Amirkabir Journal of Civil Engineering

Amirkabir J. Civil. Eng., 51(2) (2019) 65-67

DOI: 10.22060/ceej.2017.13235.5353

Evaluation of detention tanks for reducing urban floods

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ABSTRACT: The sustainable urban drainage systems approach or LID devices (low impact development) are designed to detain, store, infiltrate, or treat urban runoff, and so reduce the impact of urban development. The purpose of this research is to evaluate the application of detention tanks from low-impact structural methods in order to eliminate or reduce the rainfall flood in the collecting network and conveyance of surface drainage water in small part of the urban area in Babolsar city. By using the simulation of rainfall-runoff process at the catchment area and the runoff routing in the drainage networks with the SWMM, critical nods were identified. The results showed that some parts of system have high capacity and the others have low capacity which induces inundations. Several simulations were performed with considering detention tanks by different dimensions in the system and eventually the best option was selected. Considering a serial detention tank, no inundation occurred in 2 and 5 years return periods but for 10 year return period, inundation happened with 125 m3 flood volume. However, constructing parallel detention tank with same dimensions and place of serial type caused no inundations. Results showed that parallel detention tank has better function comparing with serial one. The results of this study emphasize the use of flood hydrodynamic simulation models to evaluate different scenarios of urban flood management.

Review History:

Received: 6 August 2017
Revised: 7 November 2017
Accepted: 9 November 2017
Available Online: 25 December 2017

Keywords:

Detention Tank
Inundation
Simulation
SWMM
Urban Flood

1- Introduction

Due to the rapid growth of cities in Iran, problems such as inundation of city-level passages and the dangers of flood spreads due to the lack of proper drainage systems and disruption of canals and channels are considered to be the main problems of many urban catchments [1]. The sustainable urban drainage systems approach or LID devices (low impact development) contains of wide range methods for detain, infiltration or treatment of storm runoff in urban environments [2-4]. The purpose of this research is the presentation of new framework in order to evaluate the detention tanks as a structural method for urban flood management in study area by use of SWMM model to remove or reduce of rainfall flood in the collecting network and conveyance of surface drainage water.

2- Methodology

The study area of Shahzade Roodkhane urban catchment with an area about 28.5 hectares is located in the downtown of Babolsar city. The main network of collecting underground pipelines is 796 meters long, with 80 cm diameter pipes. It has 13 manholes, 13 conduits and one outlet, which drains the waters directly into the Babolrood River. The map of the basin studied is shown in Figure 1.

SWMM is a dynamic physical based rainfall-runoff model for quantitative and qualitative simulating of an event or long term (continuous) urban catchment runoff [5]. Since, the catchment is small, then 2 hours design storm with 2, 5 and 10 years return periods were considered for simulating of rainfall flood in Babolsar catchment by SWMM model. Yen & Chow rainfall temporal pattern with 10 minutes time step was used for simulating of inundation caused by design storm. Rainfall- runoff simulation mainly needs to definition of sub-catchment for doing estimation [6]. After drawing of sub-catchments and entering all required data, simulation was performed and regarding to flood characteristics and location of critical nodes, unit or units of the series and parallel detention tanks were designed. For evaluating of series and parallel tank's efficiency, three criterion of flood volume, peak discharge and inundation duration reduction in each node were considered. Several simulations were performed with considering detention tanks by different dimensions, Bed elevation, locations of entrance and exits in the system and eventually the best option with minimum flood volume was selected by trail and errors.

3- Results and Discussion

The maximum conduit design discharge (discharge in full pipe) were calculated for all conduits and the ability of catchment drainage network were evaluated based on number of conduits with low, high and appropriate capacity for conveying floods that can be find in Table 1.

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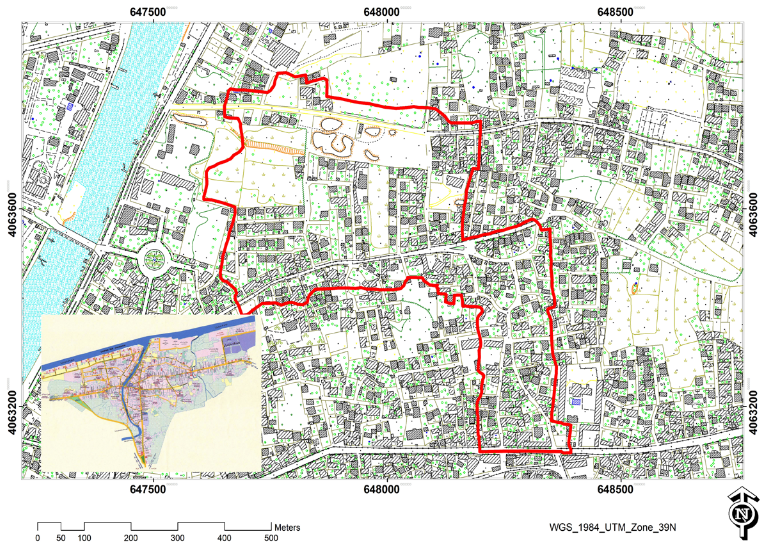

Figure 1. Geographical location of the study.

