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Flooding in Taman Universiti, Parit Raja: Causes and Solutions

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Abstract: Since last two or three decades, the risk and vulnerability of humans to the dangers of flash floods in Malaysia have greatly increased example in developed or urban areas that have high construction rates and population distribution. This can be proved by a series of horrendous floods in some states such as Johor, Kelantan, Terengganu and Selangor. In this study, the main cause of flash flood happened at roadside drain along Taman Universiti Parit Raja, Batu Pahat, Johor is investigated. A series of calculation that had been done using Manning's equation and Rational method had proved that the high intensity of rainfall is the major cause of flash flood. If there is occurrence of rainfall with intensity more than 4.5 mm/hr happen, then the excessive runoff will flow into the drain and cause overflow of water to occur and then induced the occurrence of flood. Besides that, some other causes such as the irregular constriction of the earth drain flow channel, the growth of grasses and plants in the earth drain, and the topography condition of the study area are also some of the causes of the occurrence of flood at Taman Universiti, Parit Raja, Batu Pahat. In addition, the other causes of flooding at the roadside drain of Taman Universiti, Parit Raja is the infiltration rate of soil at the study area. This is because by referring to the research that had been done earlier, it shows the soil type at Parit Raja is silty clay type with low infiltration capacity. Therefore, proper drainage system has to be constructed in order to obstruct the happening of the above scenario and to minimize the damage if the occurrence is bound to happen. Therefore, some possible flood mitigation methods such as the construction of flood wall along both sides of drain, the building of a detention pond and connect the detention pond to the drainage system and to carry out proper channelization and dredging work had been proposed. The peak discharge of the area can be analyzed by using the Hydrologic Modelling System HEC-HMS in order to obtain a precise and accurate result in the future.

Keywords: Rainfall, Drain, Infiltration Rate, Topography, Flood Control

1. Introduction

In Malaysia, for the past few decades, Johor state was among the states in Malaysia that always hits by flood. It is believed that the tide collision, coupled with the extraordinary rainfall distribution so that

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there are areas that receive a rainfall distribution equal to the rain for several months is one of the factors that contribute to the floods in the state of Johor [1]. Nowadays we can see that rapid development is increasingly dominating the whole of Malaysia. However, without us realizing behind the progress and sophistication of the mechanisms achieved have invited disasters especially related to environmental conservation. One of the natural disasters is the flash flood which is now a national issue and is often debated among politicians and even the people of this country. Flooding is the most frequent and costly natural disaster that always happen in Malaysia. Normally a drainage system for an area will be based on the normal rainfall data of that area. Therefore, if that area received unexpected and too high rainfall, it may cause the specific area to be flooded. The high intensity of rainfall and prolonged duration of rainfall were also the main causes of flooding in other states in Malaysia such as Selangor, Perlis, Melaka, Kedah, Negeri Sembilan, Penang, Perak and federal territories such as Kuala Lumpur. Based on a report by National Disaster Management Agency (NADMA), on 16 December 2019, Johor state is the most critical state that hits by flood with a total number of 2,506 families or 9,348 peoples affected by the flood that occur in December 2019 [2].

In the past ten to twenty years, the rapid and speedy growth, transformation and development has not only successfully altered the development plan of Malaysia, but it has also made an impact on the environment and socioeconomics of the country. This transformation also changed the landscape of Pekan Parit Raja, Johor from a small and undeveloped town to a city that starting to focus on various population activities nd daily life covering aspects such as education, social, economic, political and infrastructure. The development that occurred as a result of the position of Universiti Tun Hussein Onn Malaysia (UTHM) in Parit Raja, this is also supported by the Parit Raja industrial area which is also proposed as a cluster for the electrical and electronics industry [3]. Parit Raja town has been developed as a university town or city of education is very reasonable as this town houses one of the leading universities in the country, namely UTHM. Apart from that, many other educational institutions such as the Tun Hussein Onn Teaching Institute, MARA Sri Gading High Skills College and Batu Pahat Nursing College have also made their contribution for Parit Raja town to become a university town or city of education. Taman Universiti, Parit Raja is situated in Johor, Malaysia. Taman Universiti is located quiet near to the main campus of UTHM. The accurate location of Taman Universiti, Parit Raja is as Figure 1 and Figure 2.

