Urban Inundation Reduction Effect by Early Operation of Drainage Pumping Station

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1. Introduction

The urban drainage system consists of flood drainage facilities and operating practices. The facilities are composed of sewer networks, gates, and pumping stations to drain the flood efficiently to outer rivers. The operating practice consists of pump or gate operation. Among them, the improvement of the operating practice has more research attentions currently. Then, a real time simulation system is required to simulate the actual inflow and the pump operation in urban basin. With this system, the efficient pump operating rule can be developed to diminish the possible flood damage on urban areas. Related study to operation of the urban drainage system including a retard basin and a pumping station was performed continually. Martin et al. (2006) proposed the efficient management policy in urban drainage system [1]. Dubrovin et al. (2002) studied the real-time reservoir operations using fuzzy model [2]. In low-lying districts of urban areas, drainage pumping stations were built to protect urban inundation by the heavy rain and, in the pumping station, the pump operation is performed by only reservoir depth. But the effect of pump operation can be improved by various pumping rules. This study would like to analysis the reduction effects of urban inundation by early operation of pumps. The various design rainfall events were applied to Gasan 1 pumping station in Seoul and then, the most effective period of early operation was 10 minutes. Also, the maximum water levels of reservoir simulated by early pump operation were 10～70 cm lower than results by the existing operation rule and the overflow volumes in upstream sewer network were reduce by about 50%. Therefore, in urban areas, the flood control stability can be improved by efficient operation of the existing pumping station.

2. Early Operation Model for Drainage Pumping Station

The developed operation model calculates runoff in a basin using the calibrated SWMM 5.0 drainage data set and time dependent rainfall data set, also renewals the depth of the retard basin considering the backwater effect. The developed model is different from the former models on analysis and pump operation rules. Former models used calculated runoff hydrograph as an input data set and operate pump hourly. However the developed model analyzes the runoff on real time situation and operates pump using that simulated data.

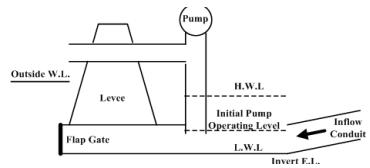

Figure 1. Structure of pump station

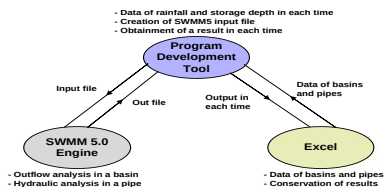

Figure 2. Structure of developed model

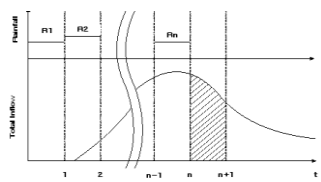

Figure 3. Hydrograph at t=n

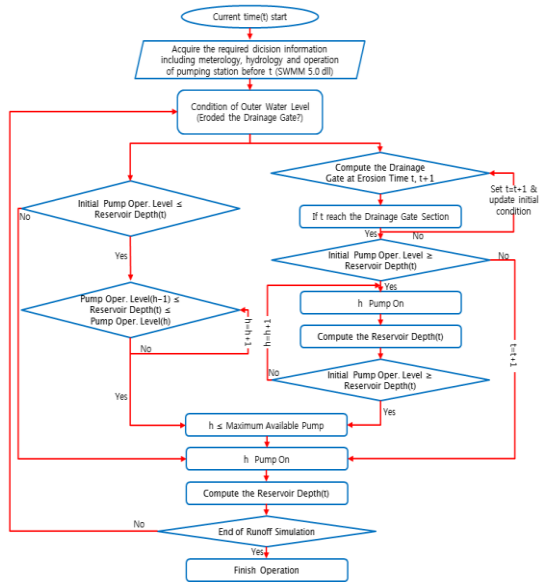

Figure 4. Early operation algorithm of pumping station

General structure of a drainage pump station including a retard basin is as Figure 1. In a drainage pump station, the H.W.L. (High Water Level) is usually higher than the crown elevation of the directly linked inlet pipes. As the depth of retard basin, the backwater effect makes inflow decreasing to the retard basin and the decreased inflow is accumulated the sewer network and as a result surcharges in sewer network increases. Therefore, the proper operation of urban drainage system requires considering backwater effect generated by a retard basin. To make a higher accuracy of simulation, it is necessary to analyze the inflow to a retard basin considering the time dependent depth of retard basin. Consequently, the developed model is able to reflect the depth changing at every time step and renewals the inflow to acquire more accurate inflow hydrograph to a retard basin. The developed model used linked SWMM 5.0 DLL to Visual Basic and equipped with MS Excel. The relations between them are as following Figure 2.

Developed model repeats rainfall runoff calculation at every time step with the renewal the rainfall and depth data of a retard basin. The time step can be determined by the engineers or the other users considering the time of concentration in a basin. Therefore, model is able to perform the simulation at any given time step set by the users using the updated rainfall and depth data to get the runoff from a basin and inflow to a retard basin at the next time step. In fact, the automatic system installed at the pumping stations receives rainfall and depth data at every minute that can be used to this model for operating automatically. In any given time step (t=n), inflow to the retard basin is effected by the depth of the same time step (t=n) and the accumulated rainfall data from the initial time step to the present time step (t=0~n). On this occasion, if the backwater effect is considered in the retard basin, then inflow will be decreased according to the depth of retard basin. In other words, the result in any given time step (t=n) is effected by the simulation results at the 1 past time step (t=n-1) and used to performing the simulation of next time step.

3. Application and Results

The suggested pump operation model was applied to perform a pumping simulation for the Gasan1 pumping station in Seoul. The rainfall events of 100-years frequency are used for the simulation. As results, the backwater effect cannot be ignorable to estimate the amount of inflow. In the results, maximum water levels of reservoir simulated by early pump operation were 10～70 cm lower than results by the existing operation rule and the overflow volumes in upstream sewer network were reduce by about 50%. Therefore, in urban areas, the flood control stability can be improved by efficient operation of the existing pumping station.

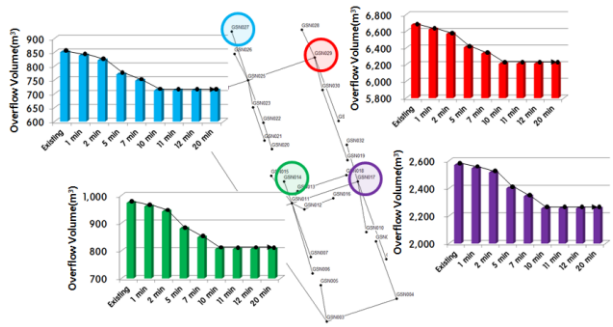

Figure 5. Overflow reduction rate of upstream sewer network

4. Conclusions

The current models are not suitable to be applied in automatic operating systems because that the inflow is changeable at every time steps in accordance with the surcharging, backwater, rainfall changes and so on. Therefore, in this study, the early operation pumping model was developed to improve the workability of pump facilities for urban inundation prevention.

5. Acknowledgement

This research was supported by a grant (13AWMP-B066744-01) from Advanced Water Management Research Program funded by Ministry of Land, Infrastructure and Transport of Korean government.

6. References

[1] Martin, C., Ruperd, Y., Legret, M., “Urban stormwater drainage mangement: The development of a multicriteria decision aid approach for best management practices”, *European J. of Operational research*, 181, 338-349, 2007.

[2] Dubrovin, T., Jolma, A., Turunen, E., “Fuzzy Model for Real-Time Reservoir Operation”, *Journal of Water Resources Planning and Management*, 299, 300-311, 2002.