Table 1. Evaluating of the ability of catchment drainage network for conveying flood

Return Periods	Number of Conduits	No. Conduits with Low Capacity	No. Conduits with High Capacity	Flood Volume(m3)	Number of Flooded Nodes
2	13	6	7	56	6
5	13	6	7	547	8
10	13	6	7	1019	8

As it can be seen in Table 1, the network cannot perfectly discharge storm water even in 2 years return periods and part of runoff after entrance to the network comes to ground surface in downstream nodes and makes inundation because of insufficient cross section and or conduit hydraulic characteristics.

Based on simulation results for three return periods which all flood volume exited from network are belong to node 6 as shown in Figure 2. Then the location of detention tank/tanks will be in upstream of this node. Table 2 shows the efficiency of detention tank for solving the inundation problem of urban drainage network in different return periods.

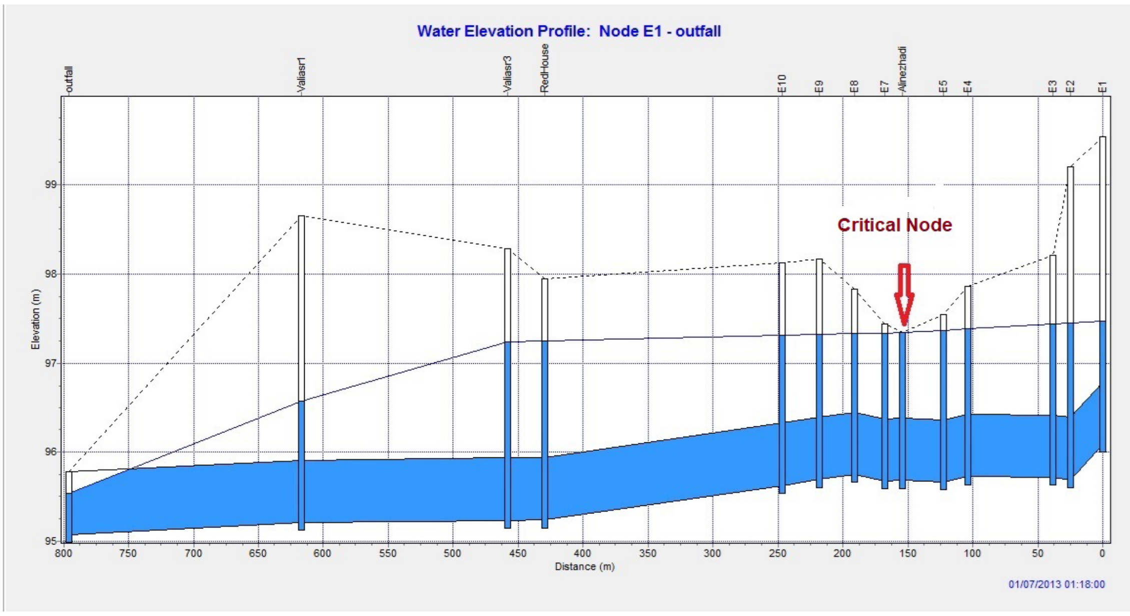

Figure 2. Longitudinal profile of the main conduit and hydraulic line for a 10-year return period

Table 2. Evaluation of series and parallel detention tanks usage in flood control with 2, 5, 10 design return periods

Kind of Tank	Area (m2)	Number inundated Nodes			Flood Volume (m3)			Peak Discharge (Liter per Second)			Inundation Duration (minutes)		
		Tr=2	Tr=5	Tr=10	Tr=2	Tr=5	Tr=10	Tr=2	Tr=5	Tr=10	Tr=2	Tr=5	Tr=10
Present Condition	*	6	8	8	56	547	1019	90	365	580	21	45	59
Series Tank	500	0	0	1	0	0	125	0	0	184	0	0	19
Parallel Tank	500	0	0	0	0	0	0	0	0	0	0	0	0

4- Conclusions

Conducted simulations for design storms shows that installing parallel detention tank causes no inundations in manholes comparing to series one. Then designed parallel detention tank can eliminate inundation problem in study area. Results of the study show that SWMM model can effectively find critical points of network and suggest appropriate countermeasure.

The results of this study shows the high ability of SWMM model for optimum design of flood control systems. Since of rapid and unplanned growth of most cities of country, applying constructional methods such as detention tank is one countermeasure for urban flood control. The results indicate a better performance of the parallel detention tank than the series one in reducing the peak flow rate and flood volume.

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Please cite this article using:

V. Karimi1 ,M. Rashidpour ,Evaluation of detention tanks for reducing urban floods ,*Amirkabir J. Civil* Eng , 51(2)(2019)197-204.

DOI: 10.22060/ceej.2017.13235.5353