Newsletter on the Latest Technologies Developed by RTRI

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Railway Technology Newsletter

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GENERAL INFORMATION

ARTICLES

Vision of RTRI and Implementation of Dynamic R&D

Norimichi KUMAGAI
President

Celebrating the 50th anniversary of the Tokaido Shinkansen last year, we renewed our awareness that the innovative technology contributed a lot to Japanese society and impacted the later development of other high-speed railway systems on a global scale. The transportation networks including the high-speed, intercity railways have drastically changed how people move. We believe that RTRI should address challenging research and development to create new values in the society, just as Shinkansen created innovative railway systems.

Specifically, RTRI has launched a new vision titled RISING (Research. Initiative and Strategy - Innovative, Neutral, Global) with a message to clearly denote the direction of its activities: "We will develop innovative technologies to enhance the rail mode so that railways can contribute to the creation of a happier society." This vision includes establishment of the following three missions:

- To intensify research and development activities so as to improve railway safety, technology and operation, responding to customers' needs and social change;
- To develop professional expertise in all aspects of railways and, as an independent and impartial research body, to fulfill our tasks using the best science available in an ethical way; and
- To pioneer cutting-edge technologies for Japanese railways and become a world-leader.

For the important challenges related to safety, RTRI will push ahead with research on disaster-reduction technology based on an active safety concept. As an example high-performance simulation models will be used to help railways build robust counter-measures against natural disasters such as a large-scale earthquake, strong winds, and deluging floods, etc. As for prevention of human-error triggered accidents, RTRI will start a basic study on the relationship between behaviors of a crew during train operation and accompanying changes in physiological indices such as their brain activity. In addition, RTRI will pursue innovative railway systems based upon information networks by utilizing information and communication technology (ICT) and analyzing large-scale data bases. In terms of energy conservation, we are developing high-temperature-superconducting power feeding cables which reduce power losses. As an example of dynamic research and development, basic studies will be conducted to clarify dynamic phenomena so as to reduce aerodynamic noise and prevent derailments.

I am confident that RTRI's presence will be enhanced by providing quality research outcomes and winning trust. Aside from addressing challenges in safety, energy efficiency, and speed increase, we will allocate our limited resources to the research activities as efficiently as possible in order to produce practical results which meet the needs of railway passengers, operators and industries promptly and precisely.

14th China-Korea-Japan Railway Research Technical Meeting Held in Japan

RTRI, the China Academy of Railway Sciences (CARS) and the Korea Railroad Research Institute (KRRI) have advanced their collaborative research in railway technology fields since they entered into a research collaboration agreement in 2000.

The 14th Technical Meeting was held at the RTRI Kunitachi Institute for the 2-day period of November 20-21, 2014. Seven members of KRRI attended the meeting. Dr. Won Hee YOU, Vice President of the KRRI, and Dr. Hideyuki TAKAI, Executive Director of the RTRI, led the discussion about the future direction of the China-Korea-Japan railway research program.

At the research discussion session of the meeting, attendees had a lively exchange of views about the following research topics:

- Study of the specifications of the switch-and-lock system for large turnouts,
- Evaluation of the optimum replacement frequency for safety and reliability of railway electrification facilities, and
- Study of structural health monitoring technologies for pantograph and catenary systems.


Participants of Technical Meeting

WCRR News: Call for Papers for WCRR 2016 in Milan and Decision to Hold WCRR 2019 in Tokyo

The 11th World Congress on Railway Research hosted by *TRENITALIA* is currently calling for papers. This congress will take place in Milan between May 31 and June 2, 2016. The international railway community including railway companies, railway researchers, and other interested persons will be invited to this congress so that they may gather and share their knowledge and experiences. The theme of the congress is “Research and Innovation From Today Towards 2050”. For details of the topic, please refer to the CALL FOR PAPERS at the following website:

http://www.wcrr2016.org/

At the last meeting of the WCRR Organising Committee, the decision was made to hold the 12th WCRR in Tokyo between October 28 and November 1, 2019. Do not miss it!

