The Study on the Development of Flood Forecasting and Warning System in On-cheon Stream

Hyun Suk Shin[1], Mi Eun Kim[2], Young Su Jang, and Tae Seok Shon[3]
Department of Civil and Environmental Engineering, Pusan National University, Pusan 609-735, South Korea

Abstract. As prevention of disasters concerning flooding in coastal urban area, this study has developed the real time monitoring system aimed at the On-cheon stream in Busan. The basis of this study was a selection of various geological data based on the numerical map and computation of hydrologic GIS data. Thiessen polygon method was used to analyze rainfall on this site. And regression equation of 6th degree and Huff's Type Ⅱ was used for investigating time-distribution of rainfall. To estimate warning standard rainfall and flood discharge, risk depth was selected on Sebyeong bridge site. Flood depth and threshold runoff considering the effect of tidal water level was estimated for hydraulic analysis using HEC-RAS and urban flash flood rainfall were evaluated using PCSWMM 2002. Consequently, this study estimated warning standard of rainfall and flood discharge using ArcView GIS, HEC-RAS and SWMM on the study area. And real time monitoring system developed is to study various cases on a variety of basins to reduce natural disasters induced by flood in coastal urban area.

1. Introduction

For increasing imperviousness and decreasing roughness coefficient by urbanization and industrialization, peak discharge has increased and concentration time has decreased. As a result, flood damage in urban area was occurred by flash flood. In this study, a method using SWMM model estimated standard rainfall over the flash flood. And then real time monitoring system was installed at Sebyeong bridge site at where is flash flood hazard zone.

2. Methods

2.1. Construction of Topological Data

This study selected the optimal site for protecting citizen through installing real time monitoring system in coastal urban area. For selecting study site, there were several reasons for this. The site is overpopulated area and is easy to maintain. And the site is higher urbaniza-

[1] Civil Engineering Division
Civil and Environmental Engineering Department
Pusan National University, Busan
Tel: (82)51-510-2348
e-mail: hsshin@pusan.ac.kr
[2] Civil and Environmental Engineering Department
Pusan National University, Busan
Tel: (82)51-510-3288
e-mail: way8210@naver.com
[3] Corresponding author: Brain Korea 21 Division
Ubiquitous-Applied Construction of Port Logistics Infrastructures
Pusan National University, Busan
Tel: (82)51-510-3288
e-mail: tsshon1@hanmail.net

tion levels and has completed river maintenance and rainwater management system. For this reason, the site selected On-cheon stream in Busan for monitoring site.

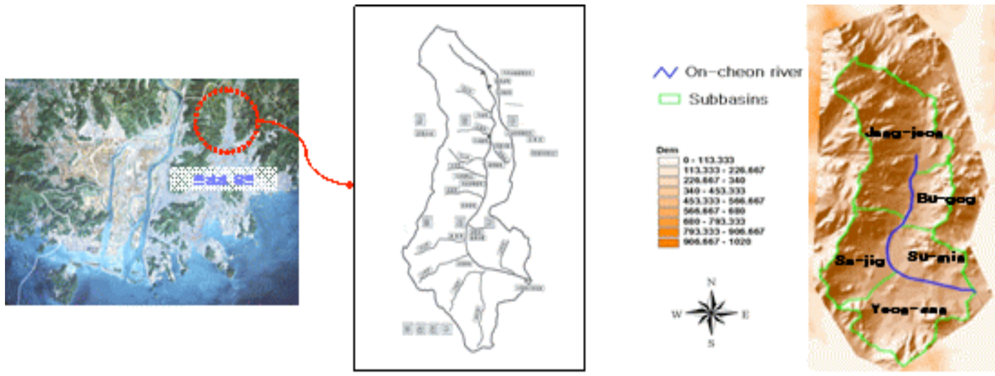


Fig. 1. State of the Watershed of On-cheon Stream and Dividing its Watershed

Fig. 2. A view on Sebyeong bridge site

2.2. Modeling

For calculating flood level and critical discharge, hydraulic model was developed using HEC-RAS model and SWMM model for implementing hydrologic model. This study estimated peak flow with rainfall and basin characteristics and duration time.

2.3. Estimation of standard rainfall

This study estimated the standard of duration time from 10 to 120 minutes for calculating standard rainfall of flash flood in the site. Risk depth defined overflow over flood plain land. The risk depth was shown in table 1.

