Newsletter on the Latest Technologies Developed by RTRI

Railway Technology Avalanche

September 27, 2013 No.44

Railway Technical Research Institute
2-8-38 Hikari-cho, Kokubunji-shi
Tokyo 185-8540, JAPAN
URL:http://www.rtri.or.jp

Editorial Office: Ken-yusha, Inc.
URL: http://www.kenf.jp/en/

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GENERAL INFORMATION

ARTICLES

Why Not Share the Outcomes of R&D Activities across the World for the Safety of Railways?

Norimichi KUMAGAI
President

In June 2013, I took office as President, Railway Technical Research Institute (RTRI), Japan.
While featuring massive volumes, rapidity and punctuality in transporting people, freight and goods, railways are now considered an indispensable mode of transport in the life of people and in the economic activity of most societies. Furthermore, in the case of electric railways, power generation technology in braking remarkably enhances the efficiency of energy utilization.
Although railways have many such a number of excellent features, we sometimes come across news reports of serious railway accidents in recent years and they can hardly be overlooked. These accidents are mostly caused by natural disasters, human mishandling and misunderstanding, computer software errors, material breaks due to insufficient strength and other miscellaneous abnormalities. It is also the case that multiple factors synergistically damage redundancy or fail-safe features, which are part of an essential mission in designing a system to guarantee safety. Different countries have painfully experienced such accidents as derailments on curves and turnouts, train collisions, crossing accidents and disastrous occurrences due to earthquakes, strong winds and heavy rains. In Japan as well, the existing railway systems have been constructed based on the experience of a number of unforgettably chaotic accidents caused by different human errors and natural phenomena.
For whom are we promoting research and development on railways? ISO defines that "safety is non-existence of unallowable risks." The more railways contribute to social development or the more chances there are for people to use railways, railways must attain higher levels of safety or, in other words, railways must have less unallowable risks. It is also essential for railways to develop into more convenient and comfortable transport facilities. As railways shall be safe for the users, so research and development on railways shall be undertaken for the customers.
To respond to the requirements by the government of Japan, JR companies and other railway operators, RTRI is now promoting approximately 280 R&D themes, of which about half are on safety issues. RTRI is eager to share problems related to the safety of railways in Japan and abroad and attain success in solving them in conjunction with the governments, universities, railway operators and research institutes all over the world.
As an ideal venue where we can raise and discuss various research themes including those on safety, the World Congress on Railway Research (WCRR) is organized by the organizing committee representation from many countries. The 10th WCRR 2013 will be held in Sydney in November 2013 under the greatest cooperation of Australian railway authorities. In addition, UIC is going to have many characteristic conferences and symposiums. It is also possible to promote joint research between research organizations in different countries. I wish that a chain of cooperation to share the results of research and development on the safety of railways be extended on a global scale from now on, and that such cooperation extends beyond the boundaries of cultures, climates and rules in different countries.

熊谷則道

Appointment of New Board of Directors

The Railway Technical Research Institute (RTRI), a Public Interest Foundation, appointed new Directors at the 7th meeting of the Board of Trustees on June 13, 2013, when the former President Hisashi Tarumi, having held the post since April 2009, resigned and Dr. Fuminao Okumura took office as a new Executive Director. Following the 7th Board of Trustees meeting, the newly appointed Directors were assigned to the following posts at the 11th meeting of the Board of Directors, as described below.

The new Board of Directors will lead RTRI to extend its wide-ranging activities under the following three principles of action:

(1) contribution to the development of society and management of railway operators by dynamically promoting a number of themes on research and development,

(2) making efforts to prove worthy of the trust by society as a neutral railway technical research organization and

(3) raising the levels of railway technologies, domestic and abroad, by utilizing the results of joint research projects with a number of research organizations including those in foreign countries.

Concretely, RTRI will systematically address research and development targets such as improvement of safety, energy efficiency, cost reduction of maintenance and facilities updating and conservation of trackside environment at high-speed running, by actively using advanced simulation technologies and information technologies.

We promote our research and development by dedicating our total ability and, in that process of, every researcher will aim to become "the only one for RTRI", and to provide reliability to railway customers, society, and railway operators.