WCRR 2016 Call for Papers Timeline

Deadline for abstract submission	**30 April 2015**
Confirmation of accepted abstracts	**31 October 2015**
Deadline for submission of full papers to be provided for review	**31 January 2016**

6th RTRI-SNCF Railway Collaborative Research Seminar Held in Paris

RTRI and the Société Nationale des Chemins de fer Français (SNCF) have advanced their collaborative research in railway technology fields since 1995 when they entered into a collaborative research agreement. The 6th Seminar conducted under this agreement was held at the SNCF Innovation & Research (Director: Mr. Eric CONTI) in Paris, France on September 29-30, 2014. 15 members of the RTRI, including Executive Director Hideyuki TAKAI, participated. The Seminar included an exchange of views on the management of research and development and a report of the collaborative research themes. Also, it was agreed upon at this latest Seminar that the RTRI and the SNCF would continuously promote collaborative research and keep close contact with each other. The next Collaborative Research Seminar will take place in Japan in 2016.


Presentation at Collaborative Research Seminar

Improvement of Seismic Parameters Estimation and Noise Discrimination for Earthquake Early Warning

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1. Introduction

Running trains need to be stopped immediately when earthquakes occur that are large enough to affect the safety of railway facilities and running trains. For this purpose, seismographs are placed along railway lines in Japan to issue warnings by estimating seismic parameters at an early phase of earthquakes by detecting feeble-amplitude of initial P-wave. In the current earthquake early warning system, the epicenter location and seismic magnitude are estimated based on the initial P-wave information in several seconds obtained at a single–station, and warnings are issued if necessary. However, the system needs to prevent issuing false warnings by accurately discriminating between seismic motions and train-induced vibrations. In this research, we have improved the algorithms for estimating the seismic parameters and the noise discrimination in order to further enhance the performance of the earthquake early warning system.

2. Improvement of the algorithm for estimating seismic parameters

In this project, the current method of estimating the epicentral distance has been replaced by a newly-developed one, and consequently the time to analyze the data has been reduced to one fourth. In addition, with this algorithm:

1) the estimation is started at the phase when somewhat strong motion arrive in P-wave, instead of the phase just after the arrival of P-wave, and
2) in order to estimate the back-azimuth, the developed algorithm uses variable time window to analyze the data of the half-wavelength of the displacement onset of P-wave. (The current system uses a fixed time window.)

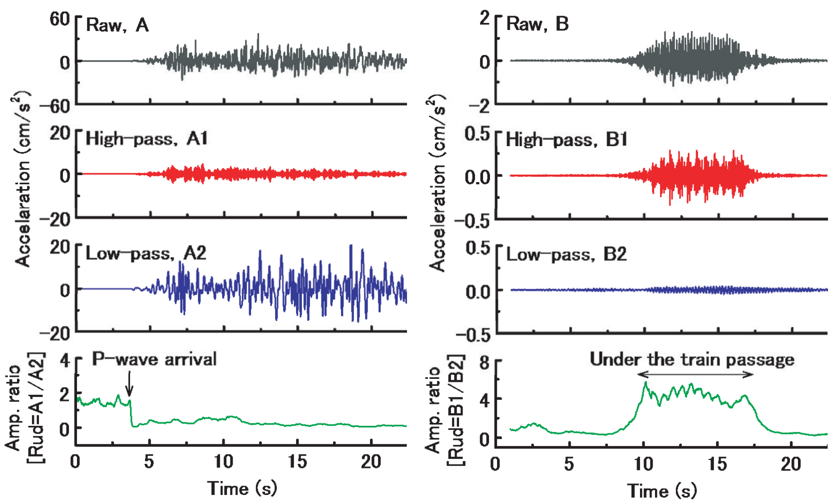
As the result, the accuracy and rapidity of estimating the epicenter location have been improved. Also, acceleration data has been introduced as a parameter to estimate the seismic magnitude, because it has been confirmed that, on average, the maximum amplitude can be detected earlier in the acceleration than in the displacement. However, if we focus on acceleration data for estimating seismic magnitudes, the accuracy is lower compared to focusing on displacement. Accordingly, the author proposes the OR operation including both acceleration and displacement data.

