Newsletter on the Latest Technologies Developed by RTRI

Railway Technology Avalanche

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GENERAL INFORMATION

ARTICLES

Railway Technology Information and the Internet

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Director, Information Management Division

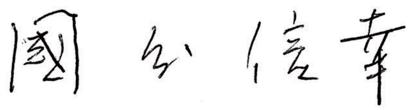
The Railway Technology Research Institute (RTRI) is always keen to provide information on technical advances in railway systems in Japan, and we know how important the Internet is in getting that information to people worldwide.

RTRI's use of the Internet goes back to 1987, when we began R&D as a juridical foundation. That was when we first participated on a trial basis in JUNET, a research-oriented computer network for Japanese academic organizations. In those early days, our Internet activities were basically limited to e-mail and electronic news services, but even so it was a momentous step for us.

RTRI's intention is to be a research institute open to the world. In April 1995, after a number of test runs, we began offering full-fledged information services online, to promote more exchanges among researchers worldwide and to provide information from Japan's rail technology research center. Our server was the first in the world to offer a wide range of information on railway technology.

We now offer technical information covering many areas, focusing especially on major results of RTRI's research and development. Much of this information can be found in our English-language "Quarterly Report of RTRI," and back numbers since June 2005 are now available online, free of charge.

We intend to continue using the Internet to present the latest information on railway technology, and invite you to visit our webpages often.



Newly Published Dictionary of Railway Technology Terms (Second Edition) and List of Railway Term Equivalents in Other Languages

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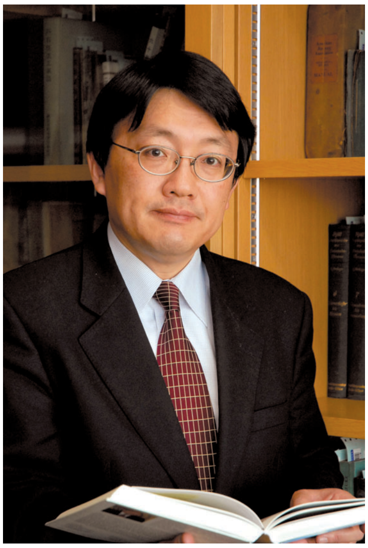
The greatest obstacle for any global project is language — communication with the world at large is impossible unless language barriers are removed. The unique qualities of the Japanese language make communication especially difficult for Japanese businesspeople pursuing commercial ventures on the world stage.

To commemorate its 10th anniversary in 1997, the Railway Technical Research Institute (RTRI) published the Dictionary of Railway Technology Terms. The dictionary listed keywords in Japanese with their English equivalents, and a supplement included a list of equivalents in French, German and Chinese beside the Japanese original. But because it was an early trial effort the content was far from complete. Also, because the supplement was published separate from the main dictionary, it was difficult to use. And so, to celebrate our 20th anniversary in 2007, we have published the second edition of Dictionary of Railway Technology Terms, a complete revision and expansion of the original. A CD-ROM List of Railway Term Equivalents in Other Languages is included.

We had hoped to harmonize our list of equivalents with the railway terminology database, RailLexic, compiled by the Union Internationale des Chemins de Fer (UIC), but had to abandon the plan at an early stage after we realized that, more often than we had assumed, terms in other languages have different conceptual shades of meaning in Japanese. We therefore tried as much as possible to harmonize our effort with the UIC railway terminology database, while adding explanatory text for terms that spring from different concepts.

The second edition was designed for use in the age of the worldwide web, so we released the contents online at the same time we marketed the book form. Anyone can access the dictionary and list of equivalents for free from the RTRI website. There was a concern that this would hinder sales of the paper and CD-ROM versions, but libraries and other institutions will always have a strong need for them, and we realized that making them available online would be a form of advertising promoting sales of the paper publication and disc.



One big advantage of an online dictionary is that entries can be added and edited at any time. This makes it possible to keep providing users with the latest information, and we could even let users themselves modify entries, as is done now for Wikipedia and similar online reference works. Unfortunately, one drawback of our online dictionary is that it is currently available only in Japanese. At a later date, we hope to modify it to make it accessible to people in other languages as well.

