Newsletter on the Latest Technologies Developed by RTRI

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Railway Technology Newsletter

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GENERAL INFORMATION

ARTICLES

An Overview of Research and Development Activities at the Railway Technical Research Institute

Ikuo WATANABE
Executive Director

The Railway Technical Research Institute (RTRI) is promoting a wide array of research and development based on its five-year master plan "Research 2020" from 2015 with the aims of maximizing safety, pursuing cost reduction, enhancing harmony with the environment and improving convenience. For the "Research and Development for the Future Railway Systems" there are four major objectives as shown in Figure 1.

In our efforts to "pursue even safer railway systems," the first objective shown in Figure 1, we are going to develop the bogies that can resist derailment by combining technologies to suppress the decrease of the wheel load and reduce the lateral force. We are also continuously building up technologies for preventing and reducing natural disasters that cause catastrophic damage to railway properties. In the research to "revolutionize railway systems with information network," we are going to propose a more efficient method of maintaining structures by applying information and communication technology (ICT). With the aim of energy saving, RTRI will develop control technology which coordinates vehicles, power feeding systems and train operation systems. For the "speed up of Shinkansen" objective, we are conducting research for prediction, assessment and reduction of a) the aerodynamic sound and pressure variation due to increasing speed, b) micro-pressure waves in tunnels and c) ground vibration. RTRI will also improve adhesive and non-adhesive brake systems for high-speed railways. In order to "construct railway simulators," RTRI is developing a simulator for each constituent system of the railway systems, and will also develop a railway simulator that enables a comprehensive analysis by combining those systems. Additionally, RTRI is continuing the construction of unique, large scale test facilities such as a pantograph testing equipment to evaluate the current collecting performance and a moving-model rig for analyzing the pressure variation phenomena in open sections during high-speed running of a Shinkansen train.

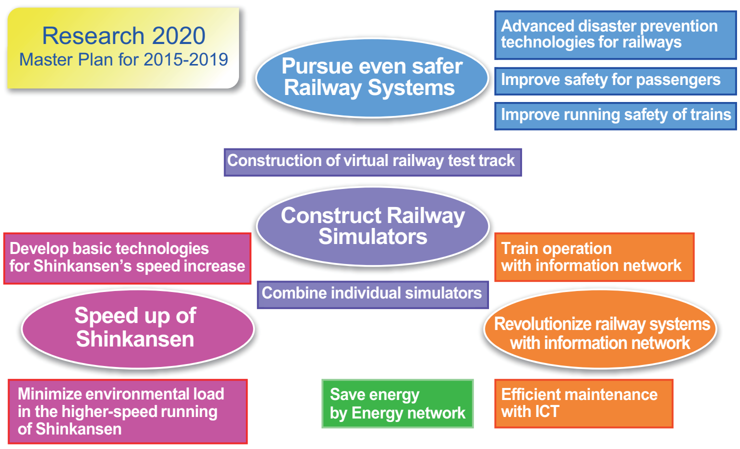
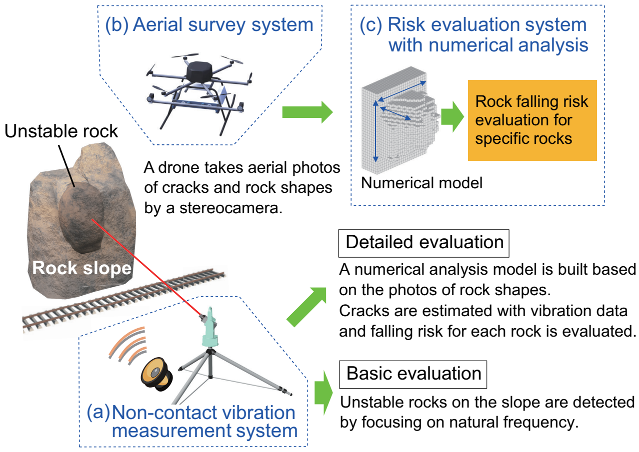


Fig.1 Research and Development for the Future Railway Systems (FY 2015-2019)

RTRI develops new risk evaluation system for falling rocks with laser beam and drone

RTRI developed a new risk evaluation system for falling rocks in order to help prevent the damage by rocks falling from trackside slopes. This system uses laser vibration measurement technology and drone survey technologies. It consists of three subsystems (see drawing on the right). Our system enables us to detect unstable rocks safely and efficiently from a distance.

