WET2016

Water and Environment Technology Conference 2016

27th-28th August 2016

Korakuen campus
Chuo University
Tokyo Japan

PROGRAM AND ABSTRACTS

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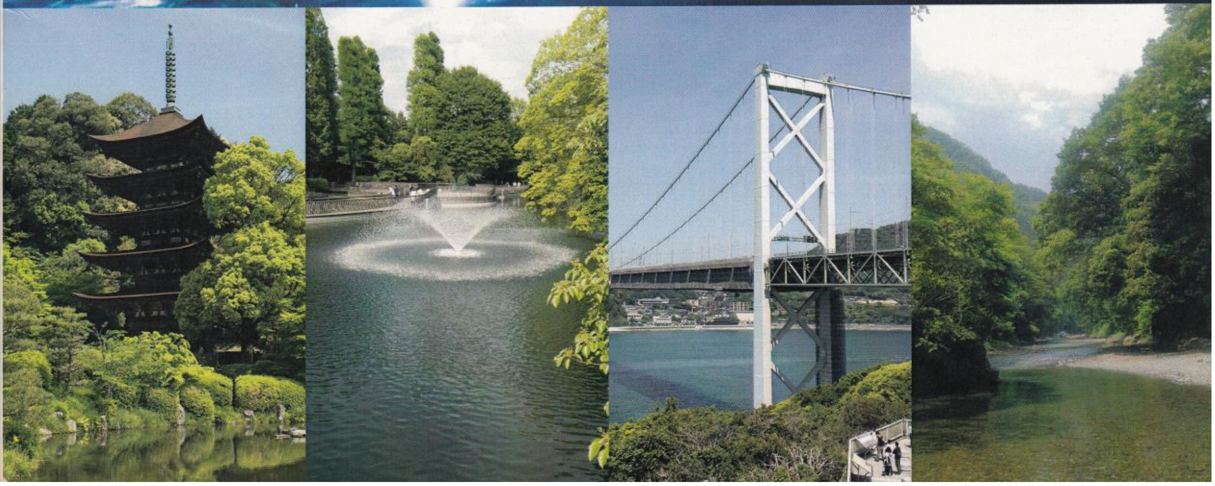

WET2016 Technical Program

Saturday, August 27th *Session 1A* — ***Chair: TERADA Akihiko***

Oral presentation: 14:00-15:20, Poster viewing: 15:20-16:20 Put up poster by 14:00, Saturday, August 27th

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Saturday, August 27th *Session 1B* — ***Chair: WATANABE Tomohide***

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1B-07

Analyses of Surface Runoff Through a Flexible Sloping Plot

Laksni SEDYOWATI*, Eko Indah SUSANTI*, SUHARDJONO**

**Department of Civil Engineering, University of Merdeka Malang, Malang 65146 Indonesia; PhD Student on Department of Civil Engineering, Brawijaya University, Malang 65144 Indonesia.*
***Department of Water Resources Engineering, Brawijaya University, Malang 65144 Indonesia*

Land slope is the main factor that influences the magnitude of runoff discharge. Estimation of runoff discharge in a region with diverse topography will give different results to areas with uniform topography. For practical purposes, it is required a set of runoff discharge data through a varied slope resulting from a rainfall event. The data is expected to provide quickly and accurately an estimation of discharge runoff that resulted from area with diverse topography. This study examines how the relationship between rainfall and runoff at various land slope. Stages of research include the manufacture of a test plot with flexible slope according to the needs of research. The test plot equipped with rainfall simulator to get the same rain events at each change in slope. Analyses of rainfall uniformity is first done to ensure the rainfall simulator has worked well. Furthermore, the discharge data is collected on each particular time interval starting from the first rainfall. This research is conducted on a test plot with a layer of impermeable pavement. The research results are hydrograph of runoff and a rainfall-runoff relationship on various land slope that used as a control in a similar study on permeable pavement layer.

