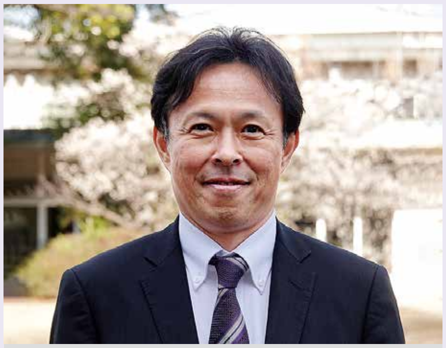
The Disaster Prevention Technology Division focuses on the prevention and mitigation of damage and degradation caused by natural disasters such as, heavy rainfall, high wind, ice and snow, and weathering, along railways and surrounding areas. It has been developing techniques to investigate and assess the topographical and geological features and ground water conditions along railways, as well as conducting research on ground vibrations from running trains. We introduce herewith the latest examples of our research and development efforts.



Dr. Osamu Nunokawa
Director,
Head of Disaster Prevention Technology Division

Recent Research and Development of Disaster Prevention Technology Division

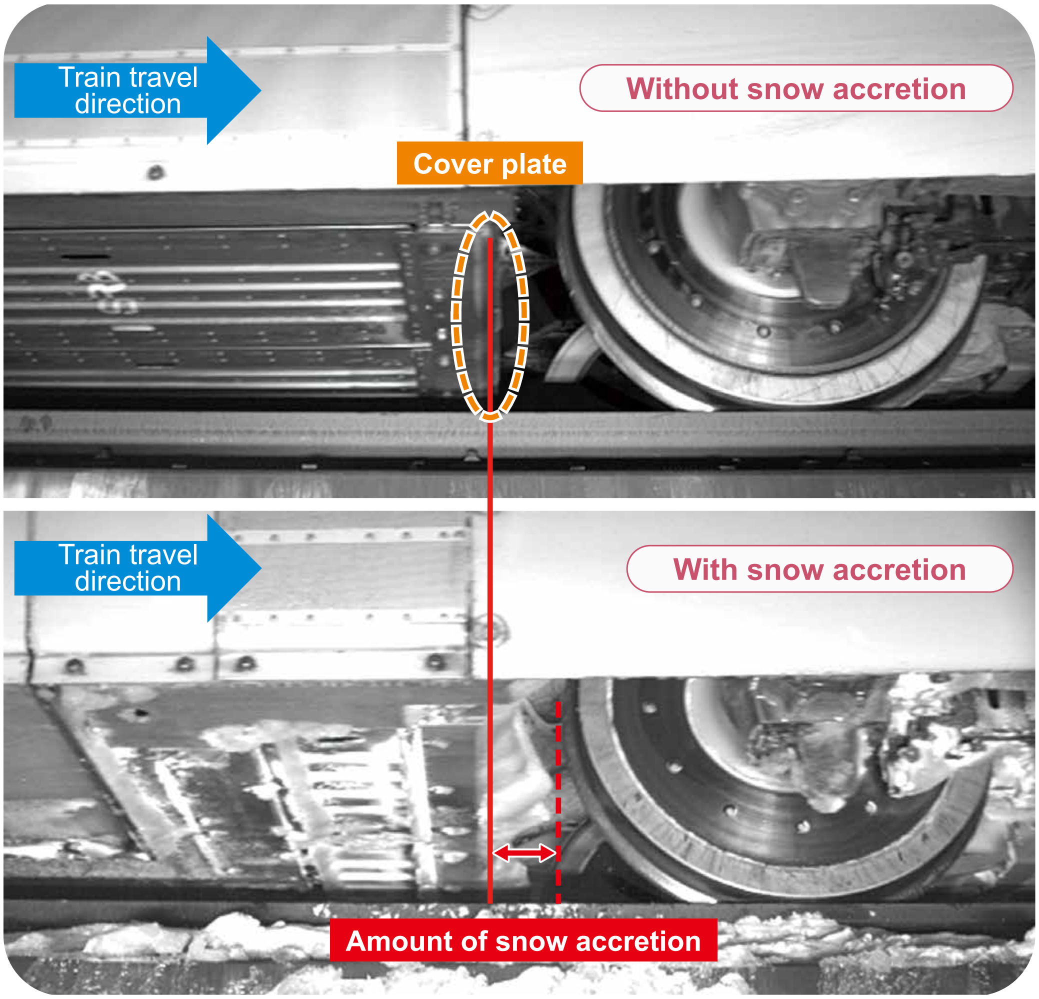
Introduction

The worsening climate change associated with global warming is raising concerns about the increasing risks of climate disasters (e.g., heavy rainfall and high wind). Japan, in particular, has been hit by various natural disasters every year due to its topographical, geological, and climatic conditions being harsher than those of Europe and the United States. The Disaster Prevention Technology Division, which is composed of the Meteorological