PROCORE - FRANCE/HONG KONG JOINT RESEARCH SCHEME COMPLETION REPORT

Project Reference Number

F-HK24/10T

Project Title

Numerical and experimental study of urban flooding flows at crossroads with or without obstacles

Particulars

	Hong Kong team	French team
Name of Project Co-ordinator (with title)	English: Chi-Wai LI Chinese: 李志偉	Nicolas RIVIERE
Name of Co-Investigator (if any)	English: Chinese:	Emmanuel MIGNOT
Institution or Institutional affiliation	[ ] CityU [ ] CUHK [ ] HKBU [ ] HKIEd [ ] HKU [ ] HKUST [ ] LU [√] PolyU	[ ] CEA [ ] CNRS No. [ ] INFREMER [√] University of Lyon (INSA-Lyon) [ ] Others: [ ] INRA [ ] INRIA [ ] INSERM No.
Other project team members (if any)		

Funding Period

	1st year	2nd year (if applicable)
Start Date	1/1/2011	
Completion Date		31/12/2012

Objective(s) as per original application

1. To carry out 3D numerical modeling of fast flows at cross junctions.
2. To conduct experimental measurements of flows at cross junctions with obstacles.
3. To carry out 3D numerical modeling of flows at cross junctions with obstacles.

[Please attach relevant document(s)]

i) Outline of proposed research and results obtained

The project dealt with the capacity of numerical codes to predict urban floods. First results focus on the capacity of these codes for supercritical flows intersection, corresponding to floods in steep streets. Available experimental data from LMFA (France) are compared against the computed results by PolyU (Hong Kong) using their own numerical code as well as the computed results using a commercial code, namely Fluent. The two codes were able to reproduce the general flow features, principal flow structures, water depth field and discharge distribution. With equally accurate results, the PolyU code use a kinematic wave equation instead of a VOF model in tracking the water surface elevation, ensuring faster calculations and being more operational at the field scale. Nevertheless, both codes show difficulties in reproducing very steep variations of water depth, i.e. for hydraulic jumps. The latter remain thus the main difficulty to simulate floods in steep slope cities.
Second results deal with the influence of obstacles, such as street furniture or vehicles, on the floods propagation in cities. These obstacles have a random character and are thus hardly ever accounted for in numerical simulations ; they thus induce an error which is worth quantified. With this purpose, experiments were performed at LMFA, in open channels reproducing a urban intersection. These experiments have quantified the impact of obstacles, of their number, of their positions within the intersection. They have shown how this impact can be amplified by the depth, the Foude number (corresponding more or less to the street slope) or the initial distribution (with no obstacle) of the discharge. Numerical simulations undertaken at PolyU proved their ability to reproduce the flows (see Mignot et al., 2012). Providing far more details than the measurements, they allowed to explain the mechanisms (wake, flow separation, blockage,...) playing a role in the modifications of the discharge distribution.

ii) Significance of research results

The numeral and experimental results show that the obstacles can modify (increase or decrease) the discharge distribution towards the downstream streets, by an amount reaching 15% of the incipient discharge. This amount will increase when increasing obstacles size. As a conclusion, it is clear that obstacles must be accounted for: explicitly in the topography when dealing with 2D or 3D simulations, or as a head-loss coefficient when dealing with 1D simulations. In addition, a drag force method has been developed and incorporated into a 3D model to effectively and efficiently simulate the blocking effects of obstacles on flow distribution in street junctions.

iii) Research output

Mignot E., Dominguez, G., Zeng, C., Li C.W., Riviere N., Bazin P.H., 2012. Impact of singularities on the discharge distribution in open-channel bifurcations, 2nd IAHR Europe Congress, June 27-29, Munich, Germany.

Mignot E., Zeng C., Dominguez G., Li C.W., Riviere N. and Bazin P.H., 2013. Impact of topographic obstacles on the discharge distribution in open-channel bifurcations, J. of Hydrology, *accepted for publication.*

Zeng C., Li C.W., Mignot E., and Riviere N., 2013. Modeling Flow Distribution in Street Junctions with Obstacles using a Drag Force Method, Proc. 2013 IAHR Congress, China.

iv) Potential for or impact on further research collaboration

A research link between the two parties has been established, which enhances the opportunity for further research collaboration.