Newsletter on the Latest Technologies Developed by RTRI

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Railway Technology Newsletter

August 29, 2014 No.48

GENERAL INFORMATION

ARTICLES

Preface

Masaru TATEYAMA
Director, Marketing and Business Development Division

On April 1, 2014, I was appointed Director of the Marketing and Business Development Division. While RTRI is funded primarily by contributions from the JR-group companies and by governmental subsidies, it also conducts a significant amount of contract business based on individual requests from the nation, railway operators, and other private firms. The annual revenue of the RTRI is approximately 18 billion Japanese Yen including 3 billion Japanese Yen of contract business. Our division has the mission of managing the contracted business itself and pursuing business development opportunities based on RTRI's research achievements.

Specific content of the contract business includes assessment and diagnosis tasks, and design and inspection projects for railway facilities. Examples of business development opportunities based on the research achievements of the RTRI include implementation of a seismic-preventive system (Earthquake Early Warning System for Railways) and the sale of design and analytical programs for railway structures. License income from patent and other intellectual properties are also included in business revenues, and technologies such as semi-active suspensions and ladder sleepers are already developing business operations overseas.

While serious derailment accidents which took place in recent years around the world may still be fresh in our memories, several accidents in Japan caused by earthquakes, landslides, or maintenance problems have raised people's awareness of railway safety. The RTRI has investigated the causes of such natural disasters and derailment accidents, and developed preventive measures, as a part of its contract business. The RTRI will continue contributing to the enhancement of railway safety in the future through these new business fields.

Center for Railway Earthquake Engineering Research Opens

RTRI opened the Center for Railway Earthquake Engineering Research on April 1, 2014. There is increasing concern about the risk of seismic disasters particularly if gigantic earthquakes spread wider and get more complex. In order to achieve safer and more secure railway systems by coping with these issues, the center was established as a unique "base site" for railway-seismic technology in Japan. The center also integrates our research resources on quake-motion, seismic engineering, and early alarming. It incorporates three research groups; Seismic Data Analysis, Soil Dynamics and Earthquake Engineering, and Structural Dynamics and Response Control.

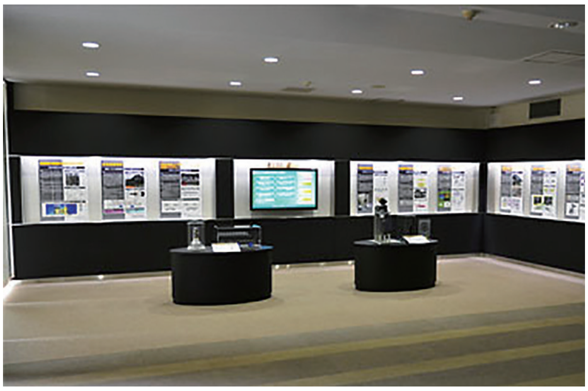
President Norimichi KUMAGAI (right) and Director, Center for Railway Earthquake Engineering Research Yoshitaka MURONO (left)

Customers Square Opens

The RTRI opened an exhibit space "Customers Square" on March 25, 2014 in the entrance lobby in order to let visitors, including railway operators, become familiar with the RTRI's research and development results. The Customers Square mainly shows RTRI's technical achievements which are ready to be utilized.

Displays include panel presentations and hands-on full-size exhibits. The full-size models currently on display are the vibration suppression control system employing variable vertical dampers and a superconducting cable for railways. The exhibits will be periodically updated in the future.

Unveiling Ceremony



Customers Square

Visit of a Group Headed by the Councilor for Science and Technology from the Embassy of France

On the last April 21, RTRI invited a party from the French Embassy which was headed by the Councilor for Science and Technology. We welcomed four visitors; Mr. Jacques MALEVAL (Councilor for Science and Technology), Mr. Kaddour RAISSI (Attaché for Science and Technology), Ms. Evelene ETCHEBEHERE (Attaché for Science and Technology), and Ms. Terry OUZARA (Deputy Attaché). After introducing the principal activities of RTRI's research and development program, we exchanged views about energy, environment, and information & communication technology which the Science and Technology Division, Embassy of France is responsible for. We also discussed the general area of transportation including railways. Afterwards, our guests enjoyed a tour of our major R&D facilities.

