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Behavior of Sediment-Laden Negative Buoyant Jet in Flow

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ABSTRACT

The paper deals with sediment-laden negative buoyant jets in cross flow. Special attention is paid on the effect of settling of sediment particles on plume motion. Experimental and theoretical investigations were made on the variations of plume properties. When flow distance is small, plume motion is almost same as that of non-settling matter, while with increase in the flow distance, the plume trajectory was pulled down due to settling of sediment.

KEY WORDS

Sediment-laden plume, plume in cross flow, negative buoyant plume, sediment dispersion.

INTRODUCTION

The paper describes the behavior of suspended sediment discharged vertically into horizontal uniform flow. This phenomena are closely related to many environmental problems caused by engineering operations, such as marine construction, deep sea mining, discharge of sewage sludge into the sea or river.

The buoyant jets in cross flow have been studied by many researchers on the case of non-settling matter, since the phenomena are related to many environmental problems, for example, diffusion of smoke from a chimney stuck and discharge of cooling water into sea. On the other hand, to the best of writer's knowledge, there is no systematic study on the case of suspended sediments in flow. This is because the analysis becomes so complicated when the suspended matter has fall velocity.

Generally speaking, the phenomena treated here have three regions. The first region of this phenomena looks like a jet in a cross flow, since the effect of the jet momentum is predominant. The next region is a negative buoyant plume in a cross flow, for the suspension is heavier than the ambient fluid. This region turns to the final region where particles settle by their own fall velocity in the uniform flow. Hereafter we term above mentioned phenomena as plume, for simplicity.

The purpose of the present work is to investigate the effect of fall velocity of sediment particles on the plume motion. Above all, the special attention is paid on the transition from negative buoyant plume to settling. The report, therefore, deals with the case where the fall velocity of sediment particles is not so large compared with the velocity of the uniform flow.

As a first step of the analysis of this kind of plume, we executed laboratory experiments and measured several properties of the plume, such as plume trajectories, decay of the plume flow velocity and sediment concentration, the growth of plume width, and the distributions of both plume flow velocity and sediment concentration.

Experimental results are also discussed using a mathematical model, in which the idea of an entrainment is employed.

EXPERIMENTAL SETUP

A uniform flow field was made by dividing a large tank into two parts and circulating water in it, as shown in Fig.1. This uniform flow zone has 5.0 m length, 1.35m depth and 0.5m width. Sediment particles were sand particles whose specific gravity is 2.65. The particles were sized with standard sieve. The sediment suspension is discharged vertically from the water surface into horizontal uniform flow through a nozzle. Flow veloci-