanism of resonance amplification

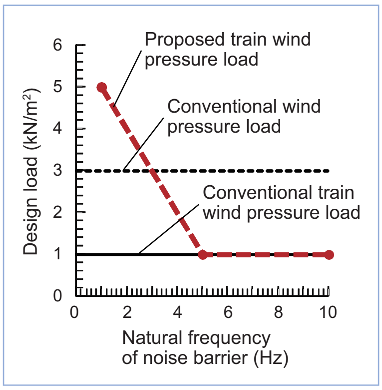

Fig. 3 Design train wind pressure load (train speed 260km/h)

High-precision Prediction of Tunnel Micro-pressure Wave Based on Theoretical Analysis

Tokuzo MIYACHI
Assistant Senior Researcher, Heat and Air Flow Analysis, Environmental Engineering Division

When a high-speed train enters a tunnel, a micro-pressure wave is radiated from the tunnel exit to potentially cause an environmental problem. The author's group is now developing a high-precision prediction method of micro-pressure wave based on theoretical analysis.

1. Micro-pressure wave

When a train enters a tunnel at high speed, a compression wave is generated in the tunnel (see Fig. 1(a)), and propagates through the tunnel while changing its shape (Fig. 1(b)). When the compression wave reaches the tunnel exit, a micro pressure wave is radiated outside of the tunnel (Fig. 1(c)). The micro-pressure wave may accompany a blasting sound and excite vibrations in neighboring buildings. As micro-pressure waves are highly speed-dependent, preventive measures are required for speed-up of trains. Thus, it is essential to predict the magnitude of the micro pressure waves.

2. Method for prediction of micro-pressure wave

To evaluate the micro-pressure wave, our group has developed a method of high-precision prediction based on non-linear acoustic theory for the three stages of micro-pressure wave generation: (a), (b), and (c) in Fig. 1 (which are referred to as the stages 1, 2 and 3, respectively, below). Figure 2 illustrates an example of the prediction results obtained by our method which combines three prediction techniques for the stages 1, 2 and 3. Here we considered the case where the train speed is to be increased from 245 to 300 km/h. As a countermeasure for the micro-pressure wave, a tunnel entrance hood with side windows is to be installed at the tunnel entrance. The purpose is to keep the peak value of the micro-pressure wave at 300 km/h equal to or less than that at 245 km/h.

Figure 2 shows the prediction results for the original case (with no tunnel entrance hood, 245 km/h) and for the two hood condition cases (300 km/h), with symbols A and B standing for two different window patterns. For the short tunnel, the peak value of the micro pressure waves are almost the same among the three cases. On the other hand, in the case of a long slab tunnel, the peak values of the micro-pressure wave for the window pattern A case is approximately twice as high as the original case, while those of the window pattern B case and the original case are about the same. In this manner, our method makes it possible to evaluate the performance of micro-pressure wave reducing measures for various conditions of tunnels.

3. Novel measures to reduce micro pressure waves

In the course of the development of the prediction method, our physical understanding of the micro-pressure wave phenomenon has advanced greatly. Taking advantage of this, our group will develop novel measures to further reduce micro-pressure waves in Shinkansen, where train speed is ever increasing.