A group photo with visitors from French Embassy

Estimation of Lateral Resistance of Ballasted Track during Seismicity

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1. Introduction

Japan is one of the world's most earthquake-prone countries and enhancing the safety of railway structures against earthquakes is critical. Several safety issues in train operation caused by earthquakes have been reported so far. Among those examples, we have found some cases in which ballasted tracks are notably deformed, although no significant or harmful deformation was recognized in the structures or roadbeds. The ballasted track deformation caused by earthquakes are characterized by remarkably large horizontal displacements in the direction perpendicular to the rail. This is considered to be caused by decline in ballast lateral resistance caused by these seismic ground motions. However, the mechanism of ballasted track deformation during seismicity has not been fully defined. Therefore, we studied the characteristics of ballast lateral resistance during seismicity by performing Large-scale Shaking Table tests using a full-scale mockup. During the test we also estimated the seismic capacity of ballasted track in both straight and curved track sections.

2. Outline

This test assumed a ballasted track of a typical cross-sectional shape for Shinkansen on a viaduct. The test configuration consisted of four sets of mockups placed on a shaking table, and each set includes one full-scale sleeper tested at a time (Fig. 1). Two track configurations were simulated: curved track simulated with a superelevation (cant) of 200 mm and straight track simulated with no superelevation. To estimate the ballast lateral resistance during vibration, we used a spring attached to each sleeper and applied tensile loads while measuring sleeper displacements. We also performed a lateral ballast resistance test before and after sinusoidal vibration (input acceleration of 800 gal) and estimated the ballast lateral resistance before and after vibration. (1 gal = 0.01 m/s^2.)

3. Test results

Fig.2 shows the relationship between the lateral resistance before and after sinusoidal 800 gal vibration. The lateral resistance declined after vibration regardless of the ballast shapes, i.e., curved or straight track simulation. Fig.3 shows the horizontal displacements of the sleeper measured when a tensile load of 4 kN was applied during vibration. The horizontal displacement of the sleeper increased abruptly during sinusoidal 700 gal vibration regardless of the ballast shapes. It has become clear from these tests that even if a tensile load during vibration is smaller than the maximum ballast lateral resistance after vibration, a large residual displacement is induced during vibration. The test results have also indicated that the geometric difference of ballasts has little effect on the lateral resistance before, during and after vibration.

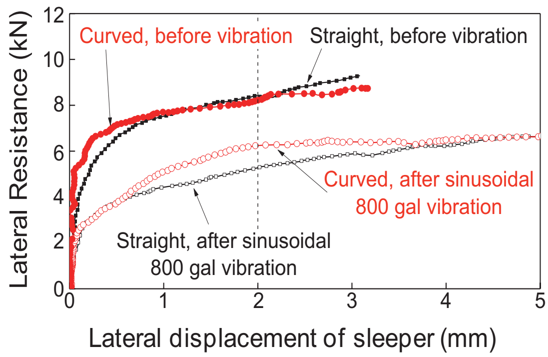

Fig. 2 Lateral resistance before and after 800 gal vibration

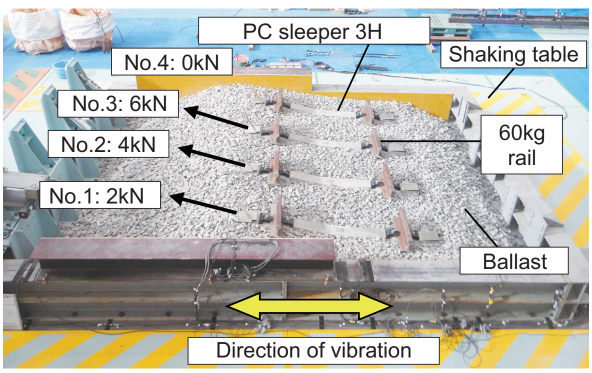

Fig. 1 Status of Large-scale Shaking Table test (sloped (with cant))

