Influence of storm drain inlet locations on urban pluvial flooding hazard at local scale

Giuseppe T. ARONICA[1], Joao P. LEITAO[2], Angela CANDELA[3]

[1] Department of Engineering, University of Messina, Messina, Italy
email: giuseppetito.aronica@unime.it

[2] Eawag, Swiss Federal Institute of Aquatic Science and Technology, Dübendorf, Switzerland
email: joaopaulo.leitao@eawag.ch

[3] Department of Engineering, University of Palermo, Palermo, Italy
email: angela.candela@unipa.it

ABSTRACT

1. Introduction

The assessment of the impact of surface drainage conditions and the related effect on urban flooding is the general aim of the present research study. The main objective is to analyze the surface drainage efficiency by evaluating the influence of storm drain inlet location on pluvial flooding. This study focuses on the impact of surface drainage system, in terms of positioning, typology and size of inlets, on pluvial flood hazard.

2. Methods

In this study the FLURB-2D propagation model has been used (Palla et al., 2018). It is a two-dimensional inertial model based on the Saint Venant equations and it was, originally, developed with a different purpose. The model was worked out to simulate alluvial plains flow propagation when topography is uneven (Aronica et al., 1998) and it was, first, applied to urban areas by Aronica and Lanza (2005). Details about the hydrodynamic model are reported in Aronica et al. (1998), Aronica and Lanza (2005) and Palla et al. (2018). Inlets in the study area have a different hydraulic behavior as a function of flow depth value: they are comparable to weirs for flow depth lower than 0.12 m and to orifices for flow depths greater than 0.12 m. Four different hypothetical scenarios for the location of the drain inlets were considered (Table 1). Drain inlets located: at street intersections ("St. crossings"); at the middle of the street ("Middle"); along the lower elevation side of the street ("Ledge"); and along the higher elevation side of the street ("Hedge"). The hydraulic capacity of an individual drain inlet was kept constant for the different scenarios depending only on the local water stage. This results in different total hydraulic drainage capacity.

Table 1. Description of the drain inlet scenarios

Scenario	Number of drain inlets	Description
St. crossings	26*	Drain inlets are located only at street crossings.
Middle	147	Drain inlets are located in the center line of the streets spaced 25 m.
Ledge	146	Drain inlets are located along the lower elevation side of the streets spaced 25 m.
Hedge	147	Drain inlets are located along the higher elevation side of the streets spaced 25 m.

* This scenario represents a substantially smaller drain inlet hydraulic capacity when compared to the three other scenarios.

3. Case study

The methodological approach presented in this study is applied in a real study area in the town of Messina (Italy). Ganzirri lake is situated within the area of Messina city, and it is located, approximately, 13 km north-east of the city center (Figure 1). The area around the lake is, entirely, densely urbanized, with streets and blocks with limited pervious parts. The drainage system is mainly separated from the sewer system and there is no stormwater drainage system. Starting from the morphology of the study area, a mesh has been defined in order to cover the entire surface drainage network, and the internal nodes were made to coincide with the drain inlets. The mesh area is about 0.47 km^2, it is discretized as 42,520 triangular elements and 24,792 nodes. Geometric features (x, y, z coordinates) of nodes have been derived from a DEM, with 0.5 m resolution obtained from a drone survey carried out in 2019.

Fig. 1. Overview of the study area, Ganzirri village, in the town of Messina, Italy (from Google Maps).

Street network of the area is covered by the mesh and each triangular element is considered impervious (paved or asphalted) while buildings are represented as voids in the mesh. Each inlet has a contributing area (totally paved) which is not, directly, connected to a single inlet as it results from the flow hydrodynamics in the domain. FLURB-2D simulates overland pluvial flow propagation, and the interactions with the subsurface drainage network are not simulated. The analysis is carried out by using as input synthetic hyetographs derived from the analysis of rainfall data. A network of inlets is considered, distributed in the study area. Direct rainfall distributed over the meshed area represents model boundary conditions in terms of inflow and the inlet stage-discharge relationship for the outflow.

4. Results

The results show that the location of the drain inlets have implications on the maximum water depth across the simulation domain (Fig. 2). This indicates that, as expected, when using detailed elevation data to set up two-dimensional flood models, the impact of the location of the drain inlets starts to become visible and needs to be taken into account.

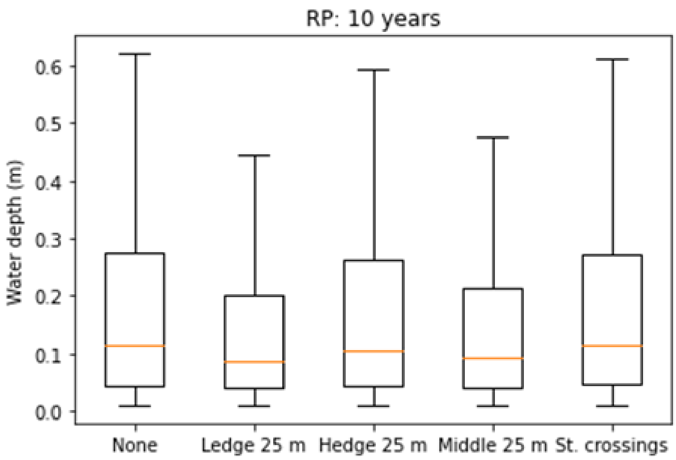

Fig. 2. Distribution of the maximum water depth across the whole simulation domain, for a rainfall event with a return period of 10 years.

5. Conclusions

These preliminary results indicate that more refined analyses need to be conducted to fully understand (i) the requirements in terms of the drain inlet representation details to accurately simulate urban flood simulations and ultimately (ii) to assess the real impact of drain inlet location on pluvial flooding and inform decision makers to improve the hydraulic performance of the drainage systems.

References

Aronica G.T., Nasello C., Tucciarelli T. (1998) A 2D multilevel model for flood propagation in flood affected areas, Journal of Water Resources Planning and Management (ASCE), 124(4), 210-217

Aronica G.T., Lanza L. (2005) Drainage efficiency in urban environment, Hydrological Processes, 19(5), 1105-1119

Palla A., Colli M., Candela A., Aronica G.T., Lanza L.G. (2018) Pluvial flooding in urban areas: the role of drainage inlets efficiency, Journal of Flood Risk Management, 11, 663-676