Development of a Method of Pinpointing Trackside Spots That Are Subject to Strong Winds

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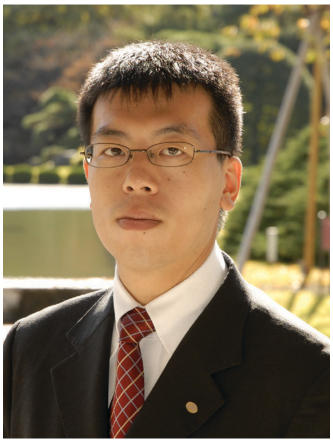

1. Introduction

In order to ensure the safety of train operation in a strong wind, it is important to install anemometers for operation control at appropriate points. To that end, it is necessary to carefully scrutinize the wind conditions at trackside areas. Recent years have seen progress in techniques for predicting wind velocities at points about 30 to 100 m above the ground by applying numerical simulations in surveys for selecting optimum locations of windmills for wind power generation, etc. The average wind velocity is predicted in those surveys. To provide railways with measures to cope with strong winds, however, a new technique for predicting the instantaneous wind velocity near the surface of the ground is called for, since in a very strong cross wind, the train can overturn in a short time. In the present study, which was intended to determine appropriate trackside points at which to install anemometers, we used a statistical technique to calculate the expected maximum value (in return period)[1] of the maximum instantaneous wind velocity at trackside areas, in addition to a numerical simulation to obtain the average wind velocity.

2. Calculating expected maximum values of average wind velocities at trackside areas

In order to calculate the expected maximum value of an average wind velocity at a given point at a trackside area, we first studied meteorological disturbances that brought strong winds to the area in the past and calculated average wind velocities in meshes of 20 km square and 3 km square, respectively, using a numerical meteorological simulation model that is applicable to a large area about 500 km square. Then we used a numerical airflow prediction model to obtain average wind velocities in smaller meshes (200 m square), and the ratios of these to the average wind velocities in the 3 km square meshes (wind velocity ratios) were calculated. The calculation results are shown in Fig. 1. The values thus obtained were used to calculate the distribution of expected maximum values of average wind velocities.

3. Calculating expected maximum values of maximum instantaneous wind velocity

Next we calculated the distribution of the expected maximum values of maximum instantaneous wind velocities. Since there are no established methods of numerically calculating the maximum instantaneous wind velocity, it was necessary to use another method. In view of the fact that any place where the ratio of maximum instantaneous wind velocity to average wind velocity (i.e., the gust factor) is relatively large has some definite topographic characteristics, we estimated the gust factor by an analytical method based on topographic characteristics. With the ratio of a day's maximum instantaneous wind velocity to a day's average wind velocity (i.e., the day's gust factor) observed by the meteorological agencies in the large area under consideration as the object variable, we estimated the day's gust factor by a multiple regression analysis with the windward topographic characteristics(undulation, openness, levelness and roughness) that significantly influence the day's gust factor as the explanatory variables. The estimation results are shown in Fig. 2.

On the basis of the results shown in Figs. 1 and 2, we obtained the expected maximum values of maximum instantaneous wind velocities over 50 years that occur at specific points on the track in a specific wind direction θ (8 different directions). By taking into account these results and the incidence of a specific wind direction on a very windy day, it was possible to calculate the expected maximum value of a specific maximum instantaneous wind velocity over 50 years at a point 10 m above the ground in each of the meshes under consideration. Fig. 3 shows an example of the distribution of expected maximum values calculated at intervals of 100 m along the track. The result provides an objective base upon which to discuss the appropriate points of installation of anemometers for operation control in a strong wind.

4. Conclusion

If the method described above is put into practical use, it should be possible to calculate the expected maximum values of maximum instantaneous wind velocities in areas along various linear structures, including railways. The tasks to tackle in the future are to verify the results obtained by the method and improve the accuracy of the expression for estimating gust factor derived from the topographic characteristic analysis. In addition, there is a need to develop a method of objectively determining the trackside points that call for special attention in regard to strong winds, with consideration given to the estimated distribution of the expected maximum values of wind velocities and the critical wind velocity at which a specific ground structure or railway vehicle can overturn.

1 The maximum value that is expected to be exceeded at least once in the given (return) period

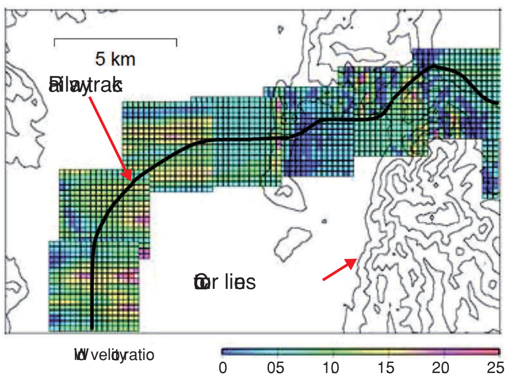

Fig. 1 Ratios of average wind velocities in a 200 m square mesh area to average wind velocities in a 3 km square mesh area, obtained by numerical calculation

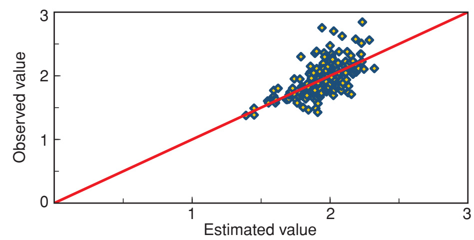

Fig. 2 Day's gust factors estimated by topographical characteristic analysis and observed day's gust factors

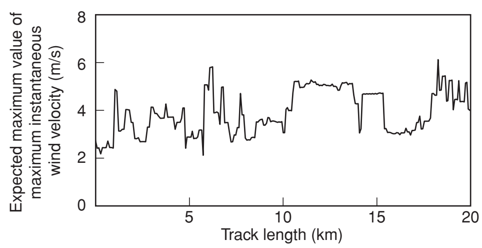

Fig. 3 Example of the calculated distribution of the expected maximum values of maximum instantaneous wind velocities (over 50 years)