PAPER • OPEN ACCESS

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To cite this article: Wenbin Liu 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **300** 022048

View the article online for updates and enhancements.

This content was downloaded from IP address 221.226.175.204 on 10/10/2019 at 19:17

Research on the deviation retrieving capacity of the guide frame in the installation of an offshore pile foundation

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Abstract. The guide frame is widely used in the installation of the pile foundation for the offshore wind power case. The guide frame can locate the position of offshore pile and retrieves the lateral deviation of pile in the piling process. This paper analysed the deviation retrieving capacity of a guide frame based on an engineering case in Jiangsu province with numerical simulation method. The relationship between the maximum lateral displacement and the depth is established.

1. Introduction

As a clear and sustainable power, the wind power is regards as an important resource to generate electricity. China's developed coastal areas are rich in wind power resources, and the utilization of offshore wind power is well developed in recent years.

The pile foundation is still a reliable and widely applicable foundation for offshore wind power engineering. The bearing capacity of piles relies heavily on the piling process. Wrong piling position and large lateral deviation may cause the failure of pile foundations. The guide frame is a good way for solving the two problems in piling process together. It helps locates the piling position and can retrieving parts of lateral deviation. The maximum lateral deviation which can be retrieved depends on the hydraulic jacks integrated in the guide frame. This paper simulated the lateral deviation retrieving process with numerical simulation model. The maximum values of lateral deviation supporting by the hydraulic jacks for the pile penetrating to different depths were calculated and plotted.

2. The engineering case

The engineering case used in analyses locates at the Jiangsu province, 55 kilometers away from the coast. The guide frames were used in piling processes, and Figure 1 shows the appearance of the guide frame. The guide frame is a two-deck structure. The lower deck is positing platform, standing on the seabed with 5 supplementary piles. The supplementary piles are 65 meters long, 2.1 meters wide and 25 millimeters thick. The higher deck is working platform, containing 8 hydraulic jacks. The maximum importing force of a hydraulic jack is 150 tons.

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Figure 1. The appearance of the guide frame

The steel pile used in this engineering case is a variable diameter pile. The diameter of pile varies from 6 meter to 7 meter. The pile is 1100 tons heavy and 90 meters long.

The soil properties of seabed are shown in Table 1, and Table 2 shows the parameters of steel piles.

Table 1. Seabed soil properties

Soil layer		Thickness (m)	Density ρ (g/cm3)	Compressive modulus Es (MPa)	Shearing strength (Directly shearing test)	
					Cohesion c (kPa)	Frictional angle φ (°)
①	Silt	3	1.98	10.88	4.8	32.9
②2	Silty clay between silty sand	5	1.97	8.9	10.1	31.1
③1	Silt	4.5	1.97	8.46	9.8	29.3
③2	Silty clay with silty soil	4	1.85	3.99	18	11.2
④1	Silty clay	5.4	2.01	7.19	55.3	17
⑤	Silty clay with silty soil	1.1	1.84	4.07	26.3	14.2
⑤	Silt	2.7	2.03	8.66	3	32.6
⑤	Silty clay with silty soil	31.6	1.84	4.07	26.3	14.2
⑥2	Silt	17.2	2.02	10.97	4.5	32.4
⑦1	Silty clay with silty soil	2.6	1.89	4.22	32.3	15.1
⑦2	Silt	2.4	1.98	10.97	5.9	32.4

Table 2. Steel pile parameters

Thickness	Weight	Poisson's ratio	Elastic modulus
60 mm	78 kN/m3	0.25	210 MPa

3. The lateral deviation retrieving capacity calculation

A three-dimension numerical simulation model was established with ABAQUS software. The soil was a 10 times of the pile diameter wide and 5 times of pile penetration deep cylinder. The Mohr-Coulomb model is used in analysis. The pile is embedded in the soil. Figure 2 shows the finite element analysis model.