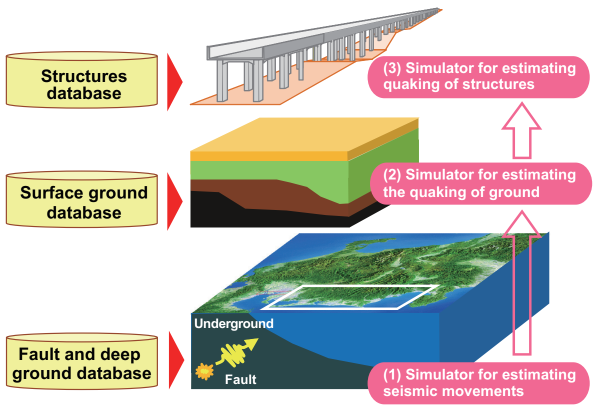
This methodology has been used to test rockfall risk evaluations on real rock blocks. Work will continue on the verification and improvement of the criteria for rockfall risk. Part of this development project was implemented with the subsidy of the Ministry of Land, Infrastructure, Transport and Tourism for railway technical development.



Overview of the new risk evaluation system for falling rocks

RTRI develops a Railway Earthquake Disaster Simulator

The Center for Railway earthquake Engineering Research of RTRI has developed the "Railway Earthquake Disaster Simulator" that can estimate the extent of quaking in a broad area and the resultant damage to railway structures in the event of an earthquake. This simulator can contribute to the formulation of anti-seismic measures, early restoration and evacuation plans. The simulator aggregates data of (1) location and scale of earthquake faults, (2) characteristics of deep ground and surface ground all over Japan, and (3) specifications such as type, height and anti-seismic performance for major viaducts and bridges in respective databases. Based on these data, the system can estimate the damage to structures caused by a certain earthquake on a super computer in a time period which is short enough for practical purposes.



Configuration of the Railway Earthquake Disaster Simulator

Start of a New Joint Study by RTRI and DB Systemtechnik

Since September 2014, RTRI and the DB Systemtechnik (DBST) have been working together on the study of micro-pressure waves in tunnels. Recently, the "Expert Exchange on Micro-pressure Waves" was organized to present an overview of the results of the joint study. Also, a research and development management meeting was held to discuss future cooperative studies. In this meeting, RTRI and DBST agreed to start a new joint study for the assessment and improvement of brake performance. On September 22, 2015, Dr. Kumagai, the president of RTRI and Mr. Lang, the president of DBST signed the agreement on the joint study. Both parties agreed to further expand and reinforce their cooperative efforts specifically in the fields of collision safety, risk analysis and assessment, and efficient maintenance.

Signing the joint study agreement on brake technology

World's Largest Superconducting Flywheel Energy Storage System

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Chief Researcher, Maglev Systems Technology Division

1. Introduction

RTRI has developed a superconducting flywheel energy storage system (Fig.1). It has a large flywheel (4,000 kg with a diameter of 2 m) levitated by an innovative superconducting magnetic bearing devised by RTRI. This system is the world's largest mechanical type of energy storage system that can be discharged and charged. The significant merit of this system is that it implemented high-temperature superconducting technology at a commercial machinery level for sustaining a superconducting state without using a refrigerant such as liquid nitrogen.

2. Superconducting Flywheel Energy Storage System

A flywheel energy storage system works by converting electric energy into the kinetic energy of a flywheel. It can be charged by increasing the revolution speed, and conversely, discharged by decreasing the revolution speed. One of the characteristics of this system is that the flywheel size has been enlarged to raise its output and capacity. Another characteristic is the use of a superconducting magnetic bearing that can levitate such a heavy object weighing about 4 tons and keep the flywheel floated for a long period of time while minimizing the loss of rotating energy. Maximum revolution speed of this system is 6,000 rpm and its output is 300 kW. It has an energy storage capacity of 100 kWh, indicating that this is the largest superconducting flywheel energy storage system in the world.

3. Future Perspectives

While solar power generation gives clean and renewable energy, it is difficult to provide stable power generation. An objective of the newly developed superconducting flywheel energy storage system is to realize smooth output of power generation by concurrently using solar power generation. It is expected that this concept will facilitate stable power supply from solar power generation to grid electricity. Moreover, by installing our system in each electric railway substation, the charging and discharging of the regeneration canceled energy can be implemented, thereby contributing to the improvement of the railway energy efficiency.

