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Optimal Surface Drainage Inlets Positioning Using Stochastic Pluvial Flooding Analysis

M.Colli[1], A.Candela[2], G.T. Aronica[3], L.G. Lanza[1]
1. Department of Civil, Chemical and Environmental Engineering, University of Genova
2. Department of Hydraulic, Environmental, Aerospace and Materials Engineering, University of Palermo
3. Department of Engineering, University of Messina
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ABSTRACT

Pluvial flooding occurs because of excess rainfall when surface runoff cannot be fully drained by the artificial network (i.e. surface drainage deficiency) and/or when the drainage systems overflows (i.e. drainage systems failures). Because of surface drainage deficiencies, however, flooding events occur quite frequently as a consequence of rain events of lower intensity than the design one, even in case of proper dimensioning of the drainage system. Inlets are in those cases the critical nodes, and efficient drainage is only ensured when care is taken on their appropriate design and positioning within the drainage area.

In the present work, a methodology is proposed to stochastically assess the optimal positioning of inlets for reducing urban pluvial local flooding and mitigate the consequent flooding hazard. The optimal inlets positions are determined by means of a derivative-free multi-objective trade-off algorithm coupled with a hydrodynamic model (FLURB-2D) describing the propagation of flood waves. A dedicated parameterization of the inlets spatial distribution is addressed with the aim of minimizing a suitable object function and improving the efficiency of the system. The FLURB-2D model (Aronica and Lanza, 2005), originally developed for simulating rainfall excess propagation over initially dry areas, is here implemented on a selected study area in the town of Genoa (Italy). The study area is located in the eastern part of the town centre developed mainly during the thirties and therefore characterized by a regular urban structure (grid plan). Synthetic hyetographs based on both univariate e bivariate statistical analysis with suitable return periods were used as input to the FLURB-2D model.

Simulation results allow highlighting, as expected, that sewer inlets' position can indeed have a large impact on the occurrence of urban pluvial flooding. In particular, the combined analysis of flood occurrence probability and hazard class maps confirm that topographic effects have the potential to produce local flooding with significant water depths and that inlets' position conditions may affect the behavior of the urban drainage system as a whole.

Overall, the stochastic approach proposed in this study constitutes a useful tool for dealing with uncertainties in sewer inlet operational conditions and, as compared to deterministic approaches, it allows a more comprehensive assessment of urban pluvial flood hazard, which in turn enables better-informed flood risk assessment and management decisions.