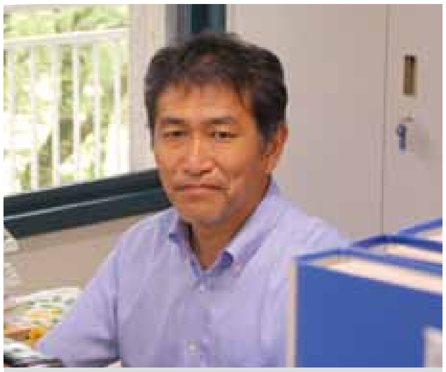
Further Improvement of Railway Safety Against Cross Wind

A mock-up of train consisted of three vehicles is installed on an eight-meter viaduct of single track to measure acting force due to natural wind. This site, Shimamaki village, Hokkaido, is known as an area of strong wind.



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In order to operate railway vehicles safely and stably, it is important to stay alert to various meteorological phenomena that can possibly affect railway operation, predict the occurrence of disaster beforehand, and implement operation control such as speed control, train service cancellation, etc. Among meteorological phenomena, cross winds are one of the causes that can lead to a rollover accident of railway vehicles. In addition, the recent trends of weight reduction and speeding up of railway vehicles have created greater challenges for the cross wind stability of vehicles.

Full-scale model tests and wind tunnel tests

Unlike aircraft, railway vehicles run near the ground, so the wind that they receive under a cross wind is not a uniform but turbulent flow that is subject to temporal and spatial change.

With that in mind, in order to help develop a wind tunnel test method that considers natural wind conditions, Railway Technical Research Institute (RTRI) conducted field tests using full-scale models of a viaduct and vehicles in Shimamaki Village, an area where strong winds blow in Hokkaido. Researchers spent about two years observing natural winds and aerodynamic forces acting on vehicles.

At the same time, RTRI began to simulate natural winds corresponding to those in the field tests using full-scale models in wind tunnel experiments. Spires and blocks, which help generate turbulent flow, were installed inside a large-scale low-noise wind tunnel measurement unit. Through this experiment, a method was developed to generate airflows (turbulent boundary layers) similar to the natural winds observed in the field tests. As a result of the measurement of aerodynamic force acting on the vehicles due to the generated turbulent boundary layers, the aerodynamic force obtained in the

Four kinds of objects (white barriers, green spires, blue and red blocks) can generate an airflow similar to the natural turbulence. Models of a viaduct and vehicles with a scale of 1 /40 are installed on a turntable which allows to blow in different attack of angles on them. A balance set inside one of vehicle models measures forces acting on it. The wind tunnel test are in agreement on measured forces with that of the full-scale models in the field.

