OPEN CHANNEL FLOW ANALYSIS OF DRAINS AT UNIVERSITI MALAYSIA PAHANG CAMPUS PEKAN USING INFOWORKS CS

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ABSTRACT

Flood can be defined as an overflow of water from water body normally occurred when the water body can no longer contain the precipitation in the area and the soil can no longer absorb the water. This resulted in overflow and one of the causes of flood. The study area is Universiti Malaysia Pahang (UMP) campus Pekan where it is located in an area where flood occurrences are recorded each year with the main reason is overflow from the Pekan River. The soil condition in the area also poses problem where it is swampy and this type of soil have low porosity and can lead to increase in surface runoff. The objectives of this study is to develop and validate 2-Dimensional hydrological modeling of UMP Pekan drainage system using Infoworks CS and to determine the capabilities of existing drain to sustained runoff at maximum level. Data are obtained from (Jabatan Pembangunan dan Pengurusan Harta) JPPH UMP such as invert level, platform level, and plan view of study area. The study area which is 60 hectares area in total was divided into three zones; Zone A, Zone B and Zone C. In order to analyze the effectiveness of the drains at UMP Pekan, two method of calculation is used which are Rational Method for calculating the surface runoff and Manning Equation for the calculation of drain flowrate. Infoworks CS will be used to simulate the event of 8 hour rainfall with data obtained from MASMA with 2 ARI. Water level is obtained after simulation process is completed. Result shows Zone C experienced overflow while Zone A drainage system experienced high water level that almost cause overflow. Only Zone B shows properly design drainage system where water level is in the mid-section of the drain. This result is proven both in manual calculation and software simulation.

ABSTRAK

Banjir boleh ditakrifkan sebagai limpahan air dari sungai yang biasanya berlaku apabila sungai tidak mampu lagi menampung hujan dan tanah tidak mampu lagi menyerap air. Kawasan kajian adalah Universiti Malaysia Pahang (UMP) kampus Pekan di mana ia terletak di kawasan kejadian banjir direkodkan setiap tahun dengan sebab-sebab utama adalah limpahan dari Sungai Pekan. Keadaan tanah di kawasan tersebut juga menimbulkan masalah di mana ia adalah berpaya dan jenis tanah ini mempunyai keliangan rendah dan boleh membawa kepada peningkatan air larian permukaan. Objektif kajian ini adalah untuk membangun dan mengesahkan 2-Dimensi pemodelan hidrologi sistem perparitan UMP Pekan menggunakan Infoworks CS dan untuk menentukan keupayaan sistem perparitan sedia ada untuk air larian berterusan pada tahap maksimum. Data diperolehi daripada Jabatan Pembangunan dan Pengurusan Harta (JPPH) UMP seperti terbalikkan pandangan tahap, tahap platform, dan pelan kawasan kajian. Kawasan kajian yang ialah 60 hektar kawasan dan dibahagikan kepada tiga zon iaitu Zon A, Zon B dan Zon C. Dalam usaha untuk menganalisis keberkesanan longkang di UMP Pekan, dua kaedah pengiraan digunakan yang iaitu Kaedah Rasional untuk mengira air larian permukaan dan Persamaan Manning untuk pengiraan kadar alir longkang. Infoworks CS akan digunakan untuk mensimulasi kejadian 8 hujan jam dengan data yang diperolehi dari MASMA dengan 2 ARI. Paras air akan diperolehi selepas proses simulasi selesai. Keputusan menunjukkan Zon C mengalami limpahan manakala Zon A mengalami paras air tinggi yang hampir menyebabkan air melimpah. Hanya Zon B menunjukkan reka bentuk yang memuaskan di mana paras air di bahagian pertengahan longkang. Keputusan ini dibuktikan dalam pengiraan manual dan simulasi perisian.

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A	-	Area of the cross section (m^2)
a, b, c, d	-	Coefficients for the IDF polynomial equations
D	-	Depth
I	-	Intensity
n	-	Manning's coefficient
Q	-	Maximum flow (m^3/s)
R	-	Hydraulic radius (m)
S_o	-	Watercourse slope
t	-	Time
tc	-	Time of concentration
tp	-	Peak Hydrograph
V	-	Velocity
W	-	Width
Pd	-	Rainfall depth
F_D	-	Area Reduction Value
t_0	-	Overland flow time
t_d	-	Drain flow time

CHAPTER 1

INTRODUCTION

Flash flood has been the problem among developing countries. The quick pace, uncontrolled development and lack in specifications to prevent flash flood have been the main factors of flash flooding. As for Malaysia, the most famous case of flash flooding happens at the capital itself, which is Kuala Lumpur. Every time when copious rain falls for about two to three hours a few settlements and major trunk roads in the city will be flooded (Jamaluddin, 1985). Solutions have been provided but somehow failed to prevent the problems from happening.