Board of Directors

Eisuke Masada, Chairman
Norimichi Kumagai, President (Promotion)
Atsushi Ichikawa, Vice President
Kiyoshi Sawai, Vice President (Promotion)
Atsushi Kawai, Executive Director
Hideyuki Takai, Executive Director
Fuminao Okumura, Executive Director (New appointment)
Mitsutoshi Inami, Auditor

Front row from left to right: K. Sawai, N. Kumagai, A. Ichikawa
Back row from left to right: M. Inami, H. Takai, A. Kawai, F. Okumura

A Research Director Awarded a Decoration by Japanese Government

Shun-ichi Kubo, Director, Materials Technology Division was awarded the Medal with Yellow Ribbon at the 2013 spring recognition. The award was for his research on developing a technique to evaluate the wear characteristics of carbon composite pantograph sliders and for the invention of a new material for sliders.

The Medal with Yellow Ribbon is given to persons who are working actively at the forefront of their professions and possess good technical abilities or achievements to be good examples for other technologists.

As background information, pantograph sliders are fitted to the rooftop pantographs of EMUs to collect power while sliding along trolley wires at the train running speed. As a current of approximately 100 to 1,000A runs through the pantograph assembly, sliders are required to have the following characteristics:

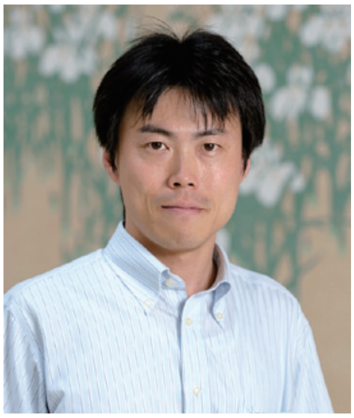
* High strength and resistance to breaking
* Low coefficient of friction for easy sliding
* High conductivity
* High wear resistance without excessively abrading the trolley wire material.

Sliders are made of sintered alloys, carbon and other materials depending on the category of EMU and the section of the route where they are used. In recent years, however, sliders made of copper-base sintered alloy are gradually giving way to carbon composite sliders. As materials of higher performance have been used for sliders in recent years, further research is under way to develop the following:

* Lightweight carbon-base sliders for narrow-gauge railways
* Sintered alloy sliders for Shinkansen EMUs having new lubricating ingredients

Development of "Micro-ribbed Wheel Tread Profile" to Reduce the Lateral Force in Curves

Daisuke YAMAMOTO
Assistant Senior Researcher, Vehicle Noise and Vibration, Vehicle Structure Technology Division



Decreasing the lateral wheel/rail force (tangential force) in curves will increase the margin against derailment and help reduce the maintenance cost of railway vehicles. With this in mind, the Railway Technical Research Institute (RTRI) is now developing a wheel having an appropriately profiled, microscopic rib (micro-rib) on the tread. Research suggests that this will reduce the lateral force during curve negotiation.

1. Tangential fore characteristics with/without microscopic ribs

As a first step, we simulated a combination of rail and wheel in contact by using a simulated rail roller and (1) a wheel roller having a smooth surface, and (2) another two wheel rollers, each having very small ribs machined on the contact surface as shown in Fig 1. With these rollers (hereinafter referred to as specimens), we repeated tests to examine the effect of humidity conditions on the characteristics of the tangential force at the contact surface. We found that the wheel specimens with the smooth surface and the surface with ribs of 1 mm pitch demonstrated similar values of tangential force, even when the humidity is low. A condition that the humidity is lower normally implies that the lubricating effect on the contact surface is smaller, affected by the smaller volume of atmospheric moisture. This means that the coefficient of friction in this state can be regarded as larger than when humidity is higher. The tests of the wheel roller with the larger (3mm) pitch of the peaks of the ribs resulted in smaller derailment coefficients (tangential force divided by wheel load) as shown in Fig. 1.

2. A proposal of "Micro-ribbed wheel tread"

To reduce the lateral force on the wheels of railway vehicles during curve negotiation based on this knowledge, we have proposed a wheel having an microscopic rib, triangular in cross-section, height 150μm and width 12mm, on a circumferential line located away from the flange on the tread, i.e., towards the outside of the tread. Hereinafter this is referred to simply as a "Micro-Ribbed Wheel Tread" and is shown in Fig 2. Figure 2 shows the calculated contact patch profiles between the inside rail and the wheels with conventional profiles and with the micro-ribbed tread. If the wheelset has displaced 5mm or more toward the outside rail, the micro-ribbed wheel tread contacts the rail in the micro-rib area to make the profile of contact patch long and narrow in the longitudinal direction. As a result, the tangential force between rail and wheel on the inside rail becomes smaller according to the characteristics of the tangential force marked ∆ in Fig. 1 and the tangential force between rail and wheel on the outside rail becomes smaller correspondingly.

