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Railway Technology Avalanche

Newsletter on the Latest Technologies Developed by RTRI

No. 5

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2-8-38 Hikari-cho, Kokubunji-shi
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GENERAL INFORMATION

ARTICLES

Foreword

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Manager, International Affairs, Information & International Affairs Division

I am very happy to have an opportunity to introduce myself on the 5th issue of "*Railway Technology Avalanche*." I have come back to International Affairs of Railway Technical Research Institute (RTRI) in July 2003 after about three-year absence. My final task of the last period at the Section was to support the 4th World Congress on Railway Research (WCRR) held at RTRI in 1999 as a manager of secretariat (hard but exciting days!). I would like to send my sincere regards to the secretariat of the 6th WCRR held at Edinburgh for its great success.

Four years ago at that time, we did not have this newsletter. As technologies of railway systems are quickly changing, it is significantly important to exchange high-quality information globally and timely. I believe that our newsletters contribute to your activities on collecting useful information on current railway technologies. The following pages have articles presenting a few examples of RTRI's principal researches. We think that it is helpful to you in easily understanding our work, not only technical aspects of the researches but also persons engaged in these researches. So the articles include their photos in their original working circumstances. Please remember their faces (including me, of course). Some day in the future, you may have a chance to meet some of them in your country or in Japan. Your memory shall bring fruitful relationships among us.

Goto, Koichi, PhD

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The editor will absolutely welcome all your inquiries on the article(s) published in "*Railway Technology Avalanche*." Moreover, your reliable contact information including your name, title, as well as e-mail and regular-mail addresses will be helpful to the editor in delivering "*Railway Technology Avalanche*" to you without fail.

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Visit Us through *Rail. Tech. Avalanche*

Sakai, Hiroyuki
Editor, *Rail. Tech. Avalanche*

You must have enjoyed the tour in the premises of Railway Technical Research Institute, which is conducted by the editor. Let me take you to another spot, in which you would have interest, if you are a worker on train operation. But, I know, all the visitors to the tour can be attracted to the scene of the site. This is because visual information basically ensures easy understanding.

TRAIN OPERATION SIMULATOR

Outline. This simulator, which is used for the following researches, exactly imitates an actual driving console as well as wayside scenes and incorporates all the basic elements of train operation, in order to reproduce train operation close to that under actual conditions in a laboratory.

-Investigation of the processes to cause human errors, dozes, and fatigue of drivers while in train operation.

-Evaluation of the train operation performance of the aged and female drivers.

-Evaluation of work loads under different operating conditions such as train types and speeds.

Feature. This simulator:

-Enables the setting of error-inducing factors depending on the test purpose (aspects of departure and block signals, door opening/closing time, emergency brake release time).

-Allows the simultaneous recording of the information on train operation including signal types, signal aspects and gradients, subject's operation, powering and braking, and movement of visual axis, brain waves and other somatological information.

-Has a navigation function (with voice and images) to inform the driver of the timing to acknowledge signals and perform braking operation, in order to expedite the acquisition of the skill in train operation.

Table 1. Major Dimensions

-Driving cab	
Size	3.0 m (depth) × 5.0 m (width) × 3.0 m (height)
Screen	Type 90 flat screen
Monitoring camera	3 sets
-Route	
Section	Up- and down-tracks for 16.7 km (10 stations)
Operation time zone	Daytime, twilight, nighttime
Weather	Clear, cloudy, fog
ATC system	Speed check type
-Vehicle	
Load factor	0, 100, 200%
Acceleration	4 stages (average 2.7 km h^{-1} s^{-1})
Deceleration	8 stages (maximum 4.0 km h^{-1} s^{-1} for service, 4.7 km h^{-1} s^{-1} in emergency)

Remarks. This simulator was completed in fiscal 2001 with a subsidy by the Ministry of Land, Infrastructure and Transport, Japan.

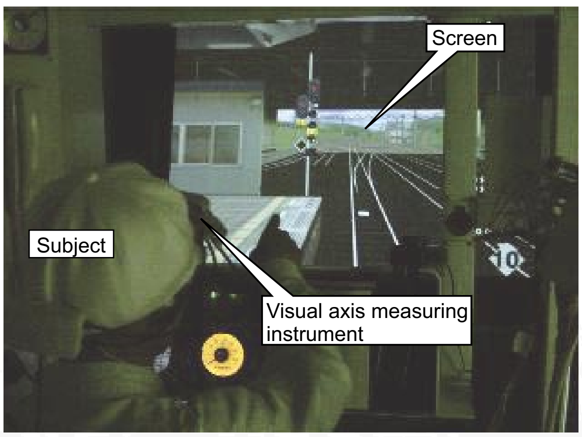

Figure 1. Scene of the driving cab in test.

