2014년도 공동학술대회 논문집 pp. 253~254

Study on the P-Y Curve around the Mono-pile Foundation of Offshore Wind Turbine by Impulsive Breaking Wave Force

Myeongjin Go · † Namhyeong Kim · Yongsu Ko***

† *Department of Civil Engineering , Jeju National University, Jeju 690-756, Korea
**JPM Engineering, Jeju 690-802, Korea

Abstract : *In offshore, various external forces such as wind force, wave force and impulsive breaking wave force act on offshore structures. Many researches about this forces are published. Kim and Cao(2008) published researche on wave force of vertical cylinder. Kim and Go(2013) performed research on the subgrade reaction by external forces. Among this forces, impulsive breaking force is more massive than other forces, especially. Therefore, the studies about impulsive breaking wave forces have been carried out. Chun and Shim(1999) analyzed dynamic behavior of cylindrical pile subjected to impulsive breaking wave force. In this study, when the impulsive breaking wave force acts on the offshore wind turbine, the subgrade reaction acting on the mono-pile of the offshore wind turbine is calculated by p-y curve. The calculation is carried out to the multi-layered.*

Keywords : *Impulsive breaking wave force, P-Y curve, Subgrade reaction*

1. Introduction

The development of offshore wind turbines has been in the spotlight as an alternative method in order to solve the problems of onshore wind farm such as securing sites, noise, and electromagnetic waves, and in order to get efficient wind power energy. Therefore, the many researches on offshore wind energy have been carried out. Among this researches, Kim and Cao(2008) published researche on wave force of vertical cylinder. Kim and Go(2013) performed research on the subgrade reaction by external forces.

In the offshore, various external forces such as wind force, wave force and impulsive breaking wave force act on structure. Impulsive breaking wave force among these external force impacts greatly on structure in a moment. Chun and Shim(1999) analyzed dynamic behavior of cylindrical pile subjected to impulsive breaking wave force.

In this study, when the impulsive breaking wave force acts on the offshore wind turbine, the subgrade reaction acting on the mono-pile of the offshore wind turbine is calculated by p-y curve.

2. Basic Equation

2.1 Wind force acting on the turbine

Offshore Wind Power Generation Technical Manual is referenced to calculate the wind force acting on the offshore wind turbine as follow:

$$F_t = q \cdot C_f \cdot A \tag{1}$$

$$q = 0.6 \cdot \left(1.7 \cdot \left(\frac{H}{Z_G}\right)^n\right)^2 \cdot G_r \cdot U^2$$

$$C_f = \begin{cases} 0.7 \cdot k_z & : \ H/D \le 1 \\ 0.7 \cdot k_z + 0.025 \cdot H/D & : \ 1 < H/D < 8 \\ 0.9 \cdot k_z & : \ H/D \ge 8 \end{cases}$$

where F_t is the wind force acting on the offshore wind turbine, A is the windward wall of the offshore wind turbine, H is the height above mean sea surface, D is the diameter, n is the index. In this study, n is 0.10 because a few obstacles are observed in coastal area. G_r is a gust coefficient, which is referenced from Offshore Wind Power Generation Technical Manual. Z_G is 250.

2.2 Impulsive Breaking Wave force acting on the turbine

Goda et al.(1966) suggest to calculate impulsive wave force as follow :

$$F_I = 0.25 f_p \eta_b \tag{2}$$

where F_I is the impulsive breaking wave force, $f_p = (\pi/2g)\omega_0 C_b^2 D$, η_b is the wave height.

† Corresponding author(member), nhkim@jejunu.ac.kr 064)754-3452
* Author, sptnsdl@jejunu.ac.kr 064)754-3453 - Speaker
** Co-author, luis69@hanmail.net 064)800-5680

2.3 Calculation of p-y Relation

If the ground is assumed to be elastic condition, subgrade reaction can be calculated by Eq.(3).

$$p = \frac{E_s}{B} y = k_h y \tag{3}$$

where E_s is the subgrade modulus, y is the horizontal displacement of foundation.

3. Analysis Results

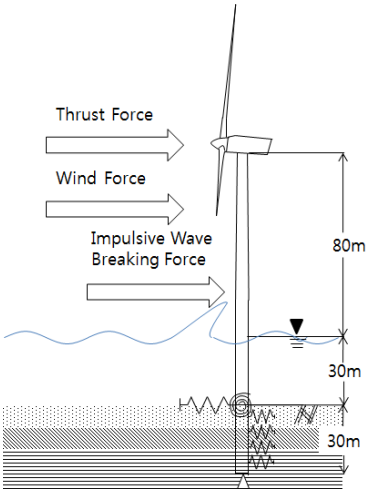

Fig. 1. Simple model of offshore wind turbine

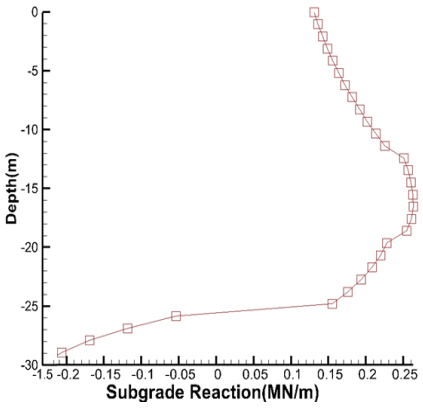

Fig 2. Subgrade reaction

The conditions of offshore wind turbine are shown from Fig. 1. The top diameter, bottom diameter and height of offshore wind turbine are 3.87m, 6m and 80m, and the water depth and embedded depth are 30m and 27.3m, respectively. The subgrade conditions are cohesive soil by Andersen et al. (2012) and sandy soil by Jang et al. (2013).

Fig. 2 shows subgrade reaction. The maximum subgrade reaction is 0.26MN/m, and the minimum value is 0.13MN/m.

4. Conclusions and Remarks

This study is carried out to investigate the subgrade reaction acting on the foundation of the offshore wind turbine with wind force and impulsive wave force.

The result shows that the minimum subgrade reaction is on the seabed and the maximum subgrade force is in the middle of subgrade. This result is considered that the confining pressure of seabed is less than the confining pressure of subgrade.

This study is conducted about the analysis of the subgrade reaction acting on foundation of the offshore wind turbine without dynamic condition. However, in the reality, various forces are acting on the offshore wind turbine, further research will be considered about effect of dynamic condition.

Acknowledgement

This work was supported by the Leading Industry of Jeju Economic Region(Jeju Island offshore wind farm development, measurement and analysis techniques developed for the marine environment) in 2014.

References

[1] Kim, N.H and Cao, T.N.T.(2008), Wave force analysis of the two vertical cylinders by boundary element method, KSCE Journal of Civil Engineering, Vol. 12, No. 6, 359-366.

[2] Chun, I.S. and Shim, J.S.(1999), Dynamic behavior of cylindrical pile subjected to impulsive breaking wave forces, Journal of Ocean Engineering and Technology, Vol. 11, No. 2, pp. 87-94(in Korean).

[3] Kim, N.H. and Go, M.J.(2013), Analysis of the Multi-layered Soil on mono-pile Foundation of Offshore Wind Turbine, J. Navig. Port Res. Vol. 37, No. 6, pp. 653-660(in Korean).