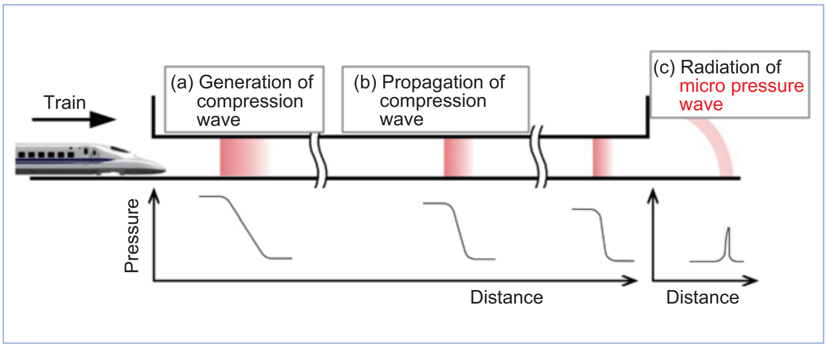

Fig. 1 Radiation of micro pressure wave

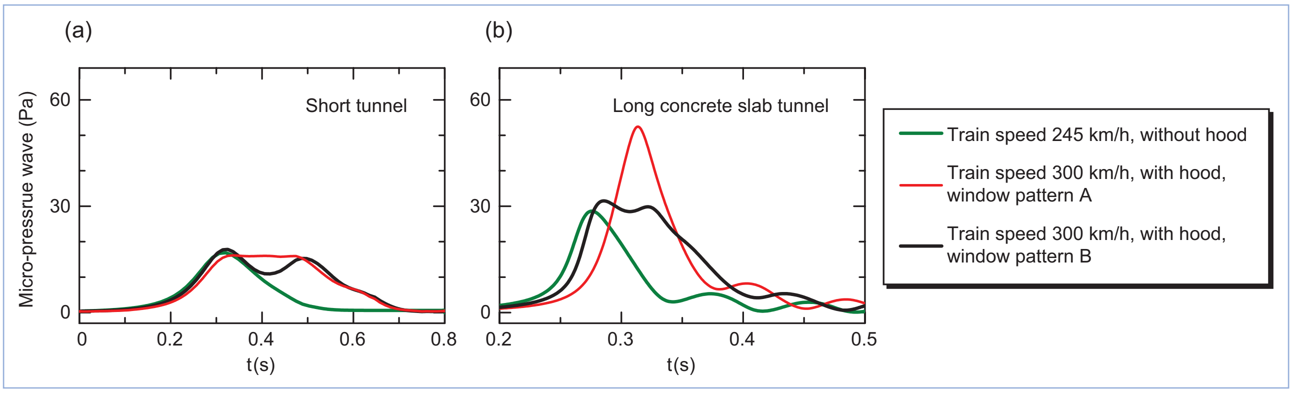

Fig. 2 An example of prediction results of micro-pressure wave at tunnel exit

A Reflecting Back Support System for Train Driver Training

Hiroharu ENDOH
Assistant Senior Researcher, Ergonomics, Human Science Division

1. Purpose and background

Train drivers are prone to commit human errors due to psychological uneasiness or tension. Errors can even occur due to relaxation after properly taking action. To prevent such unwelcome situations, it is important for train drivers to objectively review their own trends in taking action and their psychological states that occur during their training when abnormal train operation situations are encountered. Such objective reviews should be conducted using data recorded during the training sessions in order for drivers to correctly understand psychosomatic conditions into which they will potentially fall. However, it is not easy for train drivers to acquire useful knowledge through “reflecting back” by themselves within the limited training time. We developed, therefore, “A reflecting back support system” to effectively and efficiently support their reflecting back process in their training using a simulator. We also verified the system’s practicality for actual applications.

2. Principal functions

The system has the following functions to enable effective and efficient reflecting back.

• Records and controls en bloc four-split images of action data on train operating manipulations, heart rate data related to the degree of tension, train operation environment and their own expressions/behavior shot at various angles.

• (1) Has a high-usability interface to enable smooth retrieval and display of the scenes drivers want to review (kilometer posts/passing time) (Fig. 1) and (2) displays synchronized records/data in various categories immediately after completion of training.

• Automatically judges whether or not an event is an error in case one has occurred according to the rules on train operation and outputs a list of judgment results, error contents, places of error occurrence and other particulars on “Train operation check sheet” (Fig. 2).

3. Verification of practicality

We nominated 20 instructor-class subjects who have experienced train operation for a test to evaluate the reflecting back support system. They sat before a train operation simulator that runs an actual training program to experience abnormal scenarios for approximately 30 minutes and reviewed the course thereafter for approximately 30 minutes. Then, we performed a questionnaire survey to check whether the functions of the reflecting back support system had been effective for their retrospective thinking process. As a result, we obtained satisfactory results from the survey to demonstrate that the system is highly viable for practical applications.

