June 1, 2003

Railway Technology Avalanche

Newsletter on the Latest Technologies Developed by RTRI

No. 2

Railway Technical Research Institute
2-8-38 Hikari-cho, Kokubunji-shi
Tokyo 185-8540, JAPAN

GENERAL INFORMATION

ARTICLES

So as to Correctly Receive the Following Issues of *"Railway Technology Avalanche"*...

"Railway Technology Avalanche" will definitely be with you whenever published. But I understand you are quite active, therefore, I also imagine that you could occasionally fail to get it when your address where you can the most easily receive it is suddenly changed. Would you please contact the editor at www-admin@rtri.or.jp through e-mail so that he can bear in mind your name, title as well as regular-mail and e-mail addresses. The information on you as a recipient of *"Railway Technology Avalanche"* will carefully be updated in the mailing list to be re-prepared and its following issues will end up with being at you without any inconvenience.

Editor:
Sakai, Hiroyuki, PhD
Deputy Manager, International Affairs
Phone, +81-42-573-7258; Fax, +81-42-573-7356;
E-mail, www-admin@rtri.or.jp

Foreword

Tanaka, Hiroshi
Deputy General Manager, Information & International Affairs Division

Driven by the rapid development of information technologies, the globalization of information and communication is further advancing, no matter whether it is welcomed or not.

I am firmly convinced that global sharing of information is highly welcomed at least in the field of R&D of railway technologies. Since railways are developing as an international network beyond national borders, comprehensive and quick efforts to gather the information on the state-of-the-art technologies are essential not only for the daily management and maintenance of railway systems but also for the decision-making process on the phases of planning, design, and construction. Effective and continuous exchanges and sharing of information will save us time and cost for the R&D of new technologies and contribute to tightening mutual understanding among different railway systems in different countries.

With this newsletter, RTRI is trying to distribute briefly and quickly the essence of the latest R&D results at RTRI. Furthermore, RTRI is expecting that this "avalanche" might induce another avalanche of information somewhere. RTRI will keep issuing the newsletters for this purpose.

If similar activities are started somewhere around the world, it will always be welcomed. I do hope that an avalanche of information on railway technologies will sweep our society in a broad range.

The text of *"Railway Technology Avalanche"* will also be available on our web-site http://www.rtri.or.jp/index.html shortly.

Tanaka, Hiroshi, Mr.

Visit Us through *Rail. Tech. Avalanche*

Sakai, Hiroyuki
Editor, Rail. Tech. Avalanche

As you might know, a lot of facilities and equipment to develop and improve railway technologies are with us in the premises of Railway Technical Research Institute. Let me provide you with brief opportunities to easily visit us even when you are still at your desk. We will walk you step by step throughout the premises by requesting that you kindly check pages, where *"Visit Us through Rail. Tech. Avalanche"* appears, all the time when *"Railway Technology Avalanche"* is at you. It is a simple manner to find our facilities without actually coming over to us in Tokyo, Japan, that is possibly quite distant from your current location. See photos with short explanation, and enjoy your private visit to us through *"Visit Us through Rail. Tech. Avalanche."* The trip to us is always available whenever you decide to set off on it. As the first spot during the tour, we take you on sightseeing at the High-Speed Rolling Stock Test Stand. Hope you take an interesting look at the facilities.

HIGH-SPEED ROLLING STOCK TEST STAND

Outline. The high-speed rolling test stand is used to test the kinetic characteristics and drive control performance of railway vehicles placed on the rail-wheels.

Functions. The high-speed rolling stock test stand, which is only one testing machine of its kind in Japan, is used to test the control performance and kinetic characteristics of actual railway vehicles, including running stability, sine-wave-frequency responses, and ride comfort against vibration up to the speed of 500 km h^{-1}, with actual track irregularities input. The lateral force equivalent to excessive centrifugal and cross wind force can be applied to the carbody. By using this test stand, it is possible to measure detailed characteristics of rolling stock without actually running it on a main line, and perform damper/spring tuning tests and other tests under pessimum conditions that cannot be reproduced on lines in service.

