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A STUDY ON THE EFFECT OF CHANNEL MODIFICATION AT TAMAN HARMONI, SIMPANG RENGGAM, JOHOR USING SMADA

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Abstract

District of Simpang Renggam which was formerly a remote place has now changed into a developed area. Unfortunately, this change has also made the occurrence of floods at some places in the district, especially at Taman Harmoni that is facing inundation caused even by a single storm event. A study has been carried out to determine the effectiveness of the existing and proposed drainage system in order to overcome the amount of surface runoff due to urbanization activities by applying MASMA and SMADA software. The results show the existing drainage system would not be able to intercept the capacities of surface runoff for 10 years return period. The channel modification only reduces the flood area until 2010. Huge flood event will occur in year 2015 when impermeable surfaces reach to 70% and without any further improvement on drainage system.

Keywords: Urbanization, drainage system, flash flood, MASMA, SMADA

1. Introduction

Urbanization is one of causes of flash flood if development activities are not organized properly. Rapid urbanization will increase the amount of impervious surfaces. This phenomenon will increase the peak flow runoff when the drainage system is unable to convey the abundant of runoff quantity. Moreover, the continuous rainfall also contributes a flash flood when the drainage system is not capable to control the very fast flow of runoff. When the existing drainage system seems failed to transmit the capacity of normal rate, water will exit over the bank. Flash flood is frequently associated with convective storms of short duration and high intensity [1]. Factor of climate also affect the amount of rainfall between the urban and rural areas as shown in Table 1.

Table 1: Characteristics of urban climate [2]

Element	Characteristics	Amount
Temperature	Annual average Winter minimum Free of frost	0.5 - 1°C more 1 – 2 °C more 10% more
Rainfall	Total	5 – 10 % more

If the drainage system is ineffective, flood scenario will occur usually at the downstream area. Flood is a recurring phenomenon which is from a necessary and enduring feature of all river basins and lowland coastal systems [3]. With the rapid population growth and urbanization, many areas become more prone to flooding. Urban storm water runoff causes many environmental problems, including flooding, soil erosion and pollutant discharge to receiving waters. This runoff can be stored by off-site storage facilities [4].

Storm-water quantity control facilities can be classified by function as either detention or retention facilities. Detention and retention facilities can reduce the peak and volume of runoff from a given catchment (refer Figure 1), which can reduce the frequency and extent of downstream flooding. Detention and retention facilities have been used to reduce the costs of large storm-water drainage systems by reducing the size required for such systems in downstream areas [5].

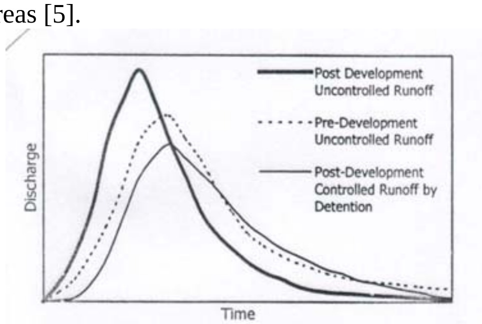

Figure 1: Hydrograph schematic [4].

Size of a detention facility requires an inflow hydrograph, a stage-storage curve (rating curve). Inflow hydrographs for a range of design storm durations must be routed through the basin to determine the maximum storage volume and water level in the basin corresponding to the maximum allowable outflow rate. The design storm duration that will produce the maximum storage volume in a basin will vary depending on catchment, rainfall and basin outflow characteristics, and it is typically somewhere between one and three times the peak flow time of concentration for the basin catchment. The design storm duration that produces the maximum storage volume is called the critical duration [5].

Taman Harmoni was selected as study area because of flood problem is 2001 where water has increased 0.4 m. In 2004, there is a huge flood scenario which affected 6 districts in Johor including Kluang where 92 mm of rainfall has been received at Simpang Rengam which is more than normal data and causes the capacity of main drainage system overflow and flooded to the nearby area. Then again, flash flood occurred in December 2006. One of the causes of flood event in Taman Harmoni is the blockage of drainage system. Rubbish and sedimentation delays the flow of water that makes the study area inundated.

Taman Harmoni is located in Simpang Renggam (Figure 1) which has been developed for various activities such as residential and business centres. In year 1999, 2424.07 acre (980.98 hectare) which is 13% of area was developed into residential, business, industrial and institution areas. About 11% (802.93 hectare or 1984.08 acre) of land was used for road and other facilities, meanwhile 76% (5861.51 hectare or 14484.09 acre) are still covered with ecology and agriculture land. The development of area is expected to be increased to 70% in year 2015.

