



Application of Percentile Rainfall Event for Analysis of Infiltration Facilities used by Prior Consultation for LID (Low Impact Development)

Kwon, Kyung-Ho* · Song, Hye-Jin**

* Corresponding author, Urban Water Cycle Research Center, Korea Institute of Safe Drinking Water Research (kwonkh@kisd.re.kr)

** Coauthor, Urban Water Cycle Research Center, Korea Institute of Safe Drinking Water Research(shj@kisd.re.kr)

ABSTRACT

Purpose: Retention and infiltration of small and frequently-occurring rainfall by LID facilities account for a large proportion of the annual precipitation volume. Based on 4 standard facilities such as Porous Pavement, Infiltration Trench, Cylindrical Infiltration Well, Rectangular Infiltration Well by Seoul Metropolitan Handbook of the Prior Consultation for LID. The total retention volume of each facility was calculated according to the type and size. The Purpose of this study is to find out the quantitative relationship between Percentile Rainfall Event and Design Volume of Infiltration Facilities. **Method:** For the estimation of Percentile Rainfall Event, Daily Precipitation of Seoul from 2005 to 2014 was sorted ascending and the distribution of percentile was estimated by PERCENTILE spreadsheet function. The managed Rainfall Depth and Percentile of each facility was calculated at the several sizes. In response to the rainwater charge volume of 5.5mm/hr by the Category "Private large site", the 3 types of facilities were planned for example. The calculated Rainfall Depth and Percentile were 54.4mm and 90% by the use of developed Calculation-Module based on the Spreadsheet program. **Result:** With this Module the existing Designed Infiltration volume which was introduced from Japan was simply converted to the Percentile-Rainfall-Event used in USA.

© 2015 KIEAE Journal

KEYWORD

Low Impact Development
Rainwater Infiltration Facilities
Design Infiltration Volume
Percentile Rainfall Event

ACCEPTANCE INFO

Received May 26, 2015
Final revision received October 8, 2015
Accepted October 13, 2015

1. Preface

1.1. Background & Purpose of the Study

The Seoul Metropolitan government established "Seoul Metropolitan Basic Ordinance on Water Circulation Recovery & Low Impact Development" for the purpose of comprehensively and systematically driving the policies for preserving the natural infiltration capacity of rainwater and prohibiting the surface runoff of it(Seoul Metropolitan Government, 2014b).

The city notified the rainwater load and the average saturated permeability coefficient for each kind of land use in order to implement the ordinance(Seoul Metropolitan Government, 2014c) Based on it, the government is running the "Prior Consultation System for LID". The government induces to establish certain scale of rainwater infiltration facilities for new development projects through the "Prior Consultation System for LID" which has been implemented since 2014. The infiltration volume required for each kind of land use is suggested as "each rainwater load" and the sum of the possible infiltration volumes of all individual facilities is indicated as the amount of reduction. The government induces to establish the rainwater infiltration facilities in order for

them to have a value bigger than each load which is defined by each kind of use and area of land. (Seoul Metropolitan Government, 2014a) In this case, the unit indicating the "rainwater load", "amount of reduction" and design capacity of each infiltration facility is mm/hr. The National Emergency Management Agency accepted the method by Tokyo and the Japan Technology Association for Basin Infiltration of Rainwater that applied the method of deducting a certain volume by cutting the base part of the hydrograph indicating the rainwater volumes which are flowed into the infiltration facilities by a certain amount accounting for the infiltration capacity as a planned unit of rainwater runoff reduction facility and it was adopted by the Seoul Metropolitan Government as the capacity calculating unit. (Seoul Special City, 2013a, Joo-seok Park et al., 2006, Tokyo, 2009) It is conceptually described well that the infiltration facilities contribute to reducing the peak flow of a flood by the designed infiltration volume during the whole period of a rainfall event regardless of the scale of a rainfall. Jong-sang Sung et al. (2004) and Young-hae Han et al. (2012), etc., once suggested the effects of the infiltration facilities by measuring and plotting the designed infiltration volumes and Young-ran Kim et al. (2013) utilized the results as the input values for designed capacities of a simulation program related to flood mitigation effects.

On the other hand, Americans indicate the designed capacity of each random rainwater infiltration facility as a rainfall depth(mm) (Schueler and Claytor, 2000) or as the percentile that the relevant rainfall depth occupies the whole rainwater event. (Comstock & Wallis, 2003; US EPA, 2009) This method has the merit that can indicate the functions of an infiltration facility that make large amount of runoff rainwater be infiltrated and evaporated after being temporarily stored at the local site while relating them to the catchment area through the management of a small scale of rainfall after paying attention to the fact that the ratio of a small scale of rainfall event occupying the total annual rainfall is considerable.

