NEWLY DEVELOPED RAILWAY INFORMATION SYSTEM FOR NATURAL DISASTERS PREVENTION

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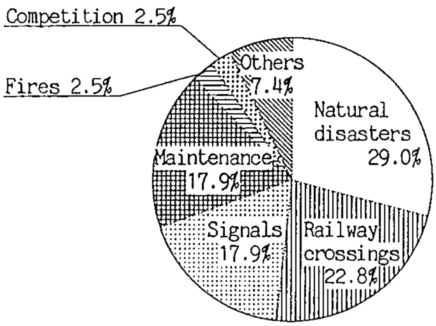
INTRODUCTION

In order to prevent railway accidents due to disasters, disaster prevention work is being conducted to strengthen various facilities. In addition, safety is being assured by detecting disasters early, knowing meteorological conditions and stopping train operation during dangerous periods of time. A new disaster prevention system has been developed for carrying out the said measures more efficiently. An overview of this system is described in this paper.

1. IMPORTANCE OF DISASTERS PREVENTION FOR ENHANCED RAILWAY SAFETY

At present, the proportion of accidents caused by natural disasters to the total number of train accidents in Japan is quite high. Among the train accidents which occurred during the ten year period from 1979 to 1988 within the service areas of the East Japan Railway Co.(JR-East), more than one-fourth of the total accidentsthat occurred were caused by natural disasters(Graph 1).



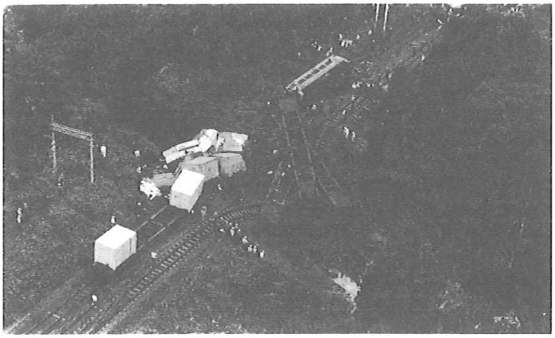
Graph 1 Rations of train accident causes within JR-East (1979 to 1988)

The frequent occurrence of natural disasters is primarily due to the meteorological, topographic, and geological conditions in Japan. Mean annual precipitation within most of the areas serviced by JR-East is higher than 1500mm, and wide areas are assaulted by strong winds and torrential rains during the landing or approach of almost every typhoon. Moreover, mainly on the Japan Sea side, the average maximum depth of snow cover exceeds 2 meters in some areas. Further, earthquakes occur in almost all areas.

A review of topographic conditions shows that about 70% of the nation's land is located in mature steep mountainous regions. Railways have been constructed along fast running rivers and sea coasts except in rural located on the plains and urban areas. Approximately 60% of the geology in mountainous regions is

Caenozoic, that is, bedrocks formed in a recent geologic era. This also contributes to the cause of natural disasters including slope failures, landslides, falling rocks, railway inundations, and snow avalanches.

At present, the number of natural disasters themselves in JR-East are still occurring at a rate of 250 to 400 cases annually. Some of them unfortunately develop into train accidents like Graph 2 . This train derailing accidents as a result of an embankment failure occurred in the premises of Rokuhara Station, Tohoku Main Line, 1989.



Graph 2

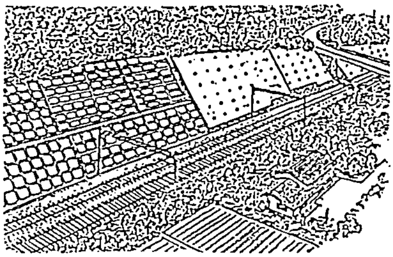
2. MECHANISMS FOR PROTECTING RAILWAYS FROM ACCIDENTS DUE TO NATURAL DISASTERS

In order to help protect railways from natural disasters, strengthening of railway facilities themselves can be considered first. For instance, prevention of slope failures due to rainfall has been accomplished by conventionally installing retaining walls, slope protection works and fences for catching falling rocks. These are referred to as hardware measures. however, a tremendous amount of money is required to install these facilities throughout whole railway lines longer than 7,500km. If these hardware measures are implemented, then the occurrence of damage due to natural disasters themselves can be prevented, so that the merit of decreased train operation delays can be expected. However, this investment will be made only to top priority lines and sections in the future.

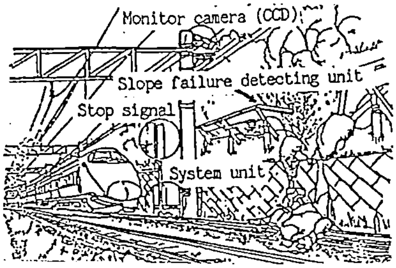
Where the direct prevention of natural disasters is difficult to achieve, then trains are stopped by detecting the occurrence of natural disasters, thereby preventing possible accidents. Falling rock and avalanche detectors have been arranged and installed by Laying electric wires along railway lines. If the wire is cut off as a result of an outbreak of a natural disaster, then a special signal light generator is interlockingly engaged. This is very simple but has fully functional up to now. However, it often creates erroneous operations, resulting in a major disadvantage being that the occurrence of a natural disaster can only be known at the site.