Table 1. Major Dimensions

Maximum speed	500 km h^{-1}
Maximum longitudinal force	200 kN
Gauge	1000 mm to 1676 mm
Maximum equivalent inertia mass	16×10^4 kN set^{-1}
Maximum axle load	200 kN
Wheel base	1600 mm to 3500 mm
Rail wheel diameter	1500 mm
Maximum additional carbody load	40 kN
Rail wheel displacement	Vertical, 0.1 Hz to 25 Hz, the maximum displacement ± 12 mm; Lateral, 0 Hz to 15 Hz, the maximum displacement ± 30 mm; Rolling, 0.1 Hz to 10 Hz, the maximum angle ± 11 mrad

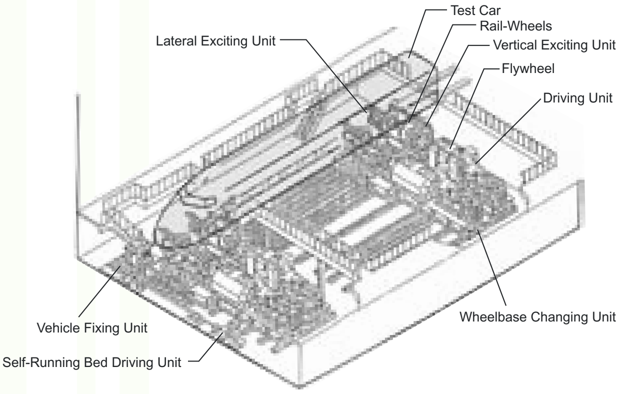

Figure 1. Effect of exciting conditions on the threshold hunting speed.

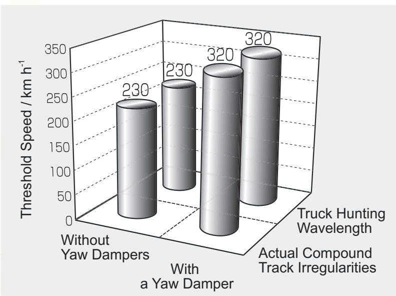

Figure 2. View of test apparatus.

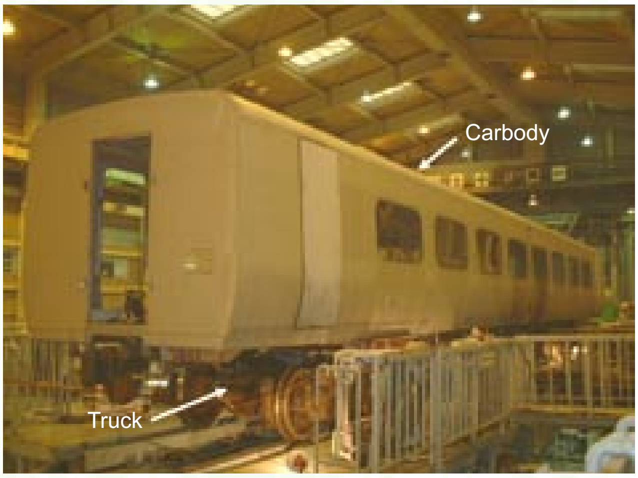

Figure 3. High-speed rolling stock test stand.

Publisher:
Tanaka, Hiroshi
Deputy General Manager, Information & International Affairs Division

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Editor:
Sakai, Hiroyuki, PhD
Deputy Manager, International Affairs
Phone, +81-42-573-7258; Fax, +81-42-573-7356;
E-mail, www-admin@rtri.or.jp

Adhesion-Increasing-Agent Jetting System "Cerajet"

Ono, Kaoru
Senior Researcher, Frictional Materials, Materials Technology Division

Cerajet, which eliminates drawbacks of conventional sanders such as freezing in low-temperature areas and provides an effective method to increase adhesion in the speed range from starting to running at a speed of 300 km h^{-1} or over, has been mounted on more than 500 rail vehicles including locomotives, streetcars, as well as even series 500 and 700 Shinkansen cars.