In this study, the researchers developed a calculation module converting the design capacity which is indicated as the sizes and designed infiltration unit volumes of rainwater infiltration facilities suggested in the Seoul Metropolitan Handbook of the Prior Consultation for LID into the rainfall depth of a catchment area and the rainfall event percentiles by using the method designed by EPA in the USA. It is intended to relate the merits which can estimate and suggest the ratio of the annual rainfall events controlled by the infiltration facilities more directly than the existing methods to the calculation table for the facility capacity targeted for the Prior Consultation for LID based on the method mentioned above.

1.2. Methods & Scope of the Study

The unit storage volume of each facility is calculated while targeting 25 types of infiltration facilities divided into the following 4 kinds, such as Porous Pavement, Infiltration Trench, Cylindrical Infiltration Well and Rectangular Infiltration Well which are specified in the Seoul Metropolitan Handbook of the Prior Consultation for LID. Based on the daily rainfall data from the recent 10 years in Seoul Region, the distribution chart of the percentile rainfall events is made. Then, the changes in the percentiles of rainfall events which can be controlled according to the size and quantity of each individual facility are investigated. Regarding to random use of a land, the percentiles of rainfall events that the rainwater management facilities satisfying the given

rainwater loads can control are calculated and suggested for example. The method and procedure of this study are shown in Fig. 1.

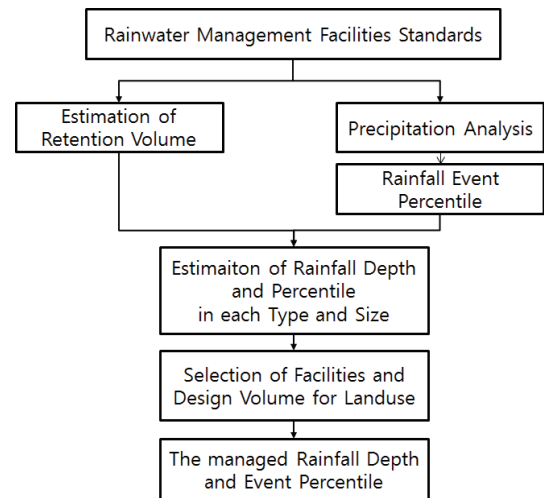


Fig. 1. Flow chart of study

2. Unit Storage Volumes of Rainwater Infiltration Facilities

2.1. Kinds and Sizes of Rainwater Infiltration Facilities

The diagrams and the sizes for each rainwater infiltration facility which is suggested in the Seoul Metropolitan Handbook of the Prior Consultation for LID are shown in Fig.2 and Table 1.

2.2. Calculation of Unit Retention Volume for Each Infiltration Facility

The calculation formula of retention spaces and the resulting values while using the randomly chosen unit areas, lengths and quantities based on the facility sizes (Table 1) and the designed unit infiltration volume (Q : m^3/hr) which are suggested in the Seoul Metropolitan Handbook of the Prior Consultation for LID are as follows. Here, the porosity of crushed stones(n_g) and sands(n_s) were designated as 35% and 25% respectively (Seoul Metropolitan Government, 2013b). The retention volume which is secured by

