Collapsing of Offshore Meteorological Tower

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ABSTRACT
This study aims to investigate the cause of the collapse of an offshore meteorological tower and offer valuable insights for preventing similar occurrences in the future. The analysis results indicate that the instantaneous wind and wave actions did not directly contribute to the collapse as the member forces were significantly lower than the design value. The measured wind data revealed a severe anomaly in the instantaneous maximum wind speeds caused by vortex-induced vibration of the tower, which persisted for four hours, leading to fatigue failure in the joint bolts.

KEY WORDS: meteorological tower; offshore wind; wind energy; gust; vortex-induced vibration; fatigue failure.

INTRODUCTION
A meteorological observation tower is typically installed at a potential site to gather wind data to aid in the successful development of a wind farm. In the case of offshore towers, they must be able to withstand various environmental loads with their own rigidity, without the need for guy ropes. Monopole-type meteorological towers can be integrated with or directly connected to the foundation pile, which simplifies the foundation and results in a relatively smaller diameter compared to truss-type towers. However, the effect of environmental loads such as wind and waves on the tower's flexibility must be rigorously studied.

Offshore meteorological towers are subjected to wind and ocean loads that may induce fluid vibrations such as buffeting, vortex vibration, and galloping. The purpose of this study is to investigate the cause of the collapse of the offshore meteorological tower and provide insights to prevent such occurrences in the future. To achieve this, various loads were quantitatively analyzed, including wind data, structural analysis, wind load analysis, ocean load analysis, and fatigue analysis. The investigation results are presented in this paper.

OFFSHORE METEOROLOGICAL TOWER

Collapsed Tower

The tower in this study was erected to collect wind data for an offshore wind farm project. As illustrated in Figure 1, it was a monopole tower standing 95m high above sea level, with a diameter of 3m at the base and 1.5m at the top. At a height of 96m above sea level, vane and ultrasonic anemometers were installed, while another vane anemometer was installed at a height of 54m. Unfortunately, there were no sensors to monitor the structural response. Design wind speed of the tower was 40 m/s in 10-minute average.

Figure 1. General view and mode shapes of tower.

Using the MIDAS, a structural analysis software, an eigenvalue analysis was performed to determine the natural frequencies of the tower. The hydrodynamic interaction effect of seawater and the spring effect of the ground soil were not considered. The tower's fundamental natural