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アンティデューンとサイクリックステップ：浮遊砂指数・流速係数に関わるそれらの特徴
Antidunes and cyclic steps: relating their features to a suspension index and a velocity coefficient

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There are very few comparative studies of the differences in hydraulic conditions and morphologic features of bed- and water-surface-waves associated with cyclic steps and antidunes. In this study, the features of both the bed and the water surface, as well as hydraulic conditions are examined over the spectrum from antidune to cyclic steps. Experiments were performed using a flume at the Osaka Institute of Technology. The resultant features of the bedforms are as follows. In the case of antidunes, bed waves and water surface waves are in phase except when they collapse. Antidunes show several kinds of behavior; migrating downstream, standing, or migrating upstream. Upstream-migrating antidunes are divided into three types such as with-breaking-waves, with-hydraulic-jumps and stable. Breaking antidunes appear alternatively with the plane bed state. Cyclic steps migrate upstream regularly associated with trains of hydraulic jumps, which divide each step. There is a significant change in water depth at the hydraulic jump, so that the phasing between the bed waves and water surface waves break at the each hydraulic jump. There is a kind of compromise between cyclic steps and antidunes, which we designate as intermediate steps. They move upstream and are associated with regular trains of hydraulic jumps. The jumps, however, occasionally collapse toward upstream. When this happens, bed waves move rapidly upstream; low-amplitude water surface waves and bed waves become in phase all over the bed shortly after the collapse. Then after some time, water surface waves become sufficiently prominent to yield regular hydraulic jumps. This cycle is then repeated.

The hydraulic conditions for these bedfoms were examined using three non-dimensional parameters, i.e. the Froude Number, the Suspension Index, and the Velocity Coefficient. The suspension index is the ratio of the shear velocity divided by the settling velocity of the sediment. The velocity coefficient is the ratio of mean flow velocity on the plane bed divided by the shear velocity on the plane bed. Data from previous experimental studies are examined together with the present data in studying the characteristic regimes of bedform formation.

In a diagram of Froude Number v.s. Suspension Index, antidunes, intermediate steps and cyclic steps can be divided along the axis of the Suspension Index. In the lowest range of the suspension index, downstream-migrating antidunes and upstream-migrating stable antidunes are found. The intermediate steps discussed above and antidunes with hydraulic jumps are located in the middle range. The highest range corresponds to cyclic steps and antidunes with breaking waves. As described above, the Suspension Index can serve as a scale to quantify the spectrum between antidunes and cyclic steps. The use of the parameter also helps verify that suspension plays an important role in the formation and maintenance of cyclic steps.

On the other hand, antidunes with breaking waves are located in the highest range of the velocity coefficient whereas cyclic steps located in the middle range. It is related to the stability of upstream-migrating antidunes, which is suggested by the weakly nonlinear stability analysis.

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