Influence of street / block flow exchanges during urban floods

PhD position at Irstea Lyon-Villeurbanne (2018-2021)

Abstract

During urban floods, the flow is generally concentrated in the streets but the exchanges with the built-up areas modify the flow patterns at local scale. These built-up areas include buildings, courtyards, gardens within which the flow can enter through gates, doors, windows, etc. In order to fill the gap in the knowledge of these exchange processes and their influence on the estimate of flood risk and hazard, the selected approach for this thesis will rely on: laboratory experiments performed within a new city quarter model installed at Irstea (MURI: physical model for the study of urban floods), representing a small urbanized area including openings within the blocks and permitting to represent all sorts of buildings; 2D numerical simulations to set up operational methods of urban floods computation accounting for the exchanges between streets & built-up areas.

Introduction

Urban floods are the cause of more and more damages. Detailed hydrodynamic modelling of such floods is thus necessary to manage such events more efficiently. A previous PhD thesis (Bazin, 2013) and an on-going thesis (T. Chibane) in the Irstea team have investigated the influence of obstacles in the streets and the vertical exchanges between the sewer network and the streets. The present PhD proposal focuses on the street /block exchanges. It aims at describing and understanding the structure of the lateral exchanges between the streets and the neighbouring built-up areas and their influence on the main flows along the streets. Main task will be experimental work using a new facility called MURI set at Irstea hydraulics laboratory (http://www.irstea.fr/la-recherche/unites-de-recherche/hhly/hall-hydraulique). The PhD work will be supervised by S. Proust with the help of A. Paquier (numerical aspects) and E. Mignot at LMFA (experimental aspects).

Figure 1. Flows in the streets of MURI

Figure 2. Upstream view of MURI.

PhD outlines

The PhD will include both experimental work in the hydraulics laboratory consisting in the description of the flow processes and numerical developments that will link the two study scales (building and quarter). The building scale (one metre order at field) concerns the site in which a flow enters or exits the street through a lateral opening in a building or a fence. The quarter scale (100 to 1000 metres order at field) comprises a large set of exchanges in order to represent the general flood dynamics with relevant details to integrate the local uncertainties and estimate the general uncertainty.
The laboratory works will rely on the facility MURI, a street surface (3.8 m by 5.4 m) with a main slope and a lateral slope that can be changed. The existing set-up includes three North-South streets and three West-East streets. Flow discharges and water depths in the streets can be controlled by flowmeters and gates. Measuring devices (ultrasonic probes for water level and ADV probes for velocity) can be installed on a bench with automatic displacement in x, y and z directions. LSPIV could also be used for a more general view of surface velocity field.
Experiments will have two aims: on the one hand, to investigate the effect of one opening in the wall along one street and, on the other hand, to estimate the effect of one building arrangement (defined, for instance, by several openings in various buildings) on the flood dynamics. A set of reference situations should be built, each one characterized, for instance, by a density of built-up, a percentage of openings in the wall, an elevation of the doors, etc. MURI by its modular construction will permit to investigate a large set of situations.
Numerical developments should permit to simulate the flow features such as measured during the experiments with the maximum of details but also, they should represent (in a simplified way) these features in more general models of the urban floods at larger scale. At such a general scale, it will be important to include the variability of the urban features and of the various openings (for instance opened or closed gates) as an uncertainty. A test of the numerical models on several real urban environments is planned at the end of the PhD.

Profile of the candidate

The student should have a recognized knowledge in hydraulics or fluid mechanics. He will register in the doctoral school MEGA of Lyon University.

References of the team

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