Cerajet is driven by the onboard air source and an electro-magnetic valve in the same manner as the conventional sander. See Fig. 1. Owing to the specially designed tank for an adhesion-increasing agent and jet nozzle, however, the system has advantages never seen with the sander (Table 1), to supply the agent properly between wheel and rail, and prevents it from being scattered by the train draft thanks to the high jetting speed even when the vehicle runs at a speed over 300 km h^{-1}. This exerts an extremely remarkable effect under the wet condition in the high speed range where the adhesion coefficient tends to decrease, partly due to the use of alumina (aluminum oxide) particles that are stronger in mechanical strength than conventionally used sands. Figure 2 shows an example of the installation of the system.

Figure 3 summarizes the results of emergency brake tests with a high-speed test train on a narrow-gauge line. The brake distance normally increases about 100 m when rails are wet, since wheels frequently skid. When the adhesion-increasing agent is jetted at the foremost axle linked with the application of emergency brake, however, skids are prevented almost over the entire train-set even under the wet condition to make the train stop at the same brake distance as that under a dry condition. This effect has also been confirmed in the operation of Shinkansen trains at 300 km h^{-1}.

It has also been proved that Cerajet effectively enhances the adhesive effect when used for locomotives to prevent skids at start and substantially cuts the running cost when compared with the conventional sander for the differences in the fuel cost and refilling cycle.

As Cerajet exhibits a high adhesion-increasing effect even on rails covered with fallen leaves, it has been mounted for skid prevention on a number of EMUs and DMUs running in mountainous areas.

Railway Technical Research Institute implemented Cerajet field tests in the UK, Germany, and Taiwan in 2001 and 2002, and will promote overseas marketing in the immediate future.

ACKNOWLEDGEMENT

This work was financially supported by the Ministry of Land, Infrastructure and Transport, Japan.

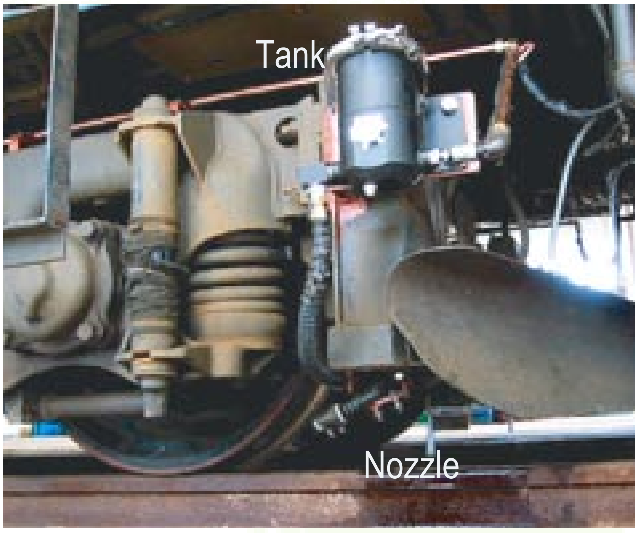

Figure 2. Equipment for supplying Cerajet.

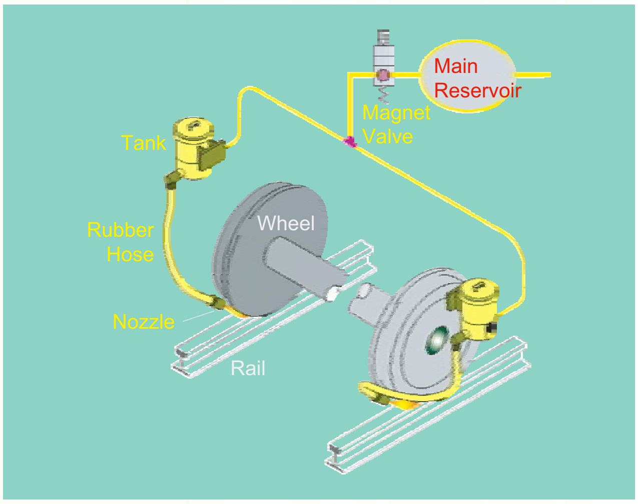

Figure 1. Cerajet.