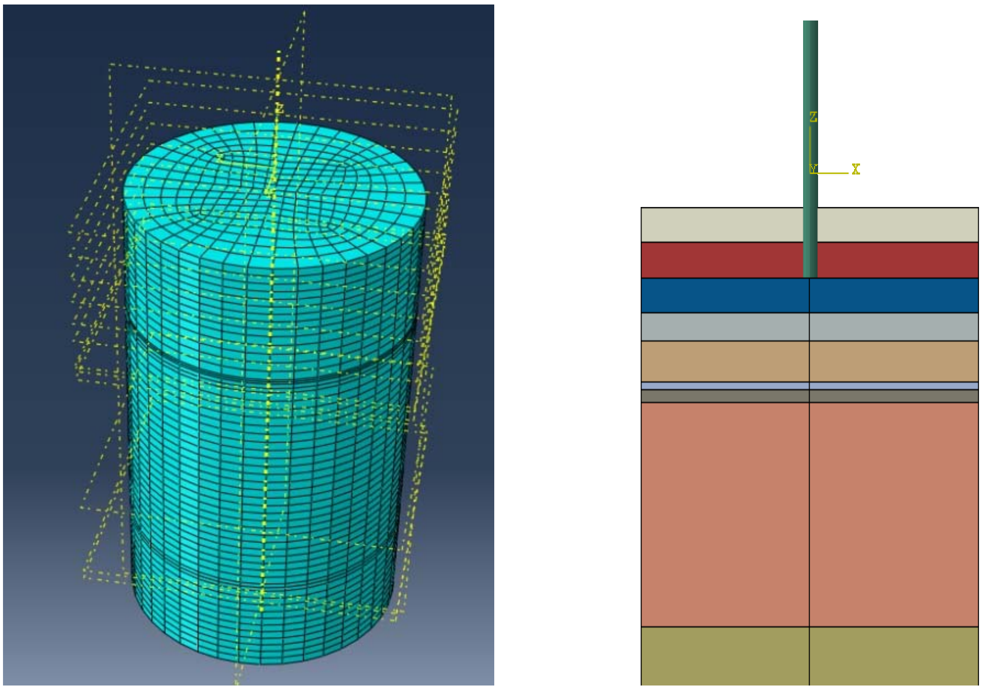

Figure 2. The finite element analysis model

The maximum lateral deviations supporting by a hydraulic jack when a pile penetrating into different depth, including 2 m, 4 m, 6 m, 8 m and 10 m, were calculated. The maximum lateral deviations were expressed as the maximum lateral displacement at the mud-line and at the location of the hydraulic jack. The relationship between lateral displacement and the penetration depth was shown in Figure 3.

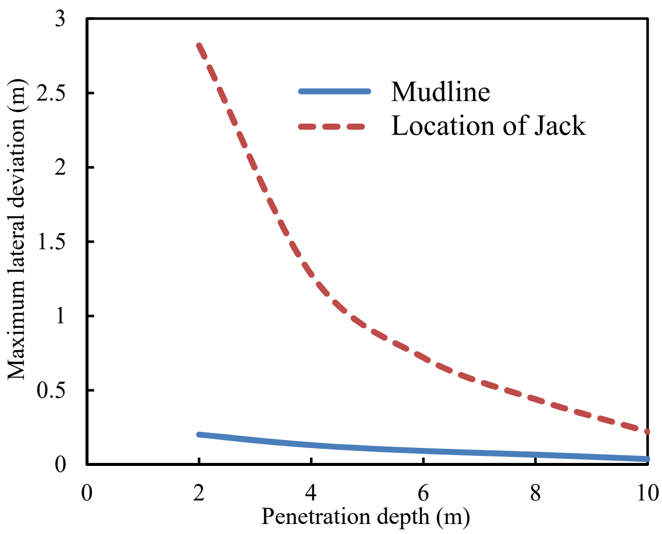

Figure 3. The relationship between maximum deviation and penetration depth

As it is shown in Fig.3, the maximum lateral deviation displacement reduces with the increasing pile penetration depth. The maximum lateral deviation at the location of hydraulic jack affects heavily before the pile penetration is lower than 4 meters. When the pile penetration is more than 6 m, the maximum lateral deviation at the location of hydraulic jack affects less. The maximum lateral deviation at mud-line affects little by the penetration.

4. Conclusion

The deviation retrieving capacity of a guide frame is calculated with 3-D finite element analysis model based on an offshore wind power engineering case. The results show that: The hydraulic jack can retrieves large lateral deviation displacement when the pile penetration is less than 4 meter. The maximum slope supporting by a hydraulic jack can be larger than 4˚ at this stage. When the pile penetration is between 6 meter and 8 meter, the lateral deviation which can be retrieved reduces. The maximum slope supporting by a hydraulic jack ranges from 2˚ to 4˚ at this stage. After the pile penetration becomes larger than 8 meter, the lateral deviation retrieving capacity of the guide frame is little.

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