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EVALUATION OF EXFILTRATION RATES AT THE BOTTOM OF MANHOLES AT AN URBANIZED AREA USING INFOWORKS

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Abstract- ***For the prevention of urban flooding and control of non-point pollution, exfiltration from infiltration facilities is quite important. However, the analyses of the performance of exfiltration from the infiltration facilities spread over the real catchment is still in require. The present study simulated the variations in the exfiltration volume and rate at manhole bottoms by changing rainfall patterns. Giving a exfiltration coefficient by extrapolating the saturated hydraulic conductivity at the surrounding natural base soil, the performance of exfiltration was predicted realistically.***

Keywords – Infoworks, Exfiltration; Exfiltration Coefficient; Natural Base Soil; Saturated Hydraulic Conductivity

I. INTRODUCTION

It's important to analyze runoff from urbanized areas from a point of flood control and water quality control. To do so, the performance of exfiltration at the bottom of manholes and sewage traps is of a big interest (Harada & Komuro 2010) [1]. The performance should be analyzed as a part of catchment scale storm water behavior. Harada & Endo (2013) [2] showed high flexibility of Infoworks to analyze storm water behavior by means of changing the overland surface runoff parameters. Based on the analyses, Harada & Kim (2014) [3] showed a high ability to prevent from flooding if we increase the volume and the rate of exfiltration at the manholes.

Generally, when we do storm water runoff analyses precisely by short time step using a distribution type models, it's important to consider how to express the performance of exfiltration at the bottom of manholes. We can simplify the expression of the performance in order to reduce the computation time and energy. However, it's necessary to take right steps like hydrological theory.

When analyzing the catchment scale runoff pattern, the necessity to set up an exfiltration coefficient by overestimating the hydraulic conductivity of the surrounding soil was suggested by Harada & Kim (2014) [3]. However, performance of exfiltration from the bottom of the manholes was not analyzed in detail. In the present study, the performance was analyzed by changing the exfiltration coefficient together with the rainfall patterns. The plausibility of the given exfiltration coefficient will be discussed.

II. MATERIALS AND THE METHODS

Infoworks is one of the distribution urban hydrological models of high performance. Water catchment area is assigned every manhole and the performance of storm water at manholes and pipes are calculated. When the bottom of manholes are permeable, a exfiltration coefficient should be given.

The study area is Fukumuro in Sendai city, the northern part of Japan same as shown in Harada & Endo (2013). Natural base soil at the area is the mixture of sand and silt, normally, the saturated hydraulic conductivity is 50-100 mm/hour.

Herath & Mushiake (1994) [4] indicated that exfiltration rate from permeation facilities might be quite higher than the saturated hydraulic conductivity of the natural base soil around the permeation facilities. Thus, we set up two exfiltration coefficient; 50 mm/hour and 1000mm/hour, the former is the same order of the saturated hydraulic conductivity and the latter is 20 times higher than the saturated hydraulic conductivity.

Properties of rainfalls A and B used for the computation were shown in Harada & Kim (2014) [3]. The total volume of both rainfalls are 60-70 mm, the magnitude is most common in Sendai city judging from the frequency analyses using 50 years data (Harada & Endo 2013) [2]. The maximum hourly intensity of rainfall A was the 22.0mm and that of rainfall B was 7.5 mm (Harada & Kim 2014) [3].

At 10 manholes, out of 1000 manholes in Fukumuro Area shown in Harada & Endo (1013) [2], the temporal variations in inflow and exfiltration were simulated.

III.RESULTS

Tables 1 and 2 show the total volume of inflow and exfiltration at the 10 manholes in rainfalls A and B. The percentages of the exfiltration to inflow at 10 manholes were shown in Figs. 1 and 2. The amount of exfiltration at each manhole varied depending on the given exfiltration coefficients. More exfiltration happened during rainfall B, the average of the percentage in case of bigger exfiltration coefficient were 7.6% and 9.1% during rainfalls A and B, respectively. But the percentages during rainfall A sometimes exceeded those during rainfall B at some manholes.