The development of this system has been carried out since FY 2012 and is subsidized by the New Energy and Industrial Technology Development Organization.

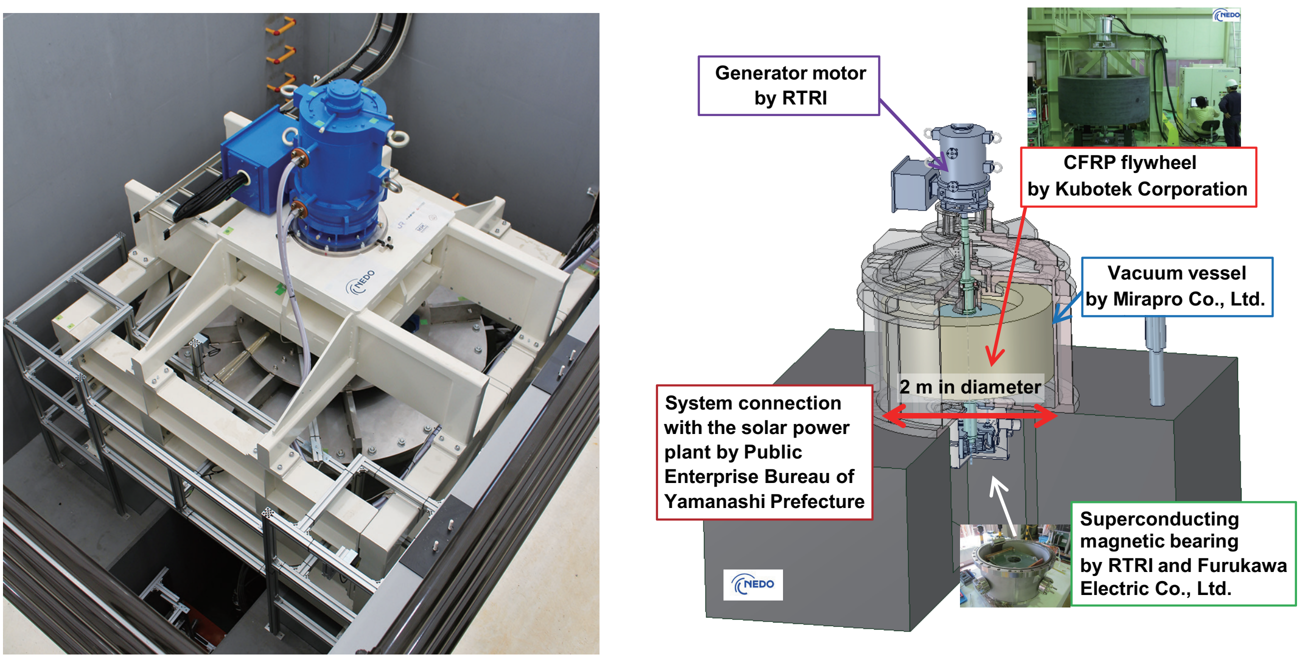

Fig.1 Superconducting Flywheel Energy Storage Unit

Development of Earthquake Information Distribution System

Shunroku YAMAMOTO
Senior Chief Researcher, Laboratory Head, Seismic Data Analysis, Center for Railway Earthquake Engineering Research

1. Introduction

After the occurrence of an earthquake, the effective resumption of train operation and early restoration of facilities will be feasible if the shake map can be accurately determined in areas where no seismograph is installed.

To achieve this objective, we have developed the Earthquake Information Distribution System for railways which estimates vibration distribution and disseminates the data immediately after an earthquake occurs.

2. Overview of the System

Figure 1 illustrates the flow of processing in the earthquake information distribution system. This system starts the processing by using the earthquake early warning (EEW) issued by the Japan Meteorological Agency as a trigger. Subsequent to receiving the trigger, the system automatically obtains the K-NET (nationwide strong-motion seismograph network in Japan) seismic wave data from the National Research Institute for Earth Science and Disaster Prevention. Then, by using the obtained seismic wave data as well as the data pertaining to ground amplification characteristics that have been provided in advance, the shake map is estimated by taking the nonlinearity of ground deformation into consideration. After the estimation, the system updates the website and sends the information to the users by e-mail.

An example of the website image is shown in Figure 2. An estimated shake map is displayed at the left of the website. The shake map can indicate three kinds of railway alarming seismic motion indicators, namely, acceleration, SI (Spectral Intensity) value and measured seismic intensity, each of which can be displayed by switching. In addition, measured values of the seismic motion indicator observed through K-NET are listed at the right of the website.