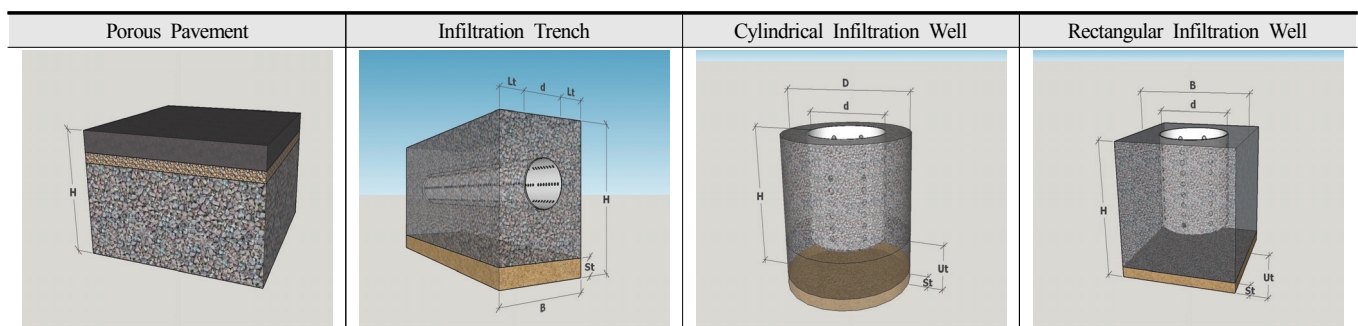


Fig. 2. Illustration of infiltration facilities

Table 1. Sizes of infiltration facilities

Name	Type	Design Head(H:m)	Breadth (B:m)	Diameter (d:m)	Distance of Left-Right (Lt:m)	Upper Distance(Or:m)	Under Distance (Ut:m)	Unit Infiltration Volume (m ³ /hr.m ² .m,EA)
Porous Pavement	T0.4	-	-	-	-	-	-	0.017
	T0.6	-	-	-	-	-	-	0.017
	T1.0	-	-	-	-	-	-	0.017
Infiltration Trench	W150	0.6	0.35	0.15	0.1	0.15	0.3	0.04
	W200	0.7	0.4	0.2	0.1	0.2	0.3	0.045
	W250	0.8	0.55	0.25	0.15	0.2	0.35	0.052
	W300	0.9	0.6	0.3	0.15	0.2	0.4	0.057
	W400	1.1	0.8	0.4	0.2	0.2	0.4	0.069
	W500	1.3	1	0.5	0.25	0.25	0.45	0.08
Cylindrical Infiltration Well	D200A	0.8	-	0.2	0.2	-	0.3	0.078
	D300A	0.9	-	0.3	0.2	-	0.3	0.098
	D450A	1.0	-	0.45	0.2	-	0.3	0.127
	D600A	1.15	-	0.6	0.2	-	0.3	0.163
	D800A	1.3	-	0.8	0.25	-	0.4	0.228
	D1000A	1.45	-	1.0	0.3	-	0.4	0.303
	D1200A	1.6	-	1.2	0.35	-	0.4	0.388
	D1500A	1.85	-	1.5	0.4	-	0.5	0.528
Rectangular Infiltration Well	D200A	0.8	0.6	0.2	0.2	-	0.3	0.087
	D300A	0.9	0.7	0.3	0.2	-	0.3	0.11
	D450A	1.0	0.85	0.45	0.2	-	0.3	0.143
	D600A	1.15	1.0	0.6	0.2	-	0.3	0.173
	D800A	1.3	1.3	0.8	0.25	-	0.4	0.246
	D1000A	1.45	1.6	1.0	0.3	-	0.4	0.33
	D1200A	1.6	1.9	1.2	0.35	-	0.4	0.424
	D1500A	1.85	2.3	1.5	0.4	-	0.5	0.575

the infiltration volume is calculated based on the saturated infiltration coefficient and it means the final infiltration capacity(f_c) under the saturated state of a land through antecedent rainfalls or consecutive ones.

If it rains continuously for 24 hours, that is, one day as the basic time unit of the rainfall event percentile method, the possible virtual retention volume which is secured by infiltration is calculated by multiplying the designed unit infiltration volume (m³/hr) by 24(hr) but considering that some rainfalls are not secured in that way, the infiltration volume for 1 hour at minimum was used.

① Porous Pavement

The calculation formula of the unit retention volumes of porous pavements and the results are shown in Table 2.

Table 2. Unit Retention Volume and calculation formula of Porous Pavements

Type	Porous V. of Gravel [m ³]	Porous V. of Sand [m ³]	V. of Porous Pipe [m ³]	V. of Infiltration [m ³]	Unit Retention Volume [m ³]
T0.4	0.14	-	-	0.017	0.157
T0.6	0.21	-	-	0.017	0.227
T1.0	0.35	-	-	0.017	0.367

Porous V. of Gravel (V_1)	$S \times H \times n_g$
V. of Infiltration(V_4)	$Q \times t$
Unit Retention Volume(V)	$V_1 + V_4$
S: Area(m ²) Q: Design Infiltration Volume(m ³ /hr), t: Min. Duration(hr)	

② Infiltration Trench

The calculation formula of the unit retention volumes of Infiltration Trenches and the results are shown in Table 3.

Table 3. Unit Retention Volume and calculation formula of Infiltration Trench

Type	Porous V. of Gravel [m ³]	Porous V. of Sand [m ³]	Porous V. of Pipe [m ³]	V. of Infiltration [m ³]	Unit Retention Volume [m ³]
W150	0.055	0.009	0.013	0.040	0.117
W200	0.073	0.010	0.025	0.045	0.153
W250	0.118	0.014	0.042	0.052	0.225
W300	0.143	0.015	0.062	0.057	0.277
W400	0.236	0.020	0.113	0.069	0.438
W500	0.351	0.025	0.181	0.080	0.637

Porous V. of Gravel (V_1)	$\left[(H - S_t) \times B - 3.1416 \times \left(\frac{d + d_t}{2} \right)^2 \right] \times n_g$
Porous V. of Sand(V_2)	$B \times S_t \times n_s$
V. of Porous Pipe(V_3)	$3.14156 \times \left(\frac{d}{2} \right)^2$
V. of Infiltration(V_4)	$Q \times t$
Unit Retention Volume(V)	$V_1 + V_2 + V_3 + V_4$

③ Cylindrical Infiltration Well

The calculation formula of the unit retention volumes of cylindrical infiltration wells and the results are shown in Table 4.