3. Improvement of the algorithm for the noise discrimination

Currently, the maximum of the ratio of vertical and horizontal vibration amplitudes (VHmax) is used to discriminate between seismic ground motions and train-induced vibrations. However, by comparing the frequency characteristics of both the seismic and the train-induced vibrations, it was found that, in vibrations caused by running trains, the high-frequency vibrations are dominant over the low-frequency ones. Therefore, we proposed a method of obtaining two sets of data obtained by high-frequency and low-frequency band pass filtering. We then calculated the ratios of their absolute amplitudes to moving averages (Rud) as shown in Figure 1. As a result of reviewing the performance of the discrimination method, it was found that good results were obtained by the method of combining the logarithms of VHmax and Rud in a linear equation.

4. Conclusion

With the improvements described in this article, not only the accuracy for estimating seismic parameters is expected to be improved, but the minimum time necessary to issue warnings can also be reduced from current 2.0 s to proposal 1.0 s. Furthermore, the reliability of warnings will be improved. Currently, we have developed and have been inspecting a prototype seismograph equipped with the upgrade algorithms described in this article so as to apply this device to practical applications.



(a) Seismic motions (b) Train-induced vibrations

Fig. 1 Typical case of Rud time-series data

Multimodal Vibration Control against Flexural Vibrations of Railway Vehicle Carbodies Using Active Mass Dampers

Yuki AKIYAMA
Researcher, Vehicle Noise and Vibration, Vehicle Structure Technology Division

1. Introduction

Improvements in passenger ride comfort can be achieved in many new designs of railway vehicles by reducing the vertical flexural vibrations of passenger carbodies. In particular, multiple flexural vibration modes that occur around 10 Hz are important. This frequency is in the range where the passengers are sensitive to vertical accelerations and affect the riding comfort greatly. Accordingly, a method for controlling those vibrations simultaneously is required. To meet this requirement, we proposed a multimodal vibration control method using Active Mass Dampers (hereinafter called "AMDs") and developed a compact AMD dedicated for that purpose.

2. Compact Active Mass Damper (AMD)

We newly developed a compact AMD consisting of a moving mass supported by an air spring and a linear actuator using permanent magnets as shown in Figure 1. This device reduces vibrations by providing an object for vibration control with inertial reaction generated when the upper moving mass is moved by the actuator. The gross mass per device is 70 kg, and the dimensions measure 390 mm long, 300 mm wide and 226 mm high. For this research, two devices were used to provide multimodal vibration control.