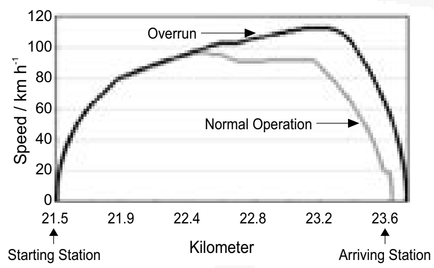

Figure 2. Example of train performance curve between two stations.

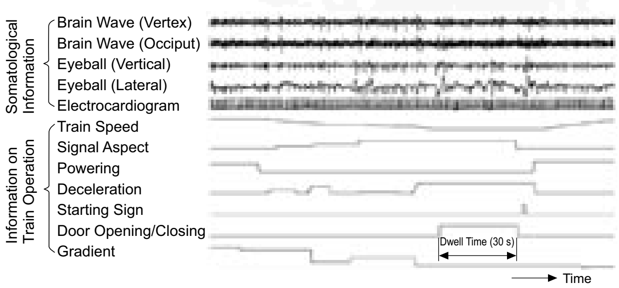

Figure 3. Example of the simultaneous recording of somatological and operating information.

Figure 4. Distribution of the visual axis dwell time during operation on a straight section. Larger circles mean that the visual axis dwells at the position for longer periods of time.

Well, at this moment, I will recommend that you proceed two more spots, if you can take time. Here are working sites for study on civil engineering as well as rolling stock engineering. The former must be the civil engineering site where you are going to be for the first time. Stay here for a while and find them interesting.

TWO-AXIS ALTERNATE LOADING TEST MACHINE

Outline. This machine is used to implement static alternate (repeated) loading tests of reinforced concrete columns, steel columns, and other structural members.

Features. This machine is equipped with two abutment test walls monolithic with a test bed to simultaneously apply horizontal and axial loads to the specimen to perform widely-ranged tests.

Remarks. This machine has two abutment test walls that are perpendicular to each other. RTRI is now discussing how to make the best use of its special features.

Table 1. Major Dimensions

-Loading device	
Main hydraulic jack	Maximum load, ± 2,000 kN; Maximum displacement, ± 250 mm
Auxiliary hydraulic jack	Maximum load, ± 2,000 kN; Maximum displacement, ± 200 mm
-Reaction equipment	
PC abutment test wall (2 sets)	6.7 (9.0) m (width) × 6.5 m (height) × 2.0 m (thickness)
PC test bed	8.7 m (width) × 11.0 m (height) × 2.0 m (thickness)
Steel reaction frame	4.0 m (width) × 2.5 m (height) × 5.5 m (thickness) (Maximum span between column and beam centers)

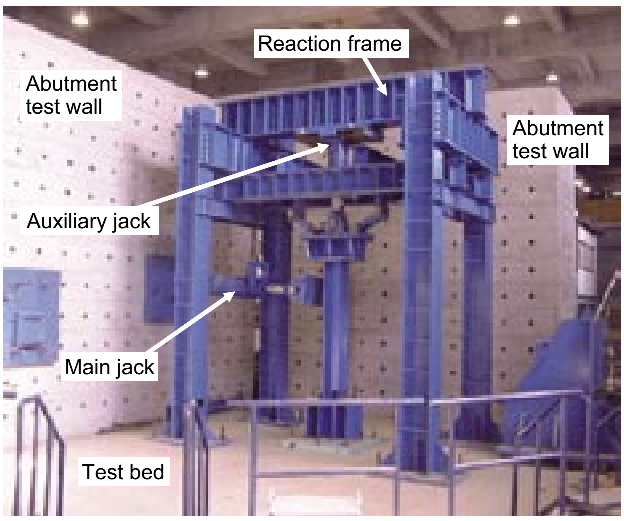

Figure 1. General view and test scene of a steel structural member.

Figure 2. Test scene of a concrete member.