Table 4. Unit Retention Volume and calculation formula of cylindrical infiltration well

Type	Porous V. of Gravel [m ³]	Porous V. of Sand [m ³]	Porous V. of Pipe [m ³]	V. of Infiltration [m ³]	Unit Retention Volume [m ³]
D200	0.064	0.007	0.13	0.078	0.162
D300A	0.093	0.010	0.037	0.098	0.237
D450A	0.140	0.014	0.102	0.127	0.383
D600A	0.205	0.020	0.225	0.163	0.612
D800A	0.399	0.033	0.430	0.228	1.090
D1000A	0.661	0.050	0.792	0.303	1.807
D1200A	1.014	0.071	1.312	0.338	2.785
D1500A	1.710	0.104	2.322	0.528	4.664

Porous V. of Gravel (V ₁)	$3.1416 \times \left[\left(\frac{D}{2} \right)^2 - \left(\frac{d+d_t}{2} \right)^2 \right] \times (H - U_t) \times n_g$
Porous V. of Sand (V ₂)	$+ 3.1416 \times \left(\frac{D}{2} \right)^2 \times (U_t - S_t) \times n_s$
V. of Porous Pipe (V ₃)	$3.1416 \times \left(\frac{D}{2} \right)^2 \times S_t \times n_s$
V. of Infiltration (V ₄)	$3.1416 \times \left(\frac{d}{2} \right)^2 \times (H - U_t)$
Unit Retention Volume (V)	$Q \times t$
	$V_1 + V_2 + V_3 + V_4$

④ Rectangular Infiltration Well

The calculation formula of the unit retention volumes of rectangular infiltration wells and the results are shown in Table 5.

Table 5. Unit Retention Volume and calculation formula of infiltration trench

Type	Porous V. of Gravel [m ³]	Porous V. of Sand [m ³]	Porous V. of Pipe [m ³]	V. of Infiltration [m ³]	Unit Retention Volume [m ³]
D200A	0.083	0.009	0.013	0.087	0.191
D300A	0.122	0.012	0.037	0.110	0.282
D450A	0.189	0.018	0.102	0.143	0.451
D600A	0.283	0.025	0.225	0.173	0.706
D800A	0.551	0.042	0.430	0.246	1.270
D1000A	0.921	0.064	0.792	0.330	2.107
D1200A	1.420	0.090	1.312	0.424	3.247
D1500A	2.405	0.132	2.322	0.575	5.435

Porous V. of Gravel (V ₁)	$[B^2 - 3.1416 \times \left(\frac{d+d_t}{2} \right)^2] \times (H - U_t) \times n_g$
Porous V. of Sand (V ₂)	$+ B^2 \times (U_t - S_t) \times n_g$
V. of Porous Pipe (V ₃)	$B^2 \times S_t \times n_s$
V. of Infiltration (V ₄)	$3.1416 \times \left(\frac{d}{2} \right)^2 \times (H - U_t)$
Unit Retention Volume (V)	$Q \times t$
	$V_1 + V_2 + V_3 + V_4$

3. Percentiles of Rainfall Events in Seoul Region

3.1. Distribution of Rainfall Events

The ascending sort of the effective precipitation among daily precipitation for the recent 10 years in Seoul Region (Fig. 3) except

for the effective precipitation less than 2.5mm (US EPA, 2009) is shown in Fig. 4.

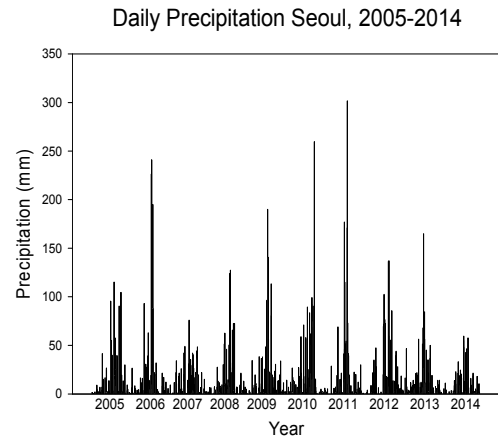


Fig. 3. Daily Precipitation of Seoul (2005-2014)

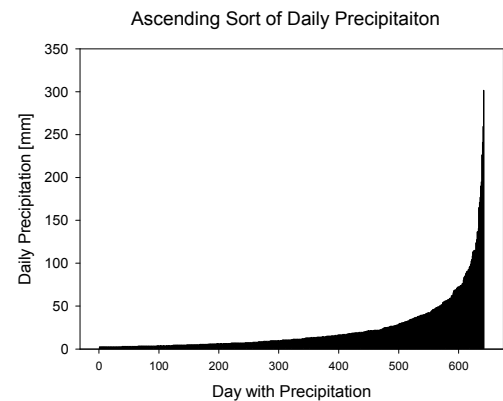


Fig. 4. Ascending sort of daily precipitation

The number of rainy days with the effective precipitation more than 2.5mm during the period was 642 days in total and the date with the biggest precipitation, 301.5mm, was July 27th, 2011.