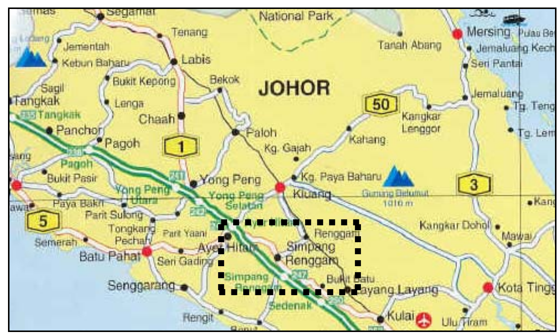

Figure 2: Study area

The purpose of this study is to determine the impacts of the urbanization to the existing drainage system. Beside that, modified channel have been proposed to control flood in the urban catchments area. Storm-water Management and Design Aid (SMADA) has been used in the study to assist in generation of watershed hydrographs and the routing of the hydrographs through a retention or detention basin.

2. Methodology

2.1 Method of Analysis

The collected data were analyzed by the Rational Method according to MASMA [5] and analyses were performed by SMADA. The watershed and rainfall data generate the hydrograph for the catchment area. The stages of discharge for detention pond generate the hydrograph of the pond (pond routing).

2.2 Catchment Area

The pervious and impervious areas were determined from the current development plan and the land uses at the study area. The catchment area is about 70 acre. About 28 acre is the impervious area or 40% of the catchment area. The impervious area are predicted to be increased to 60% in year 2010 and 70% in year 2015.

There are five conditions of data:

(i) Condition 1: ARI 2 years, 24 hours (2002, pre-development; 40% impervious surface)
(ii) Condition 2: ARI 10 years, 2 hours (2006, pre-development; without improvement, 40% impervious surface)
(iii) Condition 3: ARI 10 years, 2 hours (2006*, post development; with improvement, 40% impervious surface)
(iv) Condition 4: ARI 10 years, 2 hours (2010, post development; 60% of impervious surface)
(v) Condition 5: ARI 10 years, 2 hours (2015, post development; 70% of impervious surface)

Furthermore, the peak flow Q_{peak}, time to reach the peak flow and flooded area were determined by SMADA according to five conditions of data. 5 acre (20234.28 m^2) of area was predicted in constructing the frontal channel (modified channel) beside Sungai Berumbong with a length of 1.056 mile (1.7 km). The depth of channel is 6.56 ft (2 m) according to the level of staging and ratio of depth and bottom width is 2:1. The modified channel was included in the analysis for condition 3, 4 and 5.

3. Result and Discussion

3.1 Total rainfall and ARI for Simpang Rengam

Rainfall data from the nearest area were used to estimate the ARI for Simpang Renggam as shown in Table 2. The total rainfall is about 4 inches for ARI 2 years, 24 hours and also for ARI 10 years, 2 hours durations.

Table 2: Constant a, b, c, and d for Simpang Renggam

ARI (years)	**CONSTANTS**			
	a	b	c	d
2	4.8559	0.5385	-0.233	0.0132
5	4.7422	0.7082	-0.2558	0.0145
10	5.015	0.5939	-0.2276	0.0126
20	4.9325	0.6856	-0.2427	0.0136
50	5.2168	0.5083	-0.2208	0.0123
100	5.0339	0.7156	-0.2395	0.0131

3.2 Time of concentration, t_c

The value of t_c decreased 5 minutes with the increment of impervious surfaces where the impermeable surface increased the surface runoff and the time of concentration become shorter as shown in Figure 3.

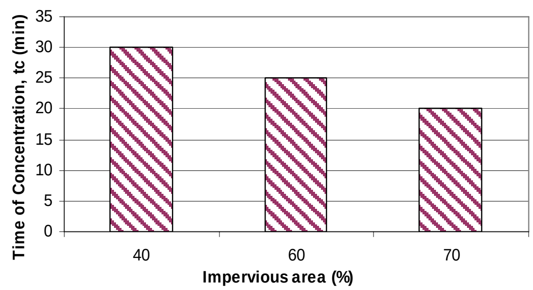

Figure 3: Time of Concentration, t_c for different percentage of impervious surfaces where i = 4.6007 mm/hr for ARI 2 years, 24 hours duration, i = 55.9411 mm/hr for ARI 10 years, 2 hours duration, n = 0.011 for concrete lined.

3.3 Peak Flow, Q_{peak}

The peak flow increased from condition 1 to condition 5 as shown in Figure 4. At condition 1, the Q_{peak} reached 12.57ft^3/s which is lower than peak flow at condition 2 (32.72ft^3/s). When modified channel was proposed to be inserted into the analysis, the peak flow for 2006 increased is about 7.2% from existing peak flow. The peak flow was predicted higher for 2010 and 2015 due to the increasing the development and construction of impermeable structures.