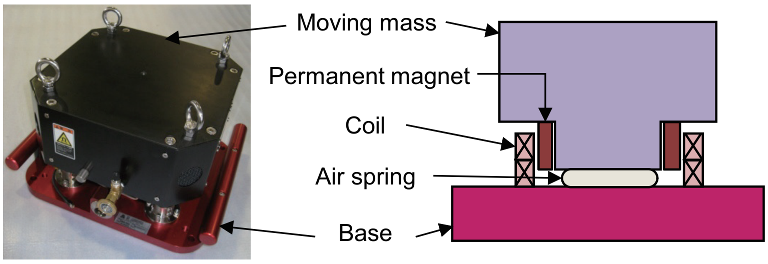


Fig. 1 The developed compact AMD

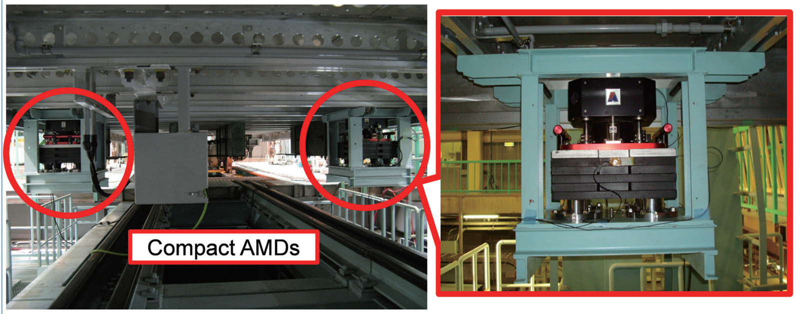


Fig. 2 Compact AMDs fitted to the underfloor of the vehicle

3. Validation of vibration control effect

In order to validate the effect of multimodal vibration control using AMD technology, we performed an excitation test. We installed two compact AMDs under the floor of the central area of a Shinkansen-type test vehicle as shown in Figure 2 and simulated the real running state (at a running velocity equivalent to 240 km per hour) in the rolling stock testing plant at the RTRI. The acceleration PSD (power spectrum density) on the floor which is the closest to the central window of the carbody is shown in Figure 3. The PSD shows large peaks corresponding to two flexural vibration modes at 9 and 11 Hz when there is no vibration control. Note that those peaks are drastically reduced when the AMD control is provided. Thus, we were able to verify from the above result that the newly developed compact AMDs are equipped with the characteristics necessary to achieve multimodal vibration control for railway vehicles. Although this article describes the excitation test results at RTRI's rolling stock testing plant, we also performed running tests on commercial lines for Shinkansen trains and conventional-line limited express trains. As a result, we have confirmed that the multimodal vibration control using compact AMDs is also effective in the real running state.

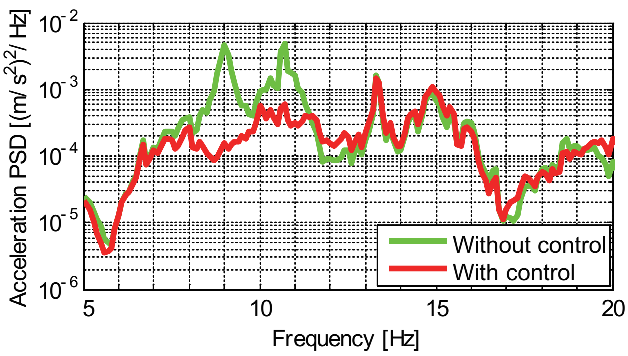


Fig. 3 Acceleration PSD measured under the central window
(Simulated running excitation corresponding to 240 km/h)

Wheel Slide Protection Method by Effective Use of Adhesion Force

Shinichi NAKAZAWA
Assistant Senior Researcher, Brake Control, Vehicle Control Technology Division

1. Introduction

Ideally, high deceleration braking should be stable in all situations. However, since the adhesion force between the sliding wheel and rail varies significantly under wet conditions, it is difficult to completely prevent wheel slide and secure stable performance. To help resolve this issue, wheel slide protection (WSP) systems were introduced in the past and achieved reasonably satisfactory results. However, all the existing WSP methods provide protection using only velocity-based information. It is difficult to for these systems to provide perfectly constant protection when the adhesion force is subject to change. Therefore, we propose a new method of providing wheel slide protection. The method estimates the adhesion force by using the equation of the wheel's rotational motion.

2. Wheel slide protection estimating adhesion status

Since it is difficult to measure the adhesion force and braking force of an actual vehicle directly, the proposed method uses the brake cylinder (BC) pressure to estimate the adhesion. Specifically, the braking force is calculated from the BC pressure and converted into deceleration by using the equation of the wheel's rotational motion, the result of which is the "estimated deceleration". This is compared to the actual deceleration found from the speed sensor measurements and we can calculate the difference between the actual deceleration and the estimated deceleration. This difference is the slide deceleration (Figure 1). The magnitude of the slide deceleration is proportional to the magnitude of the adhesion force and this relationship is an important part of the decision-making logics incorporated in the wheel slide protection system (Figure 2) that we developed. In effect, the logic is that if the slide deceleration is negative (i.e., the actual deceleration is less than the estimated deceleration) at low slip ratios, then more air is supplied to the brake cylinder. However, if the slide deceleration is positive, then the brake cylinder pressure is held constant. At very high slip ratios air is always exhausted from the brake cylinder.
A bench test, using a full-scale wheel running on a roller rig, was performed to test the methodology. Immediately after the start of braking in simulated wet conditions (water sprinkled at a rate of 200 ml/min on the contact surfaces), a large slide occurred as shown in Figure 3 by the large drop in rotational velocity compared with the translational velocity. This slide caused an exhaust of BC pressure. Though the slide continued after that, the system monitored the status of adhesion, resupplied BC pressure and kept the pressure value high. The mean deceleration (based on the braking distance) over the duration of the brake application was 4.65 km/h/s. This braking performance compares well with that achieved under dry conditions using the same loads and pressing force. The mean deceleration under dry conditions was 4.62 km/h/s.