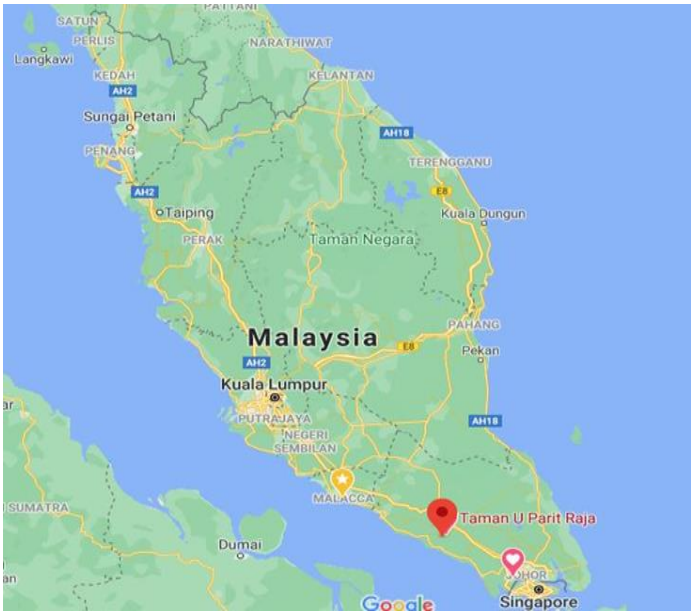

Figure 1: Location of Taman Universiti, Parit Raja

Figure 2: Location of Taman Universiti, Parit Raja

In addition, the urbanization process that has caused many modernized areas is also one of the factors that cause flash floods occur worldwide. Low-lying areas of land have been redeemed using by taking land from hilly areas. Furthermore, some of the tributaries that have been buried have also been used as construction sites. The consequences of these activities have led to causal factors flash floods occur because during the rains, water will flow rapidly from the hills to low areas and then will stagnate, and eventually the water will further increase, and flash floods will occur in the area. The flood problem in the country especially in Johor caused by the monsoon floods and flash floods will continue despite various structural and non-structural measures have been carry out by our federal and state government in pursuance of the efforts to diminish the detrimental effect and unfortunate consequences of flood. The flood problem already happened for a long time for Taman Universiti especially along the roadside drains of Taman Universiti, Parit Raja as demonstrated in Figure 3, Figure 4, Figure 5 and Figure 6.

Figure 3: Flood at Taman Universiti, Parit Raja on 4th December 2015 [4]

Figure 4: Flood at Taman Universiti, Parit Raja on 18th October 2018 [5]

Figure 5: Flood at Taman Universiti, Parit Raja on 1st November 2018 [6]

Figure 6: Flood at Taman Universiti, Parit Raja in June 2020 [7]

From all the Figure 3 to 6, it can be clearly seen that the flood problem at the roadside drain of Taman Universiti, Parit Raja already exist since long time ago. With the continuous growth in

population and development concentrated in the basins and ravines that are easily flooded, floods are very difficult to avoid. The frequency of floods has increased due to changes in land use where the drainage system in low-lying areas is not able to drain heavy rainfall and drainage system which is sedimentary due to development. In Malaysia, the flood area affected by the floods is approximately 29,000 square km or nine percent of the area of the country. According to research done earlier, the total number of people that was affected by the floods is believed to be greater than 2.7 million people or eighteen percent of the total population of the country [8].

2. Methodology

2.1 Clinometer and AR Ruler application

The first application that I will use for this study is the Clinometer. With the utilization of this application, user can obtain accurate slope measurement that uses all sides of the device and camera to measure the things that user wants to know. This can be used for simple applications such as frame alignment and can also be used for more complex applications that require slope measurements of each slope. Below is the steps or procedure to measure slope using Clinometer:

1. First, open the apps can select the measurement units in degree.
2. Next, put the phone in an upright position on the surface and select the relative angle option after adjusting the phone until the meter show zero degree.
3. Then, place the phone on the surface which will be measured and tap the lock option.
4. After that hold the phone for few seconds until a beep sound is heard which means the measurement is done and locked on screen.
5. Last the data of measurement will be shown on screen.

