Finite element eigenvalue analysis of seiche in Nagura dam reservoir: physics-based signal identification for slow seismic event detection

*Hidetaka Saomoto[1], Kazunari Nawa[1], Takeshi Kimura[2]

1. National Institute of Advanced Industrial Science and Technology, 2. National Research Institute for Earth Science and Disaster Resilience

The oscillations with 11 mHz peak frequency were quite often recorded at Ishigaki (IGK) station of the F-net broadband seismograph network. Since the free oscillation characterized by mHz-level frequency were used to detect slow seismic events and glacial earthquakes (Beroza and Jordan, 1990; Ekström et al., 2003), such oscillations recorded at IGK station obviously interfere in the signal processing for slow seismic event detection.
We first start with signal source identification of the recorded oscillations and assume that the oscillations are produced by seiche because IGK station locates close to Nagura dam reservoir. As the behavior of seiche is governed by linear shallow water equation, its eigenfrequency is easily obtained from an appropriate numerical method such as the finite element method. We implemented the computer program for eigenfrequency on a commercial finite element software (COMSOL Multiphysics) and then a series of eigenvalue analysis were conducted to investigate whether the seiche possesses the eigenfrequency of 11 mHz or not.
As a result, we found five eigenmodes of seiche with 11 mHz eigenfrequency. By taking the fact that the water depth of the dam reservoir is approximately 10 m, those five candidates are narrowed down to the following two candidates: (1) the third eigenmode with the water depth of 9.5 m; (2) the second eigenmode with the water depth of 12.2 m. Given the predominant direction of recorded oscillations (north-south), the eigenmode shape for candidate (2) is more preferable. In any case, these results support our assumption that the seiche in the dam reservoir is the source of the recorded oscillations with 11 mHz peak frequency.

References:
Beroza, G. C. and Jordan, T. H.: Searching for Slow and Silent Earthquakes Using Free Oscillations, JOURNAL OF GEOPHYSICAL RESEARCH, 1990
Ekström, G., Nettles, M., Abers, G. A.: Glacial Earthquakes, SCIENCE, Vol.302, 2003.

Keywords: oscillation, seiche, eigenfrequency, finite element method