1D LANGAT RIVER MODELLING BY USING UNSTEADY FLOW HEC RAS

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ABSTRACT

Malaysia is one of the countries that place in the equator of the Earth and face a tropical weather which contain rainy and drought seasons. Nowadays, there are a lot of flood occur near the middle Sungai Langat, Selangor which effects the society. Due to the phenomena of the flood disaster, there are a lot of lost and this situation will affect the economics of the people that live around this area. This scenario can be predicted and can be analyse by using Hydrologic Engineering Centers Rivers Analysis System (HEC RAS). HEC RAS is one of the software that has been produce by U.S Army Corps of Engineers which allows the user to perform 1 dimensional steady and unsteady flow rivers hydraulic calculations. The data collections contain cross section data, rainfall data and the discharge data. All the data will be interpret in the HEC RAS and the river modelling can be produce on it. The dimension of the river can be produce by the AUTOCAD based on the data that had been collected. The results of this research are focus only for 10 years, 50 years and 100 years return period. Based on the research, actually the channel of the river is safe during 10 years and 50 years return period but during 100 years, the river channel cannot withstand the capacity of the river. Due to this problem, the river normalization had been selected as the way to solve the problem.The focus study of this research is about the river capacity analysis, river normalization and hydraulic variable difference (river discharge, depth of water, etc) of the flow after and before the normalization.

ABSTRAK

Malaysia merupakan sebuah negaraterletak di garisan khatulistiwa bumi dan berhadapan dengan cuaca tropika yang mengandungi hujan dan kemarau setiap tahun. Pada masa kini, terdapat banyak banjir berlaku berhampiran Sungai Langat, Selangor yang memberi kesan buruk kepada masyarakat. Oleh kerana itu, terdapat banyak yang kerosakan dan keadaan ini akan memberi kesan kepada ekonomi orang-orang yang tinggal di sekitar kawasan ini. Senario ini boleh diramal dan boleh menganalisis dengan menggunakan Sistem Analisis hidrologi Pusat Kejuruteraan Sungai (HEC RAS). HEC RAS adalah salah satu perisian yang telah hasil oleh US Army Corps of Engineers yang membolehkan pengguna untuk melaksanakan 1 dimensi sungai aliran mantap dan tak mantap pengiraan hidraulik. Koleksi data mengandungi keratan rentas data, data hujan dan data pelepasan. Semua data akan mentafsir dalam HEC RAS dan pemodelan sungai boleh menghasilkan di atasnya. Dimensi sungai boleh menghasilkan oleh AUTOCAD berdasarkan data yang telah dikumpulkan. Hasil daripada kajian ini ditumpukan hanya selama 10 tahun, 50 tahun dan 100 tahun tempoh kembali. Berdasarkan kajian ini, sebenarnya saluran sungai adalah selamat dalam masa 10 tahun dan 50 tahun tempoh ulangan tetapi dalam masa 100 tahun, saluran sungai itu tidak dapat menahan kapasiti sungai. Akibat masalah ini, normalisasi sungai telah dipilih sebagai cara untuk menyelesaikan masalah.Tumpuan kajian ini adalah tentang analisis kapasiti sungai, normalisasi sungai dan perbezaan pembolehubah hidraulik (menunaikan sungai, kedalaman air, dan lain-lain) aliran selepas dan sebelum kembali normal.

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LIST OF SYMBOLS

Q	Discharge
Q_{peak}	Peakdischarge
T_{peak}	Time of peak
%	Percentage
A	Area
V	Velocity
S	Storage
q,	Lateral inflow per unit distance.
J	Mass flux
G	Acceleration of gravity
Sf	Friction slope
X	Precipitation for every return period
X_{ave}	Average precipitation
Sd	Standard derivation
Sn	Reduced standard derivation, a function of sample size N
Y_t	Reduced variety, a function of T, $-\ln\left[ln\frac{T-1}{T}\right]$
Y_n	Reduced mean, a function of sample size N
I	Rain intensity
R_{24}	Precipitation for a day
T_c	Time of concentration
D	Storm duration
t_{lag}	Time of lag
C	Rational runoff coefficient

LIST OF ABBREVIATIONS

JPS	Jabatan Pengairan dan Saliran
HEC-RAS	Hydraulic River Analysis Modelling System
RF	Rainfall Station
SF	Streamflow Station