RTRI is a member of the UIC Terminology Group, and is participating in its compilation of RailLexic. Through our ties with UIC and other railway organizations worldwide, we hope to improve the content of the List of Railway Term Equivalents in Other Languages. In this way, too, we shall contribute to the globalization of rail technology and strengthen our ability to serve as a provider of railway-related information.

Fig. 1 Second edition of Dictionary of Railway Technology Terms published by Maruzen Co., Ltd. (2006/ISBN4-621-07765-1 C3551), and the companion CD-ROM, List of Railway Term Equivalents in Other Languages

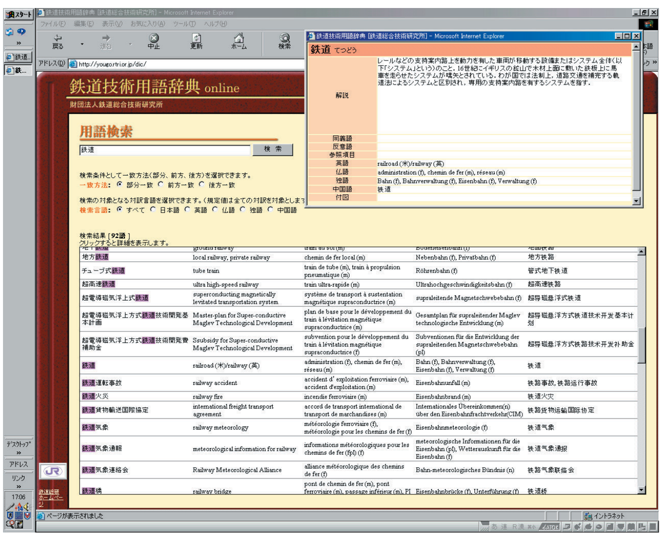


Fig. 2 Sample search screen for the online second edition of Dictionary of Railway Technology Terms, http://yougo.rtri.or.jp/dic/

Advances in Gas Pressure Welding Technology for Rails

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Gas pressure welding is accomplished by butting work pieces together, applying a suitable amount of axial pressure, and heating the joining area with an oxygen/acetylene flame to about 1,200° C, until the upsetting amount reaches a predetermined value (see Fig. 1). This welding method does not use heavy equipment, and produces highly reliable joints that are about as strong as the work pieces being jointed together. For these reasons, it is often used for welding rails and steel reinforcing bars. Fig. 2 shows usage ratios for gas pressure welding and other methods employed by the JR Group for rail welding.

The gas pressure welding method was developed in Japan and the United States around the same time in the 1940s, and the technology was later studied in the former Soviet Union and Germany, with a view to using it for rail welding. However, since the 1960s in the West, rail welding has steadily shifted to flash welding and aluminothermic welding methods, and today gas pressure welding is used very rarely there for rails.

Japan has taken a different route. Rail gas pressure welding equipment was developed here in 1953, and since then both the equipment and the method itself have been improved on numerous occasions. Gas pressure welding used to be done almost exclusively in welding plants, but since the 1970s welding equipment weight was reduced, making it feasible to perform it on-site. As a result, since then use of the gas pressure welding method has spread in Japan.

Bulges formed during the pressure welding process were traditionally removed through gas scarfing, but a hot shearing method was developed to improve workability. The hot shearing method, which removes the bulge immediately after welding, not only improves workability but also permits simple, highly precise inspections. This has greatly boosted the reliability of gas pressure welded joints. Fig. 3 shows the hot shearing method being used to remove a bulge. The combination of the advantages mentioned above makes gas pressure welding an extremely effective method for welding rails. However, welders need considerable expertise when grinding end surfaces and when using the heating burner. A shortage of welders with such expertise is predicted, so in the future companies could possibly find it difficult to ensure quality joints. Another problem is that today's gas pressure systems use acetylene as their combustion gas — the combustion reaction involving oxygen produces carbon gases, creating concern over environmental consequences.

