THE DEVELOPMENT OF RAINFALL INTENSITY-DURATION-FREQUENCY (IDF) CURVES IN KLANG VALLEY

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Report submitted in partial fulfilment of requirements
for the award of the degree of
B. Eng. (Hons) Civil Engineering

Faculty of Civil Engineering & Earth Resources
UNIVERSITI MALAYSIA PAHANG

JUNE 2016

UNIVERSITI MALAYSIA PAHANG

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LIST OF SYMBOLS

μ	Mean
N	Number of Data
σ	Standard Deviation
P	Probability
T	Return Period
In	Inches
cm	Centimeter
mm	Millimeter
km	Kilometer
hr	Hour
min	Minutes
K	Gumbel frequency
$Pave$	The average of the maximum precipitation in a specific duration
P^*_T	The frequency precipitation
S^*	Standard deviation of P* value

LIST OF ABBREVIATION

MSMA	Manual Saliran Mesra Alam
CDF	Cumulative Density Function
PDF	Probability Density Function
KS	Kolmogorov-Smirnov Test
LP3	Log-Pearson Type III
LN	Log-Normal
IDF	Intensity-Duration-Frequency
DID	Department of Irrigation and Drainage
ARI	Average Recurrence Interval
VDF	Volume Duration Frequency

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ABSTRACT

Changing in climate is one of the main parameter that affecting the water resources as it affects the whole hydrologic cycle thus causes variation in rainfall intensity, duration and frequency of precipitation. The rainfall Intensity Duration Frequency (IDF) curves relationship is one of the tools that are commonly used in water resources engineering, either for planning, designing and operating the water resources project. Department of Irrigation and Drainage (DID) is a responsible department to produce IDF curve and published as a guideline for Urban Storm water Management Manual (MSMA2). But this IDF curves use outdated data from 1990 until 2010 which is not up to date data. This IDF curves need to be update from time to time in order to ensure the IDF curves still relevant as reference. This study's purpose is to develop IDF and also to determine the appropriate frequency analysis for every district in Klang Valley based on latest data. There were two methods used in this study such as Gumbel and Log-Normal distribution. IDF curve requires Annual Maximum Series (AMS) rainfall data from the period of 5 minutes to 7200 minutes starting from year 1990 to year 2015 for 18 stations in Klang Valley. To designing the IDF curve, process involved are mean, standard deviation, frequency factor, and intensity value for 2, 5, 10, 20, 50 and 100 year return period for both methods. The Kolmogorov-Smirnov (KS) was used in goodness of fit test to determine the appropriate frequency analysis in Klang Valley. Gumbel distribution showed to fit the graph than Log-Normal by not rejecting the value above 85% than 54 tests involve for both methods. Thus, Gumbel disribution is an appropriate method that can be use in developing the IDF curves for districts in Klang Valley than Log-Normal. Comparison between the constructed IDF curves and the existing IDF curve provided in MSMA2 had been made with range +96.55% of difference at minutes 15 at duration 100 years ARI and -52.63% of difference at minutes 1440 with duration 2 years ARI.

ABSTRAK

Perubahan iklim merupakan salah satu kriteria utama yang memberi kesan kepada sumber air kerana ianya boleh menjejaskan kitaran hidrologi keseluruhan dan menyebabkan perbezaan dalam keamatan hujan, tempoh dan kekerapan hujan. Hujan Keamatan Tempoh Kekerapan (IDF) adalah salah satu alat yang biasa digunakan di dalam air kejuruteraan sumber, sama ada untuk merancang, mereka bentuk dan mengendalikan projek sumber air. Jabatan Pengaliran dan Saliran (JPS) merupakan jabatan yang bertanggungjawab dalam menghasilkan lengkung keamatan tempoh frekuensi (IDF) dan taburan hujan yang dihasilkan akan diterbitkan didalam Manual Saliran Mesra Alam Malaysia (MSMA2). Namun begitu lengkungan keamatan tempoh frekuensi yang digunakan sekarang mengunakan data dari 1990 hingga 2010 yang tidak dikemaskini. Lengkungan IDF perlu diperbaharui dari semasa ke semasa untuk memastikan lengkungan keamatan masih relevan sebagai rujukan. Berdasarkan kajian ini, lengkungan keamatan hujan bagi Lembah Klang, dan seluruh daerah bagi Lembah Klang akan dihasilkan berdasarkan data data terkini. Terdapat dua kaedah yang digunakan dalam kajian ini ialah Gumbel dan Taburan Log-Normal. IDF memerlukan Siri Maksimum Tahunan data hujan (AMS) data hujan dari tempoh 5 minit hingga 7200 minit bermula pada tahun 1990 hingga tahun 2015 untuk 18 stesen di Lembah Klang. Untuk mereka bentuk lengkung IDF, proses yang terlibat adalah purata, standard penyimpangan, faktor kekerapan dan nilai keamatan bagi tempoh 2, 5, 10, 20, 50 dan 100 tahun kembali kedua-dua kaedah. Kolmogorov-Smirnov (KS) telah digunakan dalam ketetapan ujian untuk menentukan analisis kekerapan yang sesuai di Lembah Klang. Taburan Gumbel menunjukkan untuk muat graf daripada Log-Normal dengan tidak menolak nilai di atas 85% daripada 54 ujian melibatkan untuk kedua-dua kaedah. Oleh itu Gumbel disribution adalah kaedah yang sesuai digunakan untuk membangunkan lengkung IDF untuk daerah di Lembah Klang daripada Log-Normal. Perbandingan antara lengkung IDF dibina dan lengkung IDF yang sedia ada yang diperuntukkan dalam MSMA2 telah dibuat dengan pelbagai + 96,55 % daripada perbezaan pada minit 15 pada tempoh 100 tahun kala kembali dan -52,63 % daripada perbezaan di minit 1440 dengan tempoh 2 tahun kala kembali.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND STUDY