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Malaysia is one of the countries that place in the equator of the Earth and face a tropical weather which contain rainy and drought seasons. Nowadays, there are a lot of flood occur near the middle Sungai Langat, Selangor which effects the society. Due to the phenomena of the flood disaster, there are a lot of lost and this situation will affect the economics of the people that live around this area. This scenario can be predicted and can be analyse by using Hydrologic Engineering Centers Rivers Analysis System (HEC RAS). HEC RAS is one of the software that has been produce by U.S Army Corps of Engineers which allows the user to perform 1 dimensional steady and unsteady flow rivers hydraulic calculations. The data collections contain cross section data, rainfall data and the discharge data. All the data will be interpret in the HEC RAS and the river modelling can be produce on it. The dimension of the river can be produce by the AUTOCAD based on the data that had been collected. The focus study of this research is about the river capacity analysis, river normalization and hydraulic variable difference (velocity, Froude number, depth of water, etc) of the flow after and before the normalization

1.2 PROBLEM STATEMENT

During this era, there are so many flood cases that occur near the Sungai Langat, Selangor. Sungai Langat is the one of the popular river that usually involves in flood cases.

This case is very serious due to the large number of people that involve in this problem. The river is flow from the north east to the south east of Selangor. This problem may occur due to the unsuitable dimension of the river with the river discharge. In order to prevent these incidents, the prediction of the flood level should be doing to make sure there will be no more lost in the future.

1.3 OBJECTIVE OF STUDY

There are the objectives of the Langat River research that need to be done by the HEC RAS modelling software.

- To know the maximum capacity of Langat River.
- To know the level of the flood in the Langat Riverbased on the discharge level of the river.
- To design the channel by using river normalization process.

1.4 SCOPES OF STUDY

This research is to determine and predict the flood at Langat River, Selangor which is the flood occur currently.The prediction of the flood can be determined by the trends of the river depth and the velocity of the flow. We can identified whether the dimension of the river can influents the flood to occur at the area. To do this research, the application of the hydraulics will be use which is HEC RAS software to find the trends of water level. HEC-RAS is the software that performs one-dimensional steady flow, unsteady flow, sediment transport/mobile bed computations, and water temperature modelling. It will show the flood occur based on the data that have been performed in this software.

1.5 RESEARCH SIGNIFICANCE

In this research, we will know the river capacity and predict the flood based on the factor that involve in the flood phenomena such as the hydraulic behaviour and the engineering factor.

The all the data that we get will be interpret in the software and the software will show how the trends of the flow in the river. The results will show what is the most importance factor which contributes the flood to be happened.From the analysis, we can propose a good solution to prevent the flood such as river normalization. River normalization is the activities that modified the river dimension such as increase the depth or increase the high of the river bank. There are also other methods that we can use such as build a retarding basin or other engineering structure to control the flow of the flood. All the method should be suitable with the place and the behaviour of the river so that the flood control and prevention can be take place efficiently.

CHAPTER 2

LITERATURE REVIEW

2.1 FLOOD

Based on the dictionary.reference.com, flood is the phenomenon of overflow water from the river to the area that is dry. This area will submerge and covered by the water from the river. This phenomenon is usually occur after the heavy rain which due to the over capacity of the water in the river which cause the overflow to the area surrounding.

Scottish Environment Protection Agency (SEPA) states that there are several types of flood. First, the river flooding is occur when the river is cannot withstand the capacity of the water, the water will flow above the river bank level and this will make the surrounding area of the river will be covered by the water. The other type of flood is coastal flooding which is occurring near the coastal area. The coastal flooding is occurring due to the increasing of sea level based on the water tide and the weather. When there is heavy rain during the water tide, the water will overflow to the dry area. Besides, the other type of flood is surface water flooding which the heavy rains that happens in the surface that already saturated or on paved area where the engineering part such as drainage is poor. Lastly, the flood also can happen due to the high capacity of groundwater. This phenomenon usually happen when there is heavy rain and it will cause the groundwater will rise to the surfaces.

Based on the research about this flood phenomenon, heavy rains is the main factor that contributed this phenomenon to be happen. The heavy rain will affect the capacity of the water and this situation will cause the increasing of water level which not suitable with the dimension of the storage or the river. Besides that, the engineering factors also have the roll of contributor for this phenomenon such as the poor management of waste product and the poor construction of drainage or other infrastructure.

2.2 OPEN CHANNEL HYDRAULIC

Open channel is the flow of liquid or water on the free surface such as the flow in the river, canal, and flow of water over land or the drain. All the technical activities around us such as supply of water, hydropower, and the control of flood are deal with open channels. The flow in open channel is exactly in turbulent regime which is due to the variation of flow, the velocity, the length of the channel and time. The type of flow also may contribute the flow characteristic.

