



HAL
open science

Floods in housing estate: some experimental data

Frédérique Larrarte, Augustin Doumic, Nicole Goutal

► **To cite this version:**

Frédérique Larrarte, Augustin Doumic, Nicole Goutal. Floods in housing estate: some experimental data. Proceedings of the 39th IAHR World Congress, Jun 2022, Grenade, Spain. 6 p., photos, graph. hal-03728741

HAL Id: hal-03728741

<https://hal.science/hal-03728741>

Submitted on 20 Jul 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Floods in housing estate : some experimental data

Frédérique Larrarte^(1,2), Augustin Doumic^(2,3) Nicole Goutal^(2,4)

⁽¹⁾ Université Gustave Eiffel, Département GERS - Laboratoire SRO, Cité Descartes • Bâtiment Bienvenue, 5 Boulevard Descartes, Champs-sur-Marne, 77454 Marne-la-Vallée Cedex 2, France, frederique.larrarte@univ-eiffel.fr

⁽²⁾ Laboratoire d'Hydraulique St Venant – 6 quai Watier 78401 Chatou, France

⁽³⁾ Ecole Nationale des Ponts et Chaussées – 6 et 8 avenue Blaise-Pascal - Cité Descartes - Champs-sur-Marne - 77455 Marne-la-Vallée cedex 2, augustin.doumic@orange.fr

⁽⁴⁾ EDF R&D, – 6 quai Watier 78401 Chatou, France, Nicole.Goutal@edf.fr

Abstract

The water cycle can be affected by violent events such as earthquakes, tsunamis, floods, ... In France, 17 millions of inhabitants are exposed to flood risk. One challenge during floods is to be able to access to people refugee over buildings. In order to investigate the hydraulic context generated by the grouped obstacles representative of a submerged housing estate, a preliminary experimental study was conducted. We experimentally study the flow in the presence of rows of macro-roughnesses representative of a submerged housing estate, and this for situations representing both current and more intense floods. After presenting the experimental configurations, the experimental results are given and discussed. The first conclusions are completed by the perspectives.

Keywords: Erosion; Open channels; Profilers, Bathymetry

1. INTRODUCTION

The water cycle can be affected by violent events such as earthquakes, tsunamis, floods, ... In France, 17 millions of inhabitants (about a quarter of the national population) are exposed to flood risk, i.e 16.6 million euros of insurance indemnities expenses related with 1,463,000 flood-related claims between 1988 and 2013 (Bonney 2019). And with climate evolution, floods will become more frequent and more intense. One challenge during floods is to be able to access to people refugee over buildings

The purpose of the present communication is to analyze the evolution of the velocity distribution for various flood situations from current to severe ones. (Oukacine et al., 2021) presented experimental data for a dense area and for emerged and submerged obstacles. Here we emphasize on the transition cases between emerged and submerged contexts (with just emerged and just submerged cases) and we present more graduated cases of submerged situations. This brief communication aims at giving complementary elements on upstream to downstream evolution of the velocity distribution.

This paper outlines the experimental setting (flume, measuring device, flow condition) before providing the results of the emerged and submerged flows as well as a comparison of the two flows. The major results are summarized in the conclusion.

2. EXPERIMENTAL SET-UP

Human settlement present a wide range of configuration. For this study, we focus on house and gardens configuration as defined by Stewart & Oke (2009) as they can exist in recently urbanized areas on plain areas (figure 1). We also consider oceanic climate floods rising quite slowly and producing pseudo static situations such as the famous Paris 1910 flood that is a centennial one. In such context, the private houses are flooded but their roof remains out of water. With the climate evolution, these building could be submerged.



Figure 1: Exemples of aligned housings (from Nantes Metropole, 2014)

The experiments have been carried out at the Laboratoire d'Hydraulique Saint Venant in an open channel which is 16 m long, 2 m wide and 0.5 m high. A honeycomb has been placed at the pump outlet to calm the flow. Velocity measurements were performed with a Ubertone UBLab ultrasonic profiler (Figure 2) fixed at the free surface. This set-up has the advantage of giving simultaneously a velocity profile while minimizing the disturbance of the flow except close to the free surface.