3. The verification of reduction effect of lateral force

To verify the practical validity of the micro-ribbed wheel tread, we implemented a running test with actual vehicles on a dry day (humidity approximately 30%) to measure the lateral force (Y) and the wheel load (Q) and calculated the ratio Y/Q (derailment coefficient). The results are shown in Fig 3. At the initial stage of running, the coefficient of friction between rail and wheel is smaller affected by rust and dirt to make the ratio Y/Q smaller. Rust and dirt are removed, however, after running a certain distance, to make the coefficient of friction and subsequently the ratio Y/Q larger. A comparison between the maximum values of tangential force that works on conventional and micro-ribbed wheels indicates that the ratio Y/Q is smaller with the micro-ribbed wheel tread and larger with the conventional wheel. Furthermore, the difference between the maximum and minimum values of the ratio Y/Q is smaller with the micro-ribbed wheel tread. These phenomena are due to (1) the effect of the tangential force on the inside rail being decreased by the micro-rib on the wheel tread and (2) the characteristics of tangential force being unaffected by the coefficient of friction.

Based on the above, we conclude that an appropriately profiled micro-rib located towards the outside of the tread effectively decreases the lateral force and makes it insusceptible to the coefficient of friction even with actual vehicles.

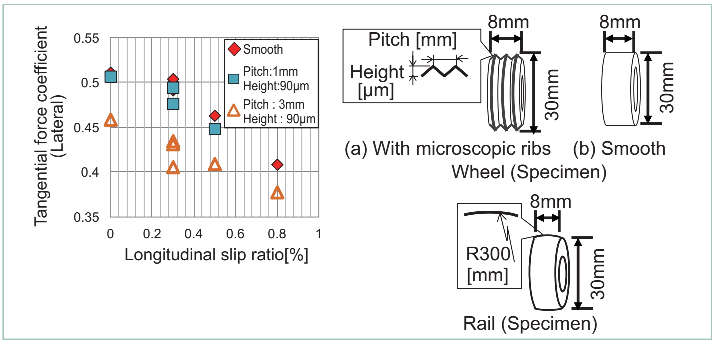


Fig. 1 Relations between contact surface and tangential force coefficient

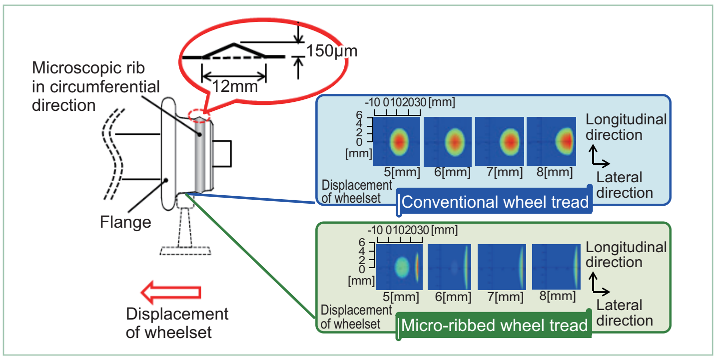


Fig. 2 Numerical analysis results of contact patch between wheel and rail

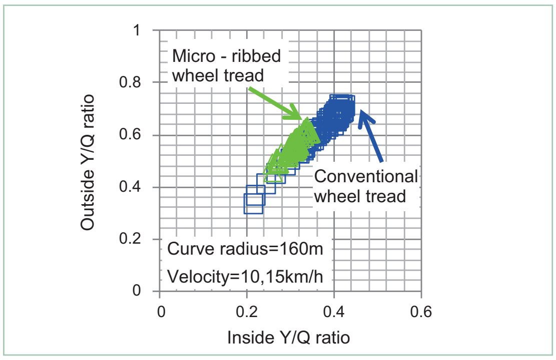
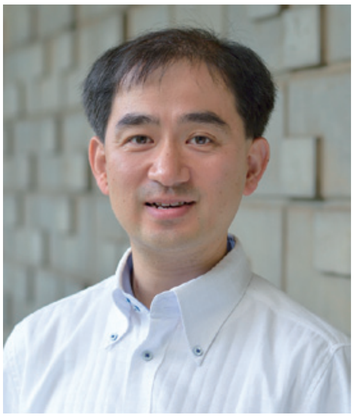