3. Conclusion

The proposed method of wheel slide protection described above requires detection of the BC pressure and provides wheel slide protection according to the adhesion status by using relationships derived from the equation of the wheel's rotational motion for each axle. The application of this method will lead to a performance upgrade of the whole braking system and is under review, although there are still many issues for practical use.

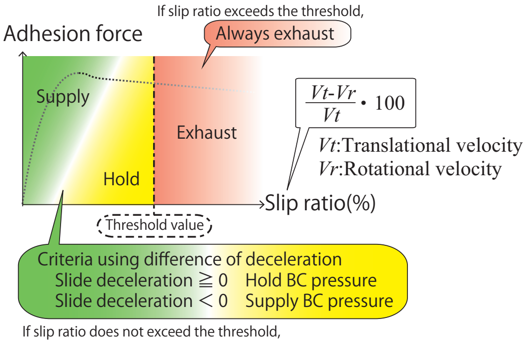


Fig. 2 Basic logics of new wheel slide protection system

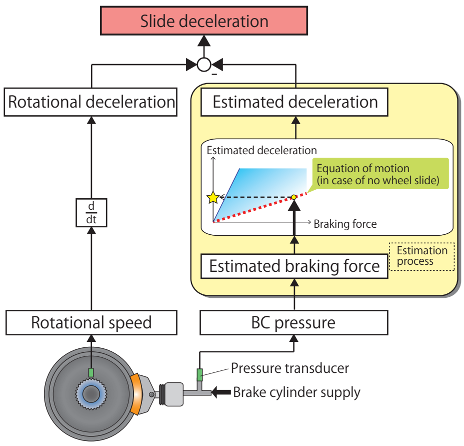


Fig.1 Process of deriving slide deceleration

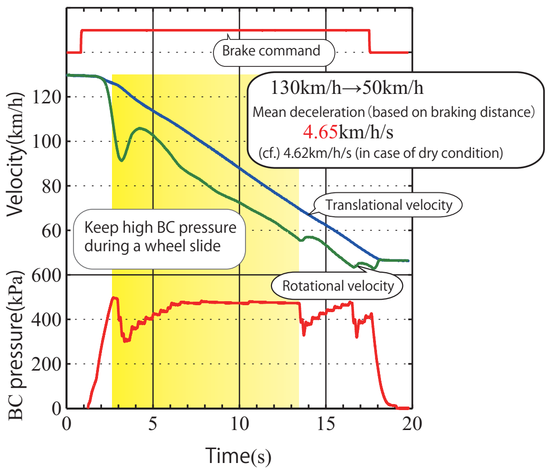


Fig.3 Example of wheel slide protection result

Modeling of Opening at Side Walls of Cut-and-cover Tunnels

Takashi USHIDA
Researcher, Tunnel Engineering, Structures Technology Division

1. Introduction

We have developed a proposed method for modeling the openings in the side walls of cut-and-cover tunnels. Such openings are often needed in construction projects such as the renewal of underground stations with cut-and-cover tunnels. This proposed method enables evaluation of the complicated three-dimensional behavior of a cut-and-cover tunnel with a large-scale opening by using a simplified two-dimensional frame analysis. The applicability of the proposed modeling method has been verified through comparison with a two-dimensional frame analysis using the previous modeling method and a three-dimensional finite element analysis ("FEA"). The method has also been validated through a soil test simulation analysis.

