**Highlights**

1. We established a detailed integrated finite-element model of wind turbine structures composed of a rotor, a nacelle, a tubular tower and its foundation.
2. We established the aerodynamic loads exerted on the wind turbine structures with consideration of rotating effect of blades.
3. We developed a calculation method for wind-induced response of wind turbine structures subjected to wind with different speeds and directions to perform wind-induced response analysis.
4. We compared the numerical results with the field test data to verify the accuracy of the proposed method for wind-induced response calculation.