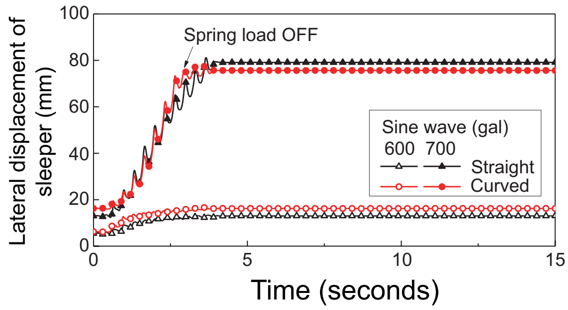

Fig. 3 Sleeper displacements during vibration (Straight: Tensile load 4 kN)

Climatic Conditions Causing Snow Accretion on Shinkansen Bogies

Yasushi KAMATA
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1. Introduction

Shinkansen trains operating in snow area have snow accretion countermeasure, like body mount system, to prevent from heavy snow accretion. However, shapes of the car bogies are complicated and then snow accretion easily occurs. When the deposited snow and ice on the bogies falls off the car, it can damage facilities. At present, snow removing operations are performed at stations to prevent such damages. In order to effectively implement such operations, it is necessary to predict the volume of snow accretion, which causes problems of trackside facilities, from climatic conditions.

2. Outline

In this study, by using data of snow accretion amount on sides of the bogies measured at a Shinkansen station, we analyzed the relationship between these snow amounts and the number of damage cases presumably caused by snow falling from trains. This enabled us to determine the snow accretion amount of high probability of snow fall damage. Subsequently, we analyzed the relationship between air temperature and precipitation along the Shinkansen track line, and proposed an predicting method of the snow accretion amount based on the air temperature and precipitation.

3. Test results

We divided the snow accretion into 9 classes and examined the percentage of the number of trains that presumably caused damage by the snow falling off to the number of trains that had snow accretion in each class (Fig. 1). It was clarified that when the snow accretion amount exceeded 0.06m^3, the damage occurrence percentage was increased, although the number of trains was small in such class.

As a result of statistically analyzing of weather conditions when snow accretion amount exceeds 0.06m^3, the average air temperature *Ta* of the time when the surveyed train was running near the weather observation point, was under -3.5 °C (Fig. 2). It was indicated in Fig. 3 that a positive relationship between the snow accretion amount (*V*) and the average value (*W*) of cumulative precipitation for 11 hours before the time when the surveyed train was running near the weather observation point. Thus the following regression formula was obtained:

$V = 0.0285 + 0.0114 \times W \quad (Ta \leq -3.5\ °C)$

In the surveyed track line, this formula enables us to estimate of snow accretion amount (*V*) from the air temperature (*Ta*) and the precipitation (*W*). Using this formula, it can be assisted in determination whether snow removal operations is necessary or not.

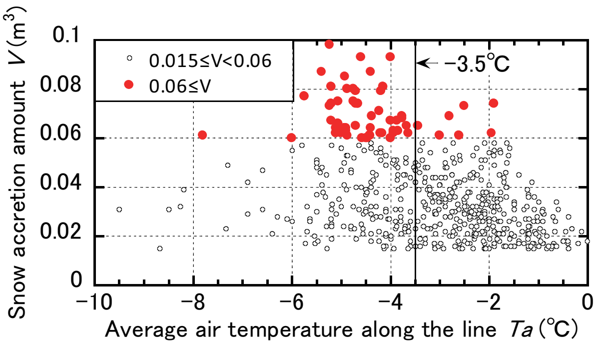


Fig. 2 Relationship between average air temperature along the track line and snow accretion amount