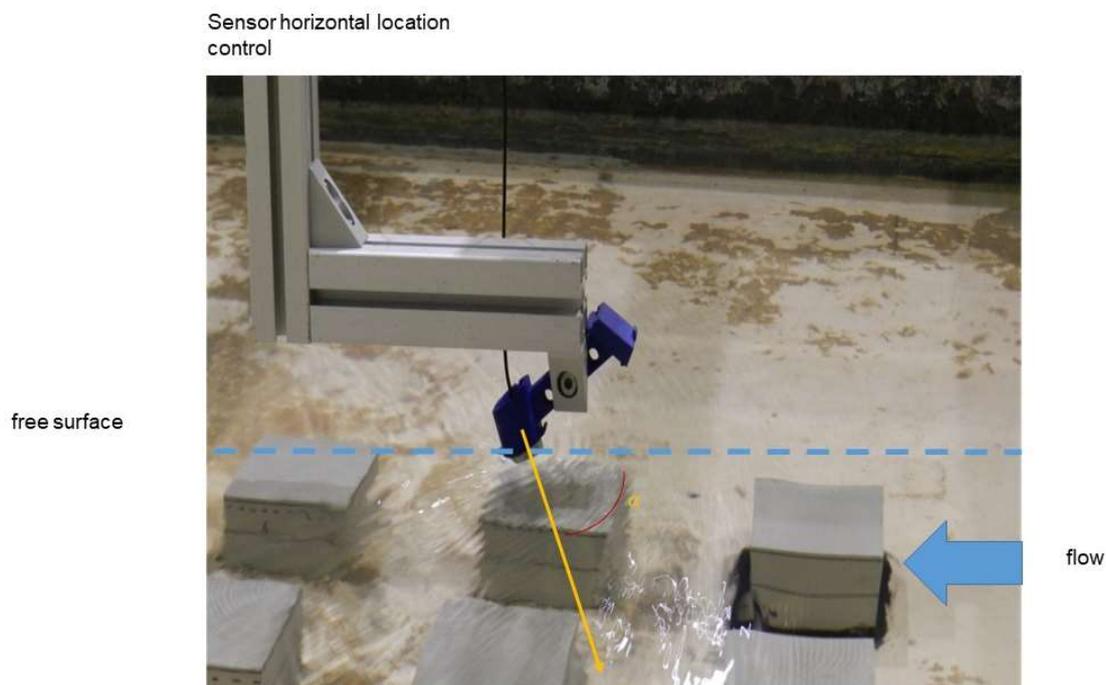


Figure 2: View of instrumentation and its implementation in the channel.

In this study, we represent a peri-urban settlement with aligned buildings (Figure 3) represented by square cylinders. The distances between the cylinders is taken equal to the square cylinder size in both streamwise and transverse direction (ie l_x and l_y). Each square cylinder has a side length $L_x=L_y= 0.1$ m.