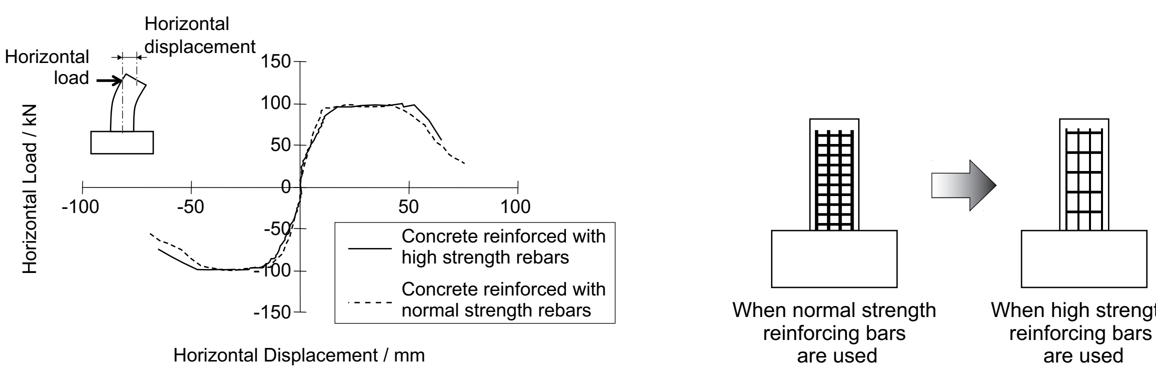

Figure 3. Comparison of the dynamic performance of concrete members reinforced with high and normal strength rebars. To improve the economy and the precision of casting concrete for reinforced concrete structures, Railway Technical Research Institute (RTRI) has promoted researches on the concrete reinforced with high strength rebars and found that the volume of reinforcing bars can be reduced while maintaining the dynamic performance equal to that of the concrete reinforced with normal strength rebars.

BRAKE PERFORMANCE AND DISK BRAKE TESTING MACHINES

Outline. The brake performance and disk brake testing machines are used to evaluate the properties of friction materials under the same conditions including inertia and speed as those in actual train operation.

-Brake performance testing machine

The brake performance testing machine is composed of a disk brake test unit, a tread brake test unit, and an adhesion test unit, each equipped with a sprinkler and a snowfall simulator.

-Disk brake testing machine

The disk brake testing machine is composed of a low-speed test unit and a high-speed test unit.

Features.

-Brake performance testing machine

The brake performance testing machine is used to test locomotives, EMUs for commuter transport and Shinkansen cars under widely-ranged test conditions, by controlling the brake shoe pressing force, deceleration, and torque in order to investigate the adhesion characteristics of disks, friction materials, rails and wheels, and is also used to perform the above test with hot water sprinkled on the track or at artificial snowfall simulated with liquid nitrogen.

-Disk brake testing machine

The disk brake testing machine is used to test the brake system of high-speed Shinkansen cars, for the stopping brake in emergency and service brake patterns or repeated at certain time intervals, and the holding brake on simulated down-gradients. The speed of the high-speed test unit is set at 2.5 times that of the low-speed test unit to test high-speed sliding materials and new disk brake systems used at higher speed than that of the conventional disk brake system.

Table 1. Major Dimensions

-Brake performance testing machine	
Maximum test speed	500 km h^{-1} (converted to the speed of ϕ860-mm wheel)
	580 km h^{-1} (adhesion test unit)
Maximum rotating speed	3,100 rpm
Diameter of test disk	ϕ350 to ϕ780-mm
Diameter of test wheel	ϕ700 to ϕ1,120-mm
Output of DC motor	350 kw
Temperature of sprinkled water	2 to 25°C
-Disk brake testing machine	
Maximum test speed	486 km h^{-1} (converted to the speed of ϕ860-mm wheel)
Maximum rotating speed	3,000 rpm (low-speed test unit)
	7,500 rpm (high-speed test unit)
Maximum diameter of test disk	ϕ780-mm (low-speed test unit)
	ϕ500-mm (high-speed test unit)
Output of DC motor	132 kW

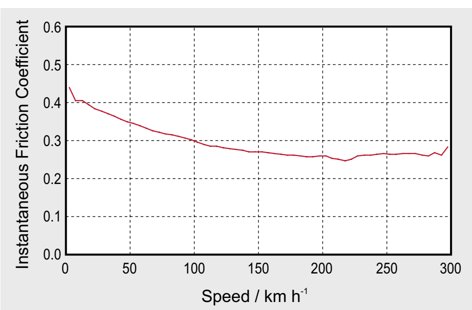

Figure 1. Friction coefficient of disk brake when the emergency brake is applied at 300 km h^{-1}.