Malaysia is considered as a tropical country with equatorial climate where the weather is hot and humid throughout the year. There is no hot season and the rainfall fall throughout the year where it is heavy and frequent. Two monsoons affect the climate of Malaysia which is the Southwest Monsoon from late May to September, and the Northeast Monsoon from November to March. The Northeast monsoon lasts from November to March, as the winds blow down to the China Sea. Since this is the greatest sweep of ocean to which the country is exposed, this season is the rainiest. It first strikes the north and east coast of Malaysia. The east coast of Malaysia, all of Sarawak and

Brunei on up to Southern Sabah, and the Sandakan Residency get more than 120 inches of rain a year. (Gould, 1969)

Most regions in Pahang receive heavy rain at this time of the year and one of the most heavily affected is Pekan. As the new Universiti Malaysia Pahang campus at Kuala Pekan has already been officially open to students in June 2011, a study has to be made to determine the area is safe and have minimum risk to flash flood in the future.

1.1. Problem Statement

It is understandable that every end of the year, heavy precipitation will fall on the east coast which resulting into flood occurrences at various locations. Flood can cause loss of lives, loss in property, and also spread disease through its contaminated water. Certainly the event of floods causes a lot of problems to the community living in the affected area.

Pekan is known to be highly affected due to the Northeast monsoon season which brings high rainfall density which leads to flooding in the area. In 2011, Universiti Malaysia Pahang (UMP) new campus is located at Kuala Pekan, outskirt of Pekan town, where 708 students are to be expected to stay at the given hostels. In case of heavy rain fall, there is a chance that Kuala Pekan will be flooded thus affecting the community in the area and also to UMP students. The learning process shall be disturbed and students will have difficulties in coping with their study. There is also another factor that may contribute to the flooding at the new campus which is the construction activities done at the area, where construction site is known to produce high quantity of runoff during raining season. Also sediments in runoff from construction sites typically 10 to 20 times greater than agricultural land and 1000 to 2000 times greater than forest lands. Furthermore, when flood happens at the area, there is a fair chance that the access road towards UMP Campus Pekan will be blocked as there are only one routes connecting the new campus with Pekan town.

1.2. Objective

The objectives of this study are:

i. To develop and validate 2-Dimensional hydrological modeling of UMP Pekan drainage system using Infoworks CS.
ii. To determine the capabilities of existing drain to sustained runoff at maximum level.

1.3. Scope of Study

This research mainly involving the effectiveness of the existing drain, by determination of the dimensions of the drainage, which later will be use to calculate the flowrate of the existing drain. The result then is compared with the calculated flowrate using the software which will later determine whether the existing drain will be able to sustain the flowrate calculated.

Obtain the data needed such as rainfall data, cross-section of the river, the geometry of structure, perimeter watershed, water level and other data required.
Among the main activities that will be done during this study are:

1. Collecting data based on site area and rainfall data
2. Determine dimension of existing drain
3. Simulations process using software

1.4. Location of Study

The location of this study is located in Kuala Pahang, Pekan. This area has been proven from time to time to be highly affected during heavy monsoon rain due to the area incapability to flow and infiltrate the excessive water. Floods in Pekan are mainly due to overflowing from Sungai Pahang which coincides with high tide that causes an increase in water level at surrounding swamps. (The Borneo Post,2011). Flooding at Pekan has causes losses to properties and even lives. In order to minimize the impact of flooding to the affected population, it is advisable for researchers to do more studies regarding flood mitigation to improve the living quality in Pekan.