3. Estimation Precision and Processing Time

We have verified the accuracy of estimation by comparing the estimated value given by this system and the observed value. Figure 3 shows an example of the verification results. From this figure, the estimated error for this earthquake is verified to be approximately 0.5 in the scale of seismic intensity. Further, by using the time recorded in the system log, we verified that the processing time from earthquake occurrence to publicizing the information was 8 to 9 minutes.

4. Future Development

The accuracy of seismic motions can be further improved by processing the seismograph data and ground data of trackside areas measured by railway companies. We will continue to improve the system to achieve even more practical solutions.

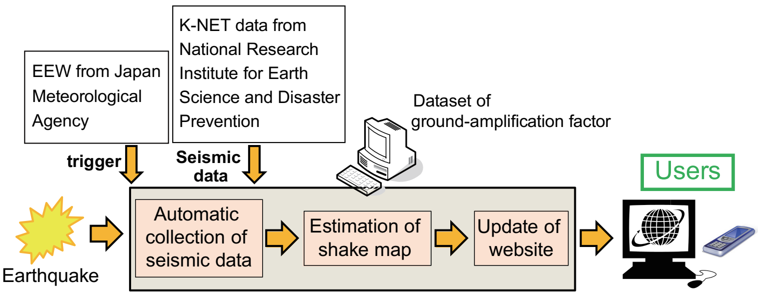

Fig.1 Processing flow in the Earthquake Information Distribution System

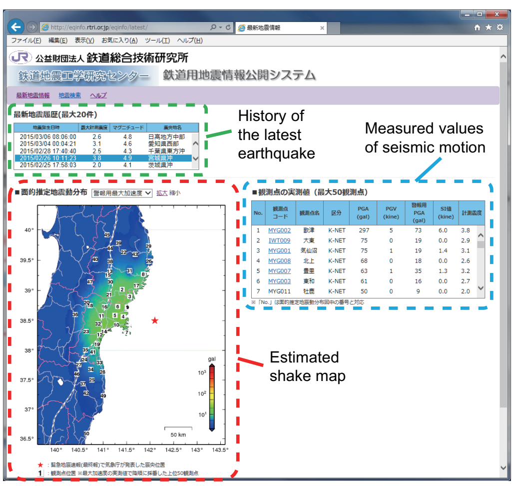

Fig.2 Example of a website image

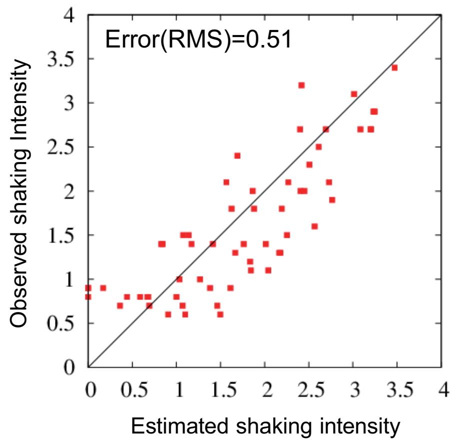

Fig.3 Comparison of Observed and Estimated Shaking Intensities for KiK-net* stations(* another observation network for seismic motion in Japan) (Off Miyagi Earthquake, Feb. 26, 2015)

Reduction of Carbody Flexural Vibration of High Speed Train through High-damping Elastic Support of Under-floor Equipment

Kenichiro AIDA
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1. Introduction

Reduction of flexural vibrations will improve the ride quality of a railway vehicle. RTRI has studied a method to reduce multi-modal flexural vibration and has now developed a high-damping elastic support to the under-floor equipment that reduces the flexural vibration of the carbody. This report describes the vibration measurement test results which verify the vibration reduction performance of the elastic support which is applied to the high speed train (Shinkansen type test vehicle).

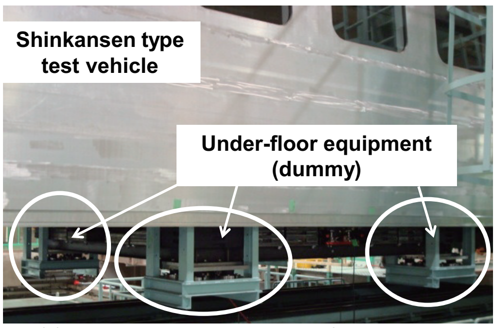
2. High-damping elastic support for underfloor equipment

Our method uses a dynamic vibration absorber that utilizes the under-floor equipment as a mass element and: (1) has no need for cumbersome procedures to adjust the natural frequency or damping characteristics, and (2) has a multi-mode vibration reduction effect.

