ANALYSIS OF WAVE CHARACTERISTICS FOR DESIGN AND CONSTRUCTION OF OFFSHORE WIND POWER PLANT

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INTRODUCTION

The potential of offshore wind power in Japan is high, because Japan is surrounded by the sea on all sides. For this reason, proving research and planning of wind farms have been conducted in various locations. However the introduction is delayed compared with Europe due to severe natural conditions such as typhoons and swells unique to Japan. Offshore Choshi is one of the suitable sites for wind power generation on the Pacific side, but there is no data about characteristics of high waves required for setting the design conditions and characteristics of low waves required for the construction onsite. Therefore in this research, we aim to establish the design and construction of offshore wind farm adapted to Japan, using wave data obtained by proving research offshore Choshi, to investigate the wave characteristics for wind farm design and construction.

OUTLINE OF EMPIRICAL RESEARCH

We installed a 2.4MW wind turbine, a wind observation tower, and a set of oceanographic observation equipment 3km from Choshi city in Chiba prefecture. The depth of installation is about 11m, and the design wave height and period in storm condition is 10.51m and 14.5sec. The ocean observation period is 7 years from Jan 2010 to Dec 2016.
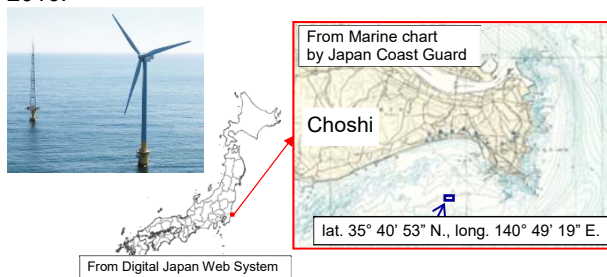

From Marine chart by Japan Coast Guard

Choshi

lat. 35° 40' 53" N., long. 140° 49' 19" E.

From Digital Japan Web System

Fig. 1 – Location of the Choshi Offshore Wind Power Station

WAVE CHARACTERISTICS OFF THE COAST OF CHOSHI

Fig.2 shows the mean value per month. It is small in summer and winter for both wave height and period, but the variation in summer and autumn is large due to the typhoon season.
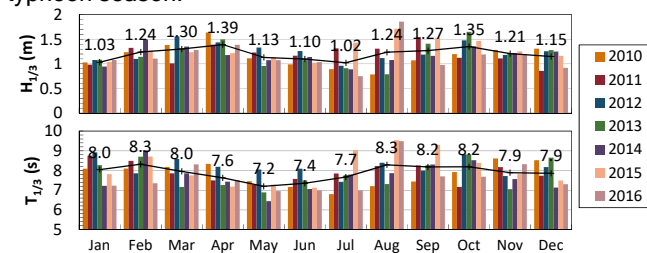

Fig. 2 – Average Wave Height and Wave Period

The maximum highest wave height during the observation was 9.52m and the significant wave period at that time was 13.3sec. In the disturbance Top 10 during the observation,

the half were due to typhoons in summer and autumn, and the other half were due to low pressure in winter. As shown in Fig.3, we were able to capture the development process of swell and wind wave due to typhoons.
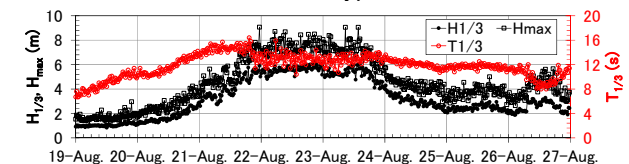

Fig. 3 – Time History of Wave Heights and Periods

APPEARANCE CHARACTERISTICS OF LOW WAVES

Fig.4 shows the appearance probability and average duration of low waves by month. The appearance probability of low waves is high and it is about 60% at 1m or less in summer. The appearance probability at 1.5m or less is greatly improved. The average duration at 1m or less is less than 10-hours, but if it is 1.5m or less it will last for a whole day in summer and winter.

In the construction of a proving research wind turbine and observation tower offshore Choshi, we used small working vessels that was procurable in Japan. Therefore, when the significant wave height became larger than about 1 m, the vessels swayed and could not work resulting in low operating rate. However, the data demonstrate that the operation will be greatly improved by the introduction of dedicated vessels enabling work and access under the wave height ~ 1.5m.
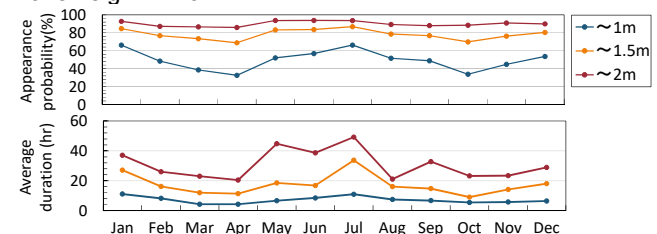

Fig. 4 – Appearance Probability and Average Duration of Low Waves

CONCLUSION

We analyzed the wave characteristics that contribute to the design and construction for wind farm, using seven years wave data obtained from proving research offshore Choshi. We confirmed the validity of design conditions for high waves and gained valuable data such as swell and wind wave development process due to typhoons. We also showed that the appearance characteristics of low waves are important in the planning of construction using small working vessels, with prospective improvement by dedicated vessels. Furthermore, by grasping the appearance characteristics of low waves, we have constructed a framework for stochastic optimum construction management in future wind farm planning.