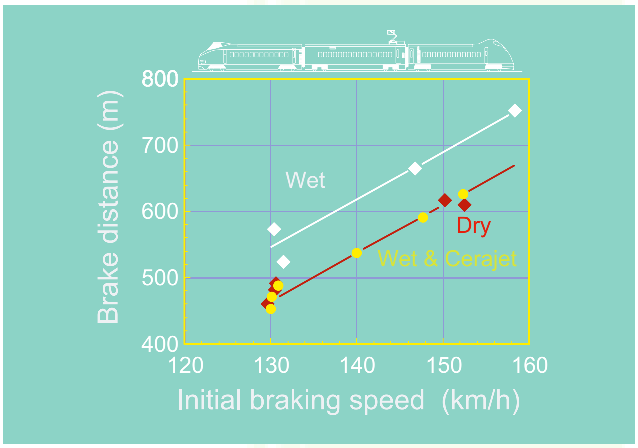

Figure 3. *TRY-Z* with Cerajet.

Table 1. Cerajet *vs.* Conventional Sanders[a]

	Jetting speed	Jetting quantity / g min^{-1}	Adhesion promoting material	Refill frequency in average
Cerajet	100 m s^{-1}	20-50	Alumina sand	Once ten days
Conventional sanders	Just dropping	1500	Natural sand	Twice a day

[a] Data from diesel cars working in Japan during a season with fallen leaves.

Diagnosis and Repair of Concrete Reinforcing Bar

Sasaki, Takahiko
Senior Researcher, Laboratory Head, Concrete Materials, Materials Technology Division

Reinforced concrete is used in quantities for viaducts and other structures installed on Japan Railway lines. Reinforcing bars do not corrode even in strong base concrete since they are protected by passive films, but are subjected to corrosion in the structures located in coastal areas or when sea sand is used without adequately desalted. This is because the passive film is decomposed by chloride ion. Corrosion of reinforcing bars causes falling-off of concrete debris or cracking and loosening of cover due to the expansion resulted from rusting, which compromise the safety of pedestrians passing under viaducts.

To repair concrete structures with corroded reinforcing bars, it is important to grasp information on the location of corroded reinforcing bars and the degree of its corrosion. As a means to detect the corrosion of reinforcing bars, the self-potential method is widely adopted with a simple and convenient device. However, the self-potential on the concrete surface is higher at lower levels of water contents than those measured near a reinforcing bar (see Fig. 1).

Railway Technical Research Institute (RTRI) has proposed a self-potential method newly developed to determine the degree of the reinforcing bar corrosion by applying the criterion given in Table 1 to the evaluation of the self-potential corrected for the variation over the difference in cover properties. Since reinforcing bars corroded by chloride ion require rust-preventive care, the local repair method is mainly adopted for the reason of economy. RTRI developed a salt adsorbent releasing nitrite ion that is known to have the effect to suppress the corrosion when the adsorbent absorbs, fixes, and detoxifies salt accelerating reinforcing bar corrosion. The adsorbent has been put into practical use as a technique for local repair named Suppressing Salt Injury Method (SSI Method) to utilize the salt adsorbent. See Fig. 2.

To confirm the long-term durability of the rust-preventive effect provided by the SSI Method, we exposed a specimen containing chloride ion more than the critical amount for rusting to a sea-salt-rich environment with a high-temperature high-humidity for seven years. After this trial, no corrosion was observed on the part applied with the repairing material blended with the chloride-ion adsorbent. At the position of reinforcing bars, the amount of chloride ion was smaller when repaired by the SSI Method than with mortar that contains no chloride-ion adsorbent (Fig 3), and the mole ratio of nitrite ion to chloride ion, which is an index of the corrosion suppressing effect by nitrite ion, was 0.6 or over (Fig. 4).

These facts clarify that the vicinity of reinforcing bars is maintained in a sufficiently high rust-preventive environment even after a seven-year exposure to an pessimum environment and guarantee the long-term rust-preventive effect of the SSI Method adopted with the salt adsorbent. About 50,000 m^2 of concrete sectional areas, which have been repaired by the SSI Method, have remained quite normal so far. RTRI will apply this method to the diagnosis and repair of all concrete structures, naturally including those of railway, and will improve their durability with corroded reinforcing bars. Moreover, the method will also contribute to their maintenance and management.