4. Water Quality Volume depending on Rainfall Depths & Rainfall Event Percentiles

The designed capacity of a infiltration facility can be indicated as “Rainfall Depth x Area of Catchment Surface” under the premise that the runoff volume which is calculated by multiplying the accumulative depth of the rainfall on a certain catchment surface by the area of the catchment surface is flowed into the relevant infiltration facility at a time and such an infiltration facility is evenly distributed on the catchment surface.

Especially, the designed capacity emphasizing the non-point pollution treatment functions of the infiltration facilities is called as Water Quality Volume. (Schueler and Claytor, 2000) Such a capacity indicates the capacity of a rainwater control facility with non-point

pollution treatment functions as a volumetric discharge coefficient representing the rainfall depth, the area of the catchment surface and the proportion of the impervious area. And the rainfall depth corresponds to the targeted precipitation which was set through the Water Quality Measurement and Modeling.

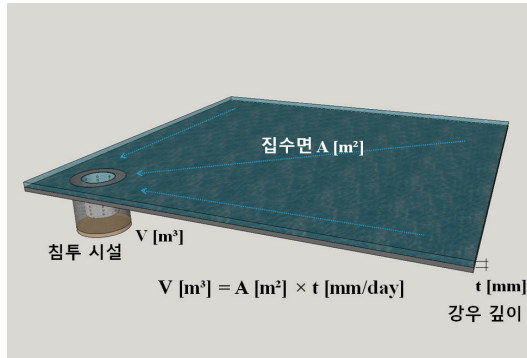


Fig. 5. Catchment area and Rainfall depth

At this time, if the rainfall depth corresponding to the targeted precipitation is indicated as the percentiles of the total rainfall events in the relevant region, the facility criteria considering the rainfall characteristics of the region can be suggested. For example, the regions having the annual precipitation 1,000mm and 1,500mm

respectively have their rainfall patterns and the precipitation distributions different from each other. Thus it can be said that the method can represent such differences of those regions by indicating the percentiles.

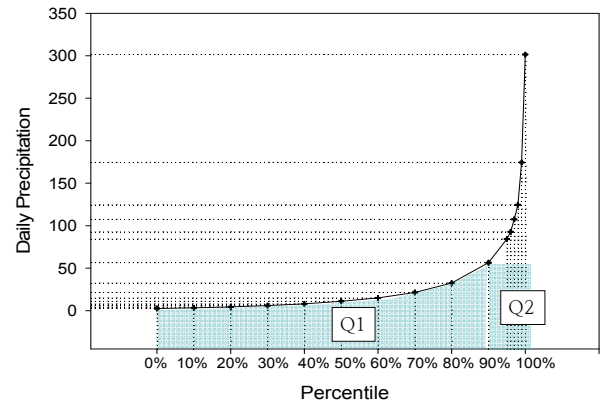


Fig. 6. Daily Precipitation Percentile of Seoul

It can be found that 90% of the total daily precipitation events is 56.4mm while referring to the Percentile Distribution of Daily Rainfall Events in Seoul shown above. If it is assumed that a facility with the targeted precipitation, 56.4mm is established on a randomly chosen area of the catchment surface, it means that 90%

	10m²			25m²			50m²		
	V [m³]	t [mm]	P [%]	V [m³]	t [mm]	P [%]	V [m³]	t [mm]	P [%]
T 0.4	1.57	15.7	62%	3.93	39.3	84%	7.9	78.5	95%
T 0.6	2.27	22.7	74%	5.68	56.8	91%	11.4	113.5	98%
T 1.0	3.67	36.7	83%	9.18	91.8	96%	18.4	183.5	100%