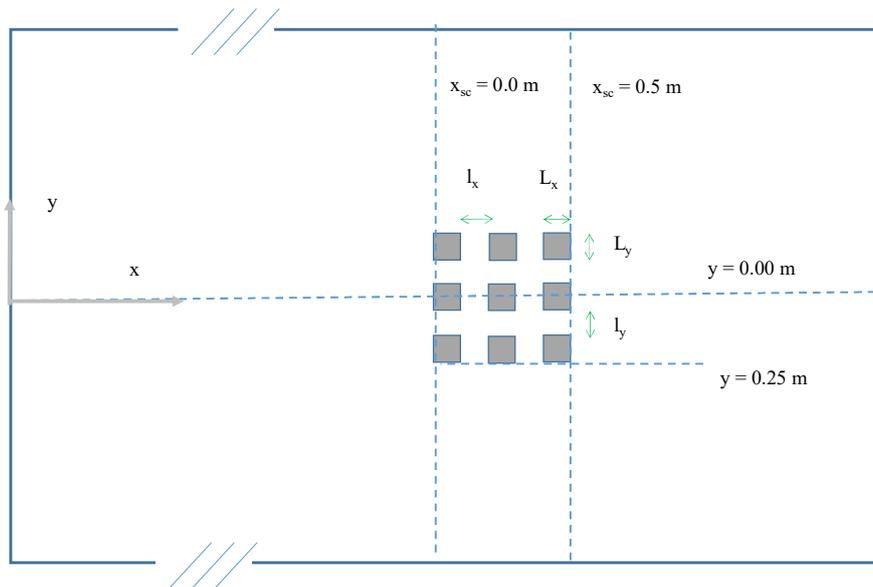


Figure 3: Experimental configuration: an array of aligned square cylinders.

The Froude number Fr ranges between 0.19 and 0.24 and the Reynolds number between 21850 and 34500, meaning a fluvial turbulent flow, with $Fr=U/(gD)^{1/2}$ and $Re = U \cdot h/\nu$, where g is the gravitational acceleration. Table 1 presents all the experimental conditions.

Table 1 : experimental cases

cases	H (m)	Q (m ³ /s)	Fr	Re
E095	0.095	0.044	0.24	21850
S105	0.105	0.048	0.23	24150
S130	0.130	0.060	0.20	29900
S150	0.150	0.069	0.19	34500

3. RESULTS

The experiments were conducted for an aligned configuration and various flow rates corresponding to the 4 cases presented in Table 1.

Visual observations made during the experiments show that a wave very similar to a bow wave was generated by the array of square cylinders (Figure 4)

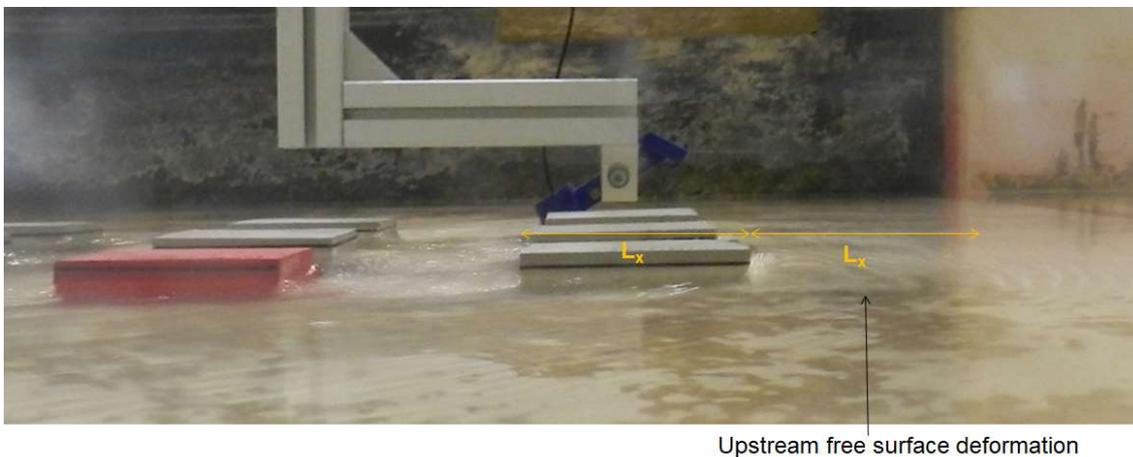


Figure 4: Free surface deformation for the E095 case.