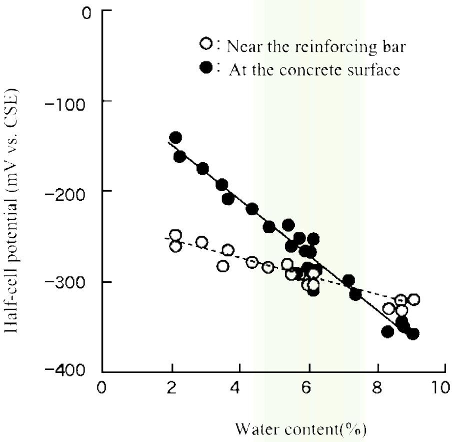

Figure 1. Relationship between the water content and the half-cell potential.

Table 1. Criteria of Reinforcing Bar Corrosion

Corrected half-cell potential	Degree of reinforcing bar corrosion
E>-250 mV	I: No corrosion
-250 mV>E>-350 mV	II: Slight spot rust on the surface
-350 mV>E>-450 mV	III: Slightly lifted rust on the surface and rust adhered to the concrete
-450 mV>E	IV: Expansive rust partial deficit or more deteriorated

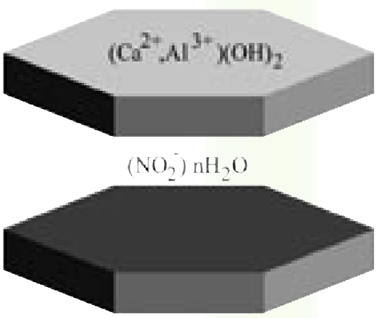

Figure 2. Schematic structure of the salt adsorbent.

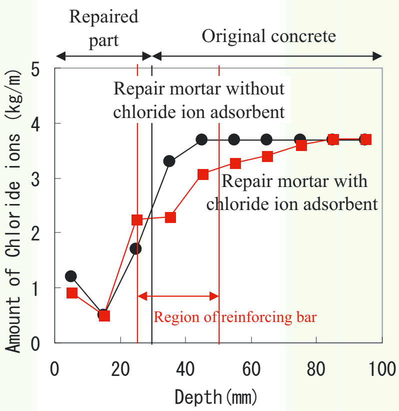

Figure 3. Profile of chloride ion across the interface.

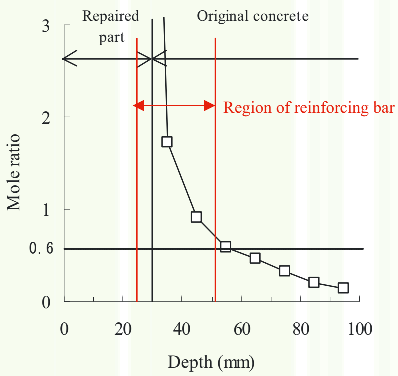

Figure 4. Profile of mole ratio (nitrite ion/soluble chloride ion) across the interface.

Human Engineering to Reduce Damage on Passengers at Train Collision

Omino, Koji
Senior Researcher, Ergonomics, Human Science Division

Railway Technical Research Institute is only one organization in Japan, where human engineering researches have been promoted to reduce the damage on passengers at train collision, with its research results on the accidents occurring with long-seat type commuter trains unparalleled in the world as outlined below.

SURVEY OF INJURIES

The author and co-researchers surveyed the accidents of long-seat type commuter trains and clarified the features of passenger injuries at accidents that the chest injuries are outstanding with seated passengers (accounting for 48% of the total injuries) and injuries on the head are with standing passengers (20%) (Fig. 1). In terms of assailant articles, 64% of the injuries taking place to seated passengers are caused by hand-rails and 80% of those to standing passengers are by the floor, columns, and other passengers (Fig. 2). As injury patterns specific to long-seat train accidents, passengers seated beside a pipe hand-rail are injured on the chest by lateral pipes, and those standing in front of a long seat collide with the floor to injure the head.

ANALYSIS OF BEHAVIORS AND COUNTERMEASURES AGAINST SEATED PASSENGERS

The author performed simulation analysis of the above-mentioned chest injury pattern of seated passengers (Fig. 3) and estimated the passenger behaviors as well as chest injury indices (to indicate the possibility of serious damage on the chest), which is significantly high for passengers seated beside a hand-rail. Against this fact, the author proposed a mechanism of releasing the hand-rail fixing point when hit by a passenger, which reduces the index by about 30%.

