Collision Analysis of Submerged Floating Tunnel by Underwater Navigating Vessel

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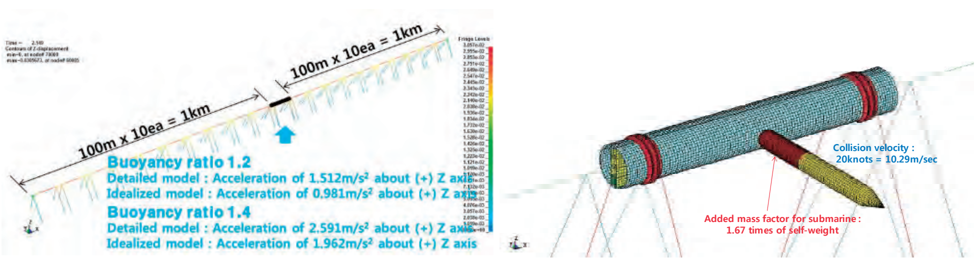
Summary

To recognize the collision behavior between a submerged floating tunnel (SFT) and an underwater navigating vessel (UNV), both structure were modeled and analyzed in this paper. The collision span of SFT is a tubular section that was modeled using concrete with steel lining. The other parts of the SFT were modeled elastic beam elements. Mooring lines were modeled as cable elements with tension. The UNV was assumed to be a 1,800 displacement tonnage (DT) submarine, and its total mass at collision was obtained through hydrodynamic added mass. The buoyancy force on the SFT was included in its initial condition using a dynamic relaxation method. The buoyancy ratio (B/W) and the collision speed were considered as the collision conditions.
Keywords: Submerged Floating Tunnel; SFT, Underwater Navigating Vessel; Collision Force; Dynamic Behavior; Mooring Line; Energy dissipation.

1. Modeling of SFT and UNV

In this study, energy dissipation behavior and local behavior that occur when SFTs collide are identified through detailed modeling, as shown in Fig. 1. The collision portion of the SFT is modeled as an elastic beam with the cross sectional properties of the SFT, and it is assumed that the other SFT parts do not undergo plastic deformation. SFT constant buoyancy is considered as the initial collision condition in the dynamic relaxation analysis (Fig. 1).
The largest UNV in South Korea presently has a size of 1,800 displacement tonnage (DT). Our collision analysis model applied the 1,800 DT class based on the internal stiffener dimension (SSLW, 2004) of an 800 ton class coastal submarine.



(a) Dynamic relaxation analysis *(b) Collision condition (1,800 ton)*

Fig. 1 FE Models of SFT and UNV

2. Conclusion

In this study, a modeling scheme for evaluating the collision behavior of an SFT and a UNV was proposed, and the relationship between deformation, member forces, and collision energy dissipation were analyzed by conducting a collision analysis.
The analysis results showed that local damage by collision caused by the tension of the mooring lines according to B/W was small, but the lateral deformation of the SFT showed a large variation. It was determined that an overall collision behavior can be demonstrated when considering a total 2 km range under current collision conditions.

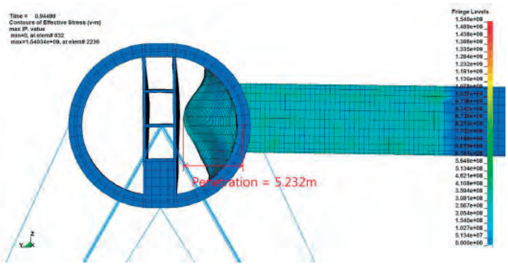


Fig. 2 Penetration of SFT by collision(B/W=1.2)

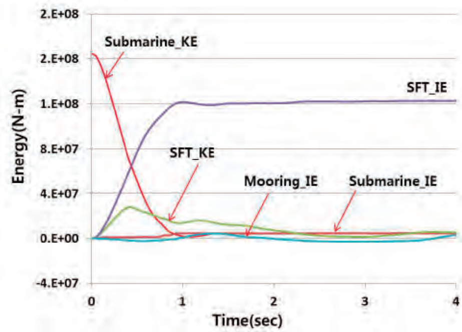


Fig. 3 Energy dissipation curve(B/W=1.2)

At the collision point, tension in the mooring lines increased to three times or more, compared to the initial tension, and was affected by B/W. Because this can cause damage in the mooring lines or anchor, additional consideration is required for this.
When B/W was small, the lateral displacement of the SFT increased, but the energy dissipation rates by the elasto-plastic deformation of the SFT were almost the same.
Most of the collision energy was dissipated by the elasto-plastic deformation of the SFT, and the contribution of the energy dissipation caused by deformation of the UNV model because of the lateral displacement of SFT was 3~11% of the initial collision energy, which is insignificant compared to regular ship collisions. The collision force of the SFT showed different characteristics from that of a regular ship, and it needs to be studied further.
Also, collision behavior evaluation for various collision conditions and cross sections, design loading, and design consideration methodologies need to be investigated in future studies.

3. Acknowledgement

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4. References

[1] Kwan-Young Hong, Gye-Hee Lee (2014) Collision Analysis of Submerged Floating Tunnel by Underwater Navigating Vessel, The journal of Computational Structural Engineering Institute of Korea, Vol.27, No.5, pp.369-377(in Korean)