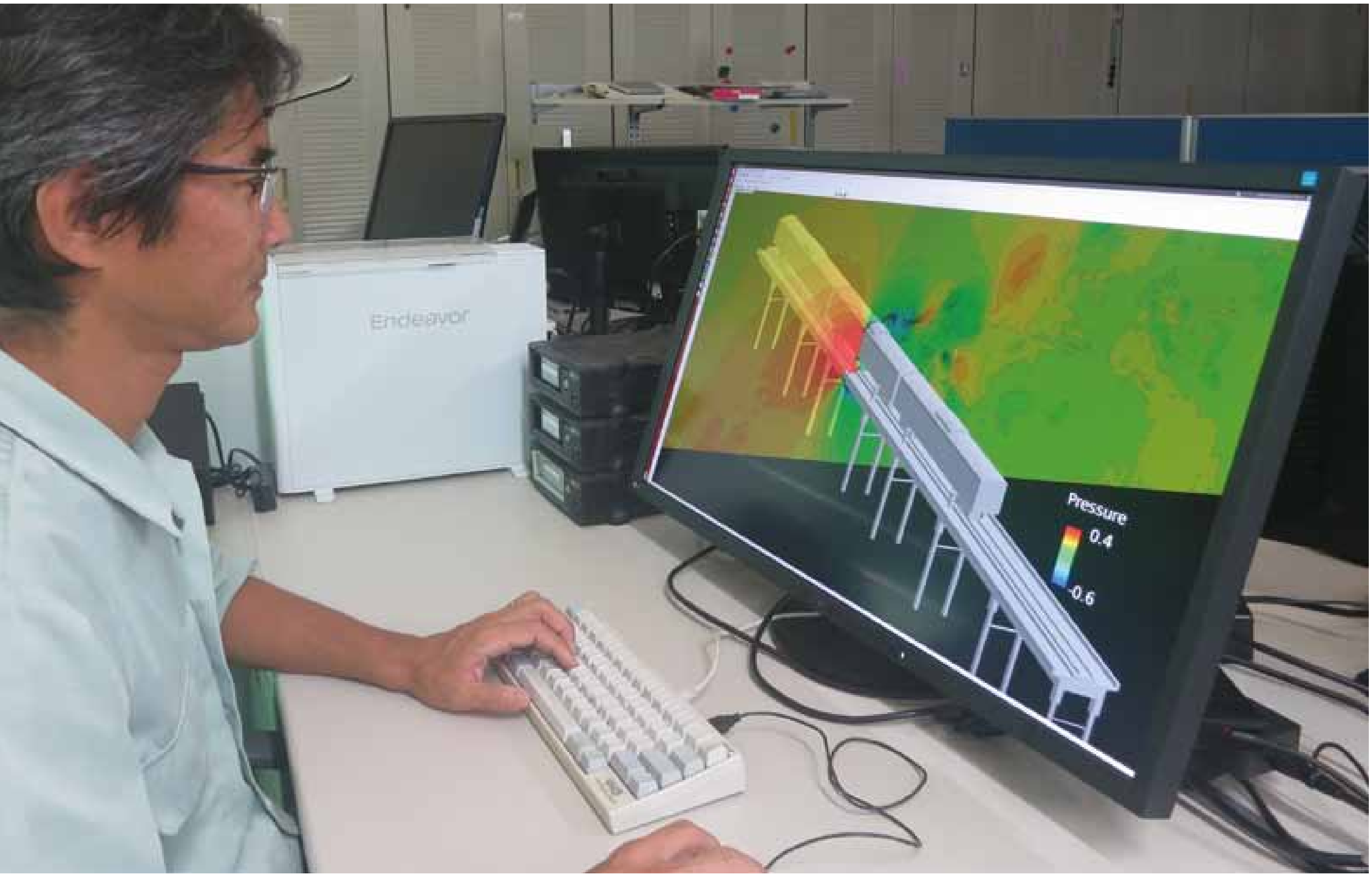
The numerical simulations are executed on RTRI's supercomputer named " 究 " (Kyu). This Chinese character stands for "learning thoroughly". This is one of two characters which compose the word " 研究 " (Ken-Kyu), "Research" in Japanese.

wind tunnel experiment was found to be in good agreement with that of the field model tests.

Also, since the aerodynamic force acting on vehicles depends not only on the shape of vehicles, but also on the shape of their structural parts, wind tunnel tests were also conducted on the combinations of five representative shapes of vehicles and seven representative shapes of structures. These tests led to successfully obtaining aerodynamic force coefficients and it became possible to estimate the aerodynamic forces for various combinations of vehicle shapes and structure shapes.

Numerical simulation

As described above, wind tunnel tests are used to understand the effect of aerodynamic force acting on railway vehicles under cross winds. Meanwhile, due to recent improvements in computer performance and the development of calculation algorithms, numerical simulation has become increasingly effective as a tool for research and development. Numerical simulation is expected to become an effective method to simulate situations which are difficultly replicated in a wind tunnel test, and to acquire detailed data from an unsteady three-dimensional flow field in the future. Therefore, RTRI has proceeded with the research and development of numerical



This screen shows a pressure distribution around the center of train. The higher pressure region (red colored) is on the upper stream side of the train. Numerical simulation is expected to become an effective method to acquire detailed data from an unsteady three-dimensional flow field.

simulation in using supercomputers, viewing it as a complementary method to wind tunnel tests that are conducted to predict the aerodynamic force acting on vehicles due to cross wind.

Research activities in the future

In order to accurately evaluate aerodynamic forces acting on vehicles due to the generation of crosswinds, it is important to measure the aerodynamic force in a condition close to that of an actual phenomenon. Therefore, RTRI developed a moving model rig that creates relative movements between vehicles and the ground during wind tunnel tests. This will more closely represent actual service conditions and enhance the measurement of aerodynamic force.

RTRI will continue to make efforts to improve technologies for estimating aerodynamic force due to the generation of cross winds, with the aim of improving the safety of railway.