1B-08

Characteristics and Long-term Change of the Groundwater Quality of Sarobetsu Mire

[illegible] YAMAMOTO*, Koichi YAMAMOTO, Rofiq IQBAL***, Harukuni TACHIBANA******

**Faculty of Engineering, Hokkai-Gakuen University, Sapporo 064-0926 Japan*
***Graduate School of Science and Engineering, Yamaguchi University, Ube 755-8611 Japan*
****Department of Environmental Engineering, Bandung Institute of Technology, Bandung 40132 Indonesia*
*****Sapporo Branch, Hokkaisuiko Consultant Corporation, Sapporo 062-0052 Japan*

Sarobetsu mire, which is located in the northern part of Hokkaido, is one of the biggest high moor in Japan and is important as wild habitats. However, because of aridification of the mire, the vegetation has been gradually changing such as invasion of *Sasa palmata* in the original high moor vegetation. The objective of this study is to clarify characteristics and long-term change of the groundwater quality in the *Sasa palmata* area, the high moor vegetation area and the transition area. The field survey was conducted from 2009 to 2015 (16 times) in the conservation area in Kami-Sarobetsu mire, where the eastern part still has the original high moor vegetation and the western part is covered with *Sasa palmata*. The results show that concentrations of dissolved organic carbon (DOC) and ammonium-nitrogen, the indicators of the peat decomposition, are higher in the *Sasa palmata* area than in high moor vegetation area, and have been increasing yearly since 2009. Furthermore, the comparison of the groundwater quality in 1993-2002 and in 2009-2015 shows the clear increase in concentrations of these compounds. This result could be explained by the acceleration of peat decomposition.

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Japan Society on Water Environment (JSWE)
Green-Plaza-Fukagawa-Tokiwa #201
2-9-7 Tokiwa, Koto-ku, Tokyo 135-0006 Japan
Tel. +81-3-3632-5351 Fax. +81-3-3632-5352
http://www.jswe.or.jp
****

August 28, 2016

This is to certify that

Ms. SEDYOWATI, Laksni
University of Merdeka Malang, Indonesia

had participated in the Water and Environment Technology Conference (WET2016) officially organized by Japan Society on Water Environment from 27th to 28th August, 2016, held at Chuo University Korakuen campus (1-13-27, Kasuga, Bunkyo-ku, Tokyo),
and had presented her presentation entitled "Analyses of Surface Runoff Through a Flexible Sloping Plot".

佐野大輔
SANO Daisuke,
Secretary of WET2016,
Japan Society on Water Environment
Associate Professor,
Hokkaido University

Analyses of Surface Runoff Through a Flexible Sloping Plot

Laksni Sedyowati [a], Eko Indah Susanti [a], Suhardjono [b]

[a] Department of Civil Engineering, University of Merdeka Malang, Malang, Indonesia

[b] Department of Water Resources Engineering, Brawijaya University, Malang, Indonesia

ABSTRACT

Land slope is the main factor that influences the magnitude of runoff discharge. Estimation of runoff discharge in a region with diverse topography will give different results to areas with uniform topography. For practical purposes, it is required a set of runoff discharge data through a varied slope resulting from a rainfall event. The data is expected to provide quickly and accurately an estimation of runoff discharge at the area with diverse topography. This study examined how the relationship between slope, runoff travel time and runoff discharge at various rainfall intensity. Stages of research included the manufacture of a test plot with flexible slope according to the needs of research. Experiment was conducted on a test plot with an impermeable layer. The test plot was equipped with rainfall simulator to get the same rain events at each change in slope. The discharge data was collected on each particular time interval starting from the first rainfall to produce runoff hydrograph. The research results are runoff travel time and runoff hydrograph on various land slope that used as a control in a similar study on permeable pavement layer.

Key Words: urban drainage, surface runoff, runoff hydrograph, sloping plot.

Corresponding author: Laksni Sedyowati, E-mail: laksnisedyowati@gmail.com

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INTRODUCTION

The development of cities is a consequence of population growth. Buildings for housing, shops, offices; road infrastructure and other facilities is developed to meet the needs of the urban population. Buildings and roads causing soil permeability decreases. This causes the depth of annual runoff and peak discharge increases by 146% and 159% respectively in 30 years in Houston, Texas. However, urbanization contributes only 77% and 32%. The rest is caused by changes in rainfall characteristics [1]. Urban development also increases flood risk in cities due to local changes in hydrological and hydro meteorological conditions. The relationship between the increasing urban runoff and flooding due to increased imperviousness is better perceived than that between the cyclic impact of urban growth and the urban rainfall via microclimatic changes [2].

Cities with a diverse topography have more complex problems. Estimates of urban runoff discharge should be made taking into account the area of impervious surface and the land slope. Runoff generation from slopes have been studied for decades, but the relationships among travel time, runoff discharge, runoff hydrograph, are still not well understood. Increasing slope gradient, the values of cumulative runoff peaked [3]. Downslope routing of water may be possible if runoff rate, runoff velocity can be reliably estimated at a particular slope length [4].