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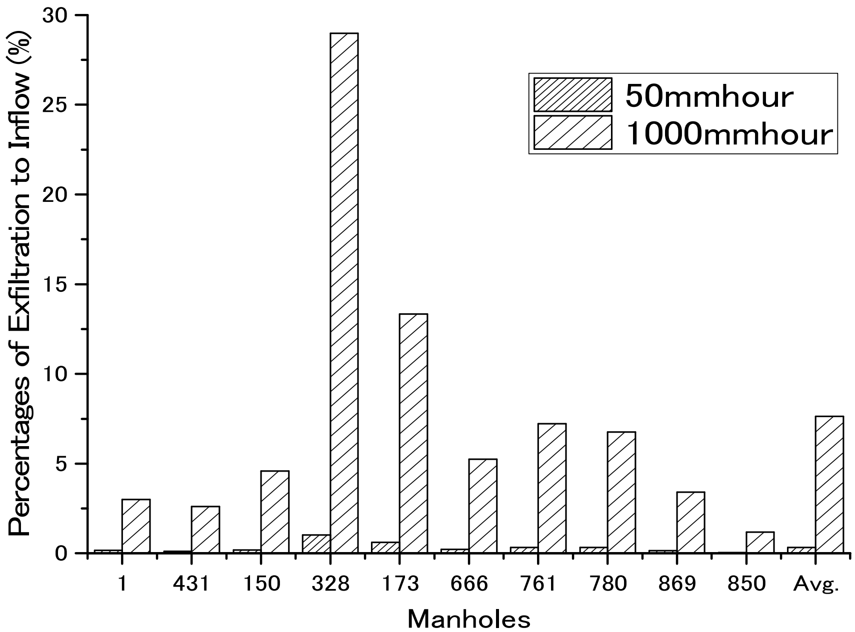

Fig. 1 Percentages of the volume of exfiltration to that of Inflow at 10 manholes during rainfall A: the legends indicate given exfiltration coefficient.

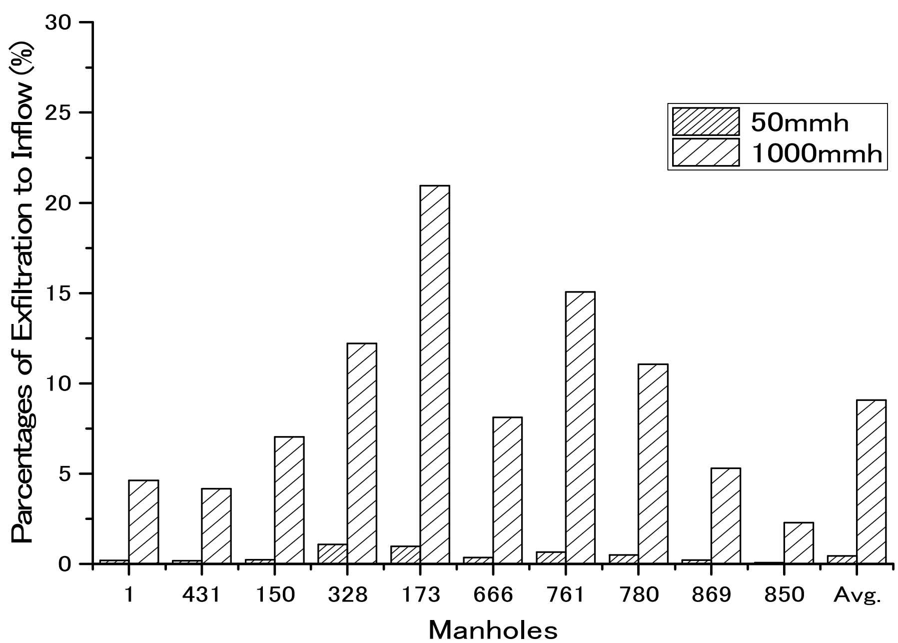

Fig. 2 Percentages of the volume of exfiltration to that of Inflow at 10 manholes during rainfall B: the legends indicate given exfiltration coefficient.