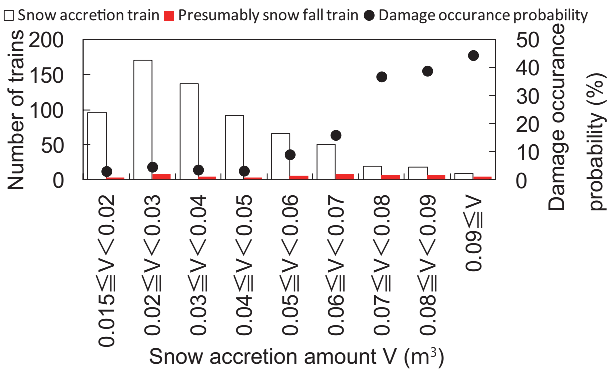


Fig. 1 Relationship between snow accretion amount and damage occurrence probability

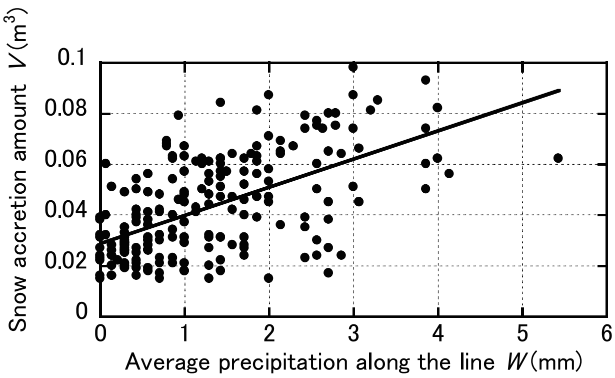


Fig. 3 Relationship between snow accretion and average precipitation along the line (for cumulative 11 hours) which has average air temperature below -3.5 °C

Enhancing the Function of the Train Operation Forecast Simulation System

Yoko TAKEUCHI
Assistant Senior Researcher, Transport Operation Systems, Signaling and Transport Information Technology Division

1. Introduction

In this study, we have implemented a program to enhance the existing train operation forecast simulation system that includes train operation and passenger behavior simulators. The goal of the study was to be able to evaluate train operation plans with higher precision by reproducing small scale delays that would occur on a daily basis in high density urban operation and to determine the impact of these small delays on the behavior of train groups.

2. Background of the Study

In a period of high frequency operation such as morning rush hours in an urban area, delay propagation is likely to occur. The propagation begins when an increase in train standing time occurs due to passenger concentration on a specific train. This results in the train being delayed and the operating interval increases between this train and the one ahead. The delayed train will then become the more crowded resulting in further delays. In turn, this delay gives rise to a higher likelihood of making the following train vulnerable to the signal-induced speed limit, and thus the delays can propagate readily. Accordingly, when evaluating a train operation schedule, these conditions need to be simulated in detail. Unfortunately, however, the currently available simulators have been unable to provide an accurate evaluation while taking these conditions into consideration.

3. Details of the Implementation

In the calculation of travel time between stations with the use of an available simulator, the signaling conditions are not taken into consideration. Thus the simulations tend to become simplified calculations to determine the running time based on a) the departure time at the last station, b) the predetermined shortest travel time between stations, c) the minimum required operation interval and d) the specified arrival time. Consequently, travel time between stations cannot be estimated precisely when a train is subjected to a speed limit by means of signaling.

Accordingly, we first developed the function to calculate travel time between stations when train operations conformed to signaling conditions by simulating the signaling status. Secondly, we analyzed the influence of the passengers' behavior, signaling conditions and operating method on actual train operations to compile Fig. 1, and installed a simulator that takes accounts of these interrelationships. To verify the effectiveness of the system, we prepared the data of a model line section. Fig. 2 shows an example display screen of the simulated results. Besides the train operation diagram, the system can display the number of occupants in each coach of a train, the degree of passenger congestion in each coach, the number of people waiting to board at each station, the operating method exercised between stations, the train locations, signaling conditions and other factors recognizable on the operation diagram.

