Design and Construction of Urban Stormwater Return Flow Design Platform Based on Big Data Platform

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Abstract. The stormwater system is an important infrastructure for the city, playing an important safety role in reducing and removing water from roads and avoiding urban flooding. With the acceleration of urbanization and the accentuation of urban heat island effect, urban surface runoff shows the trend of high flow rate and fast flow rate, which leads to the increase of drainage load of urban stormwater system and the increase of risk of urban flooding. Therefore, it is necessary to adopt a scientific method to conduct a comprehensive analysis of the overall drainage capacity and safe conveyance capacity of the urban stormwater system, so as to do the preliminary paving work for the transformation of the existing stormwater system and improve the urban drainage capacity. In this paper, based on the analysis of the current status of urban stormwater system, the concept of urban stormwater system vulnerability is proposed and the indicators of stormwater system vulnerability are determined.

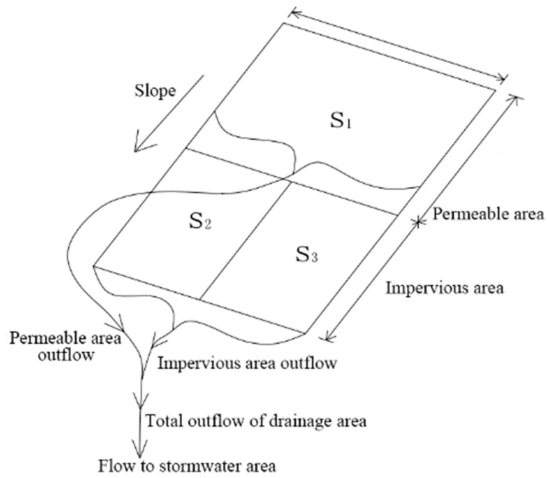
1. Introduction

Urban storm water drainage system is an important part of the urban infrastructure, refers to the city generated in the smaller catchment area on the shorter calendar period of rainwater runoff to exclude the system, including rainwater pipes and drains (including combined pipe drains) [1], check wells, drainage ditches, rainwater pumping stations, gates and valves, urban rivers and receiving water bodies, etc., in ensuring the safety of the city, to ensure the safety of people's lives and property, plays an important role [2]. Since entering the new century, with the rapid development of urbanization, the urban landscape has undergone a new round of dramatic changes [3]. An important feature of urbanization is the change in the nature of the original land use, resulting in an increase in the area of impervious surfaces in cities [4].

2. Theoretical approach of SWMM model

2.1. Sub-basin generalization method

In the SWMM simulation process, the study area is first generalized and the whole catchment area is divided into several sub-catchments [5]; then the runoff processes of each sub-catchment are calculated separately according to their characteristics; finally, the outflow of each sub-catchment is summarized by the flow evolution method [6].as shown in Fig 1.



d

Fig. 1. Schematic diagram of flow production in the catchment area

2.2. Calculation of maternal flow

(1) Calculation of flow production without depression storage impermeable surface (S_3)

For non-pitted impervious surfaces, the main loss of rainfall is surface evaporation. By subtracting the evaporation from the rainfall, the runoff volume of the catchment can be obtained. Therefore, the flow production formula is:

$$R_1 = P - E \quad (1)$$

Where, R_1 -the flow yield of impervious surface without depression storage (mm);

P-rainfall (mm);

E-Evaporation (mm).

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(2) Calculation of flow production in puddle storage impermeable surface (S_2)

Surface runoff begins to form only after the rainfall fills the depressions. Subtracting the puddle storage from the rainfall is the surface runoff formed in the area, so the flow production formula is:

$$R_2 = P - D \quad (2)$$

Where, R_2 -the yield flow rate of the impervious surface of the depression storage (mm);

P-rainfall (mm);

D-Puddle storage volume (mm).

(3) Calculation of flow production in the puddle storage permeable surface (S_1)

Rainfall first penetrates deeply into the unsaturated soil, and surface runoff begins to form when the rainfall intensity exceeds the infiltration intensity and the depression begins to store water until it is full. Therefore, the production flow rate is calculated by the formula:

$$R_1 = (i - f)\Delta t \quad (3)$$

Where, R1-the yield flow rate of the impervious surface of the depression storage (mm);

i-rainfall intensity (mm/s);

f-Intrusion strength (mm).