2. Opening modeling method

The proposed method for modeling an opening is shown in Figure 1. The method defines the stiffness of a pseudo beam so that the deformation of the opening's center may be expressed by modeling the top wall at the opening (area immediately above the side wall) as a double-end fixed beam and causing the amount of deflection at the center of the opening span to agree with the amount of shrinkage at the opening in the two-dimensional frame analysis. As a comparison, the previous method modeled the opening in the same way as the method modeled the center pillars. It defined the stiffness of the pseudo beam by considering the average deformation near the opening.

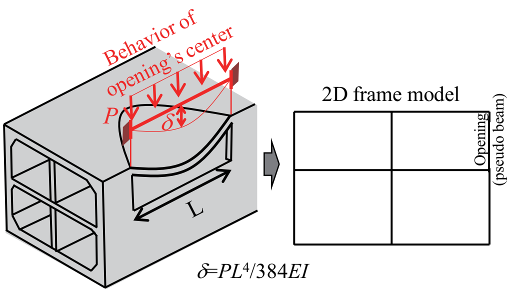
3. Validation of proposed method

First, the result of validation through analysis is shown in Figure 2. When the opening width is small, the results of the three-dimensional FEA, proposed method and previous method (two-dimensional frame analysis) indicate similar values at the focus point. As the opening width increases, the bending moment tends to increase as shown by the result of the three-dimensional FEA, and the proposed method was able to follow that tendency.

Next, the soil test simulation result is shown in Figure 3. In the soil test, an acrylic model of a cut-and-cover tunnel with a one-layer and two-span structure, having an opening equivalent to approximately 10 meters in actual size, was placed in the simulated ground made of the Toyoura sand and loaded with uniformly-distributed load from the top wall. The values calculated in the proposed method repeated or included the test values at the top wall near the opening. Besides, the bending moment (inward tension) was generated at the ends of the top wall, which showed the same tendency as the three-dimensional FEA.

From the comparison between the analytical and test results, we were able to verify the applicability of the proposed method to a renewal construction with a large-scale opening in the side wall.

Finally, I would like to add that a part of this research was supported by the grants of 2011 and 2012 for railway technology development costs, funded by The Ministry of Land, Infrastructure, Transport and Tourism.



=> Determine the stiffness reduction rate of the pseudo beam so that the calculated amount of shrinkage at the opening in the 2D frame analysis agrees with the above amount of deflection.

Fig. 1 Method for modeling side-wall opening

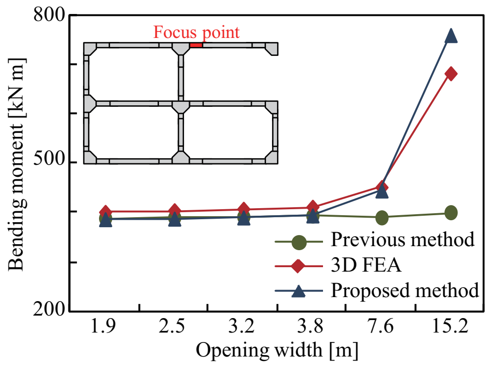


Fig. 2 Relation between opening widths and bending moments

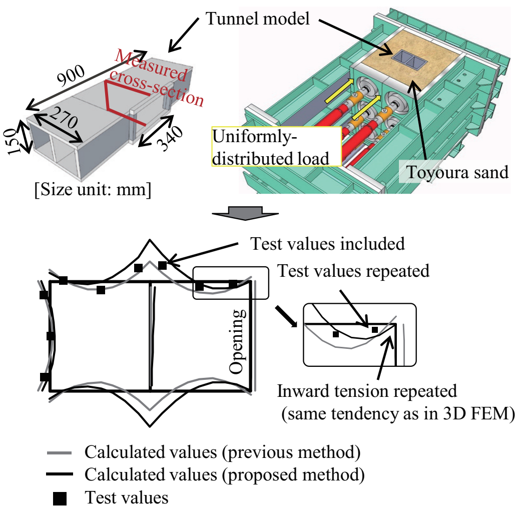


Fig. 3 Test result and analytical result by proposed method