The second application that I will use for this study is the AR Ruler. With the utilization of this AR Ruler application, the measurement of any length or distance that needs to be measured can be carry out by using the camera of smartphone. Below is the steps or procedure to measure length and distance using AR Ruler:

1. First, open the apps can select the measurement units in meter in the app setting.
2. Then select the linear measurement option and aim the phone's camera to the three-dimensional plane where measurement will be carried out.
3. After that selection of surface need to be done by tapping on the screen.
4. Measurement can be carried out by select a base point of measurement on the plane and then adjust the line of measurement to the targeted point that need to be measured.
5. Last the data of measurement will be showed on screen.

2.2 Manning's equation and Rational method

Manning's equation is used to determine the value of open channel flow parameters such as cross section area, channel slope, Manning roughness of coefficient or normal depth when the rate of water flow through open channel is given or provided. Before the calculation of the flow rate of water in an open channel using Manning's equation, it is necessary to determine the value of parameters such as Manning's roughness of coefficient, cross-sectional area of flow, bottom slope of channel and hydraulic radius. The Manning equation can be used for calculation for open channel flow in natural channels as well as in man-made channels. The examples for natural channels are natural rivers, brooks, streams and tiny hillside rivulets. The examples for man-made channels are lined canals, flume, roadside drains

and sewers. The Manning's equation for for International Systems of units (S.I.) is shown below [9]. The Manning Equation for the International Systems of units (S.I.) is in Equation 1.

$$Q = \left(\frac{1.00}{n}\right) A \left(R^{\frac{2}{3}}\right) \left(S^{\frac{1}{2}}\right) Eq.1$$

Where
Q = volumetric water flow rate passing through the stretch of channel, ft^3/sec (m^3/s for S.I.)
A = cross-sectional area of flow perpendicular to the flow direction, ft^2 (m^2 for S.I.)
S = bottom slope of channel, (dimensionless)
n = Manning roughness coefficient (empirical constant), dimensionless
R = hydraulic radius = A/P in ft (m for S.I.)

Figure 7 below show the general step involve in the calculation of flow rate using Manning's equation.

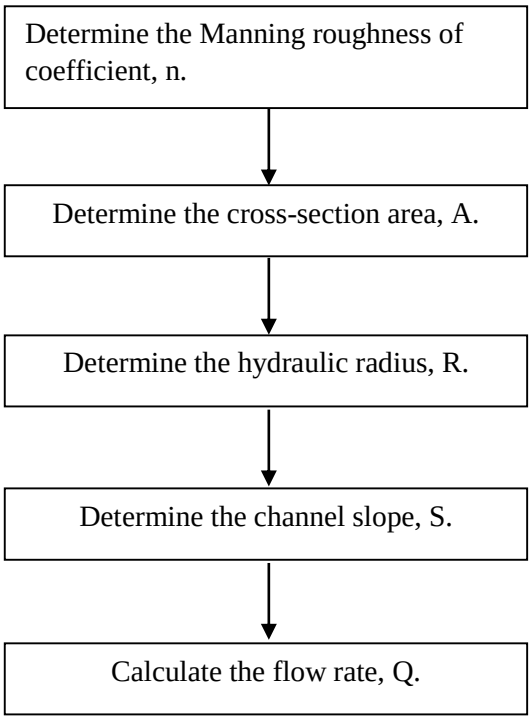

Figure 7: General step involve in the calculation of flow rate using Manning's equation [9]

Rational method is used to calculate the peak run-off, Q, following a rainfall event. Urban drainage system suitable for estimating flood quantities for urban areas and catchment areas for rural areas. The purpose of the rational method is to obtain a discharge or peak flow rate for an urban area. It is based on the area of the area, the intensity of rainfall during the concentration period, the land use for the area and the side effects of the channel. Before the calculation of the peak flow using Rational method, it is necessary to determine the value of parameters such as area, time of concentration, intensity of rainfall and the runoff coefficient [10]. The equation for Rational method is as shown in Equation 2.

$$Q = CiA \; Eq.2$$

Where:
Q = design discharge (m^3/s)
C = runoff coefficient (dimensionless)
i = design rainfall intensity (m/s)
A = watershed drainage area (m^2)

Figure 8 below show the general step involve in the calculation of peak run-off using Rational method.