Disaster Prevention, Geo-hazard and Risk Mitigation, and Geology laboratories, has thus pushed forward with research and development efforts that focus on techniques to prevent and mitigate the damage from natural disasters along railways (*Technical Fields Covered by the Disaster Prevention Technology Division*). Our main research subjects and examples of the specific themes we examine are as follows:

Heavy rainfall	:	Landslide disasters triggered by heavy rainfall, damage to bridges due to water level rise
High wind	:	Derailment and overturning accidents caused by high wind
Ice and snow	:	Avalanches, snow accretion on railway vehicles, frost accretion on overhead contact lines
Weathering	:	Landslide disasters triggered by ground weathering

We are also developing investigation and assessment techniques related to topographical and geological features and ground water conditions, and conducting research on ground vibrations from running trains. Below are the latest examples of our research and development on countermeasures against snow, wind, and weathering.

Technical Fields Covered by the Disaster Prevention Technology Division

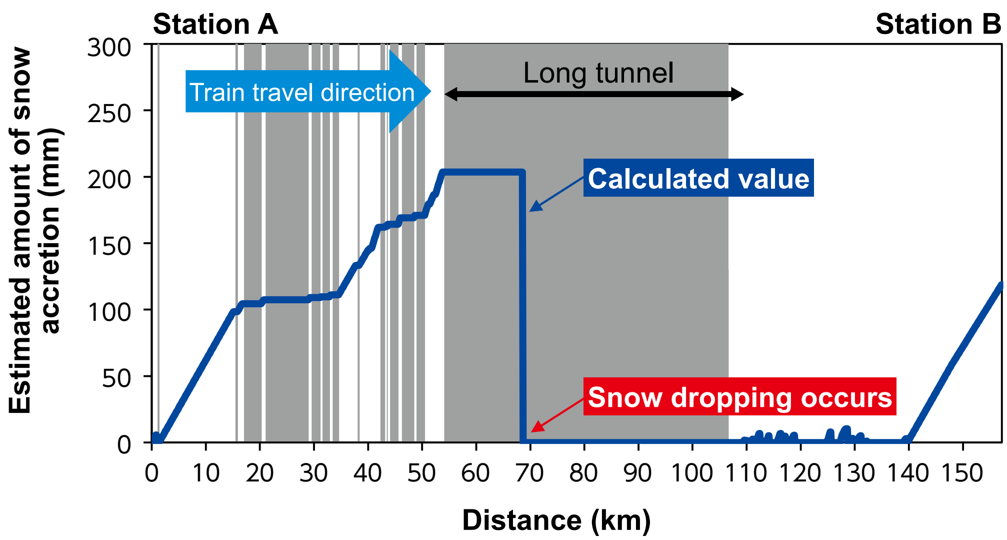


Example of Snow Settling on Bogie End Cover Plate[4)]

