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Simulation of Noise Sound Propagation Radiated from Offshore Wind Power Generation in very-shallow water

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1. Introduction

Wind power, solar power, and hydropower, nuclear power are attracting attention as power generation technologies that emit less carbon dioxide. Among, Japan is an island country, and it is surrounded by the sea, so the introduction of offshore wind power generation is being promoted. However, there are some problems in the introduction. Sound noise generated from offshore wind power generation in shallow water[1)]. It has been a concern about the influence of underwater sound emitted in marine life[2)].

Numerical simulation was widely used to estimation of sound pressure level from noise source in shallow water. Finite differences time domain method is a popular numerical analysis method used by explicit difference formula, and it is possible to directly obtain the propagated pulse wave[3)].

On the other hand, in Japan, the seafloor slope is often larger in the sea area where offshore wind power generation is performed compared to Europe and the United States. Therefore, it is expected that the noise propagation characteristics will differ depending on the presence or absence of the seafloor inclination depending on the noise reflected from the seafloor and the noise propagating from the seafloor medium into the sea.

In this study, we calculated sound propagation in shallow water by numerical simulation. We changed the tilt angle of the seafloor and the type of the seafloor medium, and compared the simulation results to examine how each element affects the propagation characteristics.

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2. Simulation model

The analysis model diagram is shown in **Fig.1**. The analysis range was set to x = -450 to +450 m, z = -450 to +450 m, depth y = -3 to 60 m, and the spatial step size was Δh = 1 m. The absorbing Higdon's boundary condition of was applied to the boundary side surface[4)], and the seafloor inclination was set only in the z-axis direction. The sound source is rod-shaped assuming the underwater support of an offshore buoyancy power generation facility.

The sound source position was set to the center of the region (x, z) = (0, 0) and set only in the sea. The waveform was a continuous sine wave. In addition, the sound source frequency was analyzed at 30 Hz, which are the predominant frequencies of underwater sound. The time step width Δt is 0.3 ms, and the number of repetitions t_max is 5000 steps (1.5 seconds). The analysis was performed. The blue range was the seafloor medium, and the seafloor medium was clay. We show the results of sound wave propagation analysis in shallow water where the depth changes in shallow water areas, and we explain the characteristics of sound wave propagation in extremely shallow water.

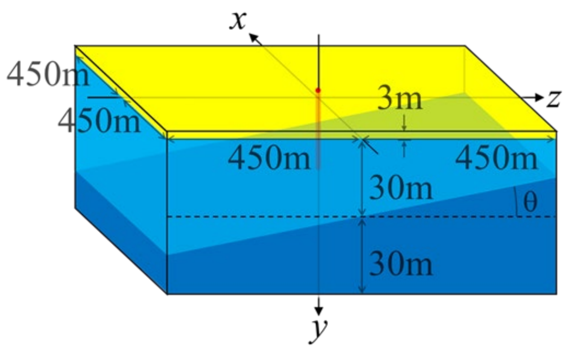
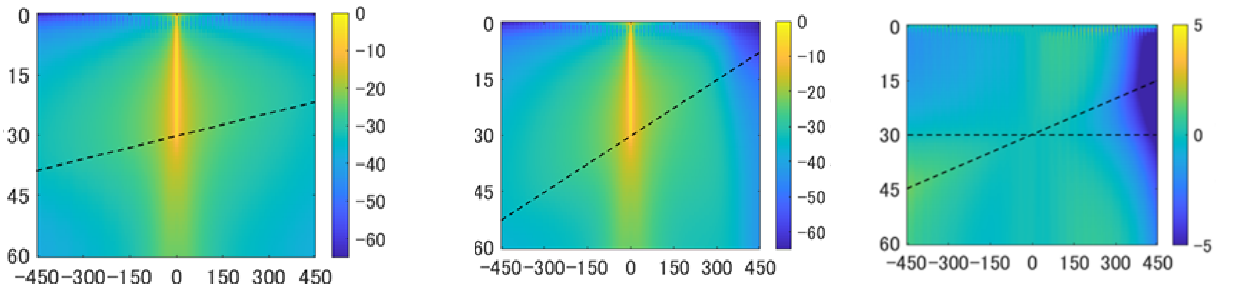