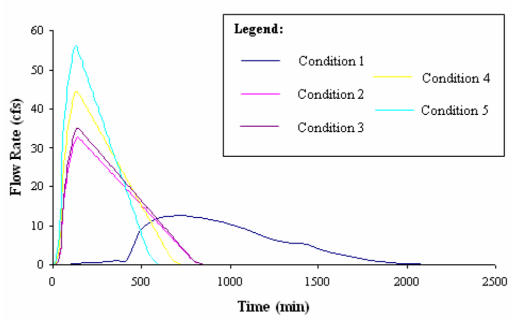

Figure 4: The Flow Rate for 2002, 2006, 2006*, 2010 and 2015

3.4 Time to Peak and Inundation Area

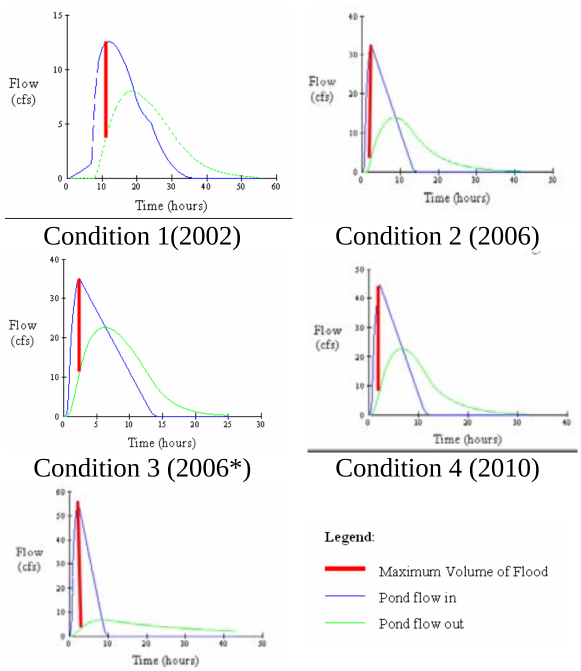

Figure 5: Time to peak

From Figure 5, the time to peak for Condition 1 is 12 hours but the time decreased about 81% (2.33 hours) at condition 2. This value remained for Condition 3 because there was no changes in return period and percentage of impermeable surface. In 2010 (condition 4) and 2015 (condition 5), the time to peak decrease to 2.25 and 2.17 hours respectively because of the increment of the impervious surface increase to 60% and 70% respectively.

The flooded area was predicted for becoming years. The analysis of maximum volume of flood in Figure 5 was figured in acre as shown in Figure 6.

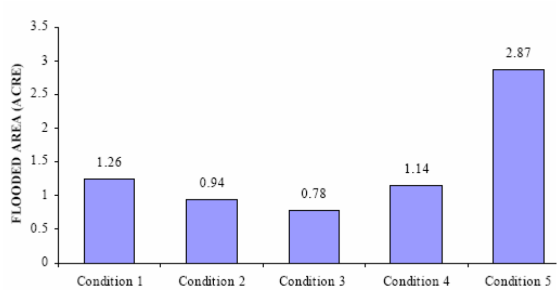

Figure 6: The flooded area

At condition 1 (2002), 1.26 acre was figured as the effected area but decreased about 25.4% in 2006 with ARI 10 years, 2 hours duration. When the modified channel has been used in the analyses, the flooded area was reduced to 17% compare with condition 2. The flooded area is increased about 268% (2.87 acre) after improvement, although the flooded area was decreased in 2010. Therefore, more improvement is needed to control the capacity towards year 2015.

Table 3 and 4 show the differences of the peak flow and flooded area for the modified channel according to two types of ARI. Time to peak for ARI 100 years increased about two times from the ARI 10 years. Meanwhile, the differences of flooded area between two ARI are about 0.6 acre for all conditions except for condition 5.

Table 3: Peak flow and flooded area for ARI 10 years

ARI	10 years, 2 hours			
	C2	C3	C4	C5
Peak flow (ft^3/s)	32.72	35.06	44.52	56.05
Flooded Area (acre)	0.94	0.77	1.14	2.87

Table 4: Peak flow and flooded area for ARI 100 years

ARI	10 years, 2 hours			
	C2	C3	C4	C5
Peak flow (ft^3/s)	58.21	62.37	76.67	95.07
Flooded Area (acre)	1.47	1.35	1.78	4.09

4. Conclusion and recommendation

The existing channel could not cater the capacity of flow although the flooded area decreases within 2002 to 2006. Furthermore, the frontal channel achieves in decreasing the capacity of flow but not able to control the high flow after 2010.

As a recommendation, the dimensions of frontal channel need to be reviewed for further improvement.

Acknowledgements

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