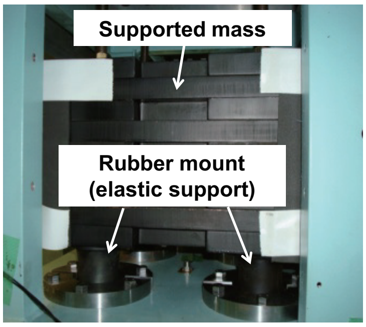
Figure 1 shows how the dummy underfloor equipment was attached to the carbody and supported elastically by simple rubber mounts for the excitation tests. In one Shinkansen train set, most underfloor equipments of several hundreds of kilograms are attached discretely but some vehicles have traction transformers or main traction converters of several tons in the center of the underfloor. In consideration of this situation, following two types of underfloor equipments arrangements (Fig.2) were used for the excitation tests: (a) distributed mass with a set of four dummy under-floor equipment assemblies (about 245 kg/assembly), and (b) one concentrated mass of 3380 kg. Each rubber mount was designed so that the dummy under-floor equipment had a natural frequency somewhat lower than the target frequency. To exert the high-damping properties, the rubber mount was made of butyl rubber.

3. Result of excitation tests

The excitation tests were carried out at the RTRI rolling stock testing plant for the two loading conditions. Both configurations were tested with rigid and elastic (rubber) support mounts. Figure 3 shows the acceleration power spectrum densities (PSDs) on the floor area closest to the central window of the carbody for each loading configuration. (The simulated running excitation corresponds to 240 km/h). The PSDs show large peaks corresponding to two flexural vibration modes at 9 Hz and 11 Hz when the rigid support was used. Both peaks were reduced by the high-damping elastic support and therefore the multi-modal vibration reduction effect was clearly confirmed under both loading conditions (distributed and concentrated mass).



(a) Test vehicle with dummy under-floor equipment



(b) Dummy under-floor equipment

Fig.1 Setting of the dummy under-floor equipment to the carbody

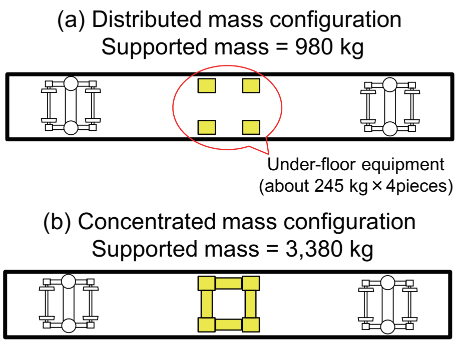


Fig.2 Loading conditions of the under-floor equipment

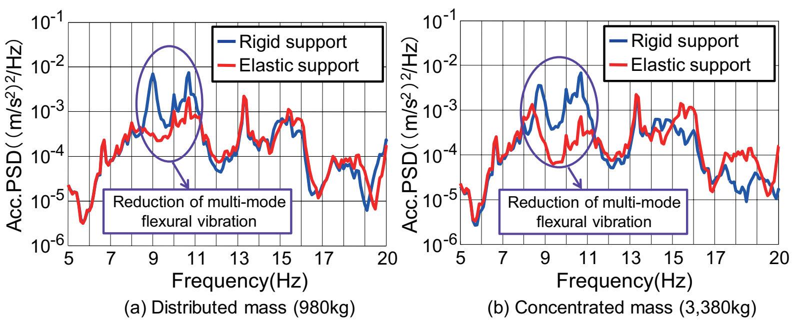


Fig.3 Acceleration PSD on the carbody floor measured under the central window (Simulated running excitation corresponding to 240 km/h)

Development of a Traction Circuit for a Battery-powered and AC-fed Hybrid EMU

Yoshiaki TAGUCHI
Assistant Senior Researcher, Traction Control, Vehicle Control Technology Division

1. Overview of Battery-Powered and AC-Fed Hybrid EMU

The battery-powered and AC-fed hybrid EMU (Electric Multiple Unit) can reduce environmental load and maintenance cost in non-electrified line sections by replacing aged diesel trains. This hybrid vehicle has no engine and, while running in AC-electrified sections, its motors are driven by electric power from overhead contact lines and its on-board batteries are recharged. In non-electrified sections, the vehicle is powered by batteries.