Fig. 3 Reduction effect of lateral force on the wheel tread

Development of High-Efficiency Induction Motors for EMUs

Minoru KONDO
Senior Researcher, Drive Systems, Vehicle Control Technology Division



1. Reducing energy consumption by EMUs is very important from the viewpoint of saving costs and helping preserve the global environment. High-efficiency traction motors are important for commuter transport EMUs because they have large traction motor losses that account for an enormous amount of energy consumption. This is because the service requires repeating powering and regenerative braking operations frequently. Thus, the Railway Technical Research Institute (RTRI) has conducted research and development to raise the efficiency of induction motors that are widely used as traction motors for EMUs. To promote this research theme, we had a prototype high-efficiency induction motor manufactured. We maintained the fundamental performance and dimensional characteristics of the existing motor and implemented tests to verify the performance of the prototype motor. See Fig. 1 for a photograph of the prototype motor.

2. To raise the motor efficiency in this research, we kept within the general scope of conventional design technologies, in that we used materials featuring small losses for iron cores, rotor conductors and stator windings. We also decided on the number of stator coil turns based on raising the traction motor efficiency rather than minimizing the required capacity of inverter. To ensure the high efficiency of the prototype motor, we also designed a cooling structure to reduce the flow rate of cooling air and subsequently the loss caused by ventilation. Furthermore, we adopted a rotor having a new structure developed to eliminate the loss (harmonic secondary copper loss) due to the current in the conductor surface generated by the magnetic field that is disturbed by the stator slots. For this purpose, the iron core profile is devised to make conductors evade the space around the rotor surface, which is prone to the effect of stator slots (Fig. 2).

3. Figure 3 compares the prototype motor and existing motors with respect to the loss rate (loss divided by input power) that has been evaluated though stationary tests. Figure 3 indicates that the loss rate of the prototype motor is approximately 4% (about 3% lower than that of existing motors) and thus the efficiency of the prototype is approximately 96%.

To estimate the energy-saving effect of the newly developed high-efficiency motor in passenger operations, we implemented a running simulation in which we calculated the rate of energy consumption decreased from that of existing motors recorded for sections between stations. We plotted the results against the inter-station distance, as shown in Fig. 4. The rate of decreased energy consumption is 6% to 11% for different station-to-station sections, which amounts to 9% for all the simulated section.

4. Through this research and development, we were able to demonstrate that induction motors can attain efficiency values as high as 96% to substantially cut energy consumption. In this study, we applied various techniques to raise the efficiency of induction motors, each of which is effective even when applied independently. We expect that the results of this study will be reflected in the design of induction motors to be manufactured in the future.

At the end of this report, we wish to add that this research and development project has been promoted partly by the use of subsidies from the government of Japan.

