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DETERMINATION OF FLOW VELOCITY FOR GRASS SWALE IN UTHM

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Abstract

Grass swales are widely employed to encourage ground infiltration and reduce storm runoff in urban areas. Precipitation that infiltrated into surrounding soils is collected and conveyed by swales into nearby water bodies to prevent localized flooding. Swales are one of the means to reduce peak flows, reduce the water table, and minimize the causes of flood. However, a well functioned swale requires a systematic planning of construction. The aim of this study is to determine the flow velocity for grass swale in Universiti Tun Hussein Onn Malaysia (UTHM) based upon the observed swale profile. Next, determine its effectiveness on reducing flow discharge of the swale. Data collection was conducted on wet grassed swale with the total length of swale is 100 meters. The swale is divided into three sections, where every section has three points. The measurements of flow velocity have been taken three times at each point after a rainfall event by using the current meter flow. As a preliminary study, levelling work has been done on the swale beforehand to obtain the swale profile. The results showed various values of flow velocity according to the profile of swales and its flow depth, also showed the difference in flow discharge of the grass swale. A well functioned swale must have a suitable swale profile so that the swale could slow down the flow velocity and reduce the flow discharge of the swale.

Keywords : *grass swale; swale profile; flow velocity; flow discharge*

Introduction

Grass swale is a vegetated, open channel management practices designed specifically to treat and attenuate stormwater runoff for a specified water quality and quantity volume [1]. Establishment of grass swale is a potential solution wherever stormwater needs to be transported from impervious surfaces, slowed down, and allowed to infiltrate into soils. When properly designed to accommodate a predetermined storm event volume, a grass swale results in a significant improvement over the traditional drainage ditch in both slowing and cleaning of water [2]. In general, the swales work as decreasing the velocity of flow, acting as storm runoff detention facilities, and pollutant removal.

Grass swale is widely applied in the campus of Universiti Tun Hussein Onn Malaysia (UTHM). Swales are environmentally-friendly drainage system, which is derived from the Manual Saliran Mesra Alam Malaysia (MSMA). MSMA is required in order to provide a systematic construction so that the swales can be function properly to reduce the risk of flooding. This study was conducted at the UTHM campus and focus on the flow velocity for wet grassed swale. The hydraulic parameters involved in this study are cross-sectional area of swale, flow velocity, flow depth, and flow discharge. The objectives for this study are to determine the flow velocity for grass swale in UTHM based upon the swale profile and to determine its effectiveness on reducing flow discharge of the swale. Figure 1 shows the wet grassed swale in UTHM.

Figure 1: Wet grassed swale

Materials and Methods

Data collection was conducted at wet grassed swale in Universiti Tun Hussein Onn Malaysia (UTHM) campus, which collected after the rainfall event. The equipment used to collect the data is shown in Figure 2, and the uses of equipment are as follows :

(i) Current meter flow – measures the energy of moving water in the swale and translates it into a flow velocity [3].
(ii) Levelling instrument – measures the cross section of swale in order to develop the swale profile.
(iii) Measuring tape – measures the width and depth of surface drainage [4].

(i) (ii) (iii)

Figure 2: The equipment used to collect the data at swale

The length of swale is 100 meters and divided into three sections, which are Section A, Section B, and Section C. The distance from Section A to Section B is 50 meters and distance from Section B to Section C is also 50 meters. Figure 3, Figure 4, and Figure 5 show the cross sections of swale at Section A, Section B, and Section C. The data obtained from the swale are :

i) Flow depth of the swale, Y
ii) Flow velocity in the swale, V
iii) Top width of the swale, T

This data are important to determine the effectiveness of the swale in terms of its hydraulic parameters, which are :