ANALYSIS OF BEHAVIORS AND COUNTERMEASURES AGAINST STANDING PASSENGERS

The author also performed similar simulation analysis on the head injury pattern of standing passengers as described earlier, discussed countermeasures, and proposed a squatting posture on the floor as shown in Fig. 4 to ensure safety at accidents in which passengers have several seconds leeway until the accident occurs after noticing that it is unavoidable. Calculations have verified that the index to seriously damage the head (Head Injury Criterion, HIC) is decreased by 38% when passengers are standing while gripping a hand strap from that when taking the standard standing posture (without gripping a hand strap). It was furthermore estimated that the HIC is decreased by 98% when passengers take the proposed posture (Fig. 5).

The hand strap arrangement to reduce the head injury index is also being examined. The author will perform simulation analysis to study more effective measures against the aforementioned injury patterns and discuss other injury patterns from now on.

ACKNOWLEDGEMENT

This work was financially supported by the Ministry of Land, Infrastructure and Transport, Japan.

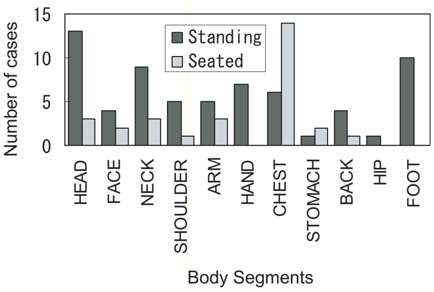

Figure 1. Body segments injured at a train collision.

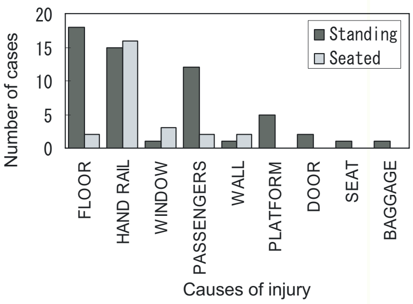

Figure 2. Causes of injury.

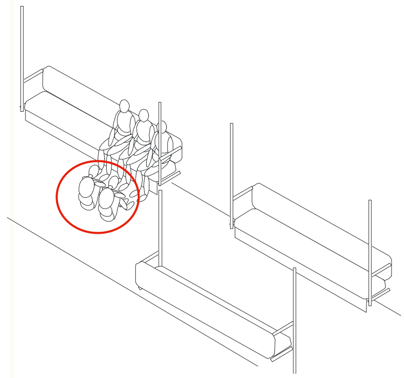

Figure 4. A safe position for standing passengers.

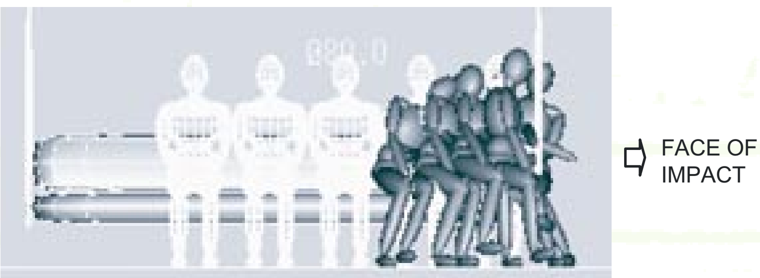

Figure 3. A computer simulation of passengers sitting on a long seat. Passengers are simulated by white wire frame bodies before the impact and by dark bodies 0.8 s thereafter.

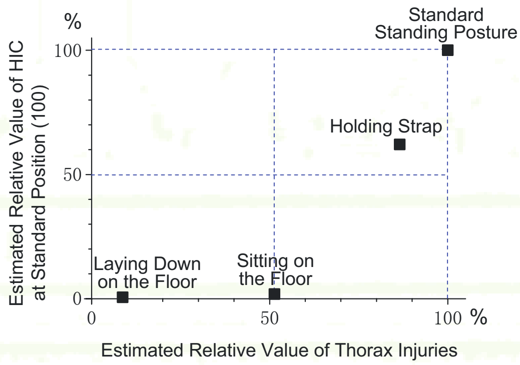

Figure 5. Positions of passengers on board and injury percentages.