Moreover, meteorological observation instruments such as rain gauges, speedometer and seismographs have been installed mainly along the railways, while control values for rain, wind, and earthquakes have been established by taking account of the characteristics of respective lines and areas. These were made by presuming the natural disasters for which the location of occurrence cannot be determined in advance. If the control values are exceeded, trains are stopped or driven slowly; facilities such as tracks are inspected by railway maintenance worker; and the restarting of operation is permitted only after verifying safety. Operation controls based on disaster detection and meteorological conditions are called software measures. In the future, the natural disaster prevention measures will be mainly taken based on software measures for local lines in rural areas.

The image of a railway section mainly made of hardware measures and the image of another railway section mainly made of software measures are shown in Graph 3 .



Facility image of a railway section utilizing mainly hardware measures



Facility image of another railway section primarily utilizing software measures

Graph 3

A new railway information system has been constructed for the purpose of concentrating investment in hardware measures in urban areas in the future as well as for enhancing safety, reducing unneeded operation control time, and promoting labor savings by mechanizing local railway sections primarily through the use of software measures.

3. THE NEW RAILWAY INFORMATION SYSTEM TYPE I (FOR NATURAL DISASTERS)

3.1. Conventional Meteorological Observation System

Conventionally, meteorological observation equipment existed alone without any on-line arrangement, and water levels in rivers were checked on site by naked eye observation of the persons in charge of the facilities. Therefore, data transmission from the meteorological observation equipment along the railways was generally made by telephone communication from observer to railway maintenance worker to facility commander. The maintenance worker who received a report had to make a separate call to report it to another division again. because of this, the following problems occurred:

- Much time was consumed for issuing operation controls or guarding.
- No record was kept of oral communications using telephones; information was often inaccurate and complicated matters could not be communicated effectively.
- Since the meteorological observation equipment existed by itself, some

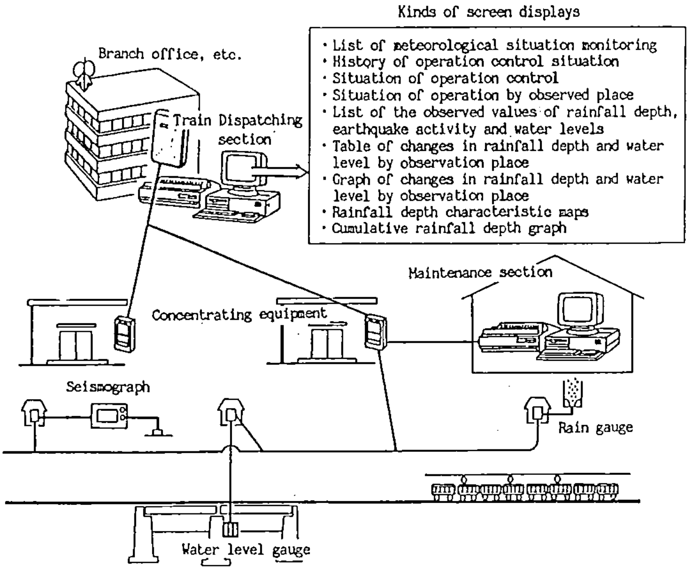
persons had to go to the site directly in order to check the observed values even during bad weather.
・Since only the values of observed data were indicated, much time was needed for making comparisons with the operation control standard values by combining and analyzing several values.

3.2. Characteristics of The New Railway Information System Tipe I (For Natural Disasters)

Since the existing system retains portions that still rely on the direct involvement of workers, it was decided to develop a new railway information system Tipe I capable of the folloing:

(1) on-line observation instruments with automatic measurement;
(2) simultaneous real-time display of similar contents at different places if required;
(3) effective drawing and diagram displays that can be compared directtly with opertion control values by processing the observed data by personal computer;
(4) storage of data for use in re-examining operation control values at later times;
(5) simplified keyboard operation to the extent possible for permitting quick viewing of required information from among those related to rainfall, water level, wind and earthquakes;
(6) To permit the monitoring of normal operation of respective meteorological observation equipment and data processing units.

an outline of this system is shown in Graph 4.



