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Uncertainty and Sensitivity Analysis of SWMM Model in Computation of Manhole Water Depth and Subcatchment Peak Flood

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Abstract

The main issue of this paper is to analyze the water depth uncertainty in manholes of a main pipeline of urban surface drainage system. Also sensitivity analysis for subcatchment peak flood discharge is investigated. As a case study, a basin located in the center of historical city, Shiraz, in southwest of Iran is considered. SWMM model is used to simulate rainfall-runoff process and flood routing in conduits. Monte-Carlo simulation and L.H.S method is used for uncertainty analysis. The results showed that water depth coefficient of variation in manholes varies from 12% to 66% and its probability distribution has a considerable positive skewness. Subbasin areas and precipitation parameters leave the most important effect on peak flood discharge and its uncertainty.

Keywords: Uncertainty, SWMM Model, Monte-Carlo Simulation, Manhole, Urban catchment.

1. Main text

Flooding is one of the major problems in the most populated cities of Iran. Urban flooding is usually caused by filling and failure of stormwater collection and drainage systems. Insufficient capacity of these systems is due to different reasons. One of the most important reasons is the uncertainty in design parameters (input variables) and simulation process, which result in uncertainty in dimensions of the system elements. These uncertainties are inevitable and it is required to identify their origin and nature in order to compute them. This process is a major and initial step in analysis of system reliability and reveals the effective parameters and their contribution in output error, including dimensions.

Different investigations have been conducted in this regard. A combination of separate hydrologic and hydraulic models based on simple methods is attended in most of them. As the knowledge of the authors show previous

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studies deals with open channels. Also uncertainty analysis is conducted by use of approximate techniques such as F.O.V.E in some of the previous studies.

In this paper, uncertainty analysis for water depth in manholes of a main pipeline in urban surface drainage system is considered. As a case study, a basin located in the center of historical city, Shiraz is attended. SWMM model is used for simulation of subcatchment flood and its routing in conduits. SWMM is a dynamic rainfall-runoff simulation model used for single event or continuous simulation of runoff quantity and quality for primary urban areas. The routing part of SWMM model (dynamic and other simple methods) transports this runoff through a system composed of various components. With respect to the complicated structure of SWMM, Monte-Carlo simulation and Latin Hypercubic sampling method (LHS) is used for analysis of uncertainty. Sensitivity analysis of subbasin peak flood discharge to model input parameters is calculated by use of Standard Regression Coefficient (S.R.C) and the contribution of each parameter in its uncertainty is determined.

The length of the main drainage pipe line is 1146 *m* with diameters between 1200 to 1600 *mm* and bottom slope between 0.002 to 0.0025. Six manholes are installed along the pipe which collects the runoff of six subbasins with a total area of 141 *ha*. Totally, 52 input uncertain parameters including physiographic, curve number, precipitation and hydraulic parameters are identified. The best probability distribution for each parameter is determined. In the next stage, 1200 random values are generated for each parameter and L.H.S method is used for selection of 120 samples which were introduced as 120 scenarios for SWMM model. Finally the outputs of the scenarios were analyzed by use of statistical methods.

The results showed that the water depth coefficient of variation in manholes were between 12% and 66%. The reason of high magnitudes of coefficient of variations in some manholes is related to the pipe reaction type towards discharge increase. In the other words, in critical scenarios, the surplus flow increases the water depth in manholes intensively and concentrated exactly opposite of open channels. However, probability distribution of manhole water depth has a considerable positive skewness which results in decrease of failure risk. For example, maximum failure risk and subjection to pressurized flow is about 19% and 42% respectively. The results of sensitivity analysis showed that in most of the subbasins, area and precipitation leaves the most important effect on determination of peak flood discharge and its uncertainty. Other effective parameters are roughness coefficient of impervious surfaces, impervious percentage of subcathment, curve number of impervious surfaces, roughness coefficient of pervious surfaces and slope respectively.

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