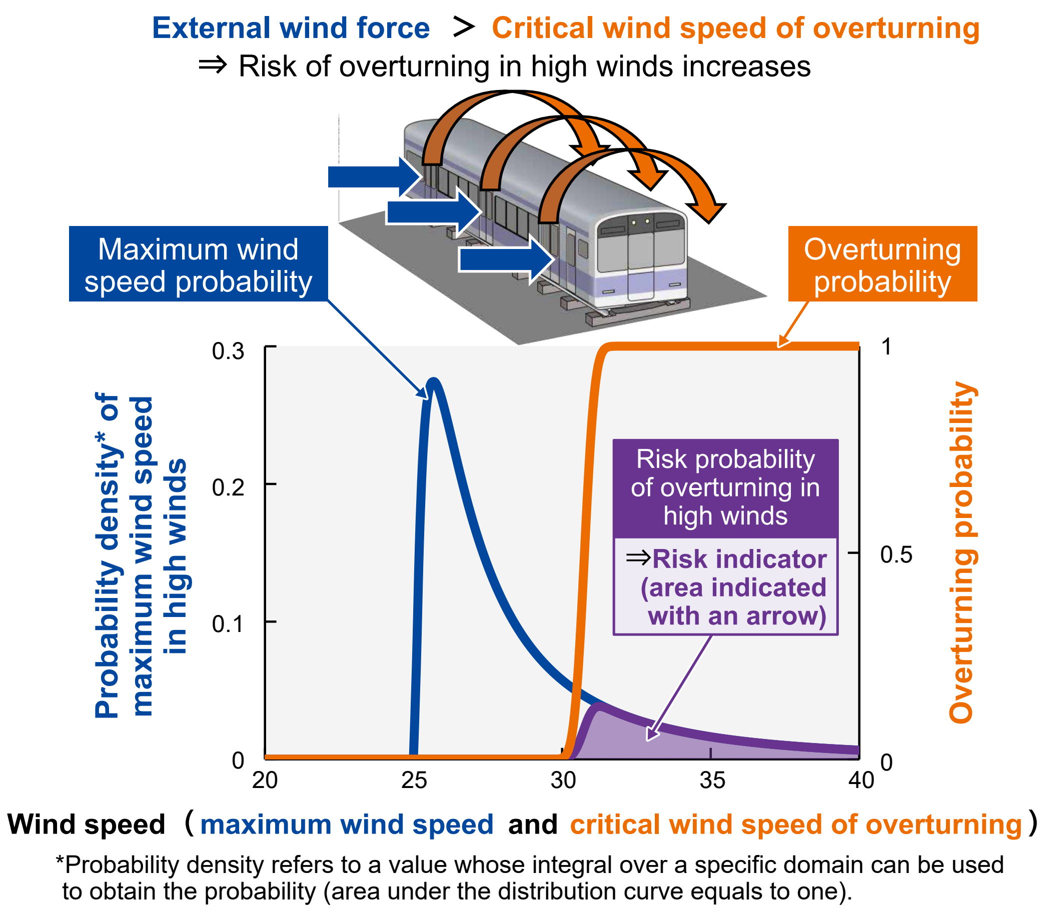
Estimating Snow Accretion and Dropping from Train Vehicles to Verify Countermeasures Against Snow Dropping

In snowy areas, snow blown up by running trains often settles on bogie end cover plates (*Example of Snow Settling on Bogie End Cover Plate*[4)]) and the like. The accumulated snow often forms chunks of ice, which can drop off while trains are running and damage ground equipment. As a countermeasure against such potential damage, railway workers have to clear accumulated snow at train stops. However, since whether or not snow removal is necessary relies only on weather forecasts, railway workers have to be mobilized at all times even when removal work is not needed.

To improve staffing efficiency, we developed a method for estimating the snow accretion on and snow-dropping from train vehicles. Our proposed method estimates the location where the snow drops off and the amount of snow accretion in real time. We calculate the amount of snow accretion on the bogie cover plates in cold open sections based on weather information along the line (*Example of Snow Settling on Bogie End Cover Plate*[4)]). The loss of snow when it drops off in warmer environments, such as tunnels, is also considered (*Example of Calculation of Snow Accretion Amount (gray shaded areas represent tunnel sections)*). We compared the actual measured and estimated amounts of snow accretion upon the train's arrival at the station and found an error margin of approximately 3 cm. We are now proceeding with our research and development to obtain a more accurate estimation.



Example of Calculation of Snow Accretion Amount (gray shaded areas represent tunnel sections)