Fig 1 Simulation model

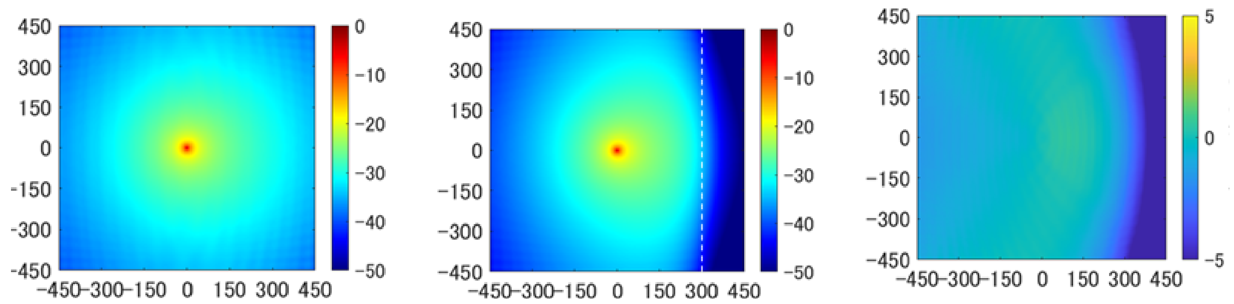
3. Results

We calculated performed by changing the inclination angle of the seafloor medium to $\tan^{-1}(1/50)$, $\tan^{-1}(1/20)$. These tilt angles were set to be approximately evenly spaced. **Figure 2** shows the analysis results of sound pressure in shallow water when the seafloor medium is sand. Fig. 2 (a) and (b) each have a seafloor inclination angle of 0 and $\tan^{-1}$ (The y-z vertical cross-sectional sound pressure distribution (x = 0 m) at 1/20) and $\tan^{-1}(1/20)$. The broken line in the figure shows the boundary between seawater and the seafloor medium. From Fig. 2 (a), the sound pressure distribution when there is no seafloor inclination is determined only by the distance from the sound source, and it can be seen that the sound pressure decreases as the distance from the sound source increases. As for the sound pressure distribution when there is a seafloor slope, the sound pressure decrease can be confirmed at a distance of 450 m in Fig. 2 (b). Fig.3 (a) and (b) show the x-z horizontal cross-sectional sound pressure distribution (y = 15 m). It can be seen that as the inclination increases, it appears as if it is translating



(a) Tilt angle $\tan^{-1}(1/50)$. (b) Tilt angle $\tan^{-1}(1/20)$ (c) Difference of Sound pressure

Fig. 2 Sound pressure distribution in y-z plane （x = 0 m）



(a) Tilt angle $\tan^{-1}(1/50)$ (b) Tilt angle $\tan^{-1}(1/20)$ (c) Difference of Sound pressure

Fig. 3 Sound pressure distribution in x-z plane （y = 15 m）

to the right. The sound pressure tends to decrease as the water depth increases, and the sound pressure tends to increase as the water depth decreases. Figure 2 (c) and 3 (c) shows the sound pressure distribution reduced from with the seafloor slope to without the seafloor slope. The points where the change in sound pressure due to the inclination is large are -1 dB at z = -450 m, +0.5 dB at z = 100 m, and -5 dB at z = 350 m, depending on the position. There is a significant difference. Especially in shallow water, the overall sound pressure drops significantly. This is thought to be due to the low frequency cutoff.

4. Summary

The purpose of this study was to understand how the noise generated by offshore wind power generators is affected by the seafloor slope and the seafloor medium. Therefore, the change in sound pressure distribution was obtained by analyzing the seafloor inclination angle by changing the seafloor inclination angle using the three-dimensional Yee-FDTD method. From the results of the sound source frequency of 30 Hz, the change in the sound pressure distribution at a certain depth increased as the seafloor inclination angle increased, and the sound pressure decreased significantly due to the cutoff in shallow water. On the day of the competition, we plan to report the results when the acoustic parameters of the seafloor sedimentary layer change, along with the results of the sound source frequency of 80 Hz.

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