Data-Driven Connection Of Mean And Fluctuating Typhoon Wind Speeds Based On Long-Term Structural Health Monitoring Observations

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Typhoon is an intense circular storm system (typically between 100 and 2,000 km in diameter) as a result of the conservation of angular momentum imparted by the Earth's rotation and is always characterized by a low-pressure center, strong winds, and heavy rain. It also triggers several secondary disasters, including storm surge, inland flooding, landslides, wind-borne debris, and even tornadoes. Therefore, the typhoon-related hazard is one of severest natural disaster that causes significant casualties and huge financial losses every year. The estimation of typhoon wind hazard in terms of the return periods or probability of exceedance of mean wind speed has been well examined using synthetic typhoon tracks. However, Wind in the typhoon boundary layer is always featured with strong gust or fluctuation due to the friction effects caused by obstruction of ground objects as well as the deep convection process. The turbulence characteristics of the typhoon are different from the large-scale(synoptic) low-pressure weather systems. It is not only affected by the surface topography, but also depends on its internal complex circulation and thermodynamics. The statistical characteristics have a large dispersion and features stronger turbulence than normal winds. Conventionally, a deterministic power spectrum density function of is employed to describe the fluctuating characteristics of typhoon winds. Due to the complexity of typhoon's structure and turbulence, it is difficult to unify the power spectrum characteristics of typhoon wind field at present. Besides, the correlation of mean and fluctuating wind speeds is not well considered. A gap needs to be filled to connect the typhoon mean wind speed and fluctuating winds considering their randomness and correlation. Based on the long-term observation data captured by the Xihoumen Bridge Health Monitoring System (HMS), this study quantifies the statistical characteristics and correlation of the typhoon power spectrum parameters and establishes a stochastic simulation algorithm based on the Monte Carlo Simulation (MCS) and the Iman & Conover Method (ICM). Besides, the influence of mean wind speed on the wind spectrum is explored, and the adaptability of the existing wind spectrum is discussed. This study provides a forward step towards the development of the uniform-risk and performance-based typhoon wind engineering.