

Suboscillations observed in the Anchorage of Fukuyama Port

*Atsushi Mukai¹

1. Faculty of Urban Management, Fukuyama City University

The Anchorage of Fukuyama Port facing the Seto Inland Sea is the narrow channel with a distance about 8.5 km, and its width changes from 950 m in the port entrance to 150 m in the deepest part. The continuous observation of the sea level changes were performed in the port during about two months in 2021, and revealed that the suboscillations were excited with two periods about 42 minutes and 13 minutes. In this study, I reproduced the suboscillations by numerically calculating the sea level variations in the port and investigated the characteristics of these suboscillations.

Water pressure gauges were installed at three sites A, B and C on the left bank of the port, and the continuous observations of the sea level changes were conducted for 64 days from September 1 to November 4, 2021. The sites A, B and C were located at 8.4, 8.0 and 7.5 km upstream from the port entrance, respectively. Since the observed data contain the atmospheric pressure changes on the sea surface, the atmospheric pressure changes obtained nearby the site A were removed the observed sea level changes.

The frequency characteristics of the observed sea level changes were investigated by using FFT. The obtained spectra showed two broad peaks around the periods of 42 minutes and 13 minutes, in addition to the sharp peaks due to the ocean tides, at every sites. It is considered that these broad peaks show the suboscillations. The amplitudes of the broad peaks were larger at the deeper site from the port entrance. The amplitude ratios from the site A to the site C were calculated to be 1.3 for the 42 minute period and 2.7 for the 13 minute period.

I numerically calculated the sea level changes in the port with the incoming regular waves by using nonlinear shallow-water equations, and confirmed that the calculation could reproduce those suboscillations. In this calculation, the underwater topography in the port was assumed by referring to the nautical charts of the Japan Hydrographic Association. The grid interval and the time step for the calculations were 10 m and 0.0125 s, respectively. The flow velocity perpendicular to the shoreline was assumed to be zero on the shoreline as a boundary condition.

The numerically calculated sea level changes were amplified around the periods of 45 and 14 minutes. These periods are close to the periods of 42 and 13 minutes for the observed suboscillations. The calculated results at both periods were larger at the site A than the site C, and agreed with the observed results. The amplitude ratios from the site A to the site C were obtained to be 1.1 for the 45 minute period and 2.3 for the 14 minute period. These ratios agree with the observed ones mentioned above as well. It is considered that the numerical calculations in this study could reproduce the suboscillations in the Anchorage of Fukuyama Port.

The calculated suboscillation at 45 minute period shows the normal mode with a node at the port entrance and a quarter-wavelength along the port anchorage. In fact, the period of suboscillation in a rectangular bay with a depth of 10 m and a length of 8.5 km is analytically calculated to be 56.5 minutes, which is close to the observed and calculated results.

The Fukuyama port anchorage turns 90 degrees around 6.0 km upstream from the port entrance. Therefore, the deepest port area with the 2.5 km length can be approximated to be a closed rectangular area. Among the normal modes occurring in a rectangular area with a depth of 4 m and a length of 2.5 km, the period of the half-wavelength mode with a node at the center was obtained to be 13.3 minutes. This normal mode corresponds to the numerically calculated and observed suboscillations around 13 minute period.

Keywords: suboscillation, Fukuyama Port