Fig. 1 Prototype motor

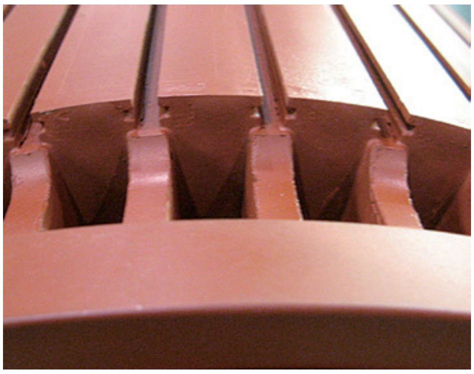


Fig. 2 Slots of the rotor of the prototype motor

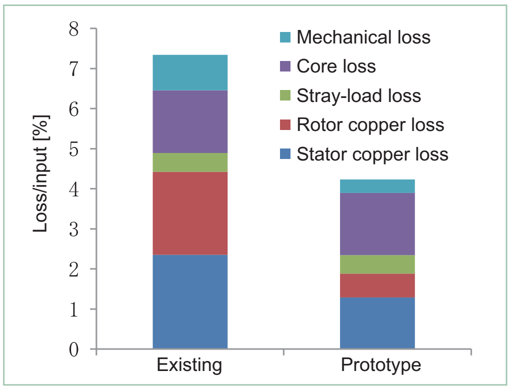


Fig. 3 Comparison of the loss at the rated point

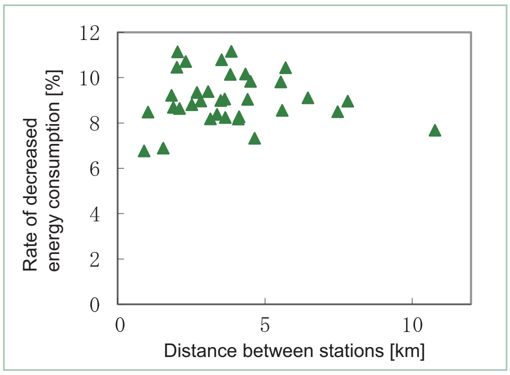


Fig. 4 Calculated rate of decreased energy consumption

Development of Integrated Bridge with Geosynthetic-Reinforced Soils

Masayuki KODA
Laboratory Head, Foundation and Geotechnical Engineering, Structures Technology Division

1. Introduction

Bridges composed of conventional girders and abutments, with their backfill embankments constructed after the abutments have been completed, are prone to (1) displacement/settlement of abutments when track supporting embankments are extended and (2) corrosion of supports/settlement of abutment backfill embankments after the bridges have been completed and put in service. Additionally, when subjected to earthquakes, abutment backfill embankments tend to sink or cause damage on the supports, which may lead to a bridge fall accident.

Thus, two versions of a new bridge have been developed in recent years: one is a bridge having reinforcing soil retaining-walls (hereinafter referred to simply as a retaining-wall bridge) and another one is called an integral bridge (Fig.1). The former has retaining walls for the reinforcing soil in back of the abutments to help solve the problems caused by the settlement of backfill embankments, while the latter has eliminated supports to avoid the problems related thereto. However, some problems still remain unsolved with these new bridges, such as (1) corrosion/damage on supports with the retaining-wall bridge and (2) settlement of backfill embankments/cracking of the bridge skeleton due to thermal elongation/contraction of floor slabs with the integral bridge.

To develop a suitable integral bridge that solves the aforementioned problems of conventional bridges, the Railway Technical Research Institute (RTRI) has developed a technique to construct reinforcing soil blocks in the backfill embankments of integral bridges. The method uses a cement-mixed gravel approach block and a reinforcing material (geo-textile) to make the bridge and backfill embankments an integrated structure (Fig. 1). A bridge constructed to this design is called " Bridge Integrated with Geosynthetic-Reinforced Soils" . Loading tests of a life-size bridge specimen of this type are described below.

2. Alternating horizontal loading tests of a life-size test bridge

To investigate the behavior and damage conditions of the reinforcing embankment integrated bridge at a L2 level earthquake, RTRI implemented alternating horizontal loading tests. The test set up is shown in Fig. 2. The load was increased at increments of 250kN up to 2,000kN, while repeating loading three times at each loading step, and implemented monotonic loading in each direction thereafter up to the maximum load withstanding capacity.

As shown in Fig. 3, the horizontal displacement toward the cement-mixed gravel approach block was 19mm on the back side at +2,200kN (at approximately 1.0 seismic intensity) , which is equivalent to the seismic motion of a L2 level earthquake and 16mm on the front side at -2,200kN. It was also verified that the residual displacement was extremely small after application of the maximum load: 4mm on the back side at +2,300kN and 8mm on the front side at -2,600kN.

As the integral bridge has a reinforcing soil block in the back, the above phenomenon reflects the fact that the reinforcing material resists the active side displacement against the horizontal force at earthquakes, while the backside reinforcing soil block resists the passive side displacement. Thus the test demonstrated the high level earthquake resisting performance of this structure. Furthermore, the residual settlement of backfill embankments was 4mm or less due to the reinforcing soil block on the back side, with only minor cracks observed at the sidewall-haunch construction joints.