For the above reasons, our research group is presently working on a new gas pressure welding system for rails that is environmentally friendly, easy to use and requires a lower level of expertise. Fig. 4 shows a gas pressure welding test being performed using a mixture of oxygen and hydrogen for rail welding. This new method is attracting attention as a more environmentally friendly gas pressure welding system for rails.

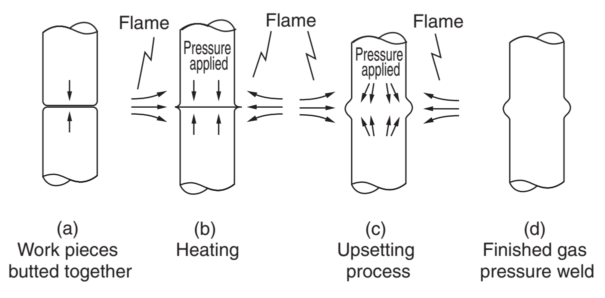

Fig. 1 Gas pressure welding process

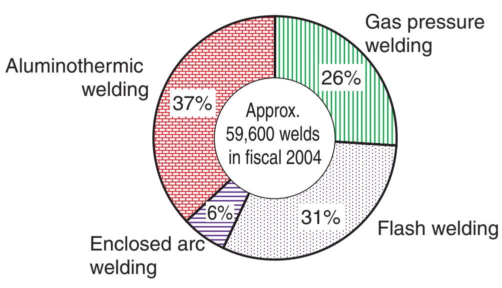

Fig. 2 Gas pressure welding, as a percentage of four welding methods used by the JR Group to weld rails

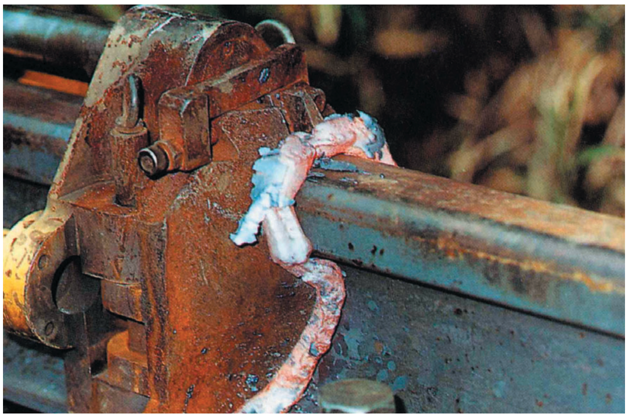

Fig. 3 Hot shearing method being used to remove a bulge

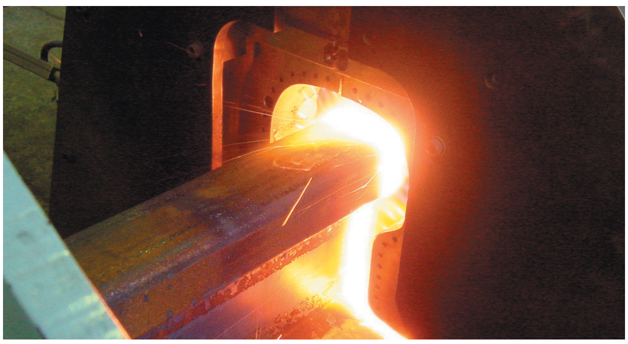

Fig. 4 Gas pressure welding test using an oxygen/hydrogen flame for rail welding

Evaluation of the Structural Soundness of Bridge Pier Foundations Under Flood Conditions

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Under flood conditions, a river can scour a bridge pier foundation, reducing its stability and even toppling it (see Fig. 1) and causing a train accident. Such an accident could be prevented through the development of a system to assess the soundness of a pier foundation during high water levels. This paper discusses changes in the nature of vibrations as the river level rises. The vibration values were extrapolated from micromotions measured with a vibration sensor mounted on the upper surface of the pier. Bearing in mind the fact that the degree of soundness of a pier foundation can be correlated with the characteristic frequencies of that pier, we developed a system to assess easily and in real time the soundness of a pier foundation during high water levels.