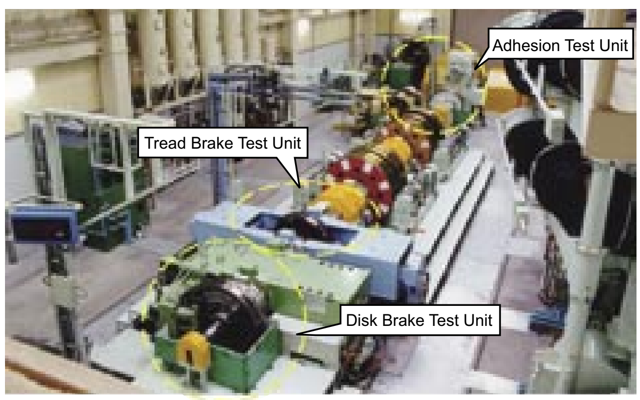

Figure 2. Brake performance testing machine.

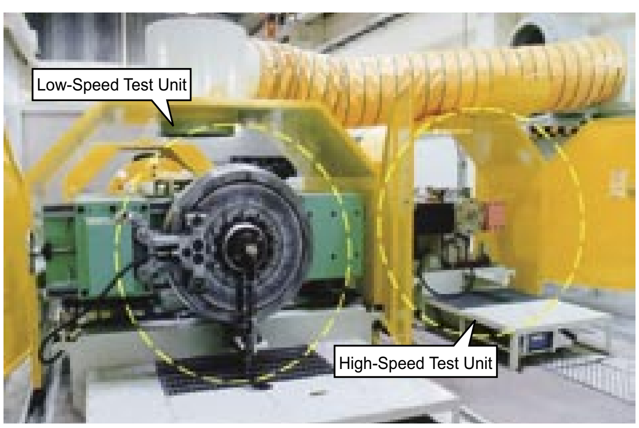

Figure 3. Disk brake testing machine.

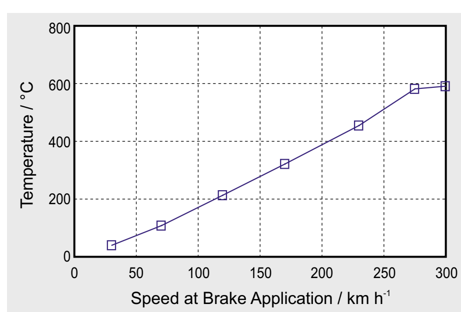

Figure 4. Maximum temperature of brake disk.

Evaluation of Tunnel Face Stability by the Rigid Plasticity Finite Element Method

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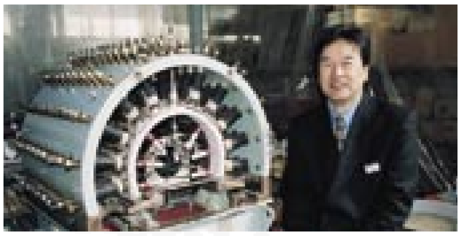

The stability of tunnel faces is one of the most important subjects in the tunnel construction even in urban areas. We have been studying a method to evaluate the conditions for face stability through model tests and numerical analysis by the rigid plasticity finite element method. While taking note only on the plastic state of the ground, the rigid plasticity finite element method uses the upper bound theorem to formulate limit analysis by the finite element method, which aptly expresses the current state at the moment when the ground starts collapsing and, therefore, is effective for the evaluation of the bearing capacity and the stability of slopes and tunnel faces.

Figures 1 and 2 show the face collapsing process and the final state of collapse of the sandy ground observed in a model test, respectively. Figure 3 shows the results of simulation by the two-dimensional rigid plasticity finite element method, in which the arrow mark represents the displacement velocity vector. The result of simulation and the first stage of collapse are in good agreement.

In urban areas in Japan where alternate sand and cohesive soil layers are dominant, however, there are few homogeneous ground conditions. Therefore, we expressed the conditions for the face stability in the ground of alternate layers with apparent cohesion, internal friction angles, and cohesion of soil layers (Fig. 4). The zone on the left hand side indicates a combination of the conditions for face stability, and that on the right hand side a combination of the conditions for the face instability.

Figures 5 and 6 show the results of three-dimensional analysis. The distribution of vertical earth pressure in the horizontal section when the face collapses shows that the vertical earth pressure in the sliding area decreases due to stress re-distribution and that around it increases (Fig. 5). In the transversal section (Fig. 6), the vertical earth pressure decreases in the sliding area ahead of the face, and the stress in the ground increases around the shoulder outside the tunnel covering work. This means that the ground shall be reinforced at this position before excavation, if it is so desired, in order to secure face stability.

It is possible to apply the rigid plasticity finite element method to the evaluation of tunnel face stability even if it is under complicated ground conditions.