The new train operation forecast simulation system can evaluate the railway operation from every conceivable aspect. We are considering deploying this simulation system in other applications such as evaluating energy consumption and train control systems.

Note that this series of studies is funded by a Technology Development Grant from the Ministry of Land, Infrastructure, Transport and Tourism.

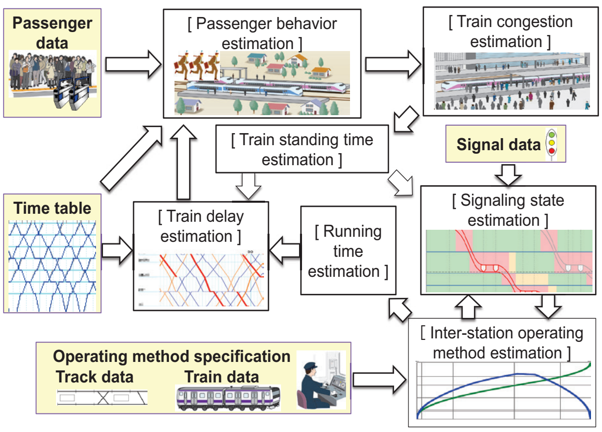
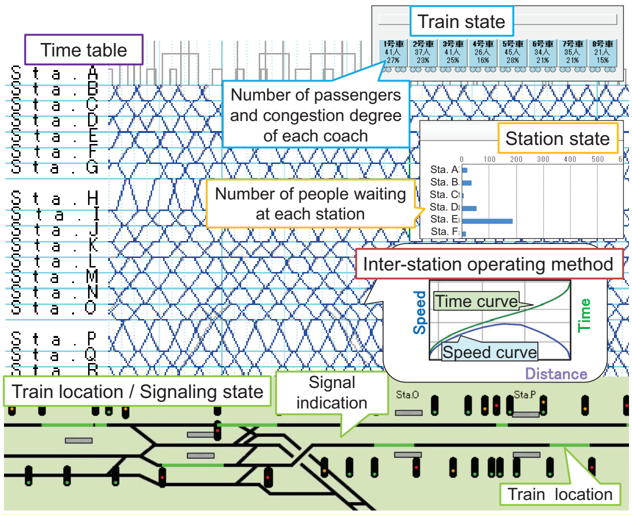


Fig. 1 The influence of passengers' behavior, signaling conditions and operating method on the train service status



No. of stations: 20, Total track length: approx. 22 km, Total No. of trains: 1,072
Total No. of passengers: approx. 193,000, Calculation time per day for train diagram formulation: 17 minutes and 30 seconds (a general purpose PC employed)

Fig. 2 Example display screen of simulation results of a model line section

Application of X-ray Fourier Analysis to Rolling Contact Fatigue Layer of Rail

Motohide MATSUI
Senior Researcher, Frictional Materials, Materials Technology Division

1. Introduction

Railway rails undergo plastic deformation due to repetitive contact with wheels resulting in the formation of a rolling contact fatigue layer on and underneath the contact surface. Experimental evaluation of the rolling contact fatigue layer has been attempted in a variety of ways. However, none of these past attempts has successfully obtained the consistent quantitative evaluation of the rolling fatigue layer from the contact surface down through rolling contact fatigue layers in the rail. The quantitative evaluation has been particularly difficult on the top surface layer. Thus, we have attempted to apply the X-ray Fourier Analysis Methodology with the objective of quantitatively and consistently evaluating the top surface and downwards through the inner layers of the rolling contact fatigue region of the rail.

2. X-ray Fourier Analysis Method

X-ray Fourier analysis refers to an approach that can determine the plastic deformation state of ferrite grains constituting the rail steel by using X-ray diffraction measurement, and subsequently analyzing the obtained diffraction data including the peak positions, its strength and shapes . From these data, the X-ray crystallite size and dislocation density can be estimated as indicators related to plastic deformation. Fig. 1 summarizes the X-ray diffraction measurement. In our case, we applied the X-ray diffraction method to small test pieces cut out from a rail, and conducted an X-ray Fourier analysis of the resultant diffraction data.

