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Effects of non-linearity in flooding frequency distribution for urban catchments

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Aim of this paper is to analyse flood frequency distribution in urban catchments to quantify the return period to assign for the optimal design of urban drainage systems, according to the New European Standard EN 752, that demands an adequate level of protection against flooding and describes a new approach for dimensioning urban runoff system based on the design flooding frequency instead of the design storm one.

Commonly, according to the currently methods of rainfall-based flood estimation, a design rainfall intensity for specified duration and fixed return period is involved to derive design floods with the same return period; however, due to the non-linearity of the transformation process, no simple link between recurrence intervals of key variables is valid, so that the equivalence of return period of rainfall input and return period of floods output is not satisfied (Train $\neq$ Trunoff $\neq$ Tflow $\neq$ Tflood damage), but for a limited set of conditions.

As case study, the experimental catchment “Parco D’Orleans”, located in the university campus of Palermo, Italy, has been chosen. The drainage network is composed of circular and eggshaped concrete conduits. Eight historical events (rainfall and discharge), recorded in the period September 1996 - November 1998, have been selected among the data collected in the catchment, to calibrate a conceptual semi-distributed rainfall–runoff model (Aronica and Cannarozzo, 2000). The calibration has been carried out using GLUE (Generalised Likelihood Uncertainty Estimation) procedure (Beven and Binley, 1992). On the basis of cumulative distribution of model parameters obtained using GLUE, the drainage network has been redesigned using the parameters quantiles for F = 0.5 and a design storm for a 10-year return period, derived by the storm event analysis.

By analysis of the standardized profiles of 35 observed storm events, the synthetic design hyetograph has been developed fitting the cumulative fraction of total precipitation for the 35 events for each time interval by Beta distribution.

After upgrading system, by the Monte Carlo simulation technique a large number of synthetic hyetograph have been run through the system, using the adopted calibrated conceptual model, to generate a series of runoff hydrograph at the outlet of the redesigned drainage system. Simulations have been carried out in studying the catchment behaviour, particularly to analyse the drainage network under surcharge conditions (pressurized flow), checking number of critical events for each node. At last a statistical analysis of the simulated flooding events has been performed to compute the recurrence interval of flooding.

The results have pointed out the effects of non-linearity of the rainfall and runoff process, with the purpose of quantify the return period to assign for the optimal design of urban drainage systems.