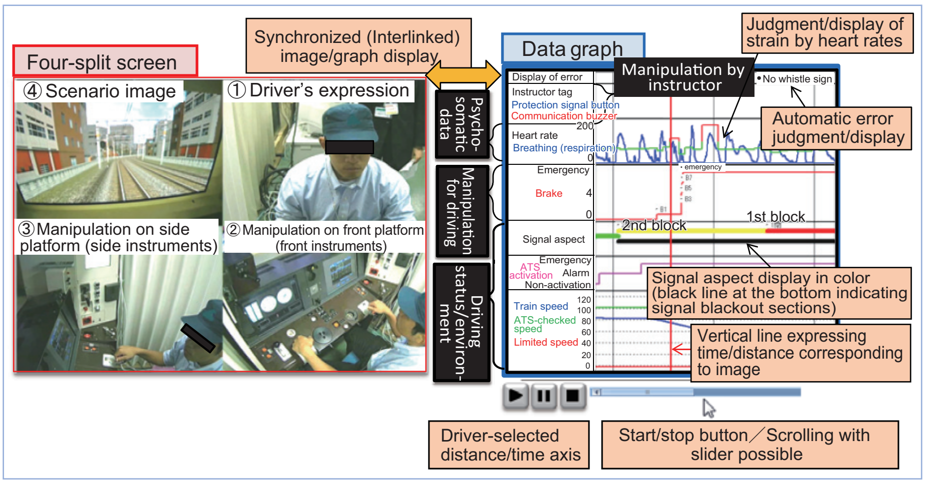

Fig. 1 Displays of playback subsystem (Left picture: screen display spit into four, right picture: data graph)

	List of regular driving procedures	Result of detection	Comment	Kilometer point	Time	Knowledge
1	When to contact the conductor, carefully coast the train.					Driver shall stop the train in principle when communicating with conductor or other personnel except on simple matters, or carefully coast or run the train at low speed in the meantime.
2	Whether or not the driver has noticed the blackout of the 2nd block signal.					
3	Stop the train at a point 50m past the 2nd block signal.	!	Train has overrun the stop position.	6.693km	13:04:27	
4	Wait for one minute.					Until an adequately long distance is secured behind the train ahead.
5	Receive (acknowledge) instructions from traffic controller.	PB Check				Driver can run the train when necessary at his/her discretion without being protected by a block system, provided that he/she notifies the traffic controller of his/her unprotected status.

The symbol “!” indicates that the driver has possibly committed an error.
“PB Check” means that the situation shall be checked with a playback display.

Fig. 2 Train operation check sheet

A Preliminary Study of Magnetic Fields on Railway Vehicles

Yoshihito KATO
Senior Researcher, Electromagnetic Systems, Maglev Systems Technology Division

1. Background

In Japan, regulations on low-frequency magnetic fields began taking effect now in force. Initial regulations in 2011 applied to electric facilities in general, but the scope of regulatory control was expanded in 2012 to cover railway electric facilities on the ground. Although railway vehicles are not included in the scope of regulation at the moment in Japan, we think that it is necessary to assess the magnetic fields in the space on railway vehicles (hereinafter referred to as "car-borne magnetic fields"). Thus, we are now beginning to evaluate car-borne magnetic fields.

2. Analysis of magnetic fields

As a number of magnetic field generating sources exist on and around railway vehicles, it is thought that the vehicles are subjected to a wide variety of magnetic fields. RTRI is studying a theoretical technique to analyze car-borne magnetic fields. To calculate the magnetic fields on railway vehicles where magnetic materials and conductors exist in quantities, we cannot rely on simple calculation formulae, but are required to perform analysis of magnetic fields. Therefore, we created a model that considers the effects of magnetic shields and car body structures and so on, to analyze the car-borne magnetic fields. We are now using the model to calculate car-borne magnetic fields by the finite element method or other means (Fig. 1). We believe that it is possible to use this technique to check in advance the effects of shields on railway vehicles.