The vertical distribution of the streamwise velocity has been measured on various verticals inside the array. Figures 5 to 8 present those profiles from upstream to downstream, from emerged to submerged cases and both between the square cylinders at $y = -0,1$ m (Figure 6a) and out of the array at $y = 0,3$ m (Figure 6b). First of all, it can be noticed on figures 5a, 6a, 7a and 8a that the flow is slowed up to one cylinder length (lx) upstream of the first row. This is associated with a slowdown of the flow at the entrance of the array. This behavior goes to up to 20% of the in-going U velocity for the lower water levels (E095 and S105) whereas for the submerged S130 and S150 cases the velocity is less affected above the cylinders. On the opposite, once between the cylinders, the flow was accelerated and a fast vein flowing up to 40% faster than the incoming velocity was created. Moreover, the velocity distributions present very complex shapes that may be due to the fully tridimensional behavior of the flow where transverse variations of the 3 components of the velocity were observed by Oukacine (2019). Unfortunately, the experimental set-up used for the preliminary study did not allow us to measure the transverse and vertical components of the velocity. The complexity of the profiles decreases when the water level increases. And the S150 case presents velocity distribution with smooth variations. One noticeable point is the existence of a dip phenomenon that was unexpected if we consider that the channel is wide (the ratio of its width to the water level is above 10) but shows that, between two lines of square cylinders, the flow behaves as with a narrow channel; even when between 2 rows such as for $xsc = 2lx$.

Outside of the array but close to it (at $0.5 lx$ out of the last lane of square cylinders), the velocity distribution have complex shapes for the just emerged E095 (Figure 5b) and just submerged S105 cases (Figure 6b) whereas, for the more deeply submerged situations S130 and S150 (Figures 7b and 8b) the profiles present progressive evolution. It can be noticed that, for the S130 and S150 cases, the flow is slightly accelerated at the level of the interval between the first and second rows of square cylinders and slightly slow down at the level of the interval between the second and third rows of square cylinders.

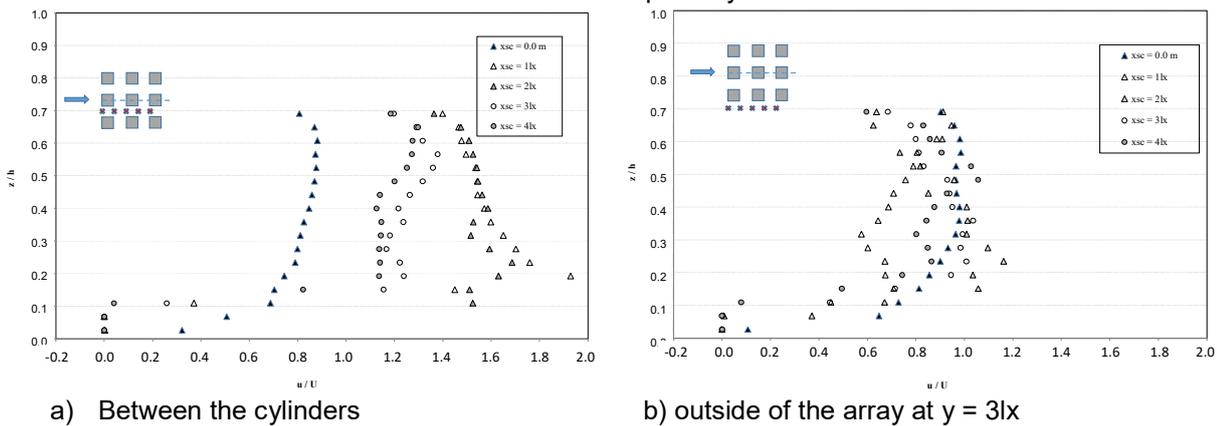


Figure 5: Upstream to downstream evolution of the velocity distribution for the E095 case