V: Retention Volume, t: Rainfall Depth, P: Percentile

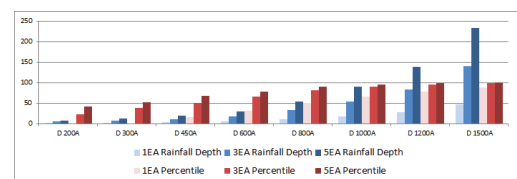
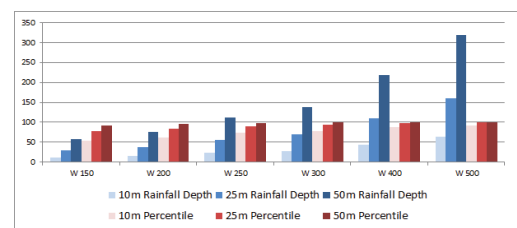
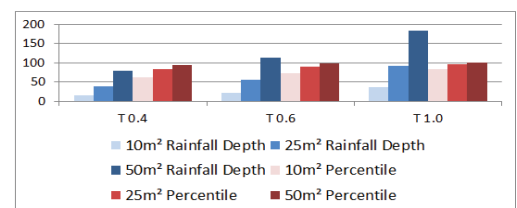
Fig. 7. Percentile of porous pavement

	10m			25m			50m		
	V [m³]	t [mm]	P [%]	V [m³]	t [mm]	P [%]	V [m³]	t [mm]	P [%]
W 150	1.17	11.7	53%	2.93	29.3	78%	5.85	58.5	92%
W 200	1.53	15.3	61%	3.84	38.4	84%	7.67	76.7	95%
W 250	2.25	22.5	74%	5.62	56.2	90%	11.24	112.4	98%
W 300	2.77	27.7	78%	6.92	69.2	93%	13.84	138.4	99%
W 400	4.38	43.8	87%	10.96	109.6	98%	21.92	219.2	100%
W 500	6.37	63.7	92%	15.93	159.3	99%	31.86	318.6	100%

Fig. 8. Percentile of infiltration trench

	1EA			3EA			5EA		
	V [m³]	t [mm]	P [%]	V [m³]	t [mm]	P [%]	V [m³]	t [mm]	P [%]
D 200A	0.16	1.6	0%	0.48	4.8	23%	0.81	8.1	42%
D 300A	0.24	2.4	0%	0.71	7.1	38%	1.19	11.9	53%
D 450A	0.38	3.8	16%	1.15	11.5	51%	1.91	19.1	68%
D 600A	0.61	6.1	31%	1.84	18.4	66%	3.06	30.6	79%
D 800A	1.09	10.9	50%	3.27	32.7	81%	5.45	54.5	90%
D 1000A	1.81	18.1	66%	5.42	54.2	90%	9.03	90.3	96%
D 1200A	2.78	27.8	78%	8.35	83.5	95%	13.92	139.2	99%
D 1500A	4.66	46.6	88%	13.99	139.9	99%	23.32	233.2	100%

Fig. 9. Percentile of cylindrical infiltration well



	1EA			3EA			5EA		
	V [m ³]	t [mm]	P [%]	V [m ³]	t [mm]	P [%]	V [m ³]	t [mm]	P [%]
W 200A	0.19	1.9	0%	0.57	5.7	29%	0.96	9.6	47%
W 300A	0.28	2.8	6%	0.84	8.4	42%	1.41	14.1	58%
W 450A	0.45	4.5	23%	1.35	13.5	57%	2.26	22.6	74%
W 600A	0.71	7.1	38%	2.12	21.2	70%	3.53	35.3	82%
W 800A	1.27	12.7	54%	3.81	38.1	84%	6.35	63.5	92%
W 1000A	2.11	21.1	70%	6.32	63.2	92%	10.5	105.3	97%
W 1200A	3.25	32.5	81%	9.74	97.4	97%	16.2	162.3	99%
W 1500A	5.43	54.3	90%	16.3	163	99%	27.1	271.7	100%

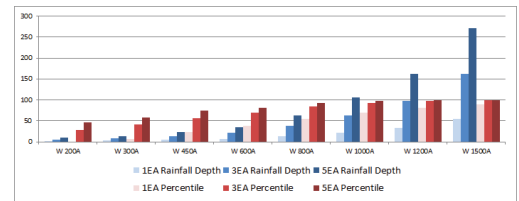


Fig. 10. Percentile of rectangular infiltration well

of the daily rainwater will be flowed and infiltrated into the relevant facility. In addition, the total quantity (Q) of the rainwater which is infiltrated at this time is the sum (1177.9mm/year) of the total daily precipitation(Q1: 828.2mm/year) less than the targeted precipitation and the rainwater volume (Q2: 349.6mm/year) flowing into when the precipitation is more than the targeted one. This corresponds to the 77.9% of the average annual precipitation, 1511.5mm.

However, as the premises for applying for such estimated values, the runoff within the scope of the given daily precipitation must be regular enough in order for all to be flowed into the relevant infiltration facility and the relevant infiltration facility must have the soil conditions in order for it to infiltrate all of the flowed rainwater within 24 hours.

