Multipurposed Detention Pond Design for Improved Watershed Management

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요 지

도시 지역 개발후 하류지역에 유출량의 증가로 인해, 첨두유량의 완화는 도시 호우 관리에서 가장 중요한 고려 대상중의 하나이다. 일반적으로 설계기준의 호우에 대해서 개발지역의 첨두유량이 개발전의 첨두유량을 넘지 않도록 설계한다. 유수지는 오리피스와 위어를 이용하여 높은첨두율을 개발전의 첨두유량으로 조절하는 역할을 한다. 그러나 비싼 토지비용 때문에 한국에서 도시지역의 유수지 사용은 그렇게 일반적이지 않다. 따라서, 많은 도시 지역이 개발로 인한 유량의 증가를 겪고 있다.
이 연구에서는 새로 개발된 한국의 울산 화봉지역의 11 ha 소유역에서 첨두유량을 조절하기 위하여 어떻게 유수지와 오리피스와 위어를 설계하는지 조사하였다. 이 지역은 새로 개발된 한국의 도시지역을 보여주는 전형적인 지역으로 고려됐으며, 유수지는 2년 빈도, 10년 빈도 그리고 100년 빈도의 설계 강우에 대한 첨두유량을 조절할 수 있도록 설계하였다. 설계 유수지 모의를 위하여 Storm Water Management Model (SWMM)의 윈도우 최신 버전인 5.006a를 사용하였다. 이 연구에서는 얼마만큼의 유수지 면적이 다목적으로 사용될 수 있는지 제시하려 하였다.

핵심용어 : 첨두유량 완화, SWMM 5.006a, 유수지, 다목적 이용

1. Applied Watershed

Ulsan-Hwabong was selected for application of this study. it was developed by the Korea Land Corporation. This region was planned and composed of the separate sewer systems for residential, commercial, and public areas. The total area of this watershed is 1,064,246㎡. Storm sewer system is in the Taehwa River discharge area. The Ulsan-Hwabong region was divided into ten subwatersheds. Only one of the ten was selected for this study. For the selected subwatershed, the drainage area is 10.97ha. The sewer system of this basin is shown in Figure 1. In Figure 1, there are 24 manholes and 23 stages (Jang, S. H. and Park, S. W., 2005). Figure 2 represent that the schematic of modeling this storm sewer system in SWMM 5.

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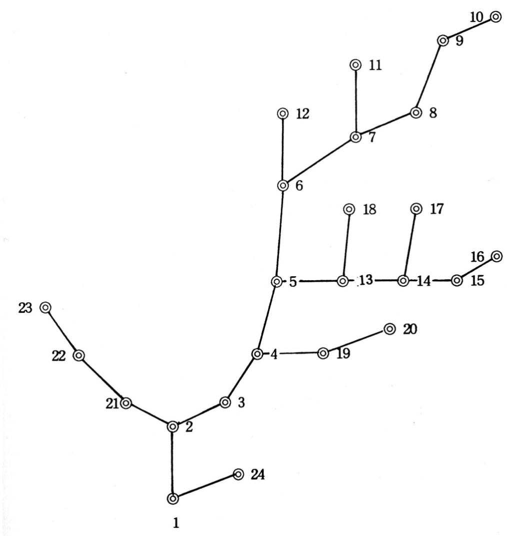


