SCALE EFFECT IN LOCAL SCOUR AROUND AN OFFSHORE PILE

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INTRODUCTION

Accurately predicting scour is important for its prevention around the foundations of offshore wind turbines. Many studies on local scour around piles have been conducted. Chen et al. (2022) conducted scour analysis using large-scale experiments and examined the maximum scour depth. However, the relationship between scour depth and time has not yet been investigated. Furthermore, only a few studies have comprehensively examined the scale effects and similarity laws. In this study, experiments for analyzing local scour around a pile were conducted at different scales, 1/13, 1/65, and 1/130, to verify the scale effects and corresponding similarity laws regarding scouring time.

EXPERIMENTS

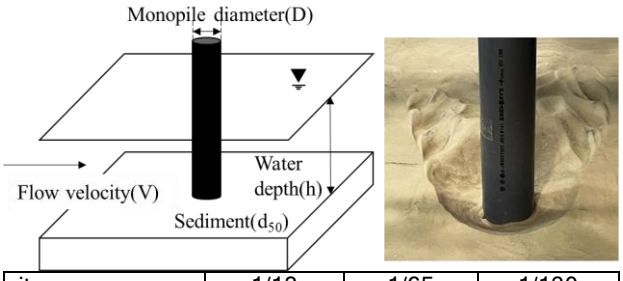
Experimental parameters such as current velocity and water depth were obtained from local environmental data. The experimental model and conditions are shown in Figure 1. The soil particles used in the experiment were selected based on the similarity of settling velocities (Jimenez and Madsen, 2003) and the particle size of the soil particles used in the experiment.

$$w_{sm}/w_{sp} = \lambda_m/\lambda_p$$

Where w_{sm} and w_{sp} are the settling velocity of the soil particles at the model and real scales, respectively, and λ_m and λ_p are the representative lengths of the model at the model and real scales, respectively. In the experiment, water was allowed to flow till the scour depth attained equilibrium. The scour depth was measured using a measuring tape placed on the side of the monopile. The final scour depth was determined by measuring the change in ground elevation before and after the experiment using a 3D scanner. The difference between the two values was considered as the scour depth.
The determined similarity ratios were 1/130, 1/65, and 1/13, and the experiment conditions were determined according to Froude's Law at this scale.

RESULTS

The relationship between equilibrium scour depth and equilibrium time for each scale is shown in Figure 2. Since the depth of scour after 10% of the time to equilibrium is between approximately 50% and 80% of the equilibrium scour depth (Melville and Chiew, 1999), t_* is defined as the time required for the scour depth to reach 80% of the equilibrium scour depth. The 1/13 and 1/130 scales are consistent with the scouring process, while the 1/65 scale is not. However, when the equilibrium scour depth was made to the same scale, the equilibrium scour depth was 4.136 m for 1/13 scale, 4.485 m for 1/65 scale, and 4.55 m for 1/130 scale. The results showed that although the scouring process do not match from scale effects, the equilibrium scour depths match, independent of the scale effects. In the future, it is necessary to determine why the scouring process is not consistent from scale to scale.



item		1/13 scale	1/65 scale	1/130 scale
Current	Water depth	$h = 2.15\mathrm{m}$	$h = 0.43\mathrm{m}$	$h = 0.215\mathrm{m}$
	Flow velocity	$V = 0.38\mathrm{m/s}$	$V = 0.17\mathrm{m/s}$	$V = 0.12\mathrm{m/s}$
	Monopile diameter	$D = 0.5\mathrm{m}$	$D = 0.1\mathrm{m}$	$D = 0.05\mathrm{m}$
Seabed material	Median particle diameter	$d_{50} = 0.1mm$	$d_{50} = 0.08mm$	$d_{50} = 0.0528mm$
	Sediment density	$2.68\mathrm{kg}/m^3$	$2.68\mathrm{kg}/m^3$	$2.68\mathrm{kg}/m^3$

Figure 1- Experimental model and conditions

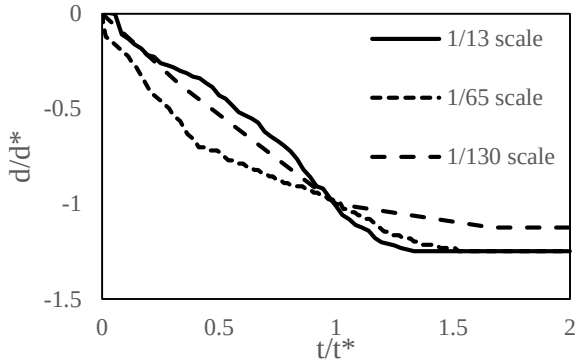


Figure 2- Results of the experiment. t is the elapsed time, t_* is the time required to complete 80% of the equilibrium scour depth, d is the scouring depth, and d_* is 80% of equilibrium scour depth

REFERENCES

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