Numerical Simulation of Wind Flow around an Ocean Observation Tower
-First Assessment of the Applicability of Numerical Simulation-

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The drag coefficient, C_D, used to quantify the wind stress, is generally expressed by a function of the wind speed 10 m above the sea surface, U_{10}. C_D, however, has not been established because of variations in field observation data. Alternatively, a number of drag coefficient models have been formulated. To develop a model of C_D, the wind stress needs to be calculated using the eddy-correlation method, which measures the horizontal and vertical wind components. In the field, observations of the wind velocity are difficult to obtain during various sea surface states because wind velocity measurements are limited to fixed installations, and the platform (e.g., the observation tower, and/or ships) affects the wind flow and wind direction. Recently, with the increasing availability of computers, it has become possible to visualize wind flow around an obstacle under various conditions via numerical simulations using computational fluid dynamics (CFD).

In this study, we investigate the applicability of a numerical simulation using CFD for selecting installation locations for measurement instruments and for determining a correction index. SolidWorks for 3D-CAD (computer aided design) was used to modeling of the Hiratsuka Tower, and the SolidWorks Flow Simulation was used in the CFD investigation and visualization of the wind flow around the Hiratsuka Tower. The inflow wind velocities are 5, 10, and 15 m/s, and the wind direction is tested at every 10° from 0° to 350°. In this study, we installed two 3-axis sonic anemometers on a handrail (at a height of 1.75 m) and on a pole (at a height of 3.75 m) on top of the Hiratsuka Tower. We started test measurements using both sonic anemometers on July 29, 2015. The effect of the Hiratsuka Tower on the wind flow was investigated by comparing the results obtained by the numerical simulation with the field measurements from these two sonic anemometers.

For the inflow wind velocities at 5 m/s, the scalar wind velocity, and wind component with flow direction at the sonic anemometer on the handrail is within 1.5 % accuracy of the sonic anemometer in the wind directions of 60° and 70°, where the sonic anemometer is located at the leeward side. The scalar wind velocity and all wind components at the top of the pole are larger than the inflow wind velocity in all wind directions. As a result of the flow visualization around the tower, the scalar wind velocity decreases on both the windward and leeward sides of the tower. The scalar wind velocity above the Hiratsuka Tower increases, owing to the separating flow generated at the windward front of the Hiratsuka Tower. The results of the inflow wind velocities at 10 and 15 m/s show the same tendencies in the differences between the calculated and inflow wind velocities for the same wind direction. The applicability of the numerical simulations is discussed by a comparison with the field measurements. We found that the wind velocity obtained by the numerical simulations tended to be similar to the measured wind speed values. Therefore, we also discussed the applicability of the numerical simulation using CFD to selecting installation locations for the measurement instruments and establishing of a correction index. The effect of the tower at distance from the center of the top of the tower was shown in the flow visualization as a

correction index at the actual installation locations.
Consequently, we showed that the numerical simulation using the CFD could be applied to the observation tower. We also showed the possibility of creating a correction index for the actual installation locations.
In this study, we calculated the numerical simulations using simple conditions as a first approach. In the future, we will investigate applications calculating the numerical simulation using complex conditions, such as shear flow.

Keywords: Wind speed measurement, Flow visualization, Numerical simulation, Computational Fluid Dynamics (CFD), Wind stress