Figure 1. Schematic sewer system of selected Ulsan-Hwabong subwatershed

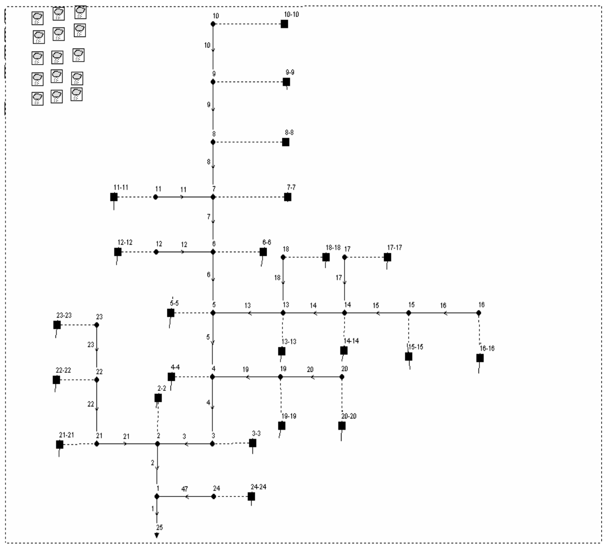


Figure 2. Schematic of modeling Figure 1. storm sewer in SWMM 5

2. Design of Rainfall Distribution and Detention Pond

2.1 Design of Rainfall Distribution

Various standard hyetographs illustrate the temporal distribution of rainfall over the storm duration. For a given design return period, duration, and depth are selected by FARD (Frequency Analysis of Rainfall Data Program). Next, SCS type II rainfall distribution for the design storm are developed. The U.S. Department of Agriculture, Soil Conservation Service (SCS), developed four synthetic 24-hr rainfall distributions (types I, IA, II and III) for different geographic regions of the United States (Akan, A. O. and Houghtalen, R .J., 2003). Total rainfall volume and the distribution of that rainfall per SCS Type II are provided in Figure 3. The distribution is provided at fifteen minutes intervals for a variety of return periods.

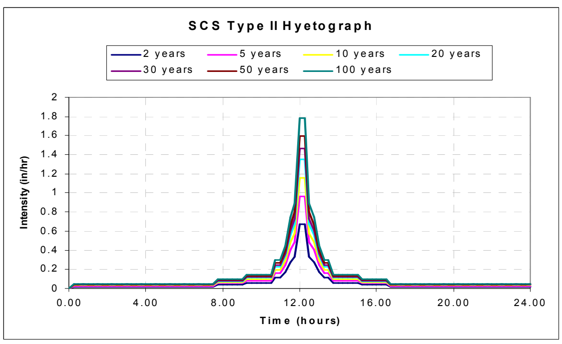
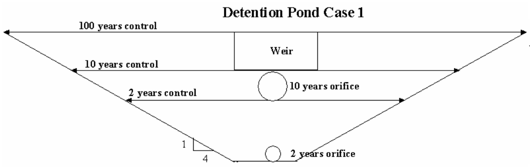


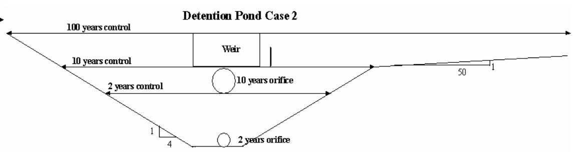
Figure 3. SCS Type II hyetographs of 2 to 100-year return period for Ulsan-Hwabong Watershed

2.2 Design of Detention Pond

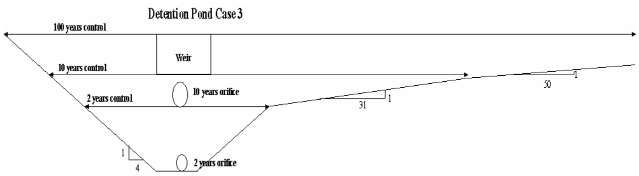
Three different detention pond designs are investigated in this study (Figure 4). The pond located at the outlet of watershed and is designed for multi-level control of 2-year, 10-year and 100-year frequency design storms, the different shapes for Cases 2 & 3 allow different multipurpose land uses for floodplain areas.