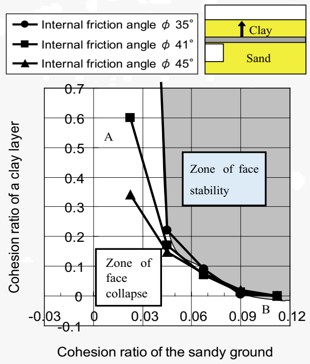

Figure 4. Conditions of cohesion in the sandy ground, internal friction angles, and cohesion of soil layers for the face stability in the ground of alternate sand and cohesive soil layers. The cohesion is normalized by the initial vertical earth pressure at the middle level of the tunnel. All the marks indicate the values dependent on the internal friction angle of the sandy ground.

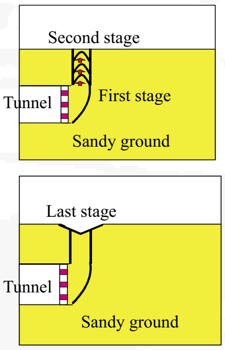

Figure 1. Process of face collapse in the sandy ground.

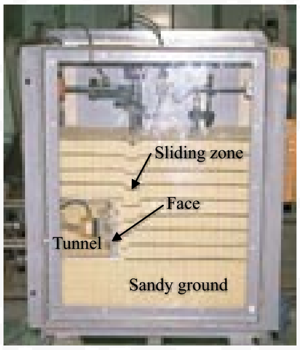

Figure 2. Face collapse in the sandy ground.

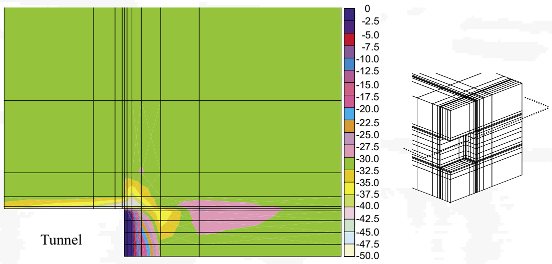

Figure 5. Distribution of vertical earth pressure in the horizontal section at face collapse (sandy ground, on the crown level). The graduation of the scale on the right hand side divides the maximum vertical earth pressure (8.49 kPa) into 20 fractions.

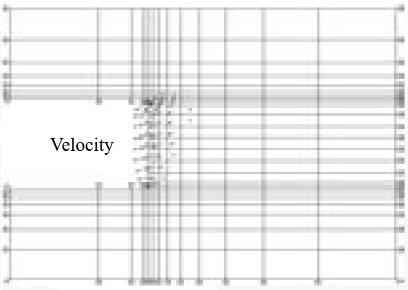

Figure 3. Results of analysis by the rigid plasticity finite element method (face collapse in the sandy ground).

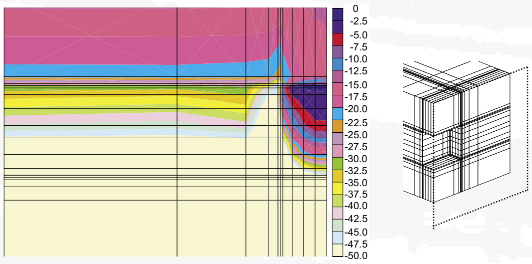

Figure 6. Distribution of vertical earth pressure in the transversal section at face collapse (sandy ground, ahead of the face). The graduation of the scale on the right hand side divides the maximum vertical earth pressure (8.49 kPa) into 20 fractions.

Development of Earthquake Resistant Bridge Abutment (Reinforced with Cement-Mixed Earth)

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INTRODUCTION

Since embankments have voids, they tend to settle when shaken at earthquakes, to a large degree in particular behind a bridge abutment added with the settlement due to the deformation caused by its forward inclination (Fig. 1), which has been pointed out for long to compromise the stability of train running.

Figure 2 shows the settlement behind a bridge abutment seen after the Hyogoken-Nambu Earthquake that attacked the southern part of Hyogo Prefecture, Japan, when large degrees of settlement were observed along the entire routes in the area. Under the circumstances, thorough measures have been required to effect sufficient earthquake resistance at earthquakes of such a large magnitude. In conjunction with the Japan Railway Construction Corporation and the University of Tokyo, therefore, we performed vibration tests of various brigde abutment types, based on which we proposed a new reasonable abutment structure with earthquake resistance high enough to keep the structure stable.

