History of The Disaster Prevention Research Laboratory

Hiroto Suzuki
Director, Disaster Prevention Research Laboratory, Research and Development Center of JR East Group

1 Introduction

The Disaster Prevention Research Laboratory was established within the Research and Development Center of JR East Group on February 1, 2006, and it has been in operation for more than ten years. Research on railway disaster prevention was previously done mainly at the Safety Research Laboratory, but the December 25, 2005 derailment accident on the Uetsu Line prompted the Disaster Prevention Research Laboratory to be established. One role of the Disaster Prevention Research Laboratory is to accumulate within the company scientific knowledge on meteorological phenomena such as localized wind pointed out as being a cause of the accident as well as on natural phenomena in general. The laboratory also conducts joint research with outside experts and research organizations along with applying technologies such as meteorological observation to railways and otherwise conducting feasible R&D as a railway operator.

The Disaster Prevention Research Laboratory originated as the Safety Research Laboratory Crossings and Disaster Prevention Group established on April 1, 1988. That was in response to a train collision accident that occurred at Higashi-Nakano Station of the Chuo Line on December 5, 1988. It later changed its name to the Disaster Prevention and Safety Assessment Group and then the Disaster Prevention Group, and eventually it became the Disaster Prevention Research Laboratory.

Vice president of JR East at the time, Shuichiro Yamanouchi, stated at the end of a column he presented on science for safety that it was his great wish for JR East, through the Safety Research Laboratory, to create systems, information, and people the company could boast of to society and to the world about in terms of safety. Everyone at the Disaster Prevention Research Laboratory along with the Safety Research Laboratory takes those words to heart, faithfully going forward with R&D that contributes to improved safety for railway operation.

2 Major R&D over the Past 10 Years

In order to improve safety of railways, the Disaster Prevention Research Laboratory conducts R&D related to disasters caused by all sorts of natural external forces such as rain, wind, and earthquakes. Of that, countermeasures against wind gusts has been the most important research theme of the Disaster Prevention Research Laboratory since its inception.

The railway accident report of the Aircraft and Railway Accidents Investigation Commission (current Japan Transport Safety Board) about the December 2005 derailment on the Uetsu Line focused on advancements in meteorological observation technologies, information processing technologies, and the like, and it also stated that serious efforts needed to be made on effective countermeasures against gusts by conducting broad-ranging research.

Gusts occur in spatially narrow ranges, making them difficult to detect by anemometers discretely arranged along tracks. Even if they are detected by anemometers, it would be too late to issue train operation control orders. Research has been ongoing since the inception of the Disaster Prevention Research Laboratory on two approaches for gusts: indirectly detecting gusts by using meteorological radar that enables area-wide observation to detect strong cumulonimbus clouds that may cause gusts such as tornados and directly detecting vortices that accompany tornados by using Doppler radar. The first approach is a method using meteorological radar data distributed by the Japan Meteorological Agency (JMA), and we made efforts as a short-term research theme using data already distributed at the time by the JMA. In the second approach, a method using Doppler radar, we proceeded as a medium-term research theme due to the need to start by identifying the actual conditions of gusts where there were many unexplained aspects.

In indirectly detecting phenomena such as tornados, we developed a method where first the passage of cold fronts is predicted from JMA weather charts, and then situations where the range in radar echo data with strong echo intensity is broad and the cloud top is high are considered to be where strong cumulonimbus clouds demonstrate the chance of causing phenomena such as gusts. If the cumulonimbus clouds may possibly pass over the tracks, train operation is stopped. Train operation control by this method has been conducted through trials in winter for lines along the Sea of Japan from January 2008. And with increased accuracy of radar echo data, we developed a method with improvements in criteria for identifying strong cumulus clouds and in the range for stopping train operation and conducted trials on this method from November 2015.

In development of a method of directly detecting vortices accompanying tornados, we are conducting research jointly with Meteorological Research Institute (MRI) of JMA. That research is being done based on observation data of the JR Doppler radar at Amarume Station on the Uetsu Line, the Doppler radar set up by MRI at Shonai Airport, and meteorological observation equipment such as anemometers and barometers set up densely across the Shonai Plain. As a result, we gained new knowledge on gusts at the Shonai Plain. This included knowledge that wind speed of vortices observed by the Doppler radar and wind speed of gusts observed by anemometer are generally the same, that
vortices proceed almost in a straight line from the Sea of Japan to inland, and that ground level gusts are located behind vortices in terms of their direction of movement. Based on this knowledge, we have been proceeding with development of a gust detection system that can automatically detect vortices and stop operation of trains if a vortex poses a risk of passing over the tracks. In this research, we are setting up a new Doppler radar (Photo 1) on the Shonai Plain in order to study how to further increase accuracy of detecting gusts.

In countermeasures against strong winds, introduction of the strong wind warning system for which research was done since the Safety Research Laboratory era was completed for all JR East lines in 2010. With that method, instantaneous wind speed is predicted a few minutes to a few tens of minutes in the future based on observations by anemometers, and train operation control is performed based on the predicted wind speed. And as a more appropriate method of making wind observations used for operation control of trains, we developed a method that uses the spatial average of instantaneous wind speed observed by three anemometers set up in a 20 m range equivalent to the length of a train car. Moreover, this spatial average of wind speed and 3-second average wind speed observed by a single anemometer were shown to have similar performance. Those methods of wind speed observation, along with a method of assessing overturn resistance of rolling stock in wind developed by the Safety Research Laboratory using the RTRI Detailed Equation, have been introduced in advance to 11 sections of four lines, including the Keiyo Line. We are currently developing a method of increasing the prediction accuracy of the strong wind warning system.

In countermeasures against heavy rainfall, a method for train operation control under rainfall that uses effective rainfall studied from the Safety Research Laboratory era was introduced to all JR East lines in 2007. In countermeasures against strong winds, introduction of the strong wind warning system for which research was done since the Safety Research Laboratory era was completed for all JR East lines in 2010. With that method, instantaneous wind speed is predicted a few minutes to a few tens of minutes in the future based on observations by anemometers, and train operation control is performed based on the predicted wind speed. And as a more appropriate method of making wind observations used for operation control of trains, we developed a method that uses the spatial average of instantaneous wind speed observed by three anemometers set up in a 20 m range equivalent to the length of a train car. Moreover, this spatial average of wind speed and 3-second average wind speed observed by a single anemometer were shown to have similar performance. Those methods of wind speed observation, along with a method of assessing overturn resistance of rolling stock in wind developed by the Safety Research Laboratory using the RTRI Detailed Equation, have been introduced in advance to 11 sections of four lines, including the Keiyo Line. We are currently developing a method of increasing the prediction accuracy of the strong wind warning system.

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