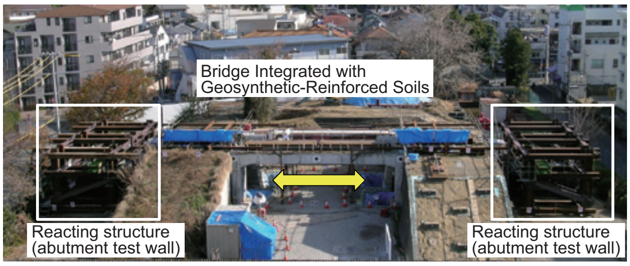


Fig. 2 Alternating horizontal loading test set up

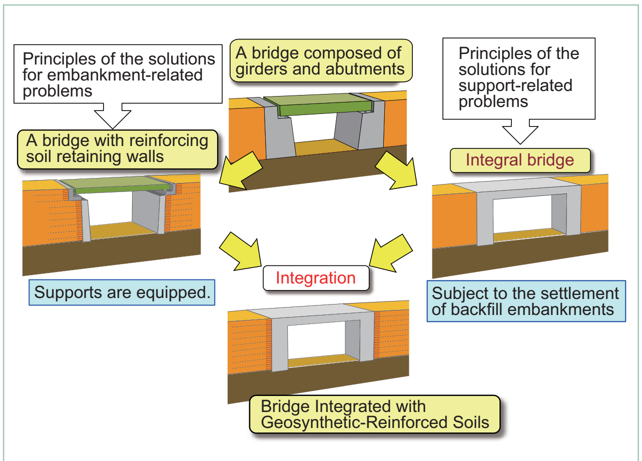


Fig. 1 Development of Integrated Bridge with Geosynthetic-Reinforced Soils

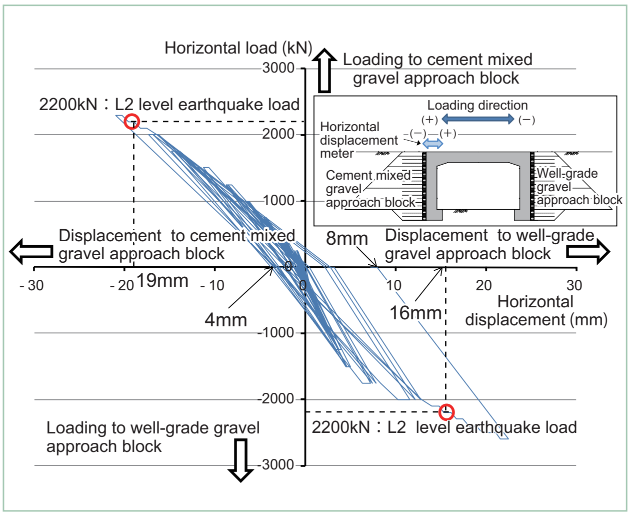
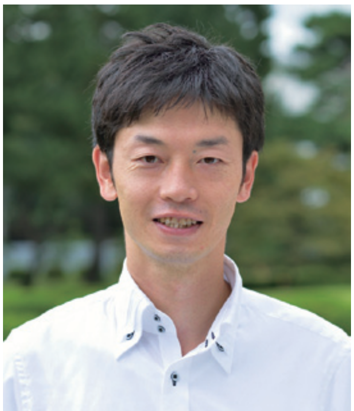


Fig. 3 Horizontal load versus displacement at the crown on the cement-mixed gravel approach block side

A Guideline for the Installation of Contact Wires for High-Speed Train Operation

Mizuki TSUNEMOTO
Assistant Senior Researcher, Contact Line Structures, Power Supply Technology Division



Ideally trolley wires (contact wires) are installed at a constant height and with high precision. In laying contact wires, however, installation errors cannot be avoided in practice. Despite the fact that installation errors can adversely affect the current collection performance, no concrete guidelines for allowances for installation errors are specified, except in recent years for Shinkansen which has an allowance for "span slope" where trains are running at 300km/h or over. To ensure stable current collection for high-speed operation of Shinkansen trains, therefore, we have proposed a new guideline for the installation of contact wires, hereinafter referred to simply as a "guideline" (a standard allowance for installation errors), by following the steps (1) to (4) below.

(1) Conduct a simulation of high-speed train operation in a Shinkansen section using the measured heights of contact wires.