3. Dosimetry

The ICNIRP (International Commission on Non-Ionizing Radiation Protection) guideline on the environmental magnetic fields prescribes that, in cases where a magnetic field exceeds the "reference levels" (Fig. 2) it shall be evaluated in terms of the electric field strength induced in the human body in low-frequency magnetic fields (This is called "the basic restrictions").

To calculate the electric field strength induced in the human body, we developed a technique to input the distribution of the car-borne magnetic fields into a numerical model of the human body which had been developed by National Institute of Information and Communication Technology (Fig. 3). By this technique, we are able to evaluate the effect of car-borne magnetic fields on the human body without directly measuring the induced electric fields.

4. Conclusion

RTRI thinks that magnetic fields in the environment are a matter of primary concern in Europe. It was decided that new regulation would be introduced last summer by an EU directive on the direct current magnetic fields in the environment surrounding professionals. We will continue research in this field from now on while keeping an eye on the development of the issue around the world.

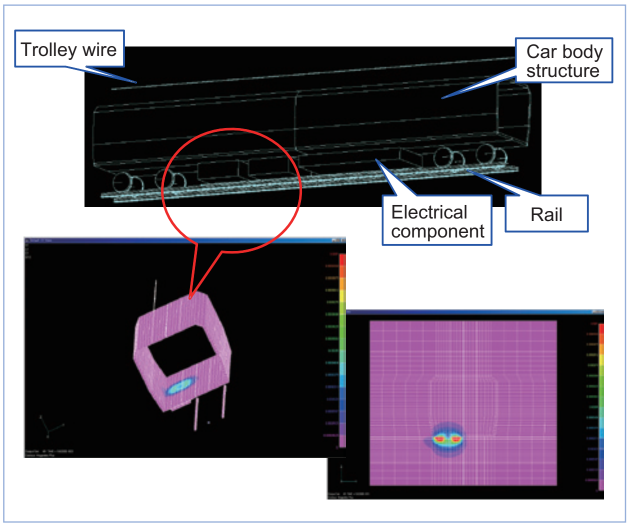

Fig. 1 Analysis of magnetic fields on railway vehicles

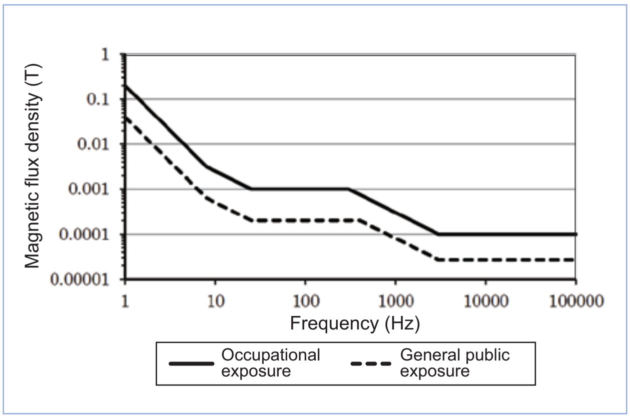

Fig. 2 Reference levels, ICNIRP guideline

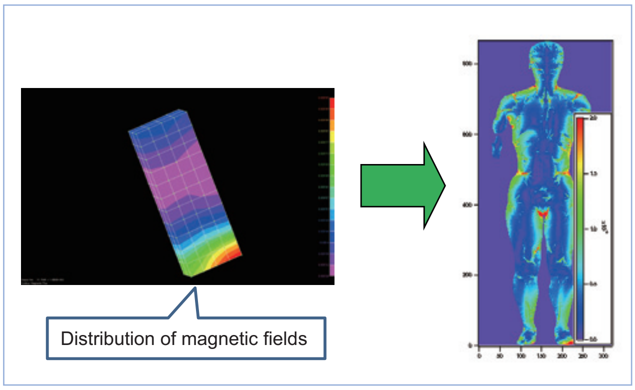

Fig. 3 A calculation of the electric field strength induced in the human body using a numerical model