HYROLOGICAL MODELLING USING HEC-HMS FOR KUANTAN RIVER BASIN

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I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor (Hons.) of Civil Engineering.

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at University Malaysia Pahang or any other institutions.

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ABSTRACT

Unusual heavy rain that happens during Northeast monsoon between November to March may lead severe flood to the east coast of Peninsular Malaysia, including Kuantan River. This phenomenon gives a great impact to human being, can cause major damage to properties and may reduce the quality of human health. Hence, an attempt has been made to mitigate the impact of flooding using modelling approach. The application of Hydrologic Engineering Centre Hydrology Modelling System (HEC-HMS) software was used to estimate the flow hydrograph of Kuantan River Basin. The objectives are to develop a calibrated and validated rainfall-runoff model for Kuantan River Basin using HEC-HMS and to predict the peak flow and produce hydrograph for 2012 Kuantan flood event. The model was calibrated and validated using historical observed data that were taken from Department of Irrigation and Drainage (DID). Event dated 04th September 2010 to 09th September 2010 was used in model calibration and two events dated 01st September 2010 to 06th September 2010 and 22nd February 2011 to 27th February 2011 respectively were used for validation process. Clark UH method was used to transform excess rainfall, whereby SCS Curve Number method was applied for calculating the losses and for estimating base flow, Constant Monthly method was used. Nash-Sutcliffe model efficiency was used to verify the model calibration and validation. The model efficiency for calibrated and validated model is 0.81 and 0.80 and 0.70 respectively, which is acceptable.

ABSTRAK

Hujan lebat yang tidak normal terjadi semasa Monsun Timur Laut diantara bulan November dan Mac boleh mengakibatkan banjir teruk di kawasan Pantai Timur Semenanjung Malaysia temasuk Sungai Kuantan. Fenomena ini akan memberi impak besar kepada kehidupan manusia, mengakibatkan kerosakan besar kepada harta benda dan akan mengurangkan kualiti kesihatan manusia. Oleh itu, satu kajian telah dijalankan untuk mengelakkan kerosakan yang disebabkan oleh banjir menggunakan pendekatan pemodelan. Aplikasi perisian Hydrologic Engineering Centre Hydrology Modeling System (HEC-HMS) telah digunakan untuk menganggarkan aliran hidograf untuk lembangan Sungai Kuantan. Objektifnya adalah untuk menghasilkan model hujan-air larian yang ditentukur dan disahkan untuk lembangan Sungai Kuantan menggunakan HEC-HMS dan untuk menjangkakan aliran kemuncak dan menghasilkan hidograf untuk peristiwa banjir di Kuantan pada tahun 2012. Model ini telah ditentukur dan disahkan menggunakan data yang diambil daripada Jabatan Pengairan dan Saliran (JPS). Peristiwa bertarikh 04 September 2010 hingga 09 September 2010 digunakan dalam proses penentukuran dan dua peristiwa bertarikh 01 September 2010 hingga 06 September 2010 dan 22 Februari 2011 hingga 27 Februari 2011 masing-masing telah digunakan untuk proses pengesahan. Kaedah Clark telah diguna pakai untuk mengubah lebihan hujan, dan kaedah SCS Curve Number telah dipakai untuk mengira kehilangan dan untuk menganggar aliran asas, kaedah Constant Monthly telah digunakan. Kecekapan model untuk model penuntukur ialah 0.81 manakala kecekapan model pengesahan ialah 0.80 dan 0.71 dimana kesemua nilai adalah diterima.

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LIST OF SYMBOLS

S	Potential maximum retention after runoff starts
I_a	Initial abstraction
T_c	Time of concentration
R	Storage coefficient
A	Catchment area
L	Main stream length
T_{lag}	Snyder's standard lag
S_i	Incremental slope
N	Manning value
L_{ca}	Distance along the main water course from the gauging station to a point opposite the watershed centroid
C_t	Regional constant representing watershed slope and storage effects
Q_{ps}	Peak discharge
C_p	Regional constant, depending on the characteristic of the region
Q_{oi}	Observed flow at time
Q_{si}	Simulated flow at time
Q_A	Average observed flow
Q_j	Flow hydrograph ordinates
i_j	Rainfall excess hyetograph ordinates
A_j	Time area ordinates
j	Number of isochrone contributing to the outlet
m^3/s	Meter cube per second
mm	Milimeter
hr	Hour
i	Rainfall intensity
km	Kilometer
km^2	Kilometer square
r^2	Coefficient of determination
d	Index of agreement
$\sum$	Summation

