CASE STUDY : I ENERGY DISSIPATER CONSTRUCTED IN KUANTAN

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ABSTRACT

In the construction of the man-made or natural channel, there are various problems that should be taking into consideration especially in the design of the hydraulic open channel. The presence of high flow velocity in open channel can destroy the function of the structure due to erosion and scouring along the channel bed. As a result, maintenance work will be costly. However