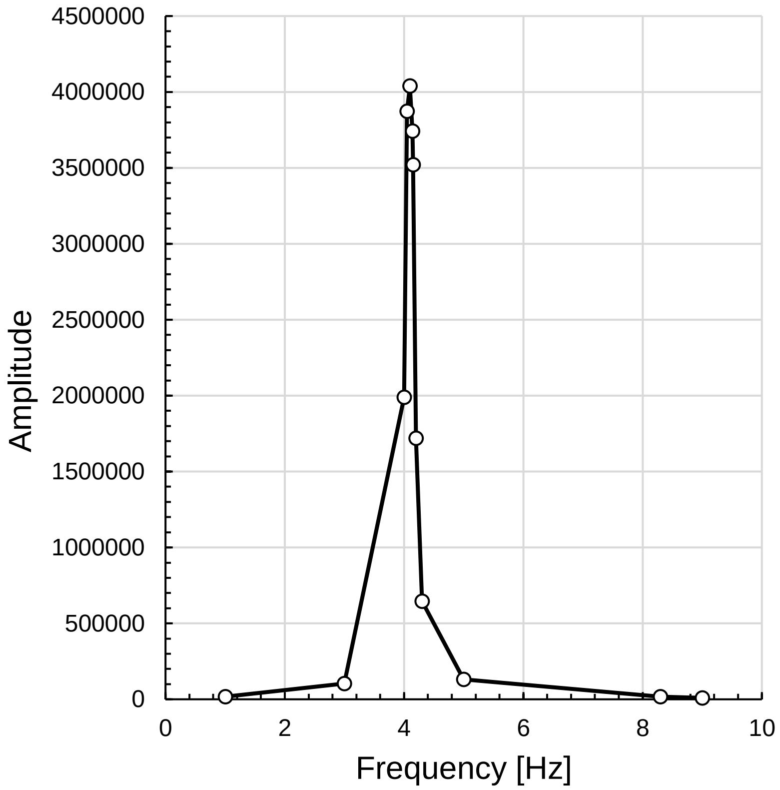

Fig. 13 Amplitude according to external cyclic load frequency in rubber joint condition

Fig. 13 shows the results of observing the amplitude while increasing the frequency of the cyclic load. The amplitude value gradually increased, and then had a maximum value at 4.0625 Hz, and it was confirmed that resonance occurred.

3.5 Discussion of numerical analysis results

Comparing the results of Fig. 9 in Section *3.3* and Fig. 13 in Section *3.4*, it can be seen that the natural frequency decreases from 9.375 Hz to 4.0625 Hz and the amplitude greatly increases from about 75000 to 400000 as the fixed end condition to the rubber joint condition. Due to the use of the rubber joint, it has a natural frequency that is prone to resonance and shows the result that higher energy contributes to the destruction.

These results show that the use of flexible materials to avoid stress concentration when connecting SFT to shore connection can lead to resonance-induced failure. Therefore, in future studies, it is necessary to quantitatively evaluate the change in natural frequency and amplitude according to the physical properties of the connection materials and the connection stiffness. It is expected that this study can be applied to the design of shore connection ㄴ that avoid natural frequencies that are prone to resonance in an underwater environment or have a small effect even if resonance occurs.

4. CONCLUSIONS

In this study, numerical analysis and small-scale model tests were performed to evaluate the dynamic behavior of the SFT by the shore connection between the subsea bored tunnel and the submerged floating tunnel. Through a numerical analysis model simulating a small-scale model test, dynamic characteristic changes were analyzed with a focus on natural frequencies when external impact load and cyclic load were applied in fixed end conditions and rubber joint conditions. This study was conducted to reduce the risk of resonance collapse caused by the natural frequency change of the SFT due to the shore connection. The main conclusions derived from this study are summarized as follows:

- Since damping does not affect the natural frequency, numerical analysis was performed ignoring it, and as a result, it was confirmed that the same natural frequency was evaluated under the impact load and the cyclic load.

- Resonance was observed in which the amplitude of the frequency domain had a maximum value and the amplitude of the time domain continued to increase under an external cyclic load of a frequency consistent with the natural frequency.

- The natural frequency of the acrylic hollow tube simulating the SFT changes according to the connection stiffness between the acrylic hollow tube and the rubber joint and the physical properties of the rubber joint.

- To avoid stress concentration, when the shore connection part is made of a flexible material, the natural frequency of the SFT has a value that is more prone to resonance, and then the amplitude also increases, so there is concern about the risk of resonance collapse.

- In the small-scale model test, the natural frequency with a value of 35 to 40 Hz was evaluated as a result of applying an impact load to the acrylic hollow tube affected by the rubber joint.

- The small-scale model test has three major limitations. The first was that only relatively short-time dynamic responses were observed using an oscilloscope. Second, there is noise due to the uncertainty of the boundary condition. Lastly, as a design problem, movement other than the vertical direction was allowed.

- These results are expected to be utilized in future research that quantitatively evaluates the natural frequency relationship of SFT according to the physical properties of the shore connection and the connection stiffness with the SFT, and supplements the limitations of the small-scale model test for more reliable verification.

ACKNOWLEDGMENTS

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. 2017R1A5A1014883).

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