RESEARCH ON VULNERABILITY IN A DRAINAGE NETWORK BY USING THE MONTE CARLO METHOD

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ABSTRACT

Traditionally, the design of drainage networks has been made in a determinist way, defining the security level as a return period associated to a design storm considered in the hydrological and hydraulic calculations. However, the variability and uncertainty of the parameters that comprise the network design, like precipitation or the roughness of the network conduits, is not habitually considered in the calculations, neither analyzed as a part of the outcome.

Therefore, an analysis of the behavior of the drainage network including the variability of the precipitation and the uncertainty of the parameters that define the problem is necessary to know more accurately which is the security level assumed in its design. The real case consists in estimating the occurrence probability of some damage levels in the urban basin of Riera Roja in Sant Boi de Llobregat, near Barcelona (Spain), quantifying the uncertainty of the results. Evidently, the failures of the network depend on the occurrence of heavy rainfall events so, the occurrence probability of these events should be firstly calculated (hazard) and then, the behavior of the drainage network studied when occurring these events (vulnerability). This is accomplished by using a Poisson-GPD (Generalized Pareto Distribution) model, where the occurrence probabilities of such rainfall events are assumed to be Poisson distributed, and the volume of precipitation is described as some GPD.

Rainfall series of the Fabra Observatory in Barcelona have been used to obtain the records of the rainfall events in order to calculate the occurrence probability of an specific volume of precipitation, following the Poisson-GPD model. This calculation has been made using the BGPE program (*Bayesian Generalized Pareto Estimation*), which develops Bayesian estimation techniques to quantify the uncertainty associated to the obtained results. This task requires the estimation of the reference threshold defining the excesses of the GPD, the shape and scale parameters of the GPD and the parameter that defines the Poisson process. These variables are estimated using prior information –knowledge about rainfall events in the basin– and sample data from the records of the Fabra Observatory.

On the other hand, the occurrence probabilities of some floods in the basin, according to the occurrence of some rainfall events, have been calculated using the Monte Carlo simulation method. Hydrological and hydraulic processes have been simulated using the mathematic model SWMM for each rainfall event, so that it is possible to know the outflows in the network nodes. The inputs that have been simulated stochastically (describing their uncertainty) are the duration and the pattern of every rainfall event and the roughness of the network conduits. The description of the rainfall events has been made analyzing again the records of the Fabra Observatory, to simulate the real rainfall patterns in the basin.

Finally, the outcome of the previous developments and the common process of designing the network using a return period associated to a standard design storm have been compared. Once the hazard, the elements exposed and their vulnerability have been defined, it has been possible to estimate the outflow occurrence probabilities in the Riera Roja basin, so analyzing its security level.