2. Traction Circuit Employed in Test Vehicles

The test train of the battery-powered and AC-fed hybrid EMU (Fig.1) was jointly developed with the Kyushu Railway Company and others. It was completed in March 2013. The first important point of this traction circuit technology that we have developed and introduced to the test train is its direct battery connecting configuration (Fig.2). Since the charging by overhead contact lines is controlled by an existing Pulse Width Modulation rectifier in this configuration, an additional power converter for charging and discharging is unnecessary. Thus the size and cost of the traction circuit can be reduced. The second important point concerns the arrangement of the fuses for the high-voltage lithium-ion battery over 1300 V. In this development project, the traction circuit has been designed to be compact by using small-sized fuses, thus minimizing the use of large-sized circuit breakers and preventing large-scale short circuit failures.

3. Results of Running Tests and Future Efforts

By conducting running tests over three seasons in spring, summer and winter of 2013, we have verified that the new train is fully equipped with such basic performance capabilities as battery-driven operations and rapid charging. Figure 3 shows the results of typical battery endurance tests. After running 30.4 km with battery power only, we could fully charge the battery by executing an 8-minute rapid charge. Furthermore, verification tests on the risks of battery temperature increase have been conducted and it was confirmed that, even in summer time, the battery temperatures can be kept in a sufficiently safe range by forced air-cooling. We also confirmed that the overhead contact line is not overheated even when the battery is under rapid charging.

In the near future, we are going to improve our system and tackle the challenges found in the test train, particularly reducing the charging time at low temperature and increasing battery capacity. We hope this future work will contribute to further the utilization and acceptance of the hybrid EMU.

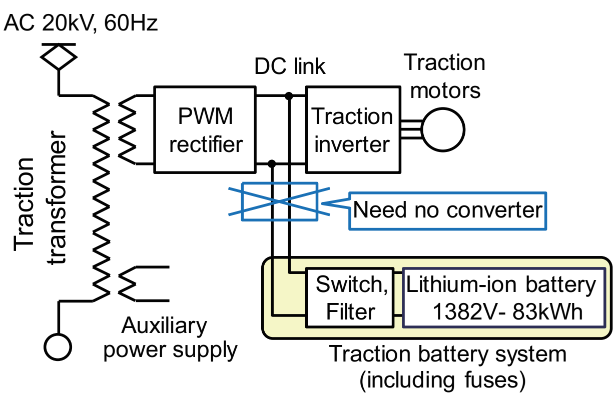


Fig.2 Configuration of the developed traction circuit

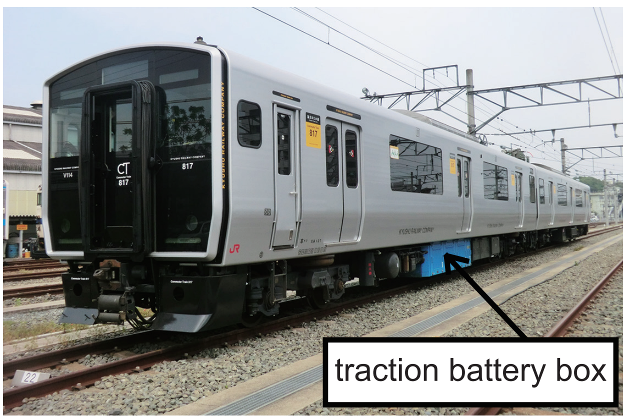


Fig.1 Battery-powered and AC-fed Hybrid EMU (test train)

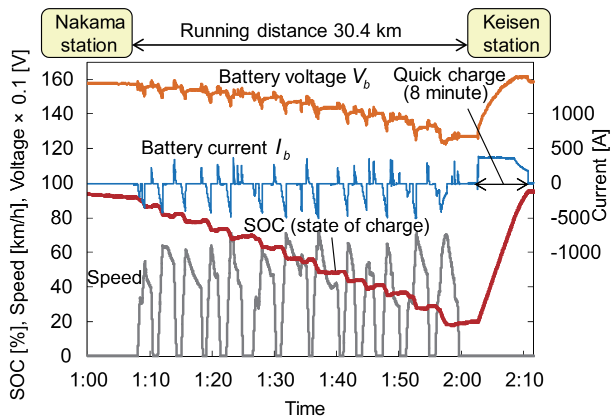


Fig.3 An example of the results of battery endurance tests