On the planning process of the urban drainage systems development, it is important to accurately determine the runoff discharge estimation. Inaccuracies on the calculation of runoff discharge into the drainage system lead the design become overestimate or underestimate. Overestimate design would impact on inefficiency, while underestimate design would have an impact on the risk or loss due to flooding and inundation. Runoff discharge can be determined by using a model or graph of rainfall-runoff relationship. The accurate rainfall-runoff relationship model can be obtained through direct field observation. The use of test plot for field observation about the relationship of slope and discharge runoff facilitate the data collection accurately. The test plots used should be able to easily accommodate the change of the slope.

This study develops design of a test plot with slope that can be changed easily. The test plot is a simulation of a real surface condition on the field that can accommodate varying slope. Characteristics of runoff generated can provide a clear overview of the effect of different slopes. Runoff characteristics consist of runnof discharge, relationship of rainfall-runoff, runoff hydrograph, time and peak discharge. Test plots are generally used to examine the surface runoff in a basin [5], in the mountains [6]; infiltration and sediment yield [7], soil loss on varying slopes [3], [8]. Some test plots in the study are equipped with rainfall simulator. Rainfall simulator is designed to reproduce the characteristics of natural rainfall [9]. Rainfall simulator is made according to the object of research and the size of the test plot.

The specific objectives of this study are: (1) to develop a flexible sloping plot equipped with rainfall simulator to examine the effects of slope to the runoff characteristics, and (2) to know the differences of travel time, runoff discharge, runoff hydrograph, time and peak discharge generated from an impermeable surface with variation of slope (2%, 5% and 10%).

MATERIALS AND METHODS

Preparation of the flexible sloping plot

To accommodate the change in slope, test plot is placed above a platform that laid on a 179 m^2 bare land. The platform has a height of 1.5 m above the ground to get variation of slope up to 25%. The platform size equals to the size of the test plot that is 2 m x 6 m. Vertical sides of the platform are made of profile steel C, while the base is made of steel plate with 10 mm thick (shown in Fig. 1). Platform foot are made of steel frame with thick of 8 mm (shown in Fig. 2). The transverse shaft of platform is made of solid iron cylinder, as a major prop of test plot (shown in Fig. 2). Platform is also equipped with four prop on each corner of the test plot. Platform prop is made flexible so it can adjust to changes of slope (shown in Fig. 2). At a distance of 1 m from the lower end of the bridge, placed a locking device to lock each slope change (shown in Fig. 2). To avoid the influence of natural rain, at the above of test plot is given a roof so that rainwater does not flow into the test plot area (shown in Fig. 1). Fig. 1 showing the test plot, the platform and the rainfall simulator, Fig. 2 showing the platform foot, the transverse shaft, the platform prop and the locking device.

Fig. 1 Flexible sloping plot and rainfall simulator

Fig. 2 Components of the platform

Preparation of rainfall simulator

Rainfall simulator designed to provide rainfall uniformly at the entire of test plot with a 2 m wide and 6 m long. Rainfall simulator consists of three sprinkle (shown in Fig. 3). Each sprinkle give rain to the area of 2m x 2m. Water supply comes from a pipe connected to a pump and a water tank (shown in Fig. 8). The pump has pressure 1.8 Kgf/cm^2 and flow discharge 10-18 liter/minute to produce rainfall intensity up to 120 mm/hour. Water tank has a capacity of 800 liters to provide a continuous water supply. Frame for pipelines and sprinkle are made flexible so it can adjust to changes in the slope of test plot. The frame can also be moved depend on the space need for rainfall observation (Fig. 3).

Fig. 3 Components of rainfall simulator

Operating procedure of the flexible sloping plot

The operation of the flexible sloping plot is like a seesaw board. To get steeper slope is obtained by lowering the lower edge. A pulley is mounted above the lower edge of the test plots as a counterweight when the slope is changed (shown in Fig. 7). The operating procedures are described as follows:

1) Unlock the locking device
2) Uplift the lower edge using the pulley to free the platform prop so that the length of prop can be adjusted.
3) Set the slope according to data needed.
4) Lock the platform prop and the locking device by tightening the screw so that the slope is kept stable.
5) The test plot with a certain slope is ready for use.

The procedure should be strictly followed to avoid damage to both the platform and test plots. Fault in operation can cause the prop of the pulley and the platform broken.