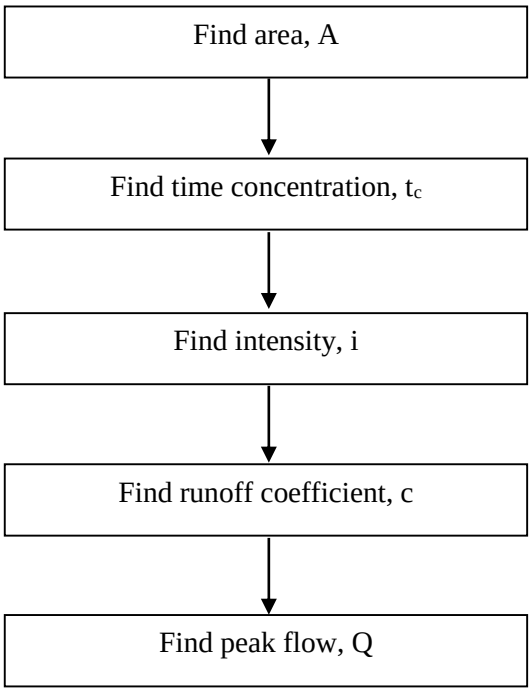

Figure 8: General step involve in the calculation of peak run-off using Rational Method [10]

3. Results and Discussion

3.1 Results

Figure 9 below shows the drainage flow and surface runoff from catchment area that will flow into the drain while the drain flow shape in Taman Universiti, Parit Raja are as shown in Figure 10. Table 1 shows the dimension of the drain flow shape while Table 2 shows the results of calculation by using Rational Method and Manning's equation.

Figure 9: Drainage flow and surface runoff from catchment area that will flow into the drain

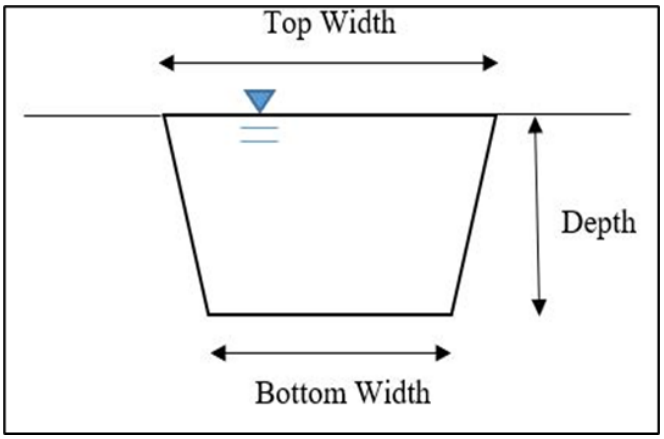

Figure 10: Drain flow shape in Taman Universiti, Parit Raja

Table 1: Dimension of drain flow in Taman Univerisiti, Parit Raja

Dimension	Measurement (meter)			Average(meter)
Depth	1.49	1.50	1.51	1.50
Top Width	4.39	4.41	4.40	4.40
Bottom Width	4.15	4.24	4.21	4.20

Table 2: Results of calculation by using Rational method and Manning's equation

Types of flow	Sum of flow
Q_{In1}	$= Q_{CIA\ 1} + Q_{DRY}$ $= 0.031 + 0.07$ $= 0.101\ m^3/s$
Q_{In2}	$= Q_{CIA\ 2} + Q_{DRY}$ $= 0.041 + 0.07$ $= 0.111\ m^3/s$
$Q_{Manning}$	$= 0.11\ m^3/s$

Where

Q_{In1} = The total of the peak surface runoff, Q_{CIA1} calculated by using the average of the highest three daily rainfall intensity from the year 2008 to the year 2017 recorded by the rain gauge at Rumah Pengawas Parit Raja with rain gauge ID 1831074 and the dry weather flow of the drainage, Q_{DRY}.