2.3. Surface convergence model

Surface catchment is the process by which surface runoff formed in a sub-catchment area flows along the ground to a stormwater inlet [7]. The SWMM model for the evolution of this process uses a nonlinear reservoir model [8]. As show in figure 2.

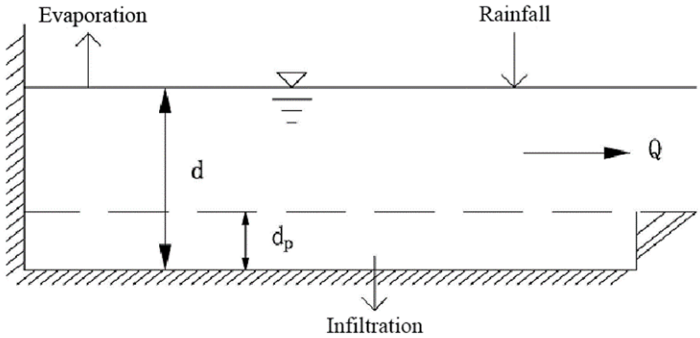


Fig. 2. Schematic diagram of sub-basin non-linear reservoirs

Table 1. Typical surface depression storage volume

Surface Type	Puddle storage volume
Impermeable to the surface	1.27mm~2.54mm
Lawn	2.54mm~5.08mm
Ranch	5.08mm
Forest Foliage	7.62mm

2.4. Simulation application of SWMM

(1) Simulation of different reproduction periods

The rainfall recurrence period P is taken as 1a, 3a, 10a and 30a, and the input of rainfall in the model is changed by setting different recurrence periods, while the other input conditions of the model remain the same [7]. The total outflow rate with time for the reproduction periods of 1a, 3a, 10a and 30a can be obtained by simulation [8], as shown in Figure 3.

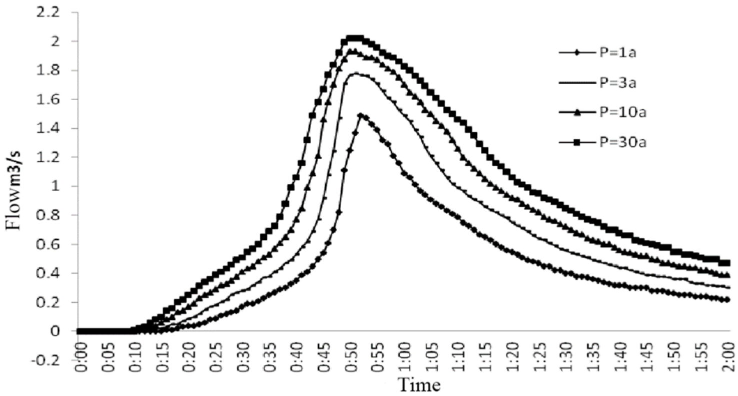


Fig.3. Subdivision exit outflow total graph

The simulations also provide information on the depth of precipitation, depth of infiltration, surface runoff, surface storage and distribution of water accumulation points, as shown in Table 2.

Table 2. Simulation results of rainfall under different recurrence periods

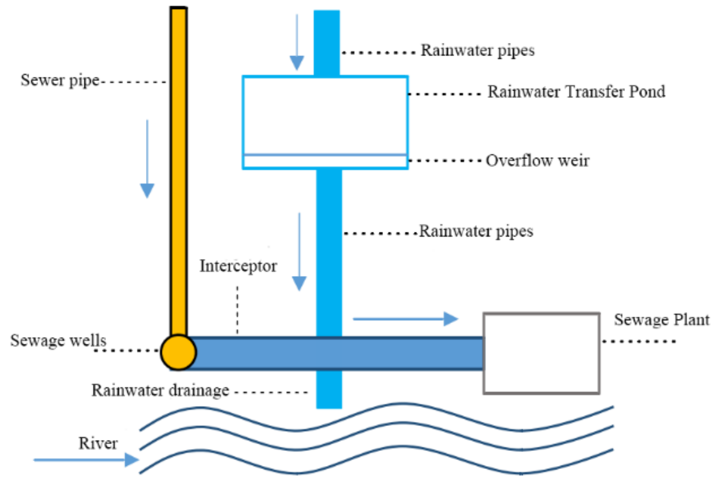
P	Precipitation depth/mm	Net surface flow/mm	Depth of infiltration/mm	Surface water storage/mm	Number of overflow points
1a	52.362	47.241	1.158	3.577	7
3a	72.807	67.692	1.525	3.602	11
10a	95.244	90.112	1.532	3.618	15
30a	115.726	110.583	1.536	3.629	17