LIST OF ABBREVIATIONS

DID	Department of Irrigation Drainage
GIS	Geographic Information System
HEC-HMS	Hydrologic Engineering Centre - Hydrologic Modelling System
UH	Unit Hydrograph
SCS	Soil Conservation Service
CN	Curve Number
RSWM	Regional Storm Water Model
SMA	Soil Moisture Accounting
EI	Efficiency Index
ME	Model Efficiency
E	Nash-Sutcliffe Model Efficiency
RMSE	Root Mean Square Error
PBIAS	Percent BIAS
RSR	RMSE-Observation and Standard Deviation Ratio
STDEV	Standard Deviation

CHAPTER 1

INTRODUCTION

1.1 Background of Study

There are two types of flooding, which is flash floods and monsoon flooding (DID, 2000). In terms of hydrology, the main difference between the two flood categories is the time taken to release the level to return to normal levels of peak flood relief. Flash floods take a couple of hours to return to normal levels of expression compared to monsoon floods that take up to a month to get down to normal levels (Mohamad et al., 2012). Normally, if it is associated with the flood, people will relate the flooding occurred due to heavy rain which was not stop during the long period of time. For example, the floods occur on the east coast of Peninsular Malaysia, during the Northeast monsoon wind due to the unusual heavy rain.

The occurring floods may cause serious impacts and damages to people and also to the properties in flood prone areas. Flood mitigation is applied to reduce the risk from flooding. Traditionally, mitigation is divided into structural and non-structural measures. Structural measures such as dams, levees and flood walls can change the flood characteristics and reduce the probability of flood in the location of interest. Meanwhile, non-structural measures such as risk mapping, hazard forecasting, and flood modelling alter the impact of flooding but have no effect on flood characteristics (Minea et al., 2011).

Flood warning system and hydrological and hydraulic modelling is the examples of non-structural measures. The advantage of the flood warning system is to identify the amount of time available for residents to implement emergency measures to protect valuables or to evacuate the area during serious flood event, while the hydrological modelling is used for stream flow forecast. The application of non-structural mitigation measures has been given more attention nowadays. Thus, a study on flood modelling is compelling as an effort to minimise the impact of flooding and as a reference in the future.

1.2 Problem Statement

Flooding problem faced in Sungai Kuantan was very worrying. This problem happened because Pahang is one of the states that related to the effects of the Northeast Monsoon which occurs from November to March every year (D/iya et al., 2014). On December 2012, Pahang was involved in a major flood, which affecting more than 10,000 people and caused serious effect to the traffic congestion including the Kuantan city (The Star Online, 2012). During the flood, more than 300 residents from several areas in Kuantan had to be evacuated to a few relief centres.

Efforts have to be done to mitigate and minimised the impact of flooding. Nowadays, non-structural flood mitigation measures are the preferable options compared to the structural measures. Therefore, an attempt has been made to perform a hydrological modelling study at Sungai Kuantan to predict the flood discharge during the 2012 flood event. The 2012 flood hydrograph will later be used in the future flood modelling works as the input to hydraulic model.

1.3 Objectives

The main objectives of this study are:

i) To develop a calibrated and validated rainfall-runoff model for Kuantan River Basin using HEC-HMS.

ii) To predict peak flow and produce hydrograph for 2012 Kuantan flood event.

1.4 Scope of Study

The selected study area is Sungai Kuantan which is roughly 93.44 km in length and covers about 1679 km^2 area. But, the study analysis only covered 430 km^2 and 36.2 km river length. The area of 430 km^2 is not including the area for Chereh Dam, which is

152 km^2 in overall because the construction of the dam was finished in July 2008. Some sets of storms events use in this study are after the Chereh Dam was constructed, so it was necessary to use 430 km^2 for the area.

The scope includes the river basin network that was established by using the Arc GIS software and the analysis was performed using HEC-HMS model. Besides that, the rainfall data and stream flow data from the Department of Irrigation and Drainage (DID) from year 2008 until 2012 was used. This study developed a calibrated and validated hydrological model to predict the peak discharge of 2012 Kuantan flood.

1.5 Significant of Study

The developed rainfall-runoff model for Sungai Kuantan can be a guideline to improve the drainage system for river basin and human activities can be controlled to prevent flood. In addition, it is important to know the stream flow data and runoff capacity to estimate the potential of flood during raining time. The hydrological model can be used for the design of drainage of basin based on the hydrological pattern. The output hydrograph is useful for further flood modelling studies of Kuantan River Basin.

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