Q_{In2} = The total of the peak surface runoff, Q_{CIA2} calculated by using the daily rainfall intensity that was recorded on 20th June 2020 at Station SMK Munshi Sulaiman Batu Pahat with station ID 1829004 and the dry weather flow of drainage, Q_{DRY}.

$Q_{Manning}$ = The drainage flow rate.

The results show that $Q_{Manning} > Q_{In1}$ but $Q_{Manning} < Q_{In2}$. The $Q_{Manning} > Q_{In1}$ show that capability of the drainage is sufficient for flowing the input water source through the drainage, thus it will not be causing the flooding issue to be occurred. But in the other hands, the $Q_{Manning} < Q_{In2}$ show that the

capability of the drainage is insufficient for flowing the input water source through the drainage if the rainfall intensity is higher than usual. The $Q_{CIA\ 1}$ is calculated by using the average of the highest three daily rainfall intensity from the year 2008 to the year 2017 of rain gauge at Rumah Pengawas Parit Raja, Johor while the $Q_{CIA\ 2}$ was calculated from the daily rainfall intensity that was recorded on 20th June 2020 where on that day there is flooding occur at Taman Universiti, Parit Raja. By using backward calculation and trial and error method, it was found out that if the rainfall intensity is more than 4.5 mm/hr, then the water in the drainage system will start to overflow out of the drain.

3.2 Causes of flooding

It is had been proved that excessive permissible development discharge is the major cause of flash flood at the roadside drain along Taman Universiti, Parit Raja. The peak flow that had been obtained from the calculation of drainage flow rate using Manning's equation is lower if compared with the peak flow that had been obtained from the calculation using Rational method. As the dry weather flow combining with the discharge due to the surface runoff, it will result for a higher value of rational discharge and causing the flooding to be occurred. This had shown that the capacity of the roadside drain along Taman Universiti, Parit Raja is not enough and insufficient to support all the surface runoff that flow into the drain when heavy rainfall occurs or rainfall continues for a long period of time. Based on the hyetograph for June of the year 2020 for three rain gauge stations that near to the study area, that are rain gauge Station SMK Munshi Sulaiman, Station Kolam Air at Semberong Dam and Station Sungai Batu Pahat, it can further prove that when heavy rainfall occurred or rainfall continues for a long period of time, there will be flooding occur along the roadside drain of Taman Universiti, Parit Raja. There is also excessively high rainfall recorded at two dams that near to the study area where 170 to 247 mm/day was recorded at Bekok Dam, and 181 to 229 mm/day was recorded at Sembrong Dam [11].

Second causes of flooding at the roadside drain along Taman Universiti, Parit Raja maybe due to the irregular constriction of the earth drain flow channel. The drainage channel is the conduit for water being carried by the earth drain. The channel can continually adjust its channel shape and path as the amount of water passing through the channel changes. The drainage flow velocity depends on shape or cross section of the channel, irregularities in the channel caused by resistant rock, and stream gradient. Friction slows water along channel edges. Friction also will be greater in wider and shallower water flow channel that will resulted in the flow of water or discharge rate to become lower. Unlined channel also does not have a consistent slope and cross section, which reduces discharge of flow draining out to outlet at downstream. This is all the reasons that show that the irregular constriction of the earth drain will cause the flooding to occur at the roadside drain along Taman Universiti, Parit Raja. Moreover, the growth of grasses and plants in the earth drain will also reduce the flow of water through the drains and reduce thus the flowrate of the drain. This will lead to the occurrence of flood because the flowrate of the drains was reduced but there is large volume of stormwater and surface runoff flow into the drainage system and will exceeded the capacity of the drainage system and cause overflow of water from the drainage system. Figure 11 show the growth of grasses and plants in the drains at Taman Universiti, Parit Raja.