Experimental Design

To know the influence of slope to the characteristics of surface runoff on an impermeable layer, this study is designed with some conditions as follows:

1) The study was conducted with three kinds of slope, that is 2%, 5% and 10%. The number of

repetitions on each variation of the slope is equal to the number of variations in the rainfall intensity.
2) Variations in the intensity of rainfall was 35 mm/hr, 55 mm/hr, 75 mm/hr.
3) Each condition generated the data of travel time, runoff discharge, runoff hydrograph, time and peak discharge.
4) Rainfall duration was 6 minutes according to the preliminary study of latest peak time.

Data collection

Procedures of collecting the data are as follows:

1. Measurement of rainfall intensity
   1) Connect the inflow pipe at step 1.1 above to the installation of the rainfall simulator, without changing or closing the tap opening.
   2) Place 5 units of rain gauge on test plots with the formation as the plan in Figure 6.
   3) Record the water level in the rain gauge at every interval of 5 minutes since the first rainfall is out from the sprinkle.
   4) Stop the flow after a time interval of at least 5 times (the total minimum of time was 25 minutes).
   5) Record the time each increase of 1 strip on the rain gauge. (E.g. 1 strip = 5 cm, then the volume = 5 cm x area of rain gauge surface).
   6) The rainfall intensity (I) is the water level in the rain gauge divided by the time to reach that level.

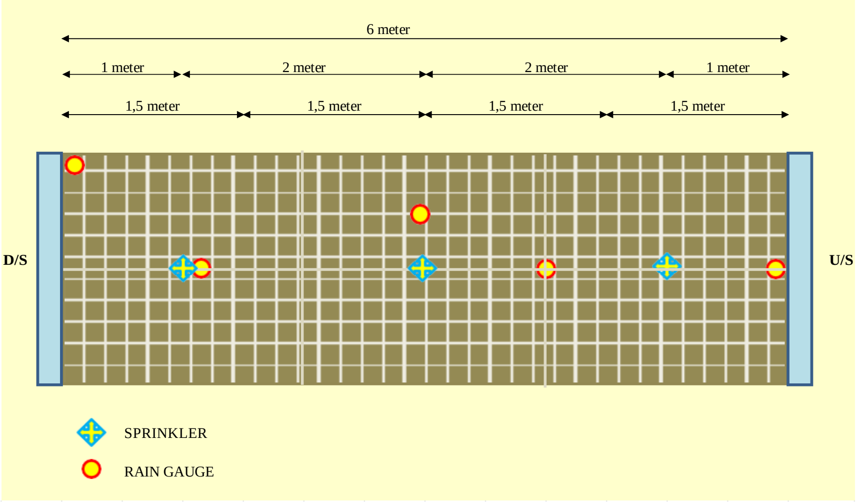


Fig. 4 Position of sprinkles and rain gauges on the test plot.

2. Measurement of travel time

   Travel time is the time that begins when rain falls at the upstream point reaches the downstream end of the test plot. the upstream point is marked with glitter. Time between the first raindrop until the first glitter reaches downstream point or control point is the travel time.

3. Measurement of runoff discharge, runoff hydrograph and water level at the v-notch
   1) Fill the water in the gutter downstream up to the v-notch base

    2) Record the time each increase of 1 strip on the water storage. (E.g. 1 strip = 5 cm, then the volume = 5 cm x length x width of the water storage). Runoff discharge (Q) = volume / time
    3) Record the volume of water in water storage every 2 minutes. Runoff hydrograph is runoff discharge for each interval of 2 minutes
    4) Record the water level above the v-notch spillway after the water level is stable (no change in water level).

4. Repeat steps 1, 2, 3 for the other tap opening, until a total of 5 different variations of tap openings.
5. Calibration of the rainfall simulator with the rainfall intensity is the relationship between the pressure (P) and the rainfall intensity (I). The obtained relationship is I = f (P)
6. Calibration of the rainfall simulator with the runoff discharge (Q) is the relationship between the pressure and the outflow discharge flowing at the gutter downstream of the test plot. The discharge is measured by a v-notch spillway at the end of the gutter. The obtained relationship is Q = f (P).
7. Rainfall – runoff model is the relationship between the rainfall intensity and the outflow discharge, expressed by Q = f(I).

Experimental data and the calculation result are shown in Table 1.