(2) Statistically analyse the relation between the following (i) and (ii)
(i) The span slope of contact wires and the supporting point slope (as an index of installation errors)
(ii) Evaluation items for current collection performance (contact loss, uplifts and strains at supporting points)

(3) Extract installation error evaluation items that are significantly correlated to current collection performance (Fig. 1)

(4) Compile a guideline to restrict the values of evaluation items for current collection performance within the specified limits to ensure satisfactory train running performance

Figure 2 indicates the evaluation items in the guideline and, as an example shows the target values for installation errors at 300km/h operation. The five indices for evaluation in the new guidelines are the currently specified span slope and newly added "Difference of span slope," "sag ratio," "supporting point slope" and "supporting point curvature."

Figure 2 indicates that the span slope of 0.3%, which is currently in effect and which was specified for 210km/h operation at the start of commercial service of Shinkansen, is no longer valid for the revenue service operation at over 300km/h.

It is thought that the guidelines contribute to the improvement of performance, reliability, security, extension of life and efficiency of maintenance of contact wires and further to the speedup of Shinkansen trains. It is also possible through a similar manner to introduce a new set of guidelines for a narrow-gauge railway, simplify facilities and introduce new maintenance methods selectively for different sections.

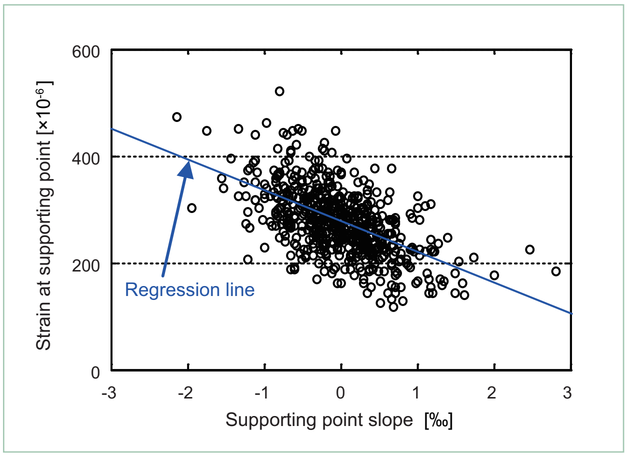


Fig. 1 Relation between the strain at supporting point and the supporting point slope

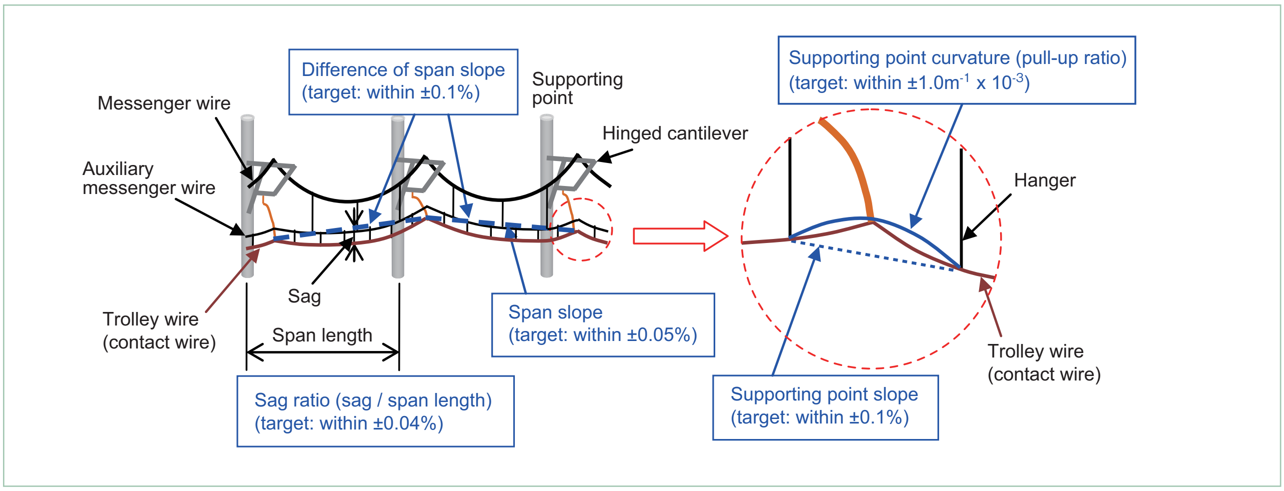


Fig. 2 Indices and targets for installation errors (for 300km/h operation)