(a) Case 1



(b) Case 2



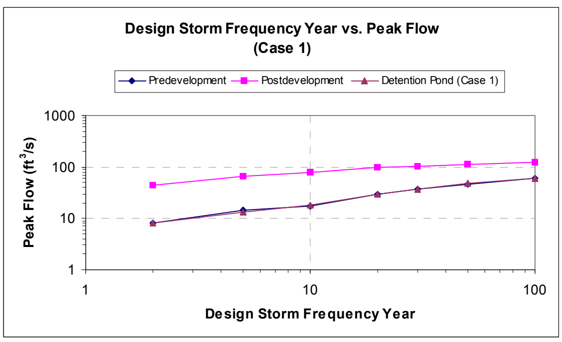
(c) Case 3

Figure 4. Three Cases Design of Detention Ponds

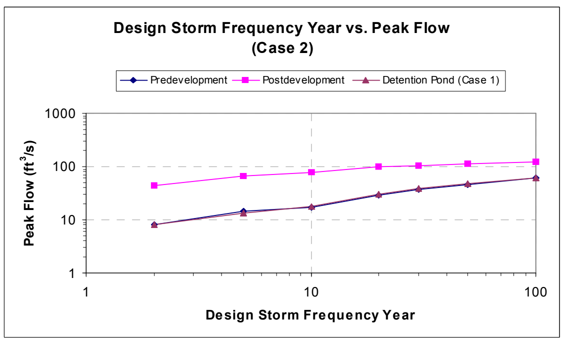
3. Results and Discussion

3.1 Peak-flow attenuation

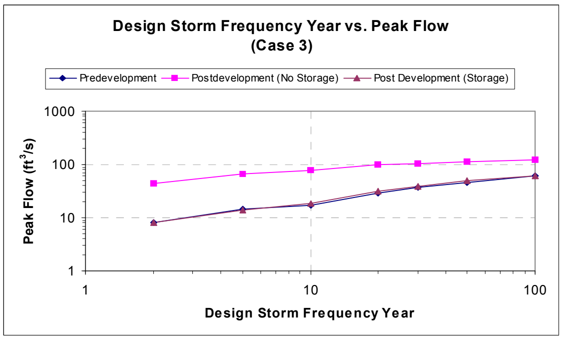
Figure 5 plots peak flow results with control by each detention pond, predevelopment and postdevelopment in three cases. All three cases control peak flow to the predevelopment level in all three cases. These figures show that the detention ponds perform very well. From these figures, It is found out that 5, 20, 30 50 years frequency rainfall are automatically controlled by detention pond designed to control the 100 year storm.



(a) Case 1



(b) Case 2



(c) Case 3

Figures 5. Peak flow for Prequency year for three detention pond cases

3.2 Multipurpose of Detention Pond

Table 1 shows that detention pond volume and surface areas for each case by design storm. It is found that total volume of the three detention ponds are the same despite the different shapes, but the surface areas are different.

Table 2 shows the detention pond construction cost estimate for each case according to design storm. Construction cost was estimated by excavation cost and land cost. Excavation cost was estimated by the Korean Unit Construction Cost (2005), and land cost was estimated by the Korean Standard Public Announcement land prices (2006).

Table 1. Detention pond volumes and surface areas for each detention pond case by design storms.

Design Storms	Pond Size	Case 1	Case 2	Case 3
2 years	Volume (m^3)	4721.5	4721.5	4721.5
	Surface Area (m^2)	5947.0	5947.0	5947.0
10 years	Volume (m^3)	7891.6	7891.6	7665.2
	Surface Area (m^2)	6583.7	6583.7	8354.0
100 years	Volume (m^3)	11636.0	12205.0	12189.0
	Surface Area (m^2)	7373.0	10570.0	14471.0
	Percent Area of Watershed (%)	6.7	9.6	13.2

The Case 1, detention pond cannot be used for multipurpose, because it has steep slopes. However Case 1 has the lowest construction cost. In Case 2, the multipurpose land use can be used above 10-year level because it was designed to two level control. The construction cost increases 28.8% comparing with Case 1. In Case 3 can do the multipurpose land use can be used above the 2-year level since it is designed for three level control. The construction cost increases 61.6% but 9750 m^2 can be used for multipurpose use. In the future research, the optimal detention pond size should be decided based on construction cost versus multipurpose land use.

Table 2. Detention Pond Construction Cost of each cases for Design Storms

Design Storms	Size	Case 1	Case 2	Case 3
Unit Cost (₩)	Excavation (m^3)	11,568	11,568	11,568
	Land Cost (m^2)	30,000	30,000	30,000
2 years	Volume (₩)	54,618,312	54,618,312	54,618,312
	Land Cost (₩)	178,410,000	178,410,000	178,410,000
	Total (₩)	**233,028,312**	**233,028,312**	**233,028,312**
10 years	Volume (₩)	91,290,029	91,290,029	88,671,039
	Land Cost (₩)	197,510,988	197,510,988	250,618,800
	Total (₩)	**288,801,017**	**288,801,017**	**339,289,839**
100 years	Volume (₩)	134,605,248	141,187,440	141,002,352
	Land Cost (₩)	221,190,000	317,100,000	434,130,000
	Total (₩)	**355,795,248**	**458,287,440**	**575,132,352**
	Percent Increase (%)	0	28.8	61.6

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