BASIC CONCEPT OF REINFORCING WORK

There are two types of settlement behind a bridge abutment in general. One is the "rocking settlement" that occurs when voids are crashed by the earthquake motion, and the other the "difference in level" generated when soil and ballast fall on account of the forward inclination of the bridge abutment. To materialize such sufficient resistance against large-scale earthquakes, it is required that measures be taken for both types of settlement.

Figure 3 shows the proposed bridge abutment that uses geotextle to connect the abutment structure and cement-mixed earth that effectively prevents rocking settlement. This design features a slim structure and footing, and prevents not only rocking settlement, but also the difference in level due to the connection between the abutment and cement-mixed earth, to significantly improve the earthquake resistance. We call this type "the bridge abutment reinforced with cement-mixed earth."

VERIFICATION OF THE EARTHQUAKE RESISTANCE OF PROPOSED BRIDGE ABUTMENT

To check the earthquake resistance of the bridge abutment reinforced with cement-mixed earth, we performed a series of vibration tests of a model and a bridge beam at the scale ratio λ =1/10, by using the medium-scale vibration table of the Railway Technical Research Institute (RTRI), for about 40 cases of different measures and exciting waveforms. Figure 4 shows the model abutment after excited under an irregular wave at 1,400 gal. It virtually did not deform in this high-frequency vibration test, but exhibited extremely high earthquake resistance even when compared with the case where the conventional measure was applied and tested under the same condition.

DISCUSSION FOR PRACTICAL USE

We proposed a designing method for this bridge abutment and applied to the test site under construction for Kyushu Shinkansen.

Figure 5 shows the cross-section of the bridge abutment. Despite the design for large-scale earthquakes, the cross-section is smaller than that of the conventional structure to prove its reasonable and economical features.

We performed a lateral loading test of the bridge abutment by applying 4,000 kN or the design load for large-scale earthquakes to prove that it has extremely high-level earthquake resistance, in that the displacement is as small as 15 mm. See Fig. 6 for a test scene. This bridge abutment will be used for projected Shinkansen lines as the standard structure.

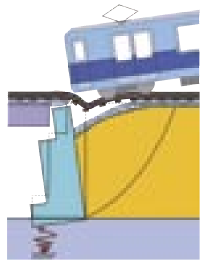

Figure 1. Image of the damaged bridge abutment at earthquake.

Figure 2. A damaged bridge abutment at Hyogoken-Nambu Earthquake (January 17, 1995).

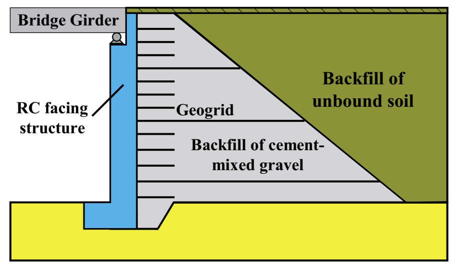

Figure 3. Typical close-section of proposed bridge abutment.

Figure 4. Deformation of the model abutment after a shaking test.

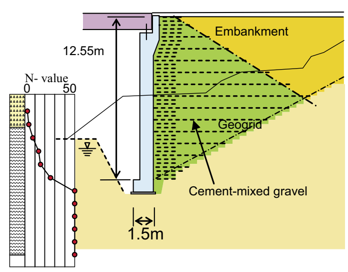

Figure 5. Close-section of Kyushu-Shinkansen abutment.

Figure 6. View of the lateral loading test in Kyushu.

COMBAT–A New Block System Using Microwave Balises for Train Detection

Nishibori, Noriyuki
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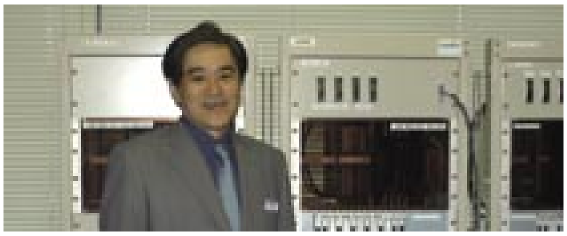

INTRODUCTION

Track circuits that are normally used for train detection sometimes fail to detect a train due to the rust or dirt on the rail surface, and must be adjusted against the changes in the leakage conductance. Therefore, we have developed a non-contact type train detection unit that uses microwaves and used it to compose a train control system that centralizes the interlocking and blocking functions along the entire route as a comprehensive interlocking system, which is called the COMBAT (COmputer and Microwave Balise Aided Train control) system.