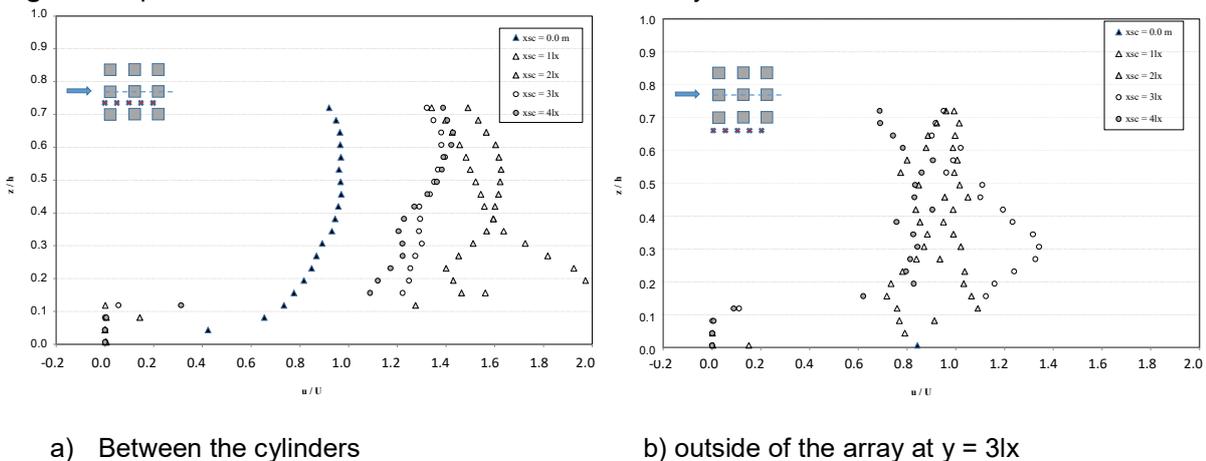


Figure 6: Upstream to downstream evolution of the velocity distribution for the S105 case

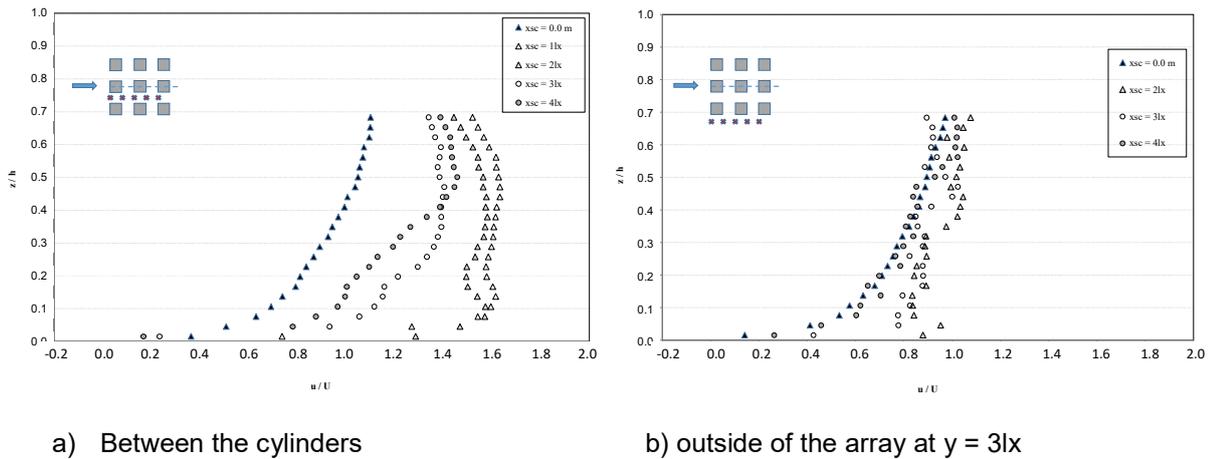


Figure 7: Upstream to downstream evolution of the velocity distribution for the S130 case