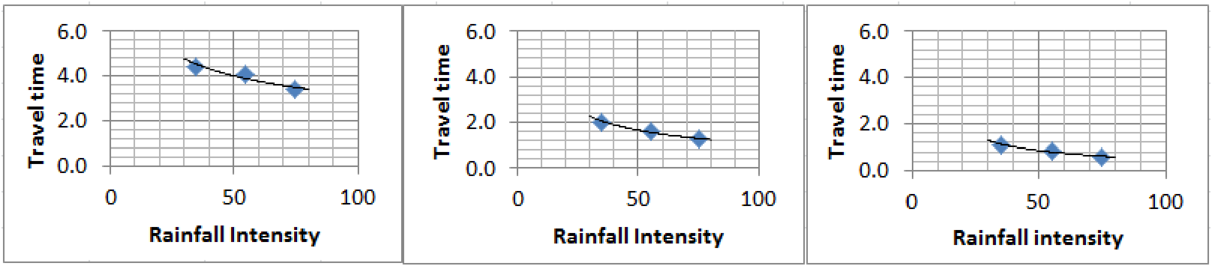
Table 1 Data of runoff hydrograph and runoff peak for rainfall duration 6 minutes.

Slope (%)	Rainfall intensity (mm/hr)	Travel time (minute)	Discharge hydrograph (l/s) at the time (minutes) of						Peak (graphical data)	
			2	4	6	8	10	12	Discharge (l/s)	Time (minute)
2	35	4.43	0.007	0.026	0.078	0.072	0.027	0.011	0.080	6.7
	55	4.11	0.008	0.055	0.101	0.067	0.033	0.013	0.100	6
	75	3.38	0.010	0.083	0.133	0.094	0.033	0.014	0.130	6
5	35	2.01	0.009	0.075	0.092	0.064	0.018	0.007	0.090	5.5
	55	1.63	0.014	0.105	0.119	0.069	0.018	0.013	0.120	5.5
	75	1.25	0.029	0.160	0.163	0.093	0.022	0.012	0.170	5
10	35	1.11	0.010	0.120	0.109	0.064	0.007	0.004	0.125	4.5
	55	0.83	0.010	0.143	0.137	0.059	0.009	0.004	0.152	4.5
	75	0.60	0.058	0.218	0.182	0.083	0.009	0.005	0.225	4.5

RESULTS AND DISCUSSION

Travel time

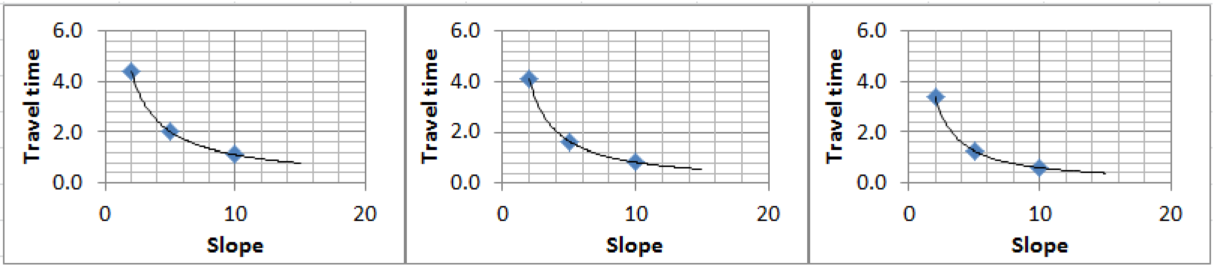
Table 1 shows that travel time is not significantly influenced by the rainfall intensity. However, change of slope give significant effect to the travel time.



(a) (b) (c)

Fig. 5 Travel time - rainfall intensity relationship at slope 2% (a), 5% (b), 10% (c)

The relationship between travel time and rainfall intensity is shown in Fig. 5. The relationship curves tend to be flat. It is meant that the change in rainfall intensity not significantly impacted on travel time. Slope of 2% has change in travel time greater than others (Fig. 5a). There is just a little difference between the curve of 5% and 10%. It is probably caused by the flow through a mild slope has a lower kinetic energy so that the change of slope has significant impact on the change of travel time.