SYSTEM COMPOSITION

The train detection unit of COMBAT is composed of a balise detector (interrogator, wayside responder, and onboard responder) and a train detection logic operator that processes the information sent from the interrogator (Fig. 1). The interrogator and wayside responder are installed at the boundary between detection sections. Each train has two onboard responders, one at the head and the other at the tail. As the interlocking and blocking system to control train operation, the train control center is equipped with a central interlocking unit, and each station with interlocking terminals to control signals, turnouts, and other local devices (Fig. 2).

SUMMARY OF FUNCTIONS

Entry of a train into the detection section is detected when the train breaks the closed loop for radio communication between the interrogator and wayside responder. This function ensures safety even when a component has failed, since the failure composes the status that the loop has broken. Entry/exit of a train is judged by the close/open status of the loop, identification of the train based on the information sent from onboard responders, and the detected-train-movement direction. Unlike the conventional track circuits that detect only the existence (0) or non-existence (1) of a train, the new system tracks trains based on the ID specific to each train to improve the safety and reliability of train detection. The interlocking and block functions have also been improved, as the train ID acquired by the train detection unit is used for train operation control.

TESTS AND EVALUATION

The COMBAT system has been subjected to long-term monitoring tests on three revenue service lines of Japan Railways (JR) and other railway companies (Figs. 3 and 4). In these tests, it correctly detected about 220,000 trains without exception. It also showed satisfactory performance in safety analyses and tests. A non-JR expert committee also judged that there were no problems in its practical use. Thus, railway operators are now discussing its introduction into service lines.

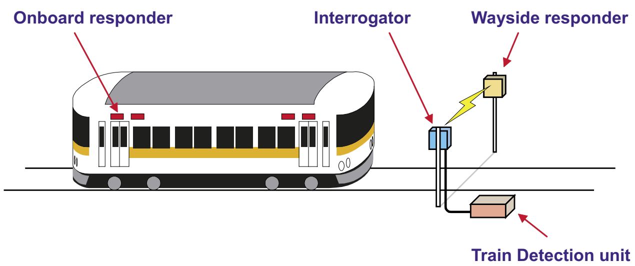

Figure 1. Train detection system.

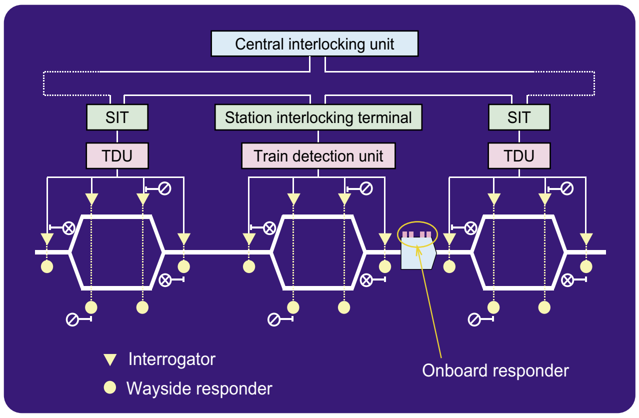

Figure 2. Basic system configuration of COMBAT.

Figure 3. Field test.

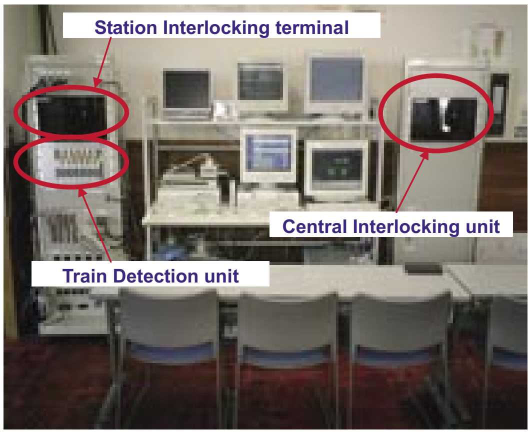

Figure 4. Center and station equipment.

Obstacle Detection System with Stereo Cameras for Level Crossings

Ota, Masaru
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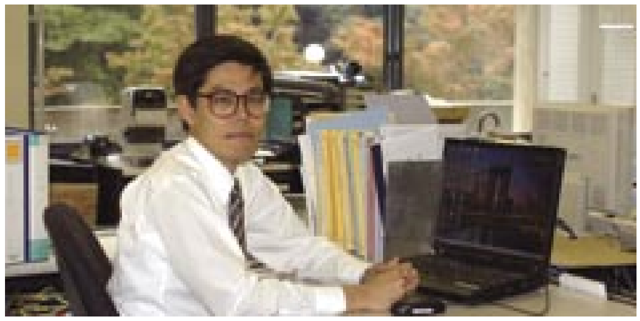

Some level crossings in Japan are installed with an obstacle detection system to prevent collision between trains and large-size automobiles captured on the track. In the aged society of Japan, however, aged people often run into trouble on level crossings in recent years. As barrier-free design prevails, more and more wheelchair users have chances to pass level crossings and are potentially involved in level crossing accidents.