Malaysia is one of the countries located at Southeast Asia, close to the equator which is damp and hot all the year. The area of Malaysia at equator zone gives Malaysia experience tropical atmosphere with two sort of monsoon season which are the northeast and southwest through the year. Northeast happen amid November to May bring moisture and more rainfall. Where southwest give wind blowing monsoon inside of May to September. These outcomes give average rainfall in Malaysia in 2500 mm with normal temperature 27^{o}C a year.

Seasonal variety give impact on rainfall pattern rely on upon topography of Malaysia that encompassed by mountain. This condition give two distinctive atmosphere which is rely on upon highland and lowland region. Accordingly, both condition cause temperature seething between 23^{o}C to 32^{o}C during that time with humidity somewhere around 75% and 80% and yearly get rainfall between 2000mm to 4000mm with 150 to 200 stormy days.

From this rainfall pattern, the data will be utilized to develop temporal pattern using rainfall intensity-duration-frequency (IDF) curves. IDF curves can be obtained based on historical data and are usually employed to evaluate the extreme values of precipitation in urban drainage systems. For instance, IDF curve estimates are crucial in urban drainage systems so as to have a consistent estimation of extreme precipitation to design the conveying and detention infrastructures. Therefore, IDF curves can be defined as mathematical tools that express the relation between intensity, duration, and

average recurrance interval (ARI) of precipitation. Rainfall IDF ought to be up and coming in accordance with the progressions of rainfall pattern due to worldwide temperature alteration impact and temperature changes.

That information from rainfall data will be use in frequency investigation system to create IDF curve. To utilize this method, local history data was expected to get maximum annual rainfall depth corresponding to various duration. Most recent duration information will be taken inside of time of 5 minutes to 120 hours with diverse ARI 2, 5, 10, 20, 50 and 100 years. Rainfall intensity-duration-frequency curves describe rainfall intensity as a function of duration for a given ARI which are important for the design of storm water drainage systems and hydraulic structures. The IDF curve will show the infinite number of rainfall event with distinctive average intensity and duration with same ARI. For a particular ARI, the average intensity will diminish as the duration increment. As the outcome, for same duration, the average intensity is higher for longer ARI than the shorter one.

1.2 PROBLEM STATEMENT

The increase in carbon dioxide concentration in the atmosphere due to industrial activities in the past and recent times has been identified as the major cause of global warming and climate change. The normal balance of the earth's hydrological cycle has been altered due to the changes in the temperature and precipitation patterns. Research related to the analysis of extreme precipitation indices have projected an increase in the annual total precipitation during the second half of the past century; the number of days with precipitation is also expected to increase, with no consistent pattern for extreme wet events.

All rainwater design in Malaysia must refer to the Urban Storm Water Management Manual Second edition (MSMA2) to take follow standard. Taking into account perception in MSMA2, the data of IDF curve for Klang Valley was overhauled until 2009. Heavy rainfall and under design drainage system can occur at Klang Valley. In Malaysia, flash flood event occur frequently in urban areas such as Klang Valley.

The environmental change in Malaysia in storm rainfall intensity may influence the information by change of most recent expansion data (MSMA2, 2012).

Based on the Urban Storm water Management Manual (MSMA), the data period for Klang Valley IDF curve mostly, between 1970 until 1990. This data not suitable as a reference to design a drainage and stormwater management because in lately the climate change increase in storm rainfall intensity (MSMA, 2000).

Besides that, there is not all stations in Klang Valley stated in MSMA2 because in MSMA2 the data only represent for major towns. This means that there is a large potential error in extrapolating to long ARI such as 100 years. The lower limit of the duration analyzed was 15 minutes and the limits of rainfall ARI between two years and 100 years (MSMA, 2000). The existing IDF curve in MSMA not reliable and need to reviewed using the additional data and latest method.

1.3 OBJECTIVES

The objectives of this study are;

i. To develop IDF curves using frequency analysis such as Gumbel distribution and Log-Normal distribution in Klang Valley.
ii. To analyse the appropriate frequency analysis for developing IDF curves in Klang Valley.
iii. To compare the rainfall intensity values between MSMA2 and appropriate frequency analysis.

1.4 SCOPE OF STUDY

This study was conducted in Klang Valley area using Annual Maximum Series (AMS) rainfall data to develop IDF curves. The duration of IDF curves from 5, 10, 15, 30, 60, 180, 360, 720, 1440, 2880, 4320 and 7200 minutes and the ARI including 2, 5, 10, 20, 50 and 100 years. The data collections are from Department of Irrigation and Drainage (DID).