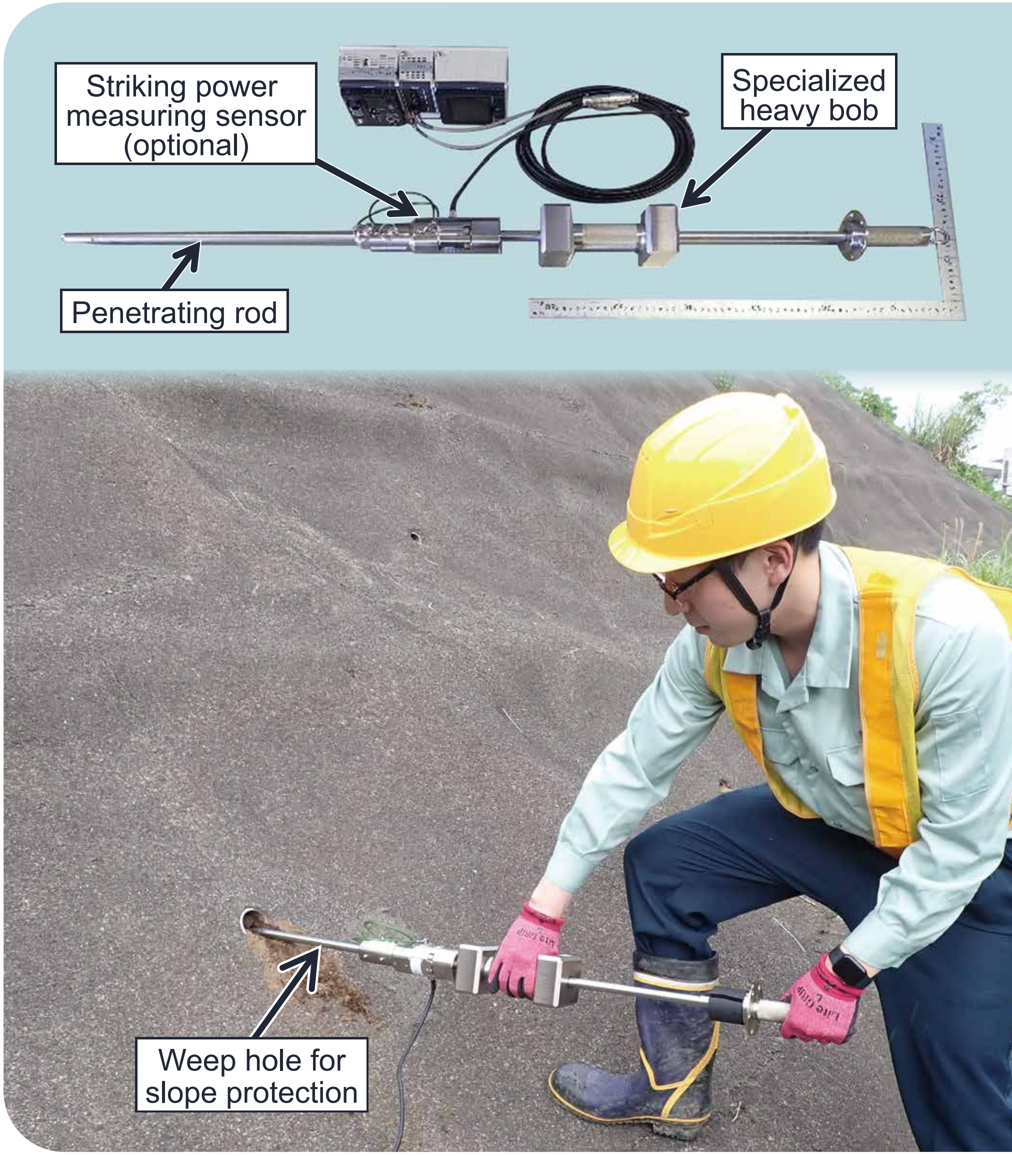


Overview of Method for Evaluating Vehicle Safety During High Winds Using Probabilistic Risk Assessment

Evaluating Vehicle Safety in High Winds Using Probabilistic Risk Assessment

To prevent overturning accidents in high winds, train operation is regulated (either slowed down or cancelled) when the wind speed exceeds a certain limit (regulated wind speed). With meteorological disasters aggravating year after year, train operations need to be regulated when the wind is strong enough to overturn trains. However, regulated values that are extremely biased toward safety may hinder stable transport operations. Therefore, before discussing regulations on wind speed, quantitative safety indicators for various types of vehicles are required against overturning accidents in high winds. We thus propose a method for evaluating vehicle safety in high winds using probabilistic risk assessment.

When the wind speed exceeds a certain critical value (critical wind speed of overturning), the risk of vehicle overturning increases. The critical wind speed of overturning varies with lateral vibration acceleration that occurs depending on the running conditions (track conditions and running speeds). Moreover, because winds are natural phenomena, the maximum value of wind speed that overturns vehicles (i.e., maximum wind speed) also varies with the situation. The proposed method calculates the risk probability of overturning by expressing these variations in terms of probability distributions to use the risk probability thus obtained as a risk indicator of overturning (*Overview of Method for Evaluating Vehicle Safety During High Winds Using Probabilistic Risk Assessment*). The safety of various types of vehicles in high winds can be quantitatively compared by using the aforementioned risk indicator for discussing the regulation of train operations when high winds blow.