i) Cross-sectional area of the swale, A
ii) Flow discharge of the swale, Q

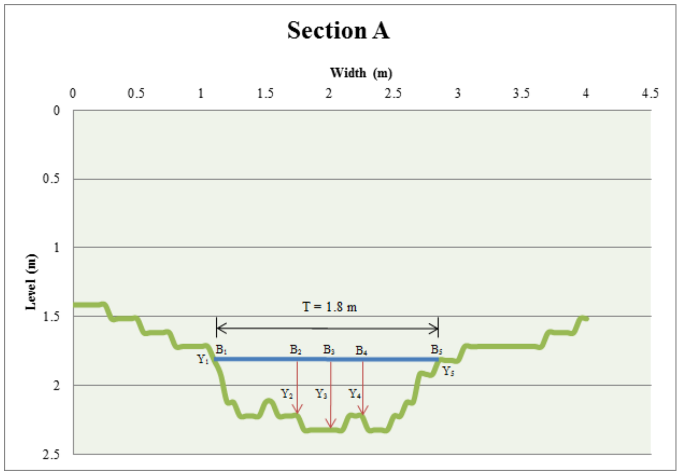

Figure 3: Cross section of swale at Section A

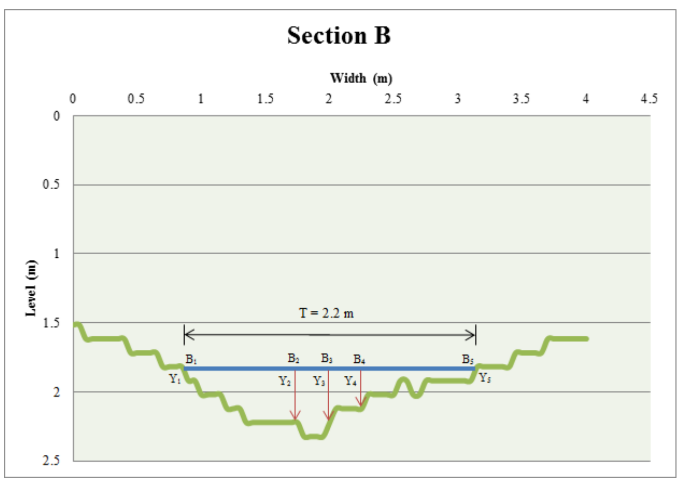

Figure 4: Cross section of swale at Section B

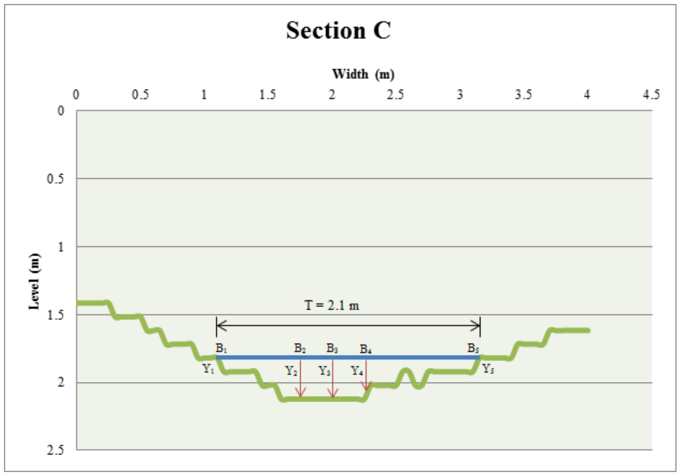

Figure 5: Cross section of swale at Section C

Results and Discussions

Table 1: Flow depth and top width of the swale at three sections for three days

Section	Date	Flow depth, Y (m)			Top width, T (m)
		Left	Center	Right	
A	31 March 2015	0.360	0.390	0.385	1.8
	02 April 2015	0.290	0.270	0.235	
	03 April 2015	0.175	0.240	0.230	
B	31 March 2015	0.375	0.380	0.320	2.2
	02 April 2015	0.210	0.215	0.195	
	03 April 2015	0.190	0.250	0.180	
C	31 March 2015	0.210	0.225	0.205	2.1
	02 April 2015	0.075	0.095	0.080	
	03 April 2015	0.070	0.085	0.065	

Table 1 show the flow depth and top width of the swale at three sections for three days. Each section is divided into three points, which labeled as Left, Center, and Right, so that the flow depth can be measured accurately along the cross sections of swale. Based on the table, the flow depth at three sections of swale on 31st March 2015 has the highest value compared to the other two days. This might be caused by the intensity of rainfall during the day, which affected the flow velocity of swale. Next, the cross-sectional area of swale is determined based on the flow depth and the top width of swale by using the suitable hydraulic equation. The average value of flow velocity in each section is calculated to determine the flow discharge of swale.

Table 2: Cross-sectional area, flow velocity, and flow discharge at three sections of swale for three days

Section	Date	Area, A (m^2)	Velocity, V (m/s)	Flow discharge, Q (m^3/s)
A	31 March 2015	0.452	0.0270	0.012
	02 April 2015	0.317	0.0013	$4.121x10^{-4}$
	03 April 2015	0.254	0.0037	$9.398x10^{-4}$
B	31 March 2015	0.496	0.0340	0.017
	02 April 2015	0.287	0.0050	$14.35x10^{-4}$
	03 April 2015	0.279	0.0033	$9.207x10^{-4}$
C	31 March 2015	0.285	0.0800	0.023
	02 April 2015	0.110	0.0017	$1.87x10^{-4}$
	03 April 2015	0.012	0.0030	$0.36x10^{-4}$

Table 2 shows the cross-sectional area, the average value of flow velocity, and the flow discharge at three sections of the swale for three days. Since the data on 31st March 2015 has the highest value among the other days, the analysis was focused on that date for each section of the swale. Based on the table, Section B has the largest cross-sectional area of swale which is 0.496 m^2, and Section C has the smallest cross-sectional area which is 0.285 m^2. However, Section C has shown that it has the highest value of flow discharge, which is 0.023 m^3/s that occurred at 0.080 m/s of flow velocity. Meanwhile, Section A has shown that it has the lowest flow discharge, which is 0.012 m^3/s that occurred at 0.027 m/s of flow velocity.

From this analysis, Section C shown that the smallest cross-sectional area has the highest value of flow velocity thus increased the flow discharge. Nevertheless, it doesn't mean the largest cross-sectional area will decreased the flow velocity and flow discharge of the swale. As can be seen on the table, the cross-sectional area for Section B is larger than Section A. Even so, Section A has the lowest value of flow velocity thus decreased the flow discharge of swale. These results may be due to several factors in terms of the swale profile, the hydraulic parameters, the length from section to section of the swale, and the type of vegetation that grew in that section of the swale.

Conclusions

In conclusion, the flow velocity in a swale is affected by the cross section of the swale. Based on the study, it shows that if the swale is appropriately designed with the suitable hydraulic parameters, then the swale will be functional as an effective drainage system. An effective grass swale would convey the stormwater runoff to the detention pond or river, and then prevent flooding from occurred. Swales should be able to carry their design flow without overtopping or eroding. If the flow velocity is too high for grass cover in the swale but the slope and cross section cannot be adjusted, the swale can be reinforced with rip-rap or turf reinforcement matting, which can withstand a higher flow velocity. Vegetation also plays an important role in the effectiveness of the swale, which act as an agent to slow down the flow velocity, thus reduced the flow discharge. Maintenance of grass swale is required to ensure that the intended use of swale can be achieved, which are controlling volume of stormwater runoff and avoiding flood.

Acknowledgements

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