From the above table, it can be analyzed that the proportion of runoff to total rainfall is 90.28%, 92.97%, 94.61%, and 95.56% for the scenarios of 1a, 3a, 10a, and 30a recurrence periods, respectively, and the proportion of runoff is high and has been increasing. The main reason is the high proportion of surface impermeability in the simulation area, which accounts for 78% of the total area; while the amount of surface infiltration increases by 0.44% for P=10a and 0.30% for P=30a on the basis of P=3a at the recurrence period P>3, and the infiltration basically tends to be stable, which is mainly determined by the nature of the soil. For surface storage volume, P=3a is 0.70% higher than P=1a, P=10a is 0.44% higher than P=3a, and P=30a is 0.30% higher than P=10a. Soil property factors, topography is basically remain the same, so in the case of increasing rainfall intensity, it is mainly reflected in the increase of runoff volume.

3. Determination of the volume of the storage tank

3.1. Diversion system online rainwater transfer tank system diagram

The system diagram of the diversion system with the main purpose of regulating the peak flow of flood is shown in Figure 4. with the extension of rainfall time and the increase of instantaneous rainfall intensity [9], the inlet flow of the storage pond is larger than the outlet flow of the storage pond, and part of the rainfall is stored in the storage pond; when the rainfall decreases or stops, the rainwater pipeline restores the transport capacity, and the stored precipitation in the storage pond enters the rainwater pipe and is discharged, thus serving the purpose of regulating the flood flow [10].As show in figure 4.



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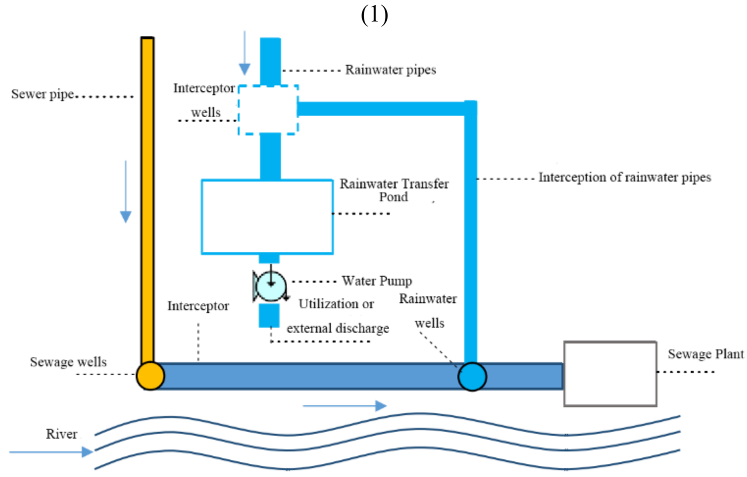

(2)

Fig.4. In-line stormwater storage pond system with the main purpose of rainwater accumulation and utilization

4. Conclusion

This paper deals with three main aspects:

First, the background of the SWMM model is introduced, mainly the composition structure of the model and the functions of the model calculation. Secondly, the theoretical methods of SWMM model are described, mainly the generalization method of sub-basin, the calculation method of flow production in catchment area, the calculation model of rainfall infiltration and the calculation model of pipe network hydrodynamics.

Thirdly, the simulation method and steps of the stormwater system of the CL cell are described by taking the CL cell as the simulation research object and combining the functional characteristics of SWMM, which include: the generalization process of the study area, the determination of the selection of the model parameters of the study area, the selection of the input rainfall rainfall type and the synthesis of the rainfall intensity; and the simulation of the performance characteristics of the stormwater system of the cell under the rainfall of different recurrence periods and different infiltration rate conditions.

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