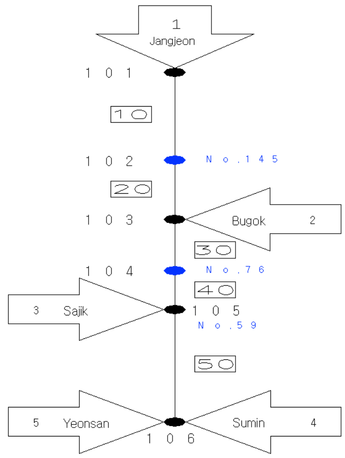
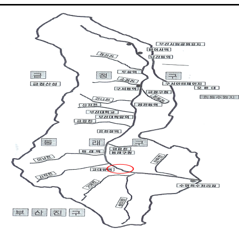
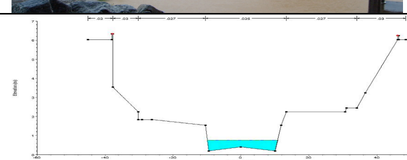
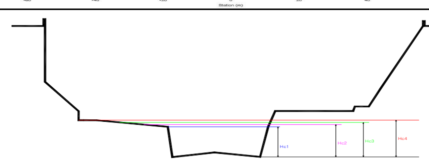


Fig. 3. SWMM Modeling Mimetic Diagram

Table 1. Risk Depth of Sebyeong Bridge site (H_c)

	Sebyeong Bridge
Site Map	
Site Picture	
Channel Section	
Risk Depth	 H_{c1}(the depth of full supply level on main channel) : 1.34 m H_{c2}(the upper 0.1m depth on flood plain land) : 1.44 m H_{c3}(the upper 0.2m depth on flood plain land) : 1.54 m H_{c4}(the upper 0.3m depth on flood plain land) : 1.64 m

Also this study estimated critical discharge as considering the site, discharge, and tide water level condition using HEC-RAS. The rating curve and regression curve were suggested in table 2.

Table 2. Threshold Runoff of Sebyeong Brigde site (Q_c)

Rating Curve		Regression Curve
H_{c1}=1.34m	18.043cms	17.847
H_{c2}=1.44m	20.263cms	21.235
H_{c3}=1.54m	22.894cms	25.006
H_{c4}=1.64m	25.526cms	29.180
Regression Curve ⇒ **(a=0.542512, b=0.362031) R^2=0.996**		

Huff's method was used for decision of time distribution by duration time using the report of Analysis of Temporal Variations for Determining the Local Design Storms from Korea institute of construction technology (1993). Therefore 10, 20, 30, 40, 50, 60, 120 minutes rainfall duration over 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 100 mm distributed in 1 minute increments with Huff method and probability rainfall calculated using continuous hourly rainfall data.

3. Results

3.1. Estimation of warning standard rainfall and flood discharge

In this study, peak flow induced by rainfall and duration time was calculated for hydrological simulation using continuous hourly rainfall data. A correlation between rainfall and discharge was shown as table 3 and correlation curve of duration-effective rainfall-discharge were in fig. 4.

Table 3. Peak flood of Sebyeong bridge by rainfall and duration (unit: ㎥/sec)

time(min) / rainfall(mm)	10	20	30	40	50	60	120
5	27.203	21.461	17.995	16.146	14.759	13.852	10.291
10	79.963	58.271	49.651	44.886	41.574	38.663	26.961
15	145.328	102.404	88.678	80.285	73.538	67.866	45.034
20	220.474	154.993	132.956	119.355	108.747	98.918	63.392
25	302.460	215.446	183.929	163.230	145.857	132.209	82.550
30	390.175	281.220	239.930	210.444	187.448	167.272	101.309
35	481.649	351.685	298.831	261.565	230.644	205.490	121.235
40	577.253	425.609	362.277	314.549	276.336	244.984	141.912
45	675.688	504.839	427.394	369.755	323.911	286.363	163.942
50	779.310	586.343	495.594	426.889	372.168	329.209	186.757
100	1986.603	1547.480	1270.273	1069.331	918.381	803.712	460.485

time(min) / coefficient	y=**a**x**^{b}** (y: rainfall(㎜), x: discharge(㎥/sec))						
	10	20	30	40	50	60	120
a	0.4719	0.5884	0.6492	0.6668	0.6754	0.6776	0.7330
b	0.6990	0.6978	0.7009	0.7131	0.7267	0.7414	0.8032

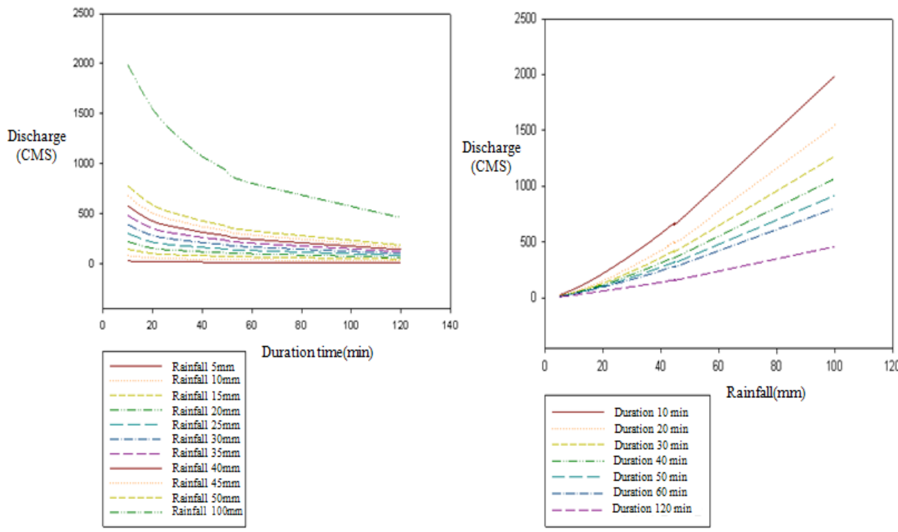


Fig. 4. The correlation curve of duration-effective rainfall-discharge

3.2. Estimation of Risk Depth

This study determined critical discharge about risk depth and peak flow by duration time. For prevention of disasters concerning flash flood using real time monitoring site, warning standard estimated using correlation between rainfall and discharge. Warning standard of 20 minutes duration was seen in table 4.