We mounted the vibration sensor on a bridge pier that stands on a spread foundation, and measured micromotions at five-minute intervals at both low water and high water. We then compared the Fourier spectra of the micromotions observed at both low water and high water (see Fig. 2). The response spectra during high water clearly indicated predominant peaks at around 7.5 and 11.5 Hz. On the other hand, at low water such a predominant spectral response was not observed. The shape of the spectra during high water closely resembles the Fourier spectra previously obtained during impact vibration (forced vibration) tests conducted at low water, and of these, the 11.5 Hz value was remarkably close to the pier's initial vibration frequency value of 11.3 Hz. From this we determined that, during high water, we could assign one predominant vibration frequency on the Fourier spectra of micromotions as a characteristic frequency for that specific pier. Fig. 3 shows the relationship between changes in water depth around the pier and changes in the pier's characteristic frequencies obtained from micromotions at various water levels. As the figure indicates, the deeper the water, the more the characteristic frequencies tend to converge toward the characteristic frequency values obtained previously during impact vibration tests.

Fig. 1 Destructive effect of scouring under a railway bridge (Japan)

Thus, by comparing characteristic frequencies obtained from impact vibration tests with the Fourier spectra of vibrations represented by micromotions, we determined that it may be possible to identify the characteristic frequencies of the pier at high water.

When in flood, a river may scour the riverbed around a pier, resulting in a shallower penetration depth for the pier. As a general rule, if a pier's penetration depth is sufficient, the pier will have enough resistance to withstand forces that would otherwise topple it, and the foundation will remain stable, keeping the pier sound. However, a reduction in penetration depth will diminish the soundness of the pier foundation. As the penetration depth declines, the pier's characteristic frequencies will tend to exhibit a corresponding decline. Focusing on the fact that characteristic frequencies change in this way, we developed a system that uses characteristic frequency values to determine the degree of soundness of pier foundations, then provides this quantitative data to be used as one factor for deciding whether or not to suspend train operations on the bridge. Fig. 4 illustrates the system process, and Fig. 5 shows the system configuration. The system is currently being tested in real-time assessments of the stability of bridge piers, with a view to improving system reliability and obtaining more data. System development has been subsidized by the Ministry of Land, Infrastructure and Transport.

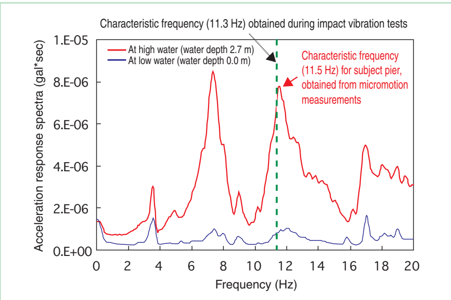

Fig. 2 Comparison of Fourier spectra of micromotions observed at low water and high water