Graph 4 Outline of the new railway information system Type I

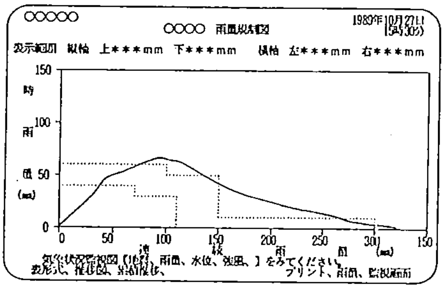
3.3. System Configuration

The present system is comprised of terminals located at those places where meteorological observation equipment are installed in the field, concentrating equipment in the communications equipment room of railway stations, information transmitting equipment consisting of dedicated cables connecting said equipment to centralized equipment at branch offices, and display units for processing the values observed as necessary information and displaying said values.

The number of observation equipment installed and the information they transmit are shown in Table 1. An example of a display screen is shown in Graph 5. Use of this system was started from April 1990 in all JR-East areas.

Table 1

Observation equipment	Number of units installed	transmitted information
Rainfall depth	582	• Pulse signal every 0.5mm
Water level	185	• Water level below girder in cm units • Information about power service interruptions
Earthquake activity	186	• Warning rank (3 class) information • Earthquake acceleration (3 directions + horizontal synthesis) • Power service interruption, problem area information
Wind velocity	271	• Max. velocity (m units) • Power service interruption, problem area information



Graph 5 An example of a display screen

3.4. Effect of the System Use

About two years has passed since the present system was first put into use. Maintenance workers, station workers and commanders can use the information jointly as required including the values of meteorological observations. Thus, incorrect transmissions have been eliminated, and operation control can now be smoothly executed and forwarded. Moreover, data such as rainfall for the past 14 days are stored in fixed disks at 5 minute intervals, and any required data can be transferred to and stored in floppy disks. Thus, data now can be effectively utilized for re-examination of control standard values. Actually, the number of control standard values used has been partially increased at 9 branch offices. As a result, the time that trains are unnecessarily stopped has been reduced.

4. THE NEW RAILWAY INFORMATION SYSTEM TYPE II (FOR NATURAL DISASTERS)

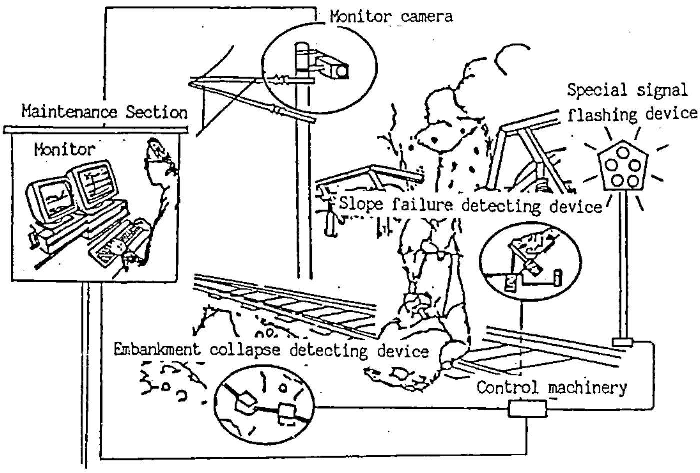
As stated above, the new railway information system (Type I), the use of which was started in April 1990, has been effective. However, trains are sometimes Halted even though natural disasters have not actually occurred. Therefore, a new railway information system Type II has been developed for use on trunk lines connecting cities having large volumes of traffic. This system will be utilized for the Yamagata Shinkansen line to be opened in July 1992 and is currently under construction.

4.1. Characteristics of The New Railway Information System Tipe II (For Natural Disasters)

The following targets have been established since the system will be used in those line sections where traffic volume is great:

(1) To detect the occurrence of natural disasters and to halt trains as required; train operation will be possible immediately prior to the occurrence of any natural disasters.
(2) To simplify the existing inspection and confirmation work done in observing natural disasters mainly by manual labor by constructing a new system capable of verifying the presence or absence of any abnormal state.
(3) To permit the determing of the situation of natural disasters from dispatching sections permitting verification of the scale of any disaster and taking appropriate recovery measures, thereby quickening the recommencement of train operations.

An outline of the said system is shown in Graph 6 .



Graph 6

4.2. System Configuration

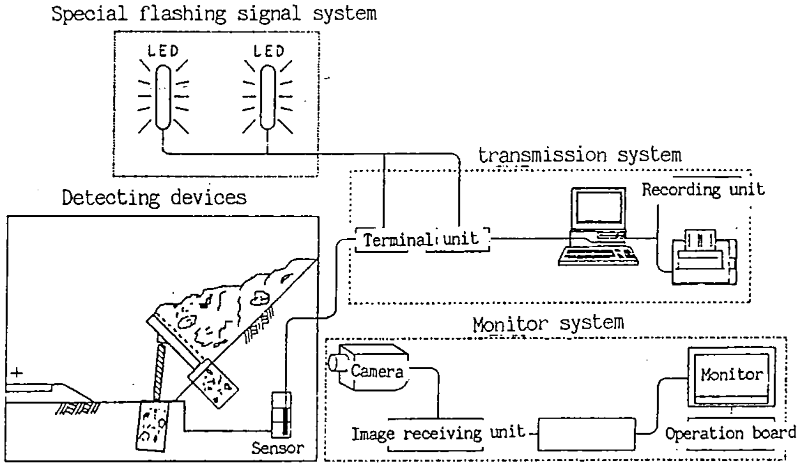
As shown in Graph 7 , the configuration of this system is:

① The occurrence of natural disasters is detected by sensors in detecting devices, its pressure is converted by a transducer to a voltage of 0 to 5V, and the signals are transmitted to a field terminal unit of the transmission system.

② Concentrating equipment in an office collects and stores data at constant intervals from each terminal unit which receives information signals from detecting devices; data is transmitted to a personal computer for display; and data are processed, an alarm buzzer activated, and graph prossing is made for informing workers of the occurrence of natural disasters.

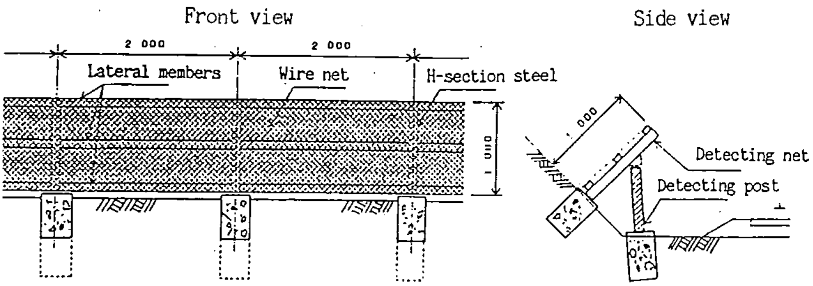
③ If the information on the occurrence of a natural disaster is relayed from detecting devices, LED signals are activated and trains are stopped by a special flashing signal system.

④ The field situation can be verified by monitor cameras of the monitoring system by the information from the transmission system.

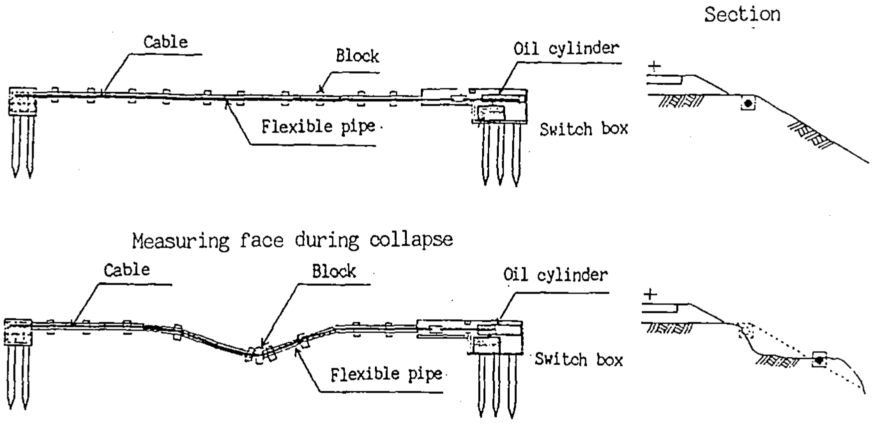


Graph 7

Two kinds of detecting devices are available: collapse of a cut and natural slope detector, and a embankment detector. An outline of both the kinds are shown in Graph 8 and Graph 9 .



Graph 8 Outline of detecting device (for cut and natural slope)



Graph 9 Outline of detecting device (for embankment)

5. RAILWAY INFORMATION SYSTEM FOR NATURAL DISASTERS OF FUTURE

In the future, we are considering to enhance the railway information system Type I (for natural disasters) for local lines. This will include not only the outline use of rain gauges, water level meters, seismographs, and anemometers along the railways, but also the use of meteorological information possessed by other organizations such as the Meteorological Agency of Japan will be considered. Information from the Meteorological Agency is able to predict rainfall up to three hours later and to provide meteorological information in a wide range and thus will be extremely useful information for observing natural disasters and executing operation control.

On the other hand, in order to reduce operation down time to a minimum on trunk lines between cities having heavy traffic volumes, it is necessary to install systems capable of stopping trains only when natural disasters are directly detected by the railway information system Type II and also capable of determining and providing information on the field situation from the commander's office. Installation of this system will be expanded. If advanced sensors for detecting devices are developed for detecting various natural disasters in the future, then both safety and regular train operations can be enhanced.

improved railway information system for natural disasters in addition to disaster prevention work aimed at completely eliminating disasters currently in progress in urban areas will develop the railways into a safer and more efficient transportation system even against natural disasters.