2.2.1 Basic of Open Channel Hydraulic

In the open channel, the flow of the fluid is unpredictable. Based on the research and the statement that Subhash C. Jain in Open-Channel Flow, "Depending on the variation of flow depth, and velocity with the length of the channel and time, different types of flow, classified as uniform, nonuniform (varied), steady, and unsteady, occur in open channels".

This statement showed that in the open channel, there are many types of flow and this variation of type is due to the characteristic of the fluid and also the dimension of the surface.In open channel hydraulics, there are several coefficients and the most important coefficient is the manning coefficient, n. Manning coefficient can be seen in the Gauckler-Manning Formula:

$$V = \frac{1.49 * R^{\frac{2}{3}} S^{\frac{1}{2}}}{n} \quad (2.1)$$

where: V = Average velocity (length/time)

S = Water surface slope (unitless)

R = Hydraulic radius (length)

n = Roughness coefficient

Based on the www.fsl.orst.edu, The Manning's n is a coefficient which represents the roughness or friction applied to the flow by the channel. The manning value is choose depends on the surface of the flow and in many flow conditions the selection of a Manning's roughness coefficient can greatly affect computational results. It's showed that when the manning value is increase, the velocity will be decrease.

Table 2.1: Manning's value

Type of Channel and Description	Minimum	Normal	Maximum
A. *Natural Streams*			
1. Main Channels			
a. Clean, straight, full, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. Same as "d" but more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy. deep pools	0.050	0.070	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stands of timber and brush	0.070	0.100	0.150
2. Flood Plains			
a. Pasture no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
2. Same as above, but heavy sprouts	0.050	0.060	0.080
3. Heavy stand of timber, few down trees, little undergrowth, flow below branches	0.080	0.100	0.120
4. Same as above, but with flow into branches	0.100	0.120	0.160
5. Dense willows, summer, straight.	0.110	0.150	0.200
3. Mountain Streams, no vegetation in channel, banks usually steep, with trees and brush on banks submerged			
a. Bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
b. Bottom: cobbles with large boulders	0.040	0.050	0.070

Sources: HEC RAS references manual

2.2.2 Channel Modification

Channel Modification is one of the method to prevent flood which modified the dimension of the river and additional of the others element to control the flow and the capacity of water.

Based on the United State Environmental Protection Agency, the channel modification is the controlling the stream or river channel regarding the capacity of the flow, the navigation, drainage improvement, and reduction of channel migration potential. The activity that involve in this method are straightening, widening, deepening, or relocating existing stream channels and clearing or snagging operations. The purpose of all the activity is actually to increase the depth of the stream and increase the dimension of the stream to become suitable with the dimension. Channel modification refer to the excavation of borrow pits, canals, underwater mining, or other practices that change the depth, width, or location of waterways, or embayment within waterways. Besides, channel modification can be done by using two type of methods which are best hydraulic channel design and stable channel design.

2.2.2.1 Best Hydraulic Channel Design

The design of a channel involves the selection of channel dimension such as channel alignment, shape, size, and bottom slope and whether the channel should be lined to reduce seepage and/or to prevent the erosion of channel sides and bottom. The physical characteristic of the channel should be suitable with the water discharge of the river. The most of the suitable dimension to make the channel design is trapezoidal shape.