The level crossing obstacle detection system that uses stereo cameras detects pedestrians and wheelchairs that cannot be detected by the conventional systems of the photoelectric (optical beam), ultrasonic, and loop coil types (Fig. 1).

Since this system uses TV cameras, it can record the images of the detected obstacle. If the memory is enlarged, it will be able to record the behaviors of the obstacle before and after it is detected, which will be transmitted to the train dispatching center, stations, and train drivers in the future.

The stereo cameras (Figs. 2 and 3) apply the principle of triangulation (Fig. 4), calculate the parallax between camera images, and convert it into a distance over the entire screen to determine the three-dimensional profile of the object. The level crossing surface is roughly two-dimensional in almost all cases. Therefore, the system detects three-dimensional objects that have entered the level crossing area as an obstacle (Fig. 5).

This system is now subjected to a long-term test on a revenue service line. Under normal weather conditions, there are only limited cases where the system fails to detect the object that is passing the level crossing, or erroneously detects direct sunlight or automobile headlights as an obstacle. The detection logic is now being improved to eliminate such failures.

Figure 3. Appearance of stereo camera unit.

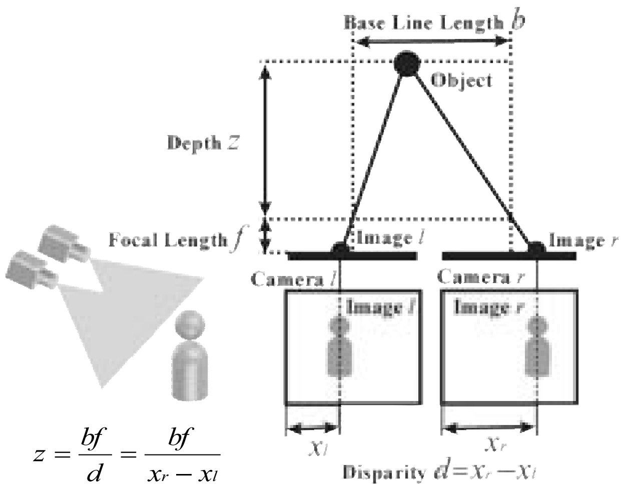

Figure 4. Principle of stereo camera.

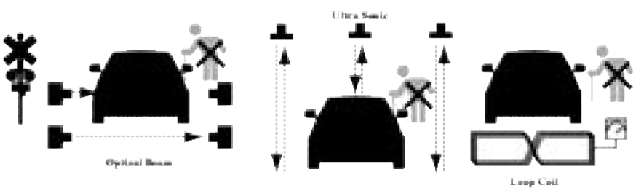

Figure 1. Conventional obstacle detection systems for level crossings: (a) Optical beam method, (b) Ultra sonic method, (c) Loop coil method.

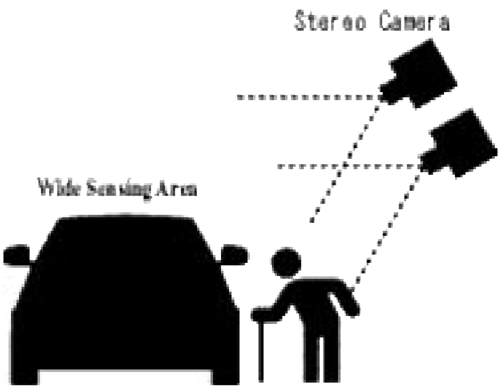

Figure 2. Stereo camera method.

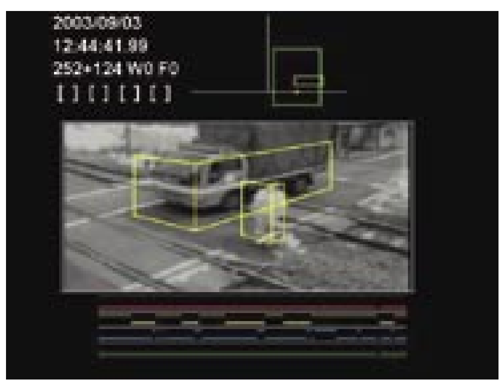

Figure 5. Example of detected obstacle.