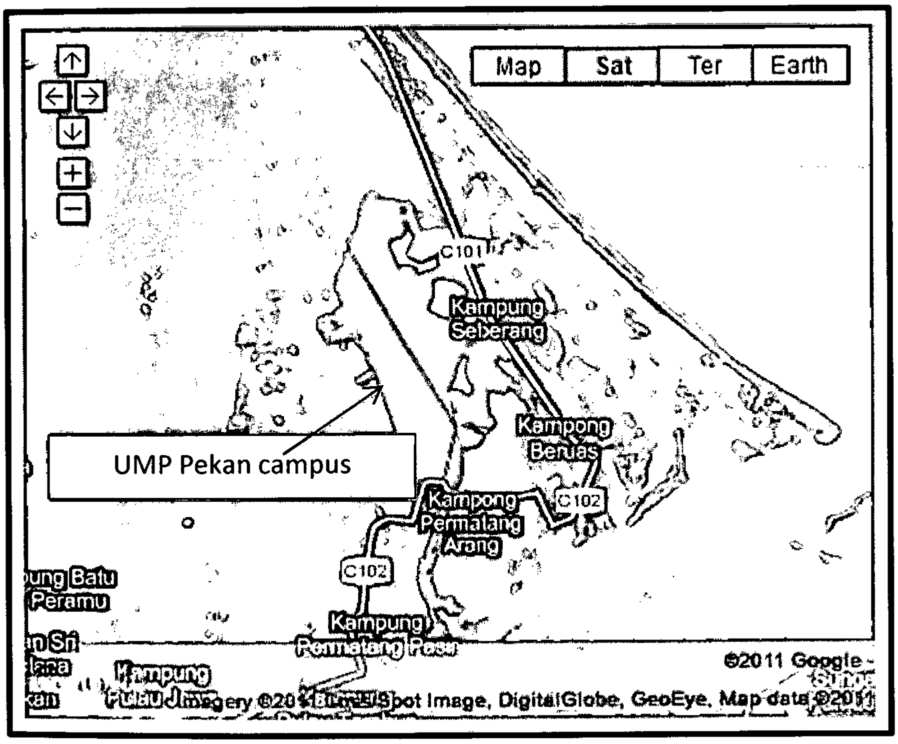

Figure 1.1: White area on the map shows UMP Pekan location. (Source: Google Earth)

Figure 1.1 shows the location of where UMP Pekan situated which is located near the Pahang river. The white area on the map shows cleared area for the construction of the campus, which can also lead to high volume of surface runoff from construction site. In case of high tide and heavy rainfall, there is a fair chance that together with all other factors taken into consideration, the area around the river will be flooded like previous years.

1.5. Significance of Study

The importance of this study is to determine the capabilities of the existing drain at UMP Pekan whether it is able to cater high volume of rainfall. Flooding will happen when existing flowrate of drainage are lower than flowrate produced by rainfall or runoff or other factors. All of this will be made possible using latest software to maintain the accuracy and persistent.

It is also as a pioneer study to be done at UMP Pekan to determine the drainage capabilities of the area and may be a tool of reference for others in pursuing study under this field.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

Floods are caused by weather phenomena and events that deliver more precipitation to a drainage basin than can be readily absorbed or stored within the basin. (USGS, 2011). Commonly it is considered to be a phenomenon associated with an unusually high stage or flow over land or coastal area, which results in severe detrimental effects. 'Flood control' implies all measures taken to reduce the detrimental effects of flood.

2.2 Type of flood

Flood results from a number of causes. However, one due to heavy and prolonged rainfall is the most frequent one. The type of flood that hit Pekan town for almost every year is under the category of river flooding, where the whole area of East Coast including the state of Pahang, Terengganu and Kelantan are under the effect of Northeast monsoon season with high precipitation combine with high tide. For systematic studies, it is necessary to classify such flood events (Ghosh, 2006).

2.2.1 River flooding

This is the major cause of flooding extensive areas as a result of heavy rains in the catchment areas as well as local areas thereby increasing the river levels that can cause major rivers to overflow their banks. The water can cover enormous areas. Even the downstream area, which does not receive any rainfall, will be affected if the quantity of water is enormous.

In large rivers case, the process is relatively slow. Water from rainfall will go into the river directly, while some of them will enter the river through seepage. When the infiltration rate of the river is low, water or runoff will be directed into other smaller river and this entire small river will be connected to the main river. This will cause the main river to receive excessive water quantity more than it can sustain.

Finally all the catchment area will show indicators of flooding when the water at the main river is slowly rising. The water will eventually flow to the sea but the process is slow and when the amount of water flowing into the river is faster than the flowing into the river water level will rise and eventually leads to flooding.

Area affected by this type of flooding is huge, where the settlers will probably be cut out from access road and will be isolated when flooding happens

2.2.2 Flash floods

In areas with steep slopes, heavy rain can cause a riverbed that held very little or no water at first, to suddenly brim with fast flowing water. The rain water is collected on the slopes, then flows downhill gathering speed and all the water comes together in the river bed. The water level rises fast. The water flows over the river banks and floods the area. Speed is the keyword where it all happens fast and rains heavily. The water flows at high speed. Because of this speed it has the strength to carry away heavy objects as can be seen in the event of Boscastle in 2004, Vaison la Romaine in 1992, and the area of Alicante in Spain in 2007. The flood stops as suddenly as it starts.

A flash flood is a very direct response to rainfall with a very high intensity or sudden massive melting of snow. The area covered by water in a flash flood is relatively small compared to other types of floods. The amount of water that covers the land is usually not very large, but is so concentrated on a small area that it can rise very high.