3. Results

Part of the X-ray diffraction data obtained is shown in Fig. 2. In comparison with an unused rail, the test rail (installed rail) data shows diffraction peaks that vary broadly under the influence of the plastic deformation due to rolling contact fatigue. Fig. 3 shows the results of X-ray Fourier analysis of the resultant diffraction peaks at depths ranging from the top surface down through the rail to inner layers displaying rolling contact fatigue. As shown, the X-ray crystallite size increases and the dislocation density decreases at greater depths from the contact surface. This confirms that plastic deformation due to rolling contact fatigue decreases below the contact surface of the rail. Thus, the X-ray Fourier analysis can not only produce a quantitative evaluation of the contact surface of rolling contact fatigue layer, but also can serve as an approach to analyze a broad region below the contact surface of the rail. Further examination of this analysis approach is expected to help determine the formation process in the rolling contact fatigue layer of a rail, thereby contributing to enhance the efficiency of maintenance actions such as rail grinding and replacement.

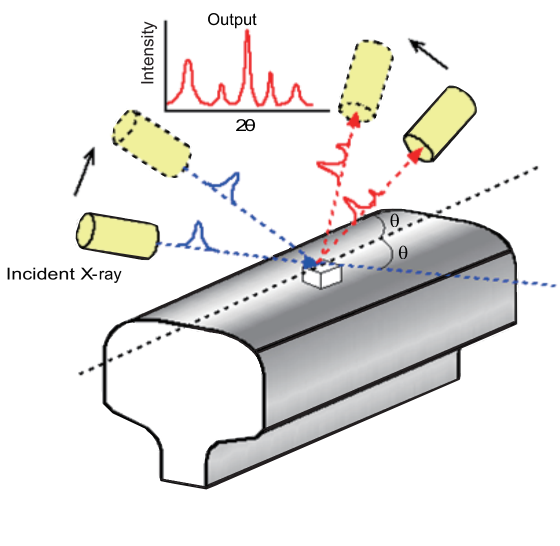


Fig. 1 Overview of X-ray diffraction measurement

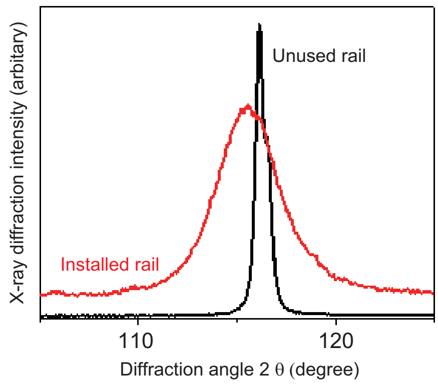


Fig. 2 Variation of diffracted peaks

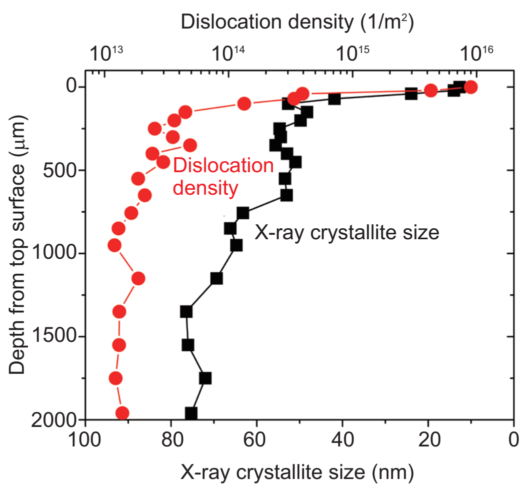


Fig. 3 Results of X-ray Fourier analysis applied to an installed rail (tangent rail, accumulated passing tonnage: 500 MGT(million gross tonnes))