Evaluation of Ride Comfort

Suzuki, Hiroaki
Senior Researcher, Laboratory Head, Ergonomics, Human Science Division

Development of technologies to reduce vibration and noise is essential to improve the ride comfort in trains. To set off the next target for development, it will be useful to have an index (scale) to evaluate the ride comfort quantitatively from the viewpoint of passengers. In order to establish the technique to well estimate the ride comfort, therefore, we have been promoting researches on various themes including the following.

EVALUATION OF THE RIDE COMFORT AGAINST VIBRATION

There are a number of factors that influence the ride comfort in trains. Among the studies on these factors, the most remarkable achievement is seen especially in the work on vibration. Since there are different types of vibration, including the lateral vibration caused by the centrifugal force on curves and longitudinal acceleration at braking, that require different prevention measures, various evaluation indices have been developed. As to the ride comfort on curved sections, for example, we have clarified that evaluation close to the actual bodily sensation of passengers is possible when we combine the lateral vibration and the stationary lateral acceleration that is equivalent to the centrifugal force. Figure 1 shows the allowable limits of acceleration/vibration to ensure the ride comfort for standing and seated passengers both. We are now studying measures to investigate the effect of the lateral vibration at extremely low frequencies on motion sickness and determine the vibration characteristics that cause the difficulty to walk on a train.

EVALUATION OF THE AURAL DISCOMFORT CAUSED BY CHANGES IN THE ATMOSPHERIC PRESSURE

High-speed trains that connect cities pass a number of tunnels in mountainous areas in Japan. Quite a few passengers complain the discomfort caused by changes in the atmospheric pressure when the train runs into a tunnel. This requires an allowable limit to be set for pressure changes as a target in adopting measures against this phenomenon. In contrast to the aural discomfort due to the difference in altitude in airplanes and elevators, that on trains is caused largely by the propagation of the pressure wave generated when the train enters a small space like tunnels. As the waveform is extremely complicated in this case (Fig. 2), we had to determine what component would cause the discomfort first and concluded that it was desirable to limit the maximum change in the atmospheric pressure to 2 kPa or less within four seconds after the train gets into a tunnel on the basis of test results.

EVALUATION OF THE COMPREHENSIVE RIDE COMFORT IN TRAINS

We are promoting researches not only into physical factors that influence the ride comfort, but also to develop an index that enables the evaluation of the comprehensive ride comfort in trains. We have developed a riding comfort simulator with a subsidy by the Japanese government that simulates the vibration, noise, temperature, and window scenes experienced on actual trains. Figure 3 shows its appearance. The simulator has a simulated passenger room furnished with 12 seats mounted on a 6-axis motion unit. Since different factors can independently be controlled, the simulator is expected to contribute to the development of the indices to evaluate the ride comfort in trains.

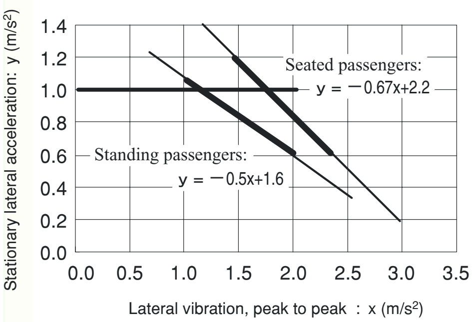

Figure 1. Allowable limit of riding comfort on curved sections.

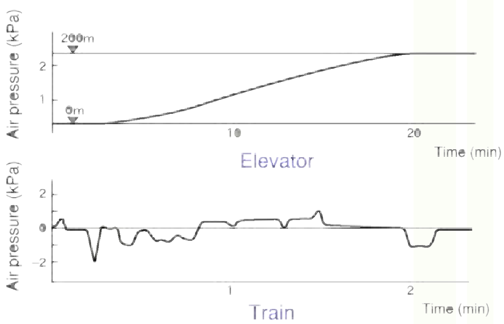

Figure 2. Examples of air pressure change.

Figure 3. Riding comfort simulator.