Because of the sudden onset and the high travelling speed of the water, flash floods can be very dangerous. The water can transport large objects like rocks, trees and cars.

2.2.3 Urban flooding

Local heavy rains up to 100mm or more in a day over the city and larger towns can cause damaging and disruptive flooding due to poor or chocked drainage and rapid runoff. The problem here is to determine the proper drainage system that will collect water due to surface runoff and channel it to other places which can sustained the water before the precipitation stop.

The Government of Malaysia has provided the Stormwater Management and Road Tunnel (SMART) solution to mitigate the urban flooding at its capital, Kuala Lumpur. The SMART system will be able to divert large volumes of flood water from entering this critical stretch via a holding pond, bypass tunnel and storage reservoir. This will reduce the flood water level at the Jalan Tun Perak Bridge, preventing spillover.

2.2.4 Storm surge or tidal flooding

This results mostly due to tropical disturbances, developing to cyclones and crossing surrounding coastlines. Cyclone induced storm surges have devastating consequences in coastal areas and such surge induced floods may extend many kilometers inland (Ghosh, 2006).

A flood starts when waves move inland on an undefended coast or overtop or breach the coastal defense works like dunes and dikes. The waves attack the shore time and again. When it is a sandy coast, each wave in a storm will take sand away. Eventually a dune may collapse that way.

2.2.5 Floods arising due to failure of a dam

A large number of large and small dams are constructed to store water for various purposes. Due to poor maintenance and due to exceptionally high precipitation a severe flood may result causing failure to the dam. This causes a surging waterfront travelling with high velocity causing destruction of properties and loss of life.

2.2.5.1 Banqiao dam failure

In 1975, China witnessed the greatest manmade disaster that caused the death of more number of people than in any other manmade disaster happened across the world so far. At the beginning of August, there occurred a typhoon because of the change in the weather pattern. When the hot, humid air of the typhoon met the cold air of the North, series of storms and rain occurred. The first one was on August 5, followed by the second one on August 6th and the third one on August 7th. The dam was designed to store 300mm of water per day. During these days within 24 hours itself more than one year's rain was poured. Banqiao and Shimantan dams were filled by August 8th and were in the urge to burst. On August 8th 12:30 am, Shimantan dam collapsed followed by the collapse of Banqiao dam by 1:00am on the same day. Totally 62 dams broke, affecting the life of eleven million people. Even the evacuation orders failed to reach many people because of the problem in communication caused by flood. People who survived in this flood were trapped without food. Contaminated water affected the health of several people. These dams were built by foreseeing the flood that may occur, but even then, the natural calamity was of that high level and the dams failed to hold the tempestuous water rained down. To prevent more disasters they even destroyed several small dams so that the water would flow to the areas with less population.

These dams, which collapsed mainly, affected the local population. According to the records nearly 26,000 people died because of flood and nearly 145,000 people died because of famine and epidemics. Nearly 5,960,000 buildings collapsed and 11 million residents were affected. Many were injured. This converted China into a land full of corpses.

