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自由水面を持たない管路内における界面波の形成
THE FORMATION OF BOUNDARY WAVES IN CLOSED CONDUITS WITHOUT FREE WATER SURFACE

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Wavelike configurations are self-formed at the boundary between water and sediment under open channel flow, and are called dunes or antidunes depending on the flow regime. There have been a large number of studies on boundary waves in rivers. It has been found that the boundary waves are strongly related to the Froude number. The formation of dunes and antidunes is caused by a phase lag and lead, respectively, between the bed and water surface profiles; so that it is suspected that the presence of free water surfaces is important for the formation of dunes and antidunes.

Meanwhile, there are only few studies on the bed configurations in closed conduits without free water surfaces. Could any similar boundary waves be formed without free water surfaces? If so, what are the boundary waves like? These are questions that have not been completely solved yet. The stability of the boundary between water and sediment in closed conduits is not completely understood. In order to predict the flow resistance of closed conduits such as sediment bypass and ice-covered rivers, it is important to obtain detailed information on boundary waves formed in closed conduits.

Seki and Izumi [2008] proposed a linear stability analysis for the formation of small scale boundary waves in closed conduits and compare with their experimental results. According to analytical results, the Shields number and the Euler number are the dominant parameters that determine the formation of boundary waves in closed conduits. In addition, they reproduced the boundary waves without free water surface in small scale experimental conduits. However, there is room for improvement of the correspondence between analysis and experimental data.

One of purposes of this study is to improve a linear stability analysis for the formation of boundary waves in closed conduits. The previous analysis by Seki and Izumi assumed that the roughness on the sand layers is same as the roughness on upper walls of conduits. Therefore we introduce the rate of friction velocities as a new parameter, and express the difference of the roughness in the linear stability analysis. As a result, this improves the correspondence and proves the importance of the new parameter.

In addition, we proposed weakly nonlinear stability analysis in order to obtain more detailed information near the critical condition for the wave formations.

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