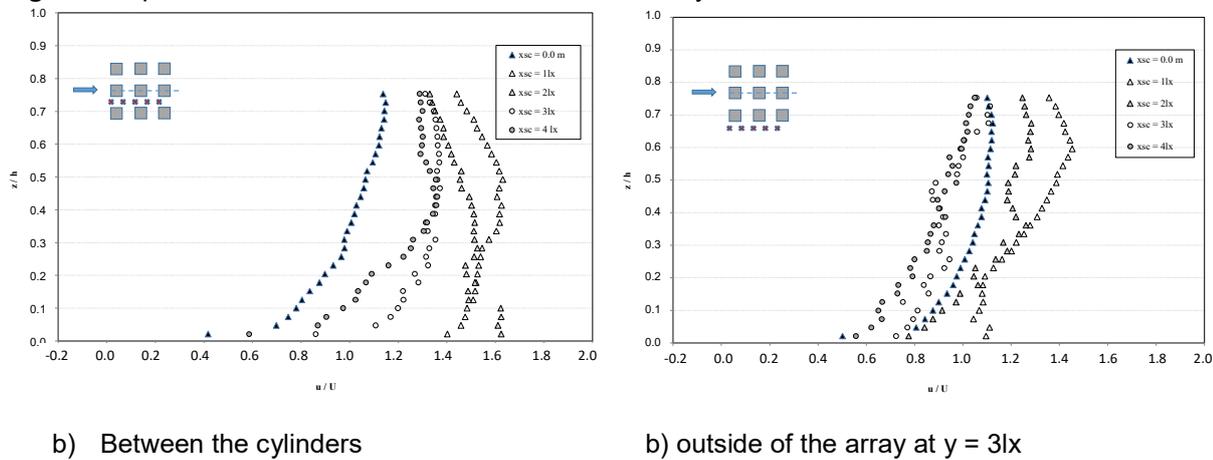


Figure 8: Upstream to downstream evolution of the velocity distribution for the S150 case

4. CONCLUSIONS

The present communication deals with settlements exposed to flooding situations from emerged to slightly submerged situations. First we presented briefly the context before detailing the experimental set-up. Second the results were presented and discussed.

Experimental vertical distribution of the streamwise velocity were measured inside and close to an array of aligned and equidistant square cylinders. The experiments have shown the influence of the cylinders on the flow and in particular the existence of a fast vein between the lines of aligned cylinders. The results also showed the high influence of the cases, either emerged or submerged, on the velocity. Visual observations during the experiments have shown that the flow is rather complex that was corroborated by the upstream to downstream variations of the profiles. The given results indicate that the two others components of the velocity as well as the turbulent fluctuations would give interesting elements. Unfortunately, the profiler used for this preliminary study did not allowed to measure the those parameters and to measure the upper part of the flow.

This preliminary study will be continued to improve the experimental set-up for measuring that. Other configurations will be investigated too, in particular to investigate the influence of the distances (both streamwise and transverse) between the square cylinders.

5. ACKNOWLEDGEMENTS

The authors thank EDF R&D for giving them access to the experimental facilities and for funding A. Doumic's fellowship.

6. REFERENCES

- Bonnefoy, N., (2019). Rapport d'information de Mme Nicole BONNEFOY, fait au nom de la MI sur la gestion des risques climatiques n° 628 (2018-2019) - 3 juillet 2019, Sénat, <https://www.senat.fr/notice-rapport/2018/r18-628-notice.html>
- Oukacine, M., (2019). Etude expérimentale et numérique des écoulements à surface libre en présence d'obstacles émergés à faiblement submergés. PhD thesis. Université Paris Est (XI) (in French)
- Oukacine, M. , Proust, S., Larrarte, F. and Goutal, N., (2021). Experimental flows through an array of emerged or slightly submerged square cylinders over a rough bed. *Scientific Data* , Nature Publishing Group, 2021, 8 (1), doi:10.1038/s41597-020-00791-w
- Stewart, I. and Oke, T., (2009). Classifying urban climate field sites by "local climate zones": the case of Nagano, Japan, *The seventh International Conference on Urban Climate, 29 June - 3 July 2009, Yokohama, Japan*