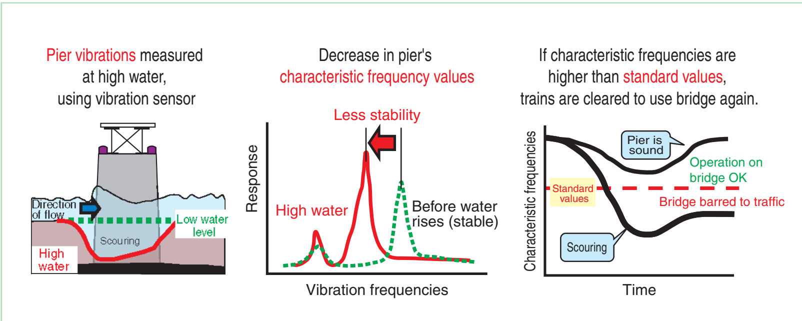

Fig. 4 Assessment of the soundness of a bridge pier foundation

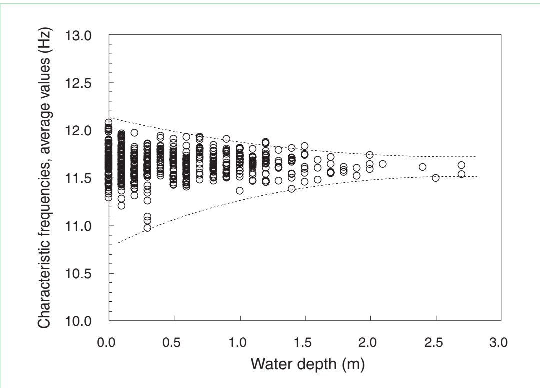

Fig. 3 Relationship between changes in water depth around pier and changes in pier's characteristic frequencies

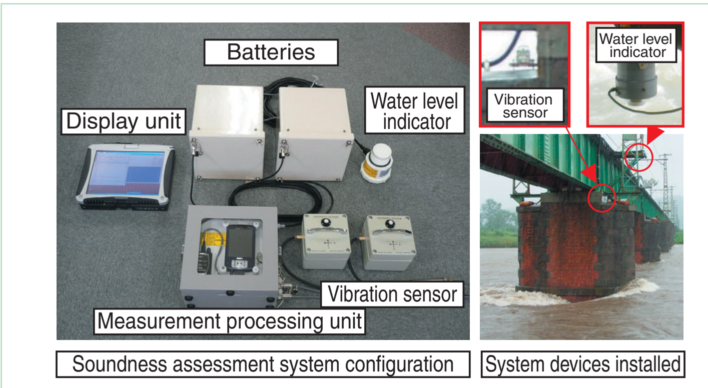

Fig. 5 Soundness assessment system configuration, and installation of system devices

Tunnel Scanning System Using Image Processing To Detect Lining Deformations

Masato UKAI
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We have developed an efficient tunnel scanner with line sensor cameras capable of taking high-precision panoramic annular images of the surface of a tunnel lining, at a low cost (see Fig. 1). The system does not require a special vehicle, but instead can be mounted on a railcar used for construction or maintenance purposes. Photographic equipment is basic, consisting of cameras, lights, control devices and the like. The 5,000 pixel line sensor cameras are mounted on the railcar and aimed at the tunnel walls. The railcar travels at a speed of 10 to 30 km/h, and can take images of the surfaces of a single-track tunnel with just one run. A double-track tunnel requires two runs, one on each track to obtain images of the entire section. Continual image taking is possible for dozens of kilometers per run. Basically, only the image taking and recording is done on the railcar, with off-line processing of image data being performed above ground. Our new system performs far better than a conventional photographic system, in terms of filming speed, recording time and memory. The resolution is the same as the number of camera pixels for cross-sectional directions, but depends on the running speed and scan rate for longitudinal directions. Under ordinary circumstances, the pixel pitch setting is around 0.8 mm horizontal/vertical.

In general, it is technically difficult to make focal adjustments for line sensor cameras under static conditions. Taking advantage of the fact that when the focal condition appears as a picture signal waveform configuration, we devised a method of analysis that evaluates the sharpness of waveforms using threshold values derived from a histogram (see Fig. 2). By quantifying the degree of focal accuracy, we made it possible to perform the proper focal adjustments.

Another problem we faced was blurred images caused by railcar vibrations. If a line sensor camera is subjected to vertical vibrations, the resulting image is conspicuously misaligned by one line per image. To correct these one-line unit misalignments we chose as a standard baseline the track's electric cables (which must be installed in a straight line), measured the amount of misalignment from the wave pattern edge, then made corrections by shifting all lines in the image by exactly the amount of measured misalignment. The system does not use a special sensor, and can obtain an excellent image with misalignments corrected.

Splicing of multiple photographic images is conventionally done by hand, but the image mosaicing method we adopted for panoramic images permits the effective production of excellent resolution panoramic annular images.

