Practical Use of the Earthquake Early Warning (EEW) System for the Shinkansen

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RTRI has carried out various research and development work to ensure the safety of train operations when earthquakes occur. Our EEW system, which stops trains as rapidly as possible by analyzing the P-wave forming the initial phase of seismic motion, is our major achievement in this field, and UrEDAS was developed as the first practical EEW system in the world. Our EEW system has the following two characteristics:

(1) Trains are stopped when a single seismograph detects an earthquake

Substations provided with seismographs exclusively for railways have been installed along the track at intervals of approximately 20 km. In order to stop trains immediately even when electric power and communication lines are cut during an earthquake, the decision to stop trains is based on data observed at a single seismograph.

(2) Coastline seismograph for earthquake detection in subduction zones

Seismographs also have been set up along the coast at intervals of approximately 100 km to detect in advance any earthquakes occurring in a subduction zones. This is termed a coastline seismograph, whereas the device described in (1), is called a railway-track seismograph. During the "2011 Earthquake off the Pacific Coast of Tohoku (Mw 9.0)" that occurred on 11th March, 2011, one of the coastline seismographs detected seismic waves and sent warning information that safely brought Shinkansen services to a halt.

Since 2000, we have developed a new algorithm for the EEW system in co-operation with the Japan Meteorological Agency with the aim of improving the system reliability. Based on the above achievements, we completed an update of the system for the entire Shinkansen network in 2007. The following three points describe the improvements made to the new EEW system for the Shinkansen.

(1) New earthquake detection algorithm

The significant point of the new EEW system for the Shinkansen is new algorithm to detect earthquakes. As a result, the accuracy of estimating the location of the hypocenter within a few seconds by detecting the P-wave improves by approximately 20%. A flow chart depicting the process is shown in Fig. 1.

(2) Standard communication telegram format

The communication telegram format that is used for communication between seismographs was standardized by RTRI. By using this standardized format, it became feasible to construct a large-scale EEW system with different seismographs produced by different manufacturers.

(3) Complete two-way communication between seismographs

Two-way communication of warning information about the P-wave and S-wave was added following the experience of the Mid-Niigata Prefecture Earthquake in 2004, which had less lead time. We assume that this function will be very effective because the warning information that will stop the trains is transmitted to the region not yet reached by the P-wave and S-wave (see Fig. 2).

Simulation of operation of the new EEW system has been carried out based on the data recorded during the Mid-Niigata Prefecture Earthquake (2004) and the lead-time after the warning has been examined. As the result, it is found that the lead-time is estimated to be almost three seconds in the vicinity of the epicenter. It is obvious that the benefit of the lead-time is limited for the trains running in the vicinity of the epicenter because Shinkansen trains need a few minutes to be stopped completely. However, it is considered that the benefit of the lead-time is higher for the trains that are approaching the epicentral area.

With the increasing speed of trains, it is imperative to improve the reliability of the EEW system by updating algorithms as well as by evaluating the performance of the system.

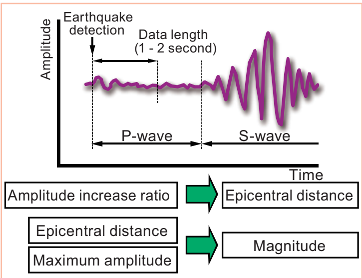

Fig. 1 Flow chart showing the process after detection of the P-wave

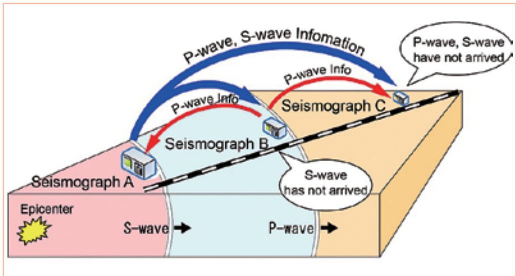

Fig. 2 Seismograph two-way communication

Identification of Thermal Cracking Criteria on Wheel Treads for Optimized Brake System Design

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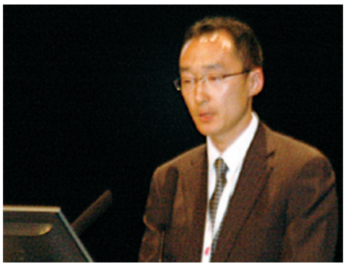

Thermal cracking of wheel treads is one of serious problems affecting wheel maintenance. However, systematic measures to deal with the problem have not been established because the mechanism of wheel cracking and the conditions, in which it occurs, are unclear. The authors reported successful reproduction of cracks by use of a full-scale apparatus at the previous WCRR (2007), which enabled a systematic approach to this phenomenon. The present study has been concentrated on the verification of a hypothesis about the crack-generating mechanism. This was formed on the basis of estimating the temperature/stress fields from the residual stress measured, on the microstructure observed by a high-resolution scanning electron microscope and on elastic-plastic FE-analysis. The predominant factor in the thermal cracking is considered to be the wheel/rail tangential force applied under a circumferential tensile residual stress field. The practical factors influencing this phenomenon are the maximum wheel temperature, the axle load and the acceleration/deceleration of the vehicle.

Since these factors depend on the vehicle specification, applying the findings of the present study as guidelines for vehicle design will enable the total optimization of the brake system design including life-cycle manufacturing/maintenance costs, as well as safer operation of rolling stock.

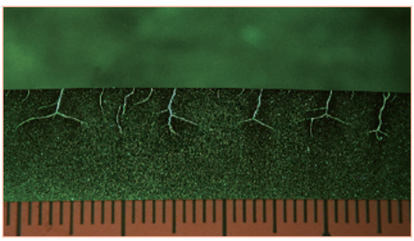

Fig. 1 Longitudinal cross section of thermal cracks in the wheel tread

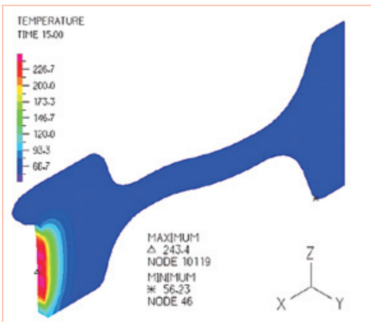

Fig. 2 Wheel temperature distribution during tread braking estimated by FEM analysis