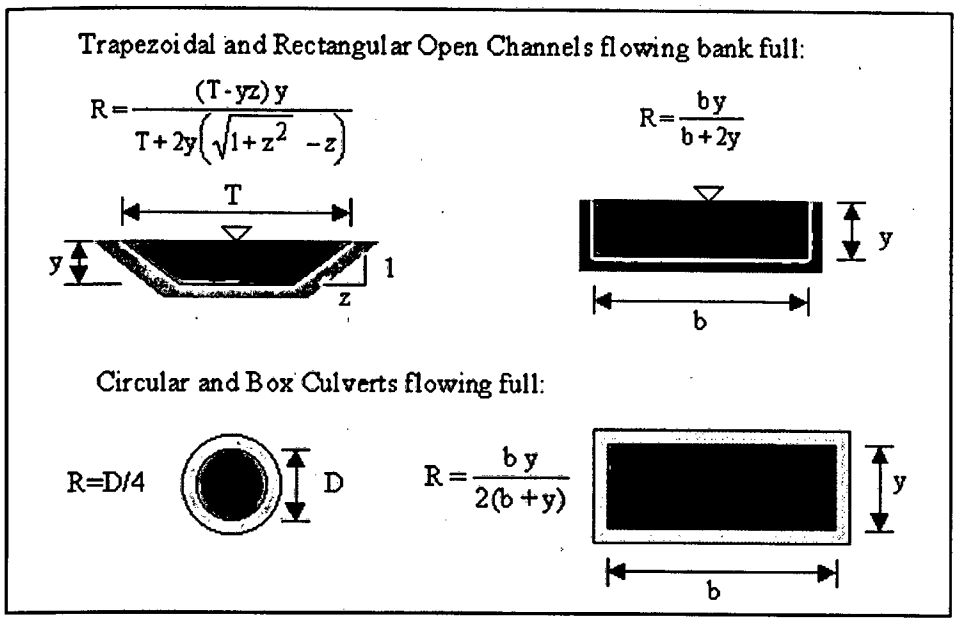

Figure 2.1: Best hydraulic channel

The trapezoidal shape is the most suitable dimension shape because of the dimension is more dynamic and it can decrease the amount of erosion of the river bank. As you can see, if the shape of theriver is square, the possibility of erosion to occur is high due to the gravitational force acting on the bank. The erosion also can easily occur due to the frictional force that comes from movement of the river stream.

Figure 2.2: Erosion of the river.

Best hydraulic channel design is the type of design that involve a lot of calculation that make the channel become similar in dimensions aspect such as the wide of the channel, the height of the water surface, and the wet perimeter of the channel.

2.2.2.2 Stable Channel Design

Based form the HEC RAS hydraulic manual, there are three approaches can be used for stable channel design which are Copeland, Regime and Tractive Force method. The Copeland method uses an analytical approach to solve stable channel design variables of depth, width and slope. Stability is achieved when the sediment inflow to a particular reach equal the sediment outflow. The Regime method is purely empirical, and within HEC RAS, uses equation develop by Blench (1975). The Regime method define a channel as being stable when there is no net annual scour or deposition in the design reach.

The Tractive Force method is an analytical scheme that defines channel stability as no appreciable bed load movement. It is important to know the characteristic of the design stream to determine which approach will work best. Each of these approaches stem from work done previously in conditions with somewhat limited validity ranges.

2.3 HYDROLOGY

Hydrology is the study of the water in this earth which includes the cycle of water, the water resources and the rainfall. The hydrology will define all the natural activity of the water in the earth and it also will explain the behaviour of the water movement around us. There are a lot of activities of the water in the cycles of its nature such as precipitation, evaporation, water surface runoff and others activities.