Figure 11: Growth of grasses and plants in the drain at Taman Universiti, Parit Raja

Besides that, the topography condition of the study area is also one of the causes of the occurrence of flood. During the site visit to the study area, it was noticed that the topography or the landscape of the study area is relatively flat. By referring to the topographic map of study area, it can be concluded that the topography of Taman Universiti, Parit Raja can be considered as flat. Slope is an important element or parameter that will affect the flow rate of water in drainage or any water channel. Besides that, if a residential area or business and commercial area is located in a low-lying area, then the area will also be a possible flood prone area. Many areas in Sri Gading can be categorized as low-lying area with the height from mean sea level just approximately between 1.5 m to 2m only [11]. Figure 12 show the topography map for Taman Universiti, Parit Raja, Johor Darul Takzim.

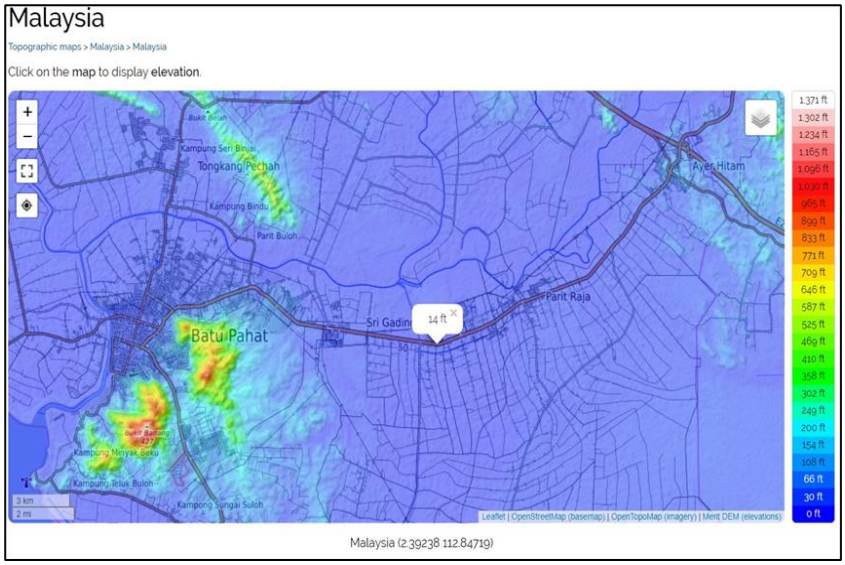

Figure 12: Topographic map of Taman Universiti Parit Raja, Johor Darul Takzim [12]

The topography of the study area is almost flat, that is around 14 feets or 4.27 m from mean sea level. As the study area can be idealized as flat area, therefore the slope of the drainage system will be small or less steep for the water in the drainage system flow from higher section to lower section. If the slope of drainage system is smaller or less steep, then the speed of water flow will be slower, and the water discharge rate is lower. This is because the water flow in drainage system which is not steep will resulted in the water flow have lower potential energy and also kinetic energy as the water flow from higher section to lower section of the drainage system. Therefore, there will be occurrence of flood if high volume of stormwater flow into the drainage system, but the discharge rate of the drainage system is low due to the slope of channel.

In addition, the other causes of flooding at the roadside drain of Taman Universiti, Parit Raja is the infiltration rate of soil at the study area. The infiltration rate of the soil at study area is an important factor. Based on a research that had been done earlier, the results of laboratory and field test analysis show that the soil at Parit Raja can be classified as silty clay type. The hydraulic conductivity obtained from the in-situ test shows that the average rate is 0.0001mm/hr and the infiltration rate was between 1.00 mm/hr to 15mm/hr, which was categorized as very low. Due to the influence of texture of soil factors, the permeability of silty clay is low [13]. It will result in a negative effect where when the rainwater flow through the impervious surfaces as surface runoff, it will cause an impact on the landscape through the development of watersheds. The occurrence of flood is easier because the flow rate is lower due to the thickness of the silty clay soil layer and subsurface layer. Despite the rainfall intensity or the precipitation rate is low, the area will still be prone to flooding.

3.3 Suitable mitigation method for flooding

The first suitable solution and mitigation method for flooding at the roadside drain at Taman Universiti, Parit Raja is to introduce the use of stormwater basin. The flood detention pond is used to control surface runoff. If the runoff is too large, the flood detention pond can be temporarily accommodated, or it can be discharged at a normal flow rate. In Malaysia, both types of stormwater basin, that are wet retention pond and dry detention pond had been used widely in construction project for residential area or non-residential area. Dry flood detention ponds are the most commonly used and the cheapest type of detention structure. This is because generally the dry detention pond is just a low-lying open space, and it only plays the function of water storage when it rains. Figure 13 show the proposed location for the dry detention pond at Taman Universiti, Parit Raja.

Figure 13: Proposed location for the dry detention pond at Taman Universiti, Parit Raja

Besides that, the second suitable solution and mitigation method for flooding at the roadside drain at Taman Universiti, Parit Raja is to build the flood wall. Figure 14 show the proposed location of flood wall at Taman Universiti, Parit Raja.

Figure 14: Proposed location of flood wall at Taman Universiti, Parit Raja

The function of the flood wall is similar to a levee as it can protect the nearby residential area and non-residential area from flooding. They are usually found on both sides of the river and water channel, and it can be natural or man-made. They basically act as barrier to prevent water from rising into the local area immediately. However, the embankment of levee is normally made of mud, like a large hill, adjacent to a river, stream or water channel. The use of soil, grass and other natural soil elements to

build a levee can bring more negative impacts to flooding as it may eroded during flood. Therefore, the levee wall that built from soil, grass and other natural soil element will require continuous maintenance and must be rebuilt periodically. In order to avoid this scenario, so the flood walls that will be proposed is either precast concrete wall or reinforced concrete wall. This is because these two types of walls are widely used in construction industry nowadays and these two types of walls can withstand the tests of time and weather and are therefore a better investment to protect local areas.

Furthermore, the third suitable solution and mitigation method for flooding at the roadside drain at Taman Universiti, Parit Raja is to carry out proper channelization and dredging work. Channelization of the earth drain refers to the linearization of the earth drain's shapes on the plane layout. About to transform the meandering earth drain into a straight or broken line-shaped artificial earth drain network. The channelization of the earth drain will straighten the drain into a straight channel, and then make it into a concrete bank revetment. Hardening of the bottom of earth drain by hard materials such as concrete and stone masonry are used for the side slope and bottom of the channel. This effort will ensure a smooth flow of wastewater in the drainage system as the Manning's coefficient of roughness for lined concrete drain is lower than that of earth drain that is covered by grasses. The smaller Manning's coefficient of roughness means there is less friction acts on the flow by the channel. For recommendation, the drainage system should be well-maintained, and an appropriate drainage system has to be designed such as lined drainage in order to address this flood incident from occurring.

4. Conclusion

The main cause of the flooding problem at the roadside drain of Taman Universiti, Parit Raja is verified based on the calculations by using the Rational method and the Manning's equations, which had been taught in the course of Hydrology and Hydraulics shows that the capacity of the roadside drain along Taman Universiti Parit Raja, Batu Pahat, Johor is insufficient if the rainfall happens with high intensity. The drainage's capacity is enough or sufficient for runoff with normal rainfall intensity. If there is occurrence of rainfall with high intensity more than 4.5 mm/hr happen, then the excessive runoff will flow into the drain and cause overflow of water to occur and then induced the occurrence of flood to happen. The other possible factor which causes flood to occur is the irregular constriction of channel flow system, growth of vegetation on water surface of drain, topography condition of the study area and the infiltration rate of the soil will also cause flood to occur. Some proposed flood mitigation methods are the construction of flood wall along both sides of drainage, the building of a detention pond and connect the detention pond to the drainage system and to carry out proper channelization and dredging work. At the end of the study, there are some recommendations that are encouraged to be carry out in the future work in order to get more accurate and precise results.

1. The water from nearby connected outlet should be consider as the inlet of the drainage system when perform the calculation of peak flow of area.
2. In order to determine the exact discharge of the drainage, on site experiment can be carried out.
3. Closed loop levelling can be carried out at study area so as to acquire the reduced level of drainage.
4. The watershed area should be calculated by traverse surveying to increase the accuracy of peak flow area obtained.
5. The peak discharge of the area can be analyzed by using the Hydrologic Modelling System HEC-HMS in order to obtain a precise and accurate result.

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