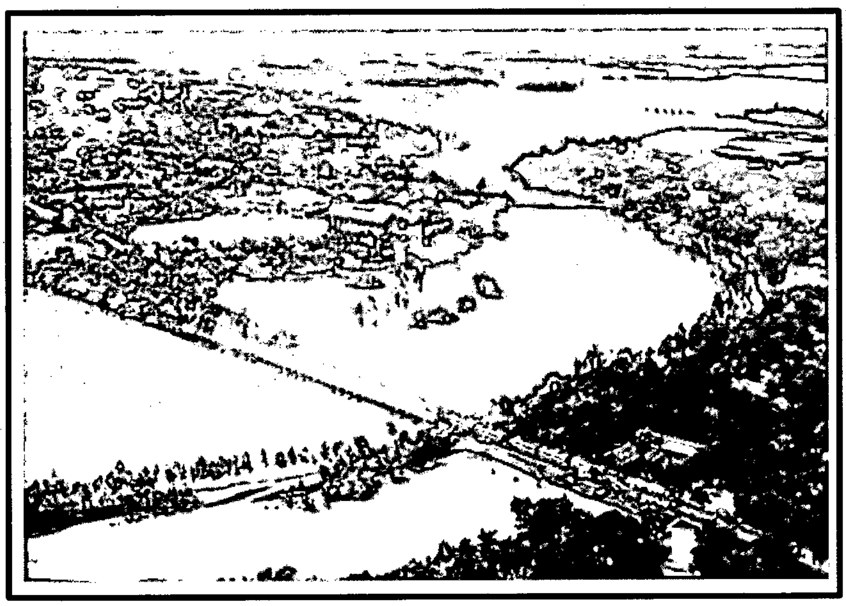

Figure 2.1 Banqiao dam failure

2.3 History

The word *hydraulics* has been derived from the Greek word *Hudour*, which means "water". Hydraulics may be defined as the science that deals with the mechanical behavior of water at rest or in motion. In some contexts it also includes the study of other fluids. The mechanical behavior may entail computing forces and energy associated with fluids at rest or momentum and energy of fluids in motion, or computation of water surface elevation in channels and flood plains, or calculation of discharge, velocity, and fluid potential, and sediment and pollutant transport in hydraulic conduits. The science of fluids at rest is called hydrostatics, and the science of moving fluids is called hydrodynamics (Cruise, Sherif, Singh, 2007).

2.4 Hydrological cycles

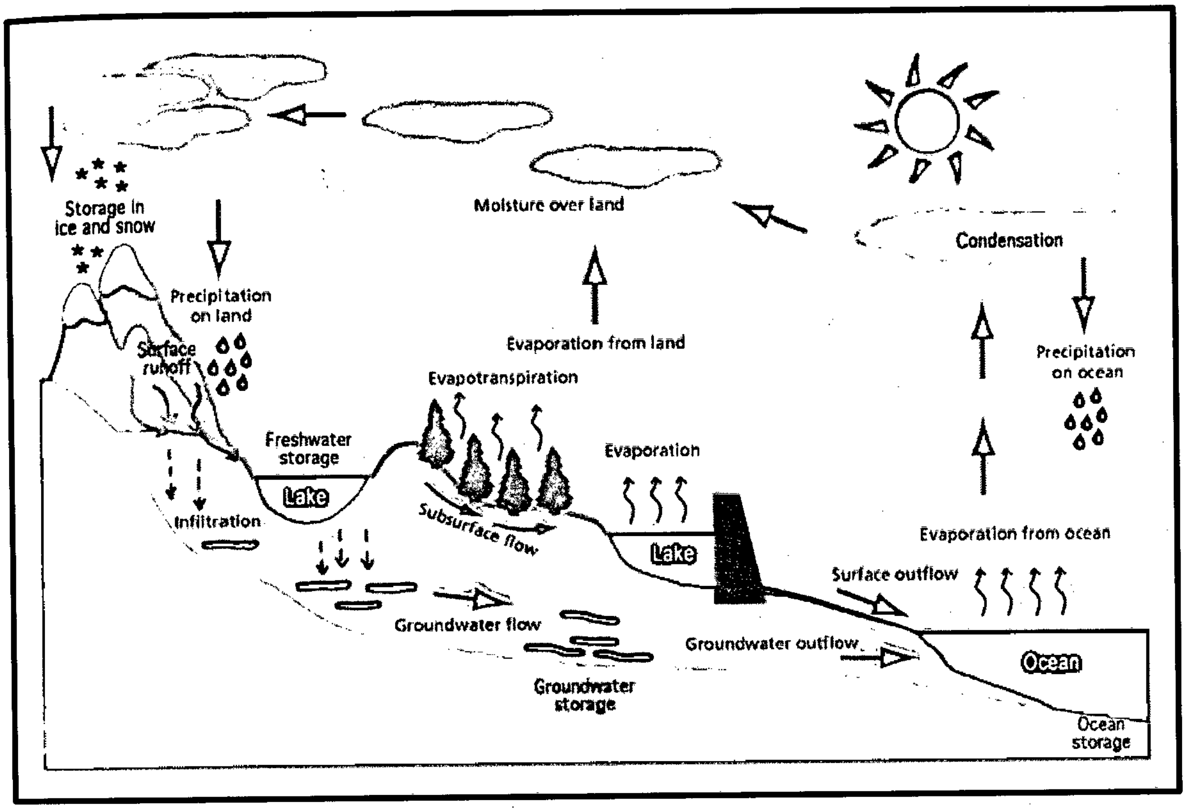

Figure 2.2: Hydrological cycles (Source: http://geofreekz.wordpress.com/the-hydrosphere)

Water is a renewable resource and follows the hydrological cycle, as shown in figure 2. The hydrological cycle is an endless circulation and has neither beginning nor end. It is a natural machine, a constantly running distillation and pumping system. The sun supplies heat energy which, together with the force of gravity, keeps the water moving; from the atmosphere to the earth as condensation and precipitation; from the earth to the atmosphere as evaporation and transpiration, to the oceans as stream flow, and within the earth as stream flow and groundwater movement; and from the oceans to the atmosphere as evaporation (Singh, 1992).