In case of calculating the designed flood level, the precision of the input rainfall data which is increased by using the conversion factor(CF) between the fixed time and the random time. (Ministry of Land, Transport and Maritime Affairs, 2012) However, in case of calculating the water circulation quantity of an infiltration facility, it is important to enter some continuous time-series data. Since the precipitation data during a fixed time, that is, a day is used as the basic data, some temporary retention and infiltration phenomena of the continuous rainfalls could not be represented, so it has a root limitation with which it is indicated that the rainwater quantity more than the real precipitation is infiltrated.

5. Manageable Percentile Rainfall Events of Each Rainwater Infiltration Facility

After assuming that an infiltration facility is established in the area of 100m² for establishing countermeasures, the calculated retention volumes, the rainfall depths and the percentiles of each facilities are shown in Fig. 7, Fig.8, Fig. 9 and Fig.10.

From the table, the kinds of the facilities which are established within the area, 100m² and the rainfall depth of each size and the difference between percentiles can be checked and it can be found that the percentile increases in proportion to the retention volume of each facility.

In case of porous pavements, if 25m² of T0.6 Type is established, it can cover 91% of the total rainfall events. In case of establishing 25m of infiltration trench(W250), all of the daily precipitation, 56.2mm/day can be infiltrated after being retained and it has the effect that around 90% of total rainfall events can be treated. In case of a cylindrical infiltration well and a rectangular infiltration well, if 3 wells (D1000A and W1000A) for each type are established, similar effect takes place.

6. Percentiles on a Large Sized Private Lands

In case of establishing a rainwater infiltration facility satisfying the rainwater load, 5.5mm/hr, designated by Seoul Metropolitan government in a large size of private land, 1,000m², the calculated rainfall depths and the rainfall event percentiles which are managed within this site are shown in Table 6 as examples.

It was assumed that the saturated permeability(ks) of the soil on a randomly chosen site is 16.43mm/hr as the average value of Seoul. However, it is preferable to use a detailed soil map, etc., in case of planning a facility to be established in a real site.

Table 6. Site conditions

Criteria		Condition
Share Volume of Rainwater Burden(A)	Private(large scale)	5.5mm/hr
Site Area(B)		1000m ²
Green area(C)		200m ²
Measurement needed area(E)	$E = B - (C \times 3/5)$ $= 1000 - (200 \times 3/5)$	880m ²
Needed measurement V.(F)	$F = A \times E \times 1000$	4.8m ³ /hr

Total retention/infiltration volume, 47.9m³/hr corresponds to the rainfall depth of 54.5mm on a 880m² area for establishing countermeasures and it corresponds to the rainfall event percentile 89.7% (around 90%). The resulting values mean that the rainfall depth to be managed is 54.5mm and it is possible to retain all of the rainwater in case that 54.5mm of single precipitation pours down at a time. It means that around 90% of all of the daily precipitation in Seoul can be infiltrated after being retained. In addition, under the situation of a continuous rainfall, such as a long rainy season, even

though the retention space is filled up by the antecedent rainfalls, it means that rainwater is continuously infiltrated at a speed of 5.5mm/hr evenly over the catchment section, 1000m², which is covered by all of the facilities. It is the same as plotting a runoff hydrograph after deducting 5.5mm/hr from the effective precipitation which is induced from the precipitation data while modeling a precipitation-runoff model.

Table 7. Type of infiltration facilities and the estimated rainwater management effect

Type	Unit Ret. Volume	EA	Retention Volume
Porous Pavement(T0.61)	0.367	100m ²	36.7m ³ /hr
Infiltration Trench W150	0.117	50m	5.9m ³ /hr
Cylindrical Infiltration Well D300A	0.226	20EA	5.3m ³ /hr
Sum			47.9m ³ /hr
Total Retention V. Rainfall Depth Percentile			47.9m ³ 54.5mm 89.7%

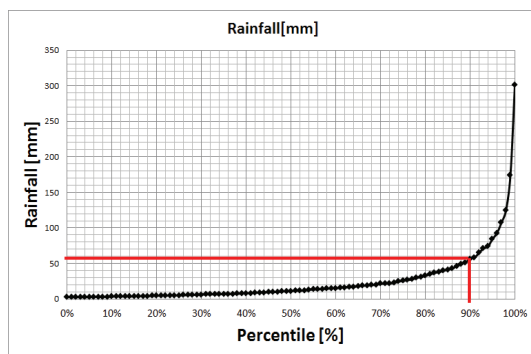


Fig. 11. Percentile of infiltration facilities in the site

It can be expected that there will be some effects such as non-point pollution reduction, water circulation and flood management/disaster prevention, depending on the sizes and structures of the rainwater infiltration facilities which are connected to the catchment sections. The current rainwater load which is set has some limitations when the flood management/disaster prevention effects are expected. Therefore, it is necessary to use the temporary retention function using some openings within the filtration facilities and small & medium sizes of retention facilities, etc., more effectively rather than reducing the damages from the floods in the city by utilizing only the infiltration quantity.