Simplified Free-Fall Striking Penetration Testing Machine (Above) and its Usage (Below)

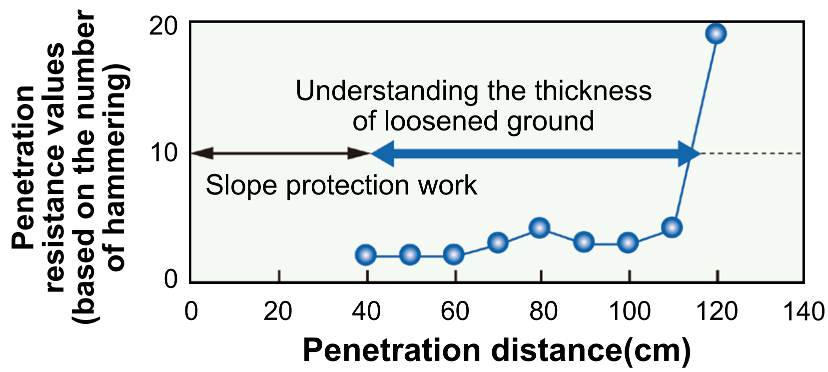
Low-Cost Deterioration Evaluation of the Backside Ground of Slope Protection Works

The excavation of grounds during railway construction in mountainous areas results in the formation of several slopes (cutting slopes). To protect the cutting slopes from weather, some slopes are treated with surface protection, such as concrete. If the backside ground deteriorates too severely with aging that it can no longer stand on its own, landslides from the ground may push the surface protection of the slope forward, eventually leading to the collapse of the slope. Conventionally, the deterioration of backside ground treated with slope protection could not be confirmed only by ordinary visual inspection but also required horizontal boring investigation, which involved large-scale devices. To address this issue, we developed a low-cost horizontal test machine (hereinafter referred to as "simplified free-fall striking penetration testing machine") to confirm the deterioration of backside ground.

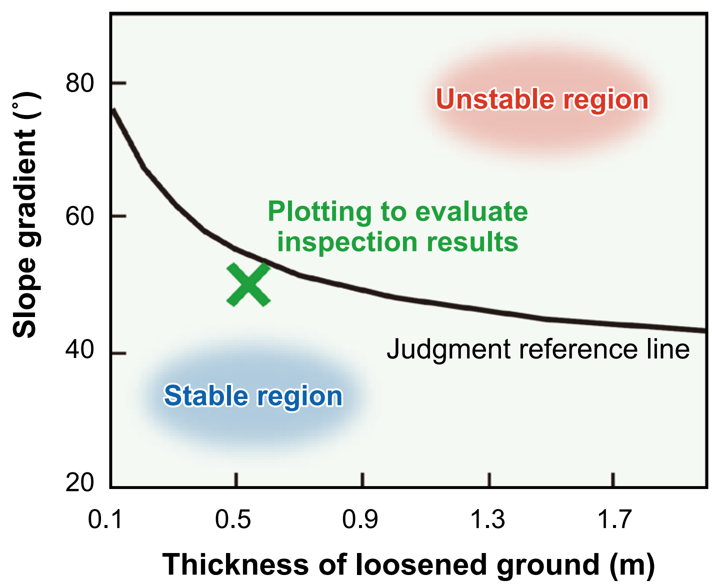
The simplified free-fall striking penetration testing machine penetrates a rod by hammering it horizontally from a point on the weep hole already installed on the slope protection surface to a point on the backside ground by a constant striking force (*Simplified Free-Fall Striking Penetration Testing Machine (Above) and its Usage (Below)*). The machine calculates the penetration resistance values based on the number of hammerings to determine the range of ground deterioration (*Example of Test Result*). Based on the test results, it evaluates slope stability by plotting the range of deterioration on a nomogram (*Example of a Nomogram for Evaluating Slope Stability*). This type of research can be done within approximately 10 minutes per location and does not require construction work, such as the removal of slope protection materials.

Conclusions

This report covered examples of the latest research and development approaches of the Disaster Prevention Technology Division. For more information about our other research achievements, please visit the Railway Technical Research Institute (RTRI) website (https://www.rtri.or.jp/eng/rd/division/rd46/).



Example of Test Result



Example of a Nomogram for Evaluating Slope Stability

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3) "Railway Accident Investigation Report", the Japan Transport Safety Board, MLIT, https://www.mlit.go.jp/jtsb/railway/rep-acci/RA2008-6-1.pdf (Received on October 25, 2022).
4) Kamata, Y., Shishido, M., and Sato, R., "Method for Estimating Snow Accretion on Shinkansen Bogies using Weather Data", Quarterly Report of RTRI, Vol.62, No.4, 2021.