We also developed an image processing algorithm for the automatic detection of cracks, which are one typical deformation in tunnel linings. Generally, cracks are darker than their surroundings and take the form of indented, blackish wavy lines. We focused on the fact that there are luminance gradient variations along line edges, and selected cracks offering more detailed luminous variations than the cameras' resolution would recognize. We then adopted a Hysteresis threshold processing method that would select only edges joined to edges detected by the high threshold values. This has made it possible to measure the width of cracks, etc., with a high degree of accuracy (see Fig. 4).

Our tunnel scanner is now being used by a number of railway operators. We plan to raise its efficiency and precision, to enable it to detect cracks with even greater precision in the future.

Fig.1. Tunnel-scanner system for tunnel wall image recording.

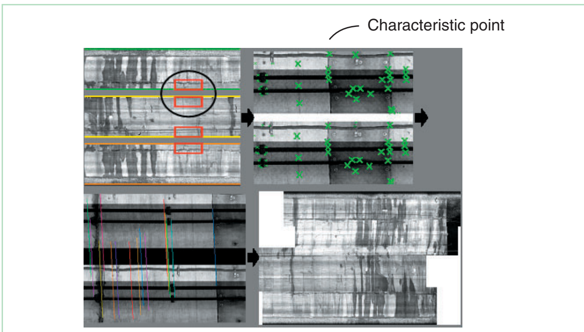

Fig.3. Joining procedure based on the characteristic points.

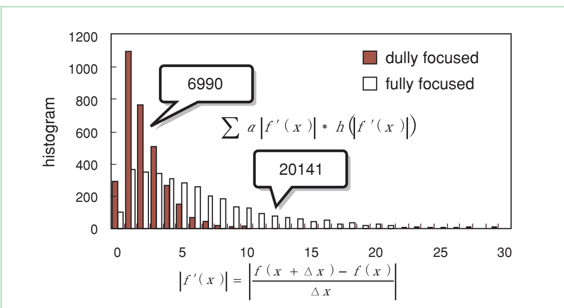

Fig.2. The first derivation histogram of line camera data.

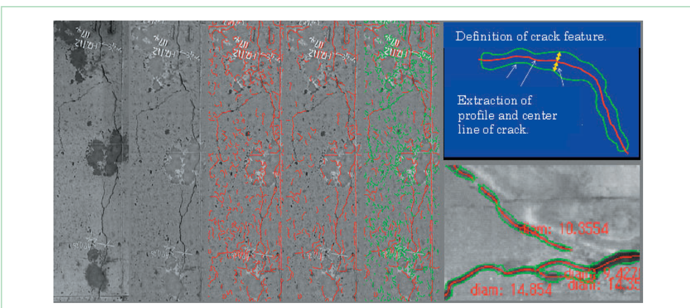

Fig. 4. An example of maximum crack width measurement.

Detour Guidance System for Passengers During a Disruption in Train Operations

Ryuji TSUCHIYA
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When train operations are interrupted by an accident, natural disaster or other incident, it is important to improve passenger satisfaction by giving them accurate information facilitating the rest of their journey. In Greater Tokyo, especially, with its complex rail network extending over a wide area, individual users need such information so that they can choose the best option to reach their own destination (see Fig. 1). We therefore developed a guidance system for users to determine whether they should wait for service to resume on the disrupted line, or take a detour route to their destination. Our system arrives at decisions after computing estimated travel times to specific stations in the area where train services are disrupted (see Fig. 2).

When developing the system, we first devised a simple model for estimating variables for the amount of time required to travel between stations in the disrupted area. We call this model the "required time variation model." We analyzed data obtained from past disruptions, then used the results of our analyses to establish parameters for the model.

For the required time variation model that we have adopted, the time required to travel between stations when the schedule is disrupted is approximated by the linear function shown in Fig. 3. The linear function has four parameters:

ε = average travel time during normal schedule conditions,

α = elapsed time from the occurrence of the disruptive incident until operations resume (the time duration required for resumption),

β = elapsed time from the resumption of operations until the resumption of normal operations, and

γ = extent of train delay after services resume.

α and β are averaged values derived from data obtained from past disruptive incidents, classified according to the type of incident.