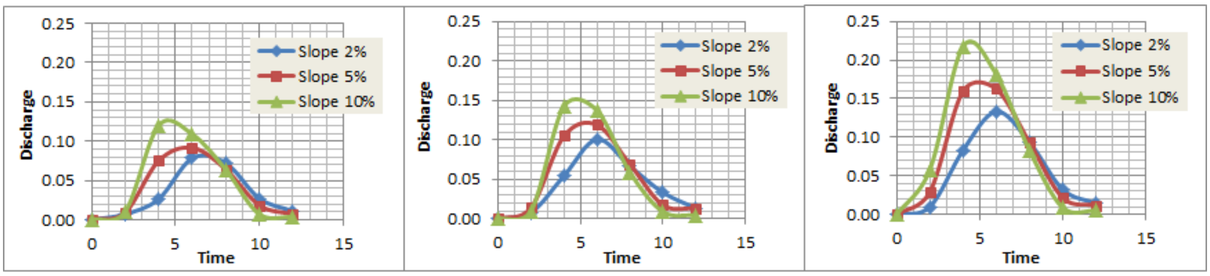
(a) (b) (c)

Fig. 6 Travel time - slope relationship at rainfall intensity 35 mm.hr (a), 55 mm/hr (b), 75 mm/hr (c)

On the other hand, the change in slope has a significant influence on the change in travel time (Fig. 6). Comparison of the three graphs above shows that the rainfall intensity differences do not lead to the significant shift of the travel time curve. Rainfall intensity of 35 mm/hour has change in travel time greater than others. The smallest change is on the 75 mm/hou rainfall intensity (Fig. 6b). It is probably caused by the low rainfall intensity has lower energy kinetic so that a little change in rainfall intensity has significant impact on the change of travel time.

Runoff hydrograph, time and peak discharge

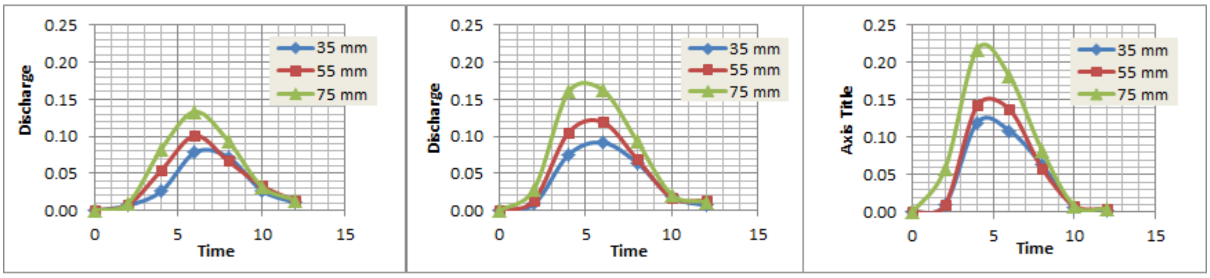
The effects of various slope and rainfall intensity on runoff hydrograph, time and peak discharge are described in Fig. 7 and Fig. 8 below.



(a) (b) (c)

Fig. 7 Change of Runoff hydrograph based on variation of slope, at rainfall intensity of 35 mm/hr (a), 55 mm/hr (b), 75 mm/hr (c)

Change in slope and rainfall intensity contribute to the change in time and peak discharge (Fig. 7). The greater the slope and the rainfall intensity, the peak time is getting short and the peak discharge is getting bigger. However, at the same slope, change in rainfall intensity do not significantly affect the change in peak time (Fig 7a, b, c).



(a) (b) (c)

Fig. 8 Change of runoff hydrograph based on variation of rainfall intensity, at the slope of 2% (a), 5% (b), 10% (c)

Fig. 8 further describes that peak time is not affected by rainfall intensity. At the same slope and different rainfall intensity, although the peak discharges are different, the peak time are almost the same. Change in rainfall intensity did not significantly affect the change in peak time . The greater the rainfall intensity, the peak time is relatively constant. On the other hand, change in slope has a significant impact on change in discharge and the peak time. The greater the slope, the greater the discharge and the shorter the peak time. Fig. 8 shows that the peak time at the slope of 2% (a), 5% (b) and 10% (c) are significantly different.

CONCLUSIONS

This study compares the differences of travel time and runoff discharge flowing through a 6m x 2m flexible sloping plot with slope of 2%, 5% and 10%. The flexible sloping plot showed good performance as a tool to examine the runoff characteristic in varying slope. The greater the slope causes the peak time and the travel time getting short, runoff discharge and peak discharge getting large. At the lower rainfall intensity (35 mm/hr), the difference of the change in travel time was more significant than others. While the change in the larger rainfall intensity (55 mm/hr and 75 mm/hr) did not give effect to the changes in the travel time. Slope is the main factor that influences the magnitude of travel time and runoff discharge, while the rainfall intensity does not affect the peak time and the travel time, and only affect the runoff discharge and the peak discharge.

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