Table 1 The total volume of inflow and exfiltration at the 10 manholes in rainfalls A

Node NO.	1	431	150	328	173	666	761	780	869	850	Avg.
Diameter (m)	2.2	2.2	2.1	4.2	2.1	2.7	2.3	2.3	2.5	3.9	2.7
Inflow (m^3)	511.2	570.1	294.9	234.2	88.5	407.9	197.3	206.4	580.0	4044.9	713.5
$Exfiltration_{50mm}$ (m^3)	0.9	0.7	0.6	2.4	0.5	1.0	0.7	0.7	0.8	2.2	1.0
$Exfiltration_{1000mm}$ (m^3)	15.3	14.9	13.5	67.9	11.8	21.4	14.3	14.0	19.9	48.1	24.1

Table 2 The total volume of inflow and exfiltration at the 10 manholes in rainfalls B

Node NO.	1	431	150	328	173	666	761	780	869	850	Avg.
Diameter (m)	2.2	2.2	2.1	4.2	2.1	2.7	2.3	2.3	2.5	3.9	2.7
Inflow (m^3)	479.8	535.2	276.6	313.7	83.1	382.9	147.8	193.8	544.4	3797.1	675.4
$Exfiltration_{50mm}$ (m^3)	0.9	1.0	0.6	3.4	0.8	1.4	1.0	1.0	1.2	3.1	1.4
$Exfiltration_{1000mm}$ (m^3)	22.2	22.3	19.5	38.3	17.4	31.1	22.3	21.5	28.9	87.4	31.1

The total volume of exfiltration was independent at each manhole, because of the difference of the environmental conditions surrounding the manholes, in addition to the differences in the diameter of the manholes e.g. at the manhole 173, the biggest diameter resulted in the highest percentage. The results underline the possibility to increase the volume of exfiltration by enlarging the manhole size. While simulation using Infoworks before implementing at the real manhole is helpful.

IV. DISCUSSION

The exfiltration formula granted at the manhole bottom in Infoworks is one dimensional. The authors think one dimensional computation is fine when computational time at the wide area has passed sufficiently infinitely. While the manhole bottom can be considered to be a point, so actual exfiltration should be emerged three dimensional. About 1000 manholes included in the area, so it isn't realistic to do numerical calculation for exfiltration from each manhole. Therefore it's important to utilize one dimensional formula to express by far the bigger exfiltration flux due to three dimensional water movement. Thus, the bigger given exfiltration coefficient (1000 mm/hour) is practical and realistic considering the results shown in Herath & Mushiake (1994) [4]. Moreover, our own quantification of three dimensional exfiltration (infiltration) rate by a watering experiment like figure 3 at the place where the natural base soil exposed in Fukumuro area justifies the bigger given exfiltration coefficient. About 2 liters water was spraied to the surface natural base soil by keeping not pondering and then emerging the lateral moving of water. We took a movie and calculated exfiltration (infiltration) rate based on the time needed to spray and the area it permeated. The exfiltration (infiltration) rate was 3600mm/hour. When we think the same strong exfiltration happens at the bottom in a manhole, there is a possibility that even 1000mm/hour is still an underestimate. The indicated rate changes the volume and the percentages of exfiltration shown in Tables 1, 2 and Figs 2 and 3 roughly more than 3 times than calculated based on the given 1000 mm/hour.

Fig. 3 Watering at the exposed natural base soil around a manhole in Fukumuro area

Ⅴ. CONCLUSION AND THE FUTURE WORKS

It was possible to find the exfiltration from the manhole bottom by the various conditions using Infoworks. Verification will be wished for from now on. The monitoring of real exfiltration at the manhole bottom is difficult, so computations by means of building simplified small piping network on Infoworks might be effective. It's necessary to calculate one in case of continuous rainfall.

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REFERENCES

[1] S. Harada and Y. Komuro, Decrease of Non-point Zinc Runoff Using Porous Concrete, Chemosphere, Vol.18, pp.488-491

[2] S. Harada and K. Endo, Application of Urban Hydrological Model for Prediction of Runoff from Agricultural Area, I.J.L.R.S.T., Vol. 2, No. 6, pp. 44-48, 2013

[3] S. Harada and J. Kim, Application of Infiltration Technic for Residential Zone in Agricultural Area, Water, Land and Environ. Eng., Vol. 82, No. 4, pp.301-304, 2014, in Japanese

[4] S. Herath and K. Mushiake, Simulation of Basin Scale Runoff Reduction by Infiltration Systems, Wat. Sci. Tech., Vol. 29, No. 1-2, pp.267-275, 1994