7. Conclusion & Discussion

A calculation module converting the designed capacity of an infiltration facility to the catchment area, the rainfall depth and percentile was developed by using a method deducting some quantity which is suggested in the Seoul Metropolitan Handbook

of Prior Consultation for LID. In case that it is assumed that all types of individual facilities are established within the impervious area of 100m², the designed capacity of the facilities within the area as well as the rainfall depths and the percentiles corresponding to such capacity were calculated and compared. While doing so, it was easy to quantitatively compare the rainwater quantities which can be managed from each type of facility.

In case of using such a percentile method together with the existing method, it can indicate the rainwater quantity managed by the relevant rainwater infiltration facility more effectively and there are some merits that the kinds of the facilities which can be applied when doing a prior consultation for LID can be expanded.

However, since a percentile method uses on one day as the boundary between the rainfall events, even though the rainfall events are the same, there is a demerit that a day can be considered as another day when the day is changed. It is necessary to study additionally on the comparison and the correlation among the measured infiltration/runoff quantities, the simulated resulting values of water circulation during a small time scale like 5 minutes and the values estimated by the percentiles.

Reference

- [1] 국토해양부, 설계홍수량 산정요령, 2012 // Ministry of Land, Transport and Maritime Affairs, Estimation of Design Flood, 2012
- [2] 김영란, 심주영, “주택정비사업에서의 빗물관리 적용 타당성 분석”, 서울도시연구, 14(2), 2013 // (Kim, Young Ran, Sim, Joo Young, “A Feasibility Analysis of Stormwater Management for the Housing Redevelopment and Reconstruction”, Seoul City Research, 14(2), 2013)
- [3] 박주석, 한무영, 송호면(역), 일본우수저류침투기술협회(저자), “일본의 빗물침투시설 기술-조사 및 계획, 2006 // (Park, Ju-Seok, Han, Moo-Young, Song, Ho-Myeon(Translator), Japan Rainwater Storage and Infiltration Technology Association(Author), “Rainwater Infiltration Facility and Technology in Japan-Investigation and Planning”, 2006
- [4] 서울특별시, “서울특별시 빗물관리 기본계획”, 2013a // (Seoul Metropolitan Government, “Rainwater Management General Plan”, 2013
- [5] 서울특별시, “서울특별시 빗물관리 기본계획-가이드라인”, 2013b // (Seoul Metropolitan Government, “Rainwater Management General Plan-Guideline”, Seoul Metropolitan Government, 2013
- [6] 서울특별시, “저영향개발 사전협의제도 안내”, 2014a // (Seoul Metropolitan Government, “Guideline of Prior Consulting for Low Impact Development”, 2014)
- [7] 서울특별시, “서울특별시 물순환 회복 및 저영향개발 기본조례”, Nr. 5617, 2014b // (Seoul Metropolitan Government, “Municipal Ordinance for Restoration of Water cycle and Low Impact Development of Seoul”, Nr. 5617, 2014)
- [8] 서울특별시, “서울특별시 빗물분담량 적용을 위한 평균포화투수계수 고시”, Nr. 3213, 2014c // (Seoul Metropolitan Government, “Official announcement of Rainwater charge volume and saturated hydraulic conductivity”, Nr. 3213, 2014)
- [9] 성종상, 이태구, 한영해, 김연금, 김남희, “분산식 우수관리를 위한 침투통 개발 및 적용효과 분석”, 한국조경학회지, 32(2), 2004 // (Sung, Jong-Sang, Lee, Tae-Goo, Han, Young-Hae, Kim, Yen-Geum, Nam-Hee, Kim, “Development and Application of the Rainwater Infiltrating Equipment for the decentralized Stormwater Managements”, The Korean Institute of Landscape Architecture, 32(2), 2004)
- [10] 한영해, 이태구, “화단형 침투시설의 단위설계침투량 산정 및 효과분석”, 한국조경학회지, 40(5), 2012 // (Han, Young-Hae, Lee, Tae-Goo, “Estimation of Appropriate Infiltration Rate and the Effects of the Flowerbed Type Infiltration system”, The Korean Institute of Landscape Architecture, 40(5), 2012)

- [11] 東京都, “神田川流域豪雨対策計画”, 東京都総合治水対策協議会, 2009
- [12] Comstock, Stewart R., Wallis, Charles, The Maryland Stormwater Management Program. a new Approach to Stormwater Design,
- [13] Schueler, Thomas R, Claytor, Richard A, “Maryland Stormwater Design Manual”, 2000
- [14] US EPA, “Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act”, 2009