Fig. 4 shows a sample panel for passenger guidance. The panel is for indeterminate users at a station, and is an

interface advising individual users whether or not it would be best to take a detour route to their destination station. Each station within the affected area is color coded with one of four colors. Colors give passengers advice on their best option to get to the station in question: "You should take a detour route;" "You should wait here;" "There is no detour route to your destination, so wait here;" and "Not affected by incident."

One can assume that when train services are disrupted, giving users information on alternative route options will greatly influence their travel behavior. To test this assumption we conducted a survey of the decisions passengers took as a result of such an information system, and found: (a) when train services are disrupted, the extent to which passengers are in a hurry is the determining factor in their choice of route; and (b) even though the information represents only possible scenarios, when users feel that the degree of certainty is at least 70%, they tend to take that option.

We are presently testing a system that lets users use their cell phones to learn their route options during a disruption in train services. Our studies are now finding that this system is effective — for example, we have found that approximately 70% of all users taking the advice arrive at their destination at the same time as, or earlier than, the time estimated by the system.

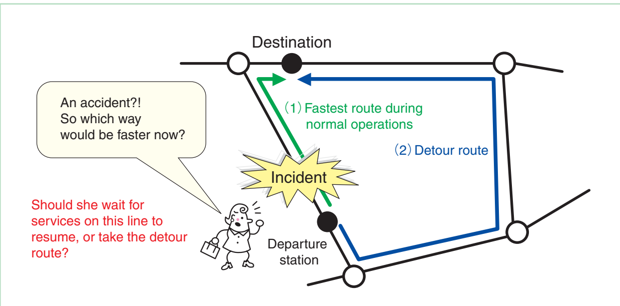

Fig.1. Choosing the best route option after interruption in rail service

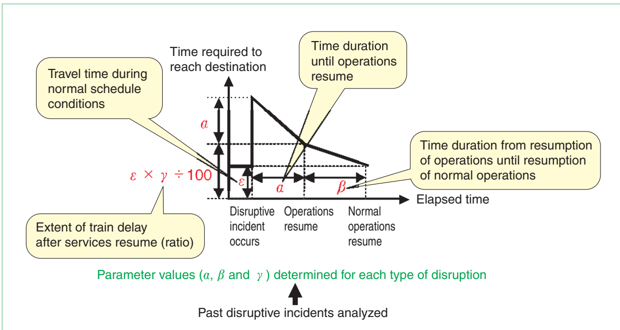

Fig.3. Required time variation model

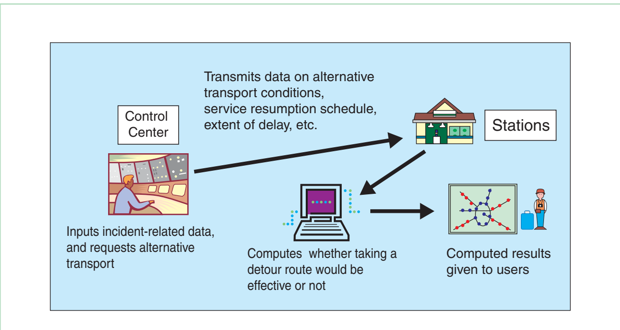

Fig.2. System operation

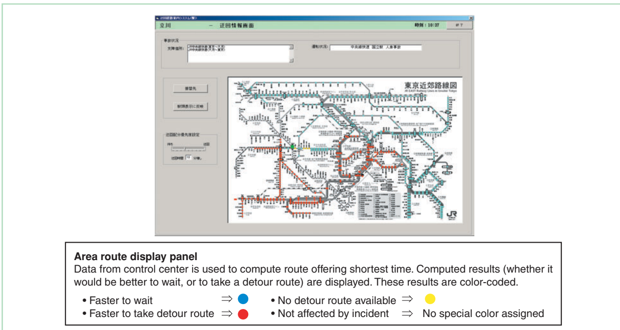

Fig.4. Guidance panel for indeterminate users at a station