Table 4. A warning standard to the watershed of On-cheon stream (Duration of 20min)

Site	Risk Level	Rainfall intensity	Standard	Note
Sebyeong Bridge	Flood watch	4 mm/20min	Rainfall at 20 minutes duration time when Risk depth H_{c1}	4.158 ㎜
	Flood warning 1	5 mm/20min	Rainfall at 20 minutes duration time when Risk depth H_{c2}	4.947 ㎜
	Flood warning 2	6 mm/20min	Rainfall at 20 minutes duration time when Risk depth H_{c4}	6.048 ㎜

3.3. Development of Real Time Monitoring System

Real time monitoring system developed to study basin cases to reduce natural flood disasters in coastal urban area. For development of real time monitoring system, radar level transmitter installed in Sebyeong bridge and rainfall observation equipment installed in Pusan national university nearby Sebyeong bridge. And this study developed real time monitoring site that could confirm real time water level, flow velocity and rainfall (http://210.118.169.13/).

4. Conclusion

This study estimated warning standard of rainfall and flood discharge using ArcView GIS, HEC-RAS and SWMM on the area. And real time monitoring system developed to various basin cases to reduce natural flood disasters in coastal urban area. For prevention of disasters concerning flash flood using real time monitoring site, warning standard estimated using correlation between rainfall and discharge. In the future, this study should be used research about flash flood using hydrological and hydraulic base data and observed data and the study on the development of flood forecasting and warning system should be considered and developed to reduce natural flood disasters in coastal urban area.

(a) Radar level transmitter (b) rainfall observation equipment

Fig. 5. Real time monitoring equipment

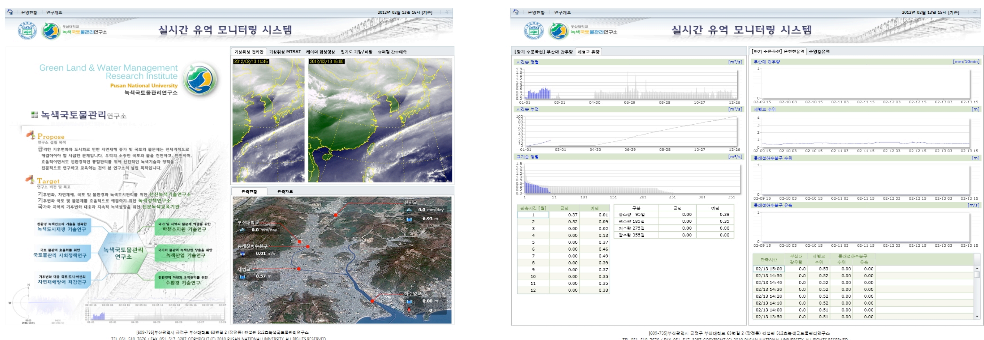


Fig. 6. Real time monitoring web-site (test version)

Acknowledgements. This research was supported by a grant [NEMA-Nature-2011-45] from the Natural Hazard Mitigation Research Group, National Emergency Management Agency of Korea.

References

Cordery, I. and Pilgrim, D.H., 1987: Storm loss and design rainfall excess, Australian rainfall and runoff, A guide to flood estimation, Volume I, Chapter 6, The Institution of Engineers, Australia.

Eric Christopher Tate, M.S.E., Francisco Olivera., PhD and David R. Maidment, 1999: Floodplain Mapping Using HEC-RAS and ArcView GIS, Center for Research in Water Resources.

Estrela, T., and Quintas, L., 1994: Use of a GIS in the modeling of flows on floodplains, Proc. of Second International Conference on River Flood Hydraulics, March 22-25, 1994, York, England, 177-183.

HEC, 2002: HEC-RAS River Analysis System Hydraulic Reference Manual Version 3.1. US Army Corps of Engineers, 3-1-3-25.

Huff, F.A., 1967: Time distribution of rainfall in heavy storms, Water Resources Research, 3(4), 1007-1019.

H.S Shin, S.W. Jeon, B.C Seo, 2000: Flood influence analysis on Suyoung river based on HEC-HMS/HEC-RAS, Korea Water Resources Association, 281-287.

H.S Shin, H.T Kim, M.J Park, 2004: The study of the fitness on calculation of the flood warning trigger rainfall using GIS and GCUH, Korea Water Resources Association, 37(5), 407-424.

H.T Kim, H.S Shin, 2005: Flash flood warning system for mountainous region based on hydrogeomorphological approach, Korea Water Resources Association, 811-815.