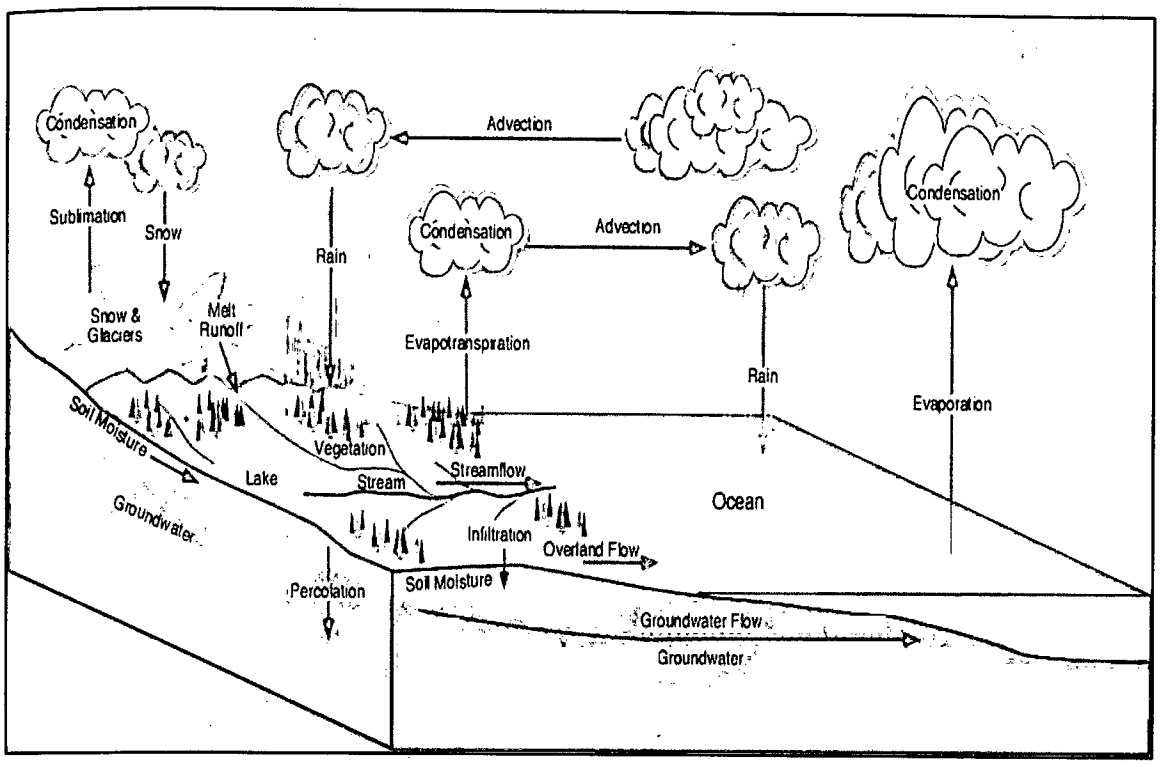

Figure 2.3: Hydrologic cycle

The hydrology cycle is very important aspect that needs to be considered because it is one of the factors that can cause disaster phenomena such as flood. According to J. Micheal Daniels (2007), the purpose of study the hydrology is to improve the prediction of the event in the future. The statement proves that the hydrological study can help us to predict the future event in the hydrology including the flood.

2.3.1 Rainfall Analysis

Table 2.2: Criteria for the suitable method

No	Types	Conditions	Results	Explaination
1	Type 1 Gumble method	CK ≤ 5.4002	CK =1.18	required
		CS ≤ 1.139	CS = 0.35	required
2	Type 3 log Pearson method	CS = 3CV + CV^3		
		0.5149	CS = 0.00	fail
		CK = 0	CK = 1.18	fail
3	Log normal method	CS ≠ 0	CS = 0.35	required
		CK = 1.5 CS (ln X)2 + 3	CK =1.18	fail
		5.674		

Based on the standard rainfall calculation, there are 3 types of methods that we need to be carried out to identify the most suitable one. There are type 1 Gumble method, type 3 log Pearson method and log normal method.

Gumbel Method Type 1:

$$X_t = X_{ave} + \frac{S_d}{S_n}(Y_t - Y_n) \qquad (2.2)$$

where: X = Precipitation for every return period

X_{ave} = Average Precipitation, 109mm

Sd = Standard derivation, 18

Sn = Reduced standard derivation, a function of sample size N, 0.9496

Y_t = Reduced variety, a function of T, $-\ln\left[ln\frac{T-1}{T}\right]$

Y_n = Reduced mean, a function of sample size N, 0.4952

Log Person Method Type 3:

$$\log X_{ave} = \log(X)_{ave} + k(Sdlog(X)_{ave}) \qquad (2.3)$$

where: X_{ave} = Average rainfall
k = Frequency factor
Sd = Standard derivation

Log Normal Method:

$$X_t = X + K_t(SD) \qquad (2.4)$$

where: X_t = Rainfall
K_t = Frequency factor

The rainfall intensity will be calculated after the suitable equation had been identified by using,

$$I = \frac{R_{24}}{24}\left[\frac{24}{T}\right]^{\frac{2}{3}} \qquad (2.5)$$

where: I = Rain intensity
R_{24} = Precipitation for a day
T_c = Time of concentration

Time to peak is needed to find due to the type of the flow which is unsteady flow. We cannot just simply take the $T_p$from the hydrograph.

$$t_{peak} = \frac{D}{2} + t_{lag} \quad (2.6)$$

where: D = Storm duration

t_{lag} = Time of lag

The rational method is the equation that relate with the flow roughness of the river.

$$Q_p = \frac{C.I.A}{3.6} = 0.28.C.I.A \quad (2.7)$$

where: Q_p = Peak Discharge

C = Rational runoff coefficient

2.3.2 Hydrograph

A hydrograph is a time data of the discharge of a stream, river and also watershed outlet. Basically, rainfall will be the main input to a watershed and the stream flow which it is considered as output of the watershed. A hydrograph shows how a watershed responds to rainfall. It is essential to use both of them in hydrological planning.

Hydrograph is an easy and fast way to explore the hydrologic conditions in hydrograph simulation analysis (HSA) to ensure the rivers are falling, rising or remaining steady.A unit hydrograph is based on hypothetical case of 1 unit (1 mm) of rain falling constantly at time interval over the catchment area. Paul Guero (2006), state that the unit hydrograph also classified in the metric model category and it is successfully used previous decades.

These unit hydrographs can describe how a river at certain point react to 1 inch of runoff and also show derive of river which will react to any amount of runoff. Amount of runoff that been calculated is used to the unit hydrograph at certain point to produce a forecast hydrograph which is specified to that place and event.