LABORATOIRE DE CONSTRUCTIONS HYDRAULIQUES

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Turbidity currents modelling in the stratified North basin of Lake Lugano

(1999 - 2001)

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Study entrusted by the Canton Ticino

Introduction

The exceptional flood of the Cassarate River in September 1994 partially disturbed the hypolimnic water balance in the Northern basin of the Lake Lugano. This observation reinforces the assumption that water of the Cassarate penetrates at various depths of the lake, according to their apparent density.

During the flood, the affluent is thus at the origin of an internal circulation likely to cause the erosion of the sediments already present on the bottom, increasing the solid load further and accelerating it. This phenomenon is known under the designation "erosive turbidity current". It depends on the stability and the consistency of the deposits on underwater banks and its own velocity and it can become a real lacustrine avalanche.

It is able to put into motion great quantities of water and can go across very high distances. Lake chemical balances can thus be deteriorated at the time of such exceptional events and the impact on the ecosystem has to be studied.

The study of turbidity currents on the bottom of a lake is based on a review of the relevant literature, on measurements of water and sediment motion on site and on numerical flow simulations.

Numerical modelling

The "traditional" models of the water column balance in lakes cannot explain the behaviour of this type of event. Only a numerical hydrodynamic model in three dimensions will be able to simulate the water circulation resulting from a flood of the above-mentioned affluent.

The numerical modelling of all these phenomena is based on the CFX-4 code developed by Computational Fluid Dynamics Services and sold by AEA Technology (Fig. 1 et 2).

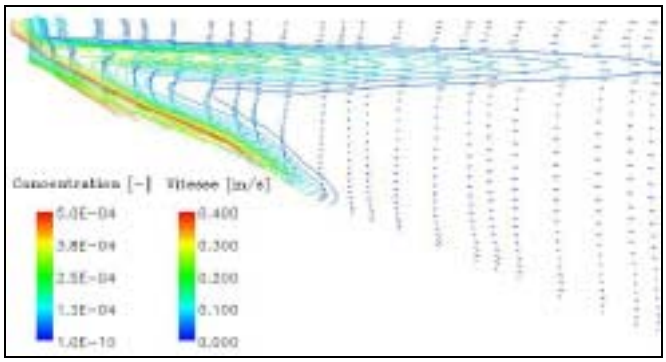

Fig.2 : Lines of equal concentration and velocity vectors in the axial longitudinal plane, one hour after the maximum discharge of the 1994 flood. Bottom density current and intrusive current

This tool allows the three-dimensional simulation of turbulent flows with solid phase in Lake Lugano.

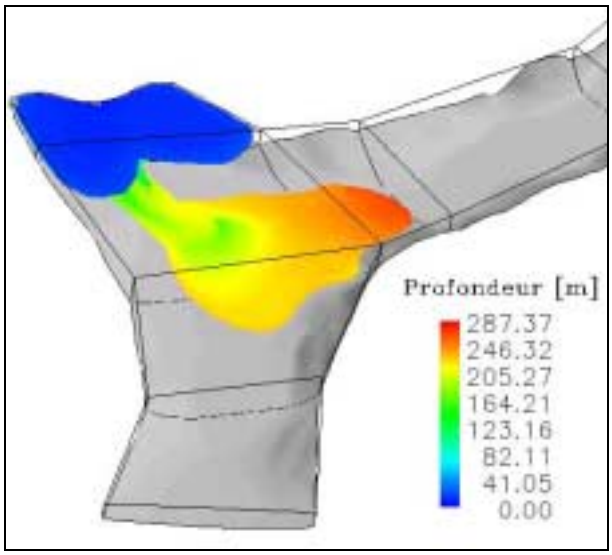

Fig.1 : Bottom density current and intrusive current five hours after the maximum discharge of the 1994 flood

In-situ measurements

The limnologic data collected these last few years in Lake Lugano by the Laboratory of the environmental studies make it possible to describe the general evolutionary tendencies of the lake. The strong thermal stratification during the summer period should be able to prevent any substantial vertical exchange between deep anoxic water and the oxygenated hypolimnion.

In parallel to the numerical calculations, a measuring site was installed on the Cassarate upstream of the mouth and some currentmeters were placed in the lake. During two consecutive years, a series of measurements were thus carried out in the Cassarate and along the principal axis of the lake from Lugano to Melide.

In addition to the flood of 1994, two significant hydrological events, which occurred in 1999 and 2000, were modelled. Additionally the impact of a hypothetical extreme event was analysed.

Technical solutions

Finally, some technical solutions were proposed and numerically tested in order to reduce the impact of floods of the Cassarate River on the ecosystem of Lake Lugano.

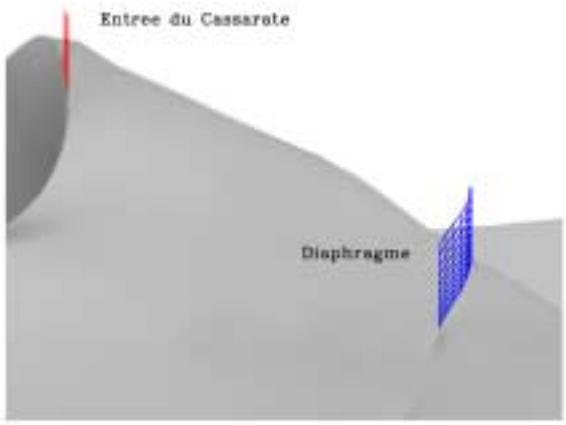

Fig.3 : Lateral view of the vertical diaphragm in the numerical model