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Abstract

INVESTIGATION OF GRAVITY CURRENTS WITH LASER INDUCED FLUORESCENCE TECHNIQUE

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Mixing caused by the actions of gravity current is studied. A two-dimensional mass and momentum conserving rigid lid model with a front layer supplying smaller density fluid and a back layer supplying larger density fluid to form the mixing region behind the current head is derived. It could be used to estimate the rate of ambient fluid entrainment to the gravity current based on measurements of the current's propagation speed, the height of its head, the depth of the following larger density fluid, and the total fluid depth.

Saline current propagating under fresh water of a finite depth is used for experiments. A specially designed 9m long, 0.65m wide and 0.6m deep water tank using the lock-exchange scheme for flow generation is built. Laser-induced fluorescence (LIF) flow visualization technique is used to qualitatively and quantitatively examine the flow structures at the current head.

Generation of gravity current by partial gate opening (15cm) in both cases of 35 cm and 45 cm total water depth is successful. Development of a three dimensional leading edge through fingering instability during the acceleration of the current at the initial stage is clearly observed. The current is found fully developed at 12 to 17 gate opening depth downstream. Flow of the developed current head is complex. It has

structures varying both in the longitudinal and transverse directions. Eddies are generated at the leading front. They are then magnified, stretched and bended by the shear flow developed behind and between the lighter and heavier fluids to form large-scale rollers similar to Kelvin-Helmholtz vortexes in free shear layers but much short-crested. Cross-stream ambient fluid entrainment actions at the foremost leading edge of the current are found significant. They initiate intense mixing, providing the needed instabilities at the flow interface, hence feeding the growth as well as creating the three-dimensionality of the subsequent large-scale rollers exhibiting the lobe-and-cleft features. Finally, estimation of the front layer fresh water depth providing fluid for the mixing region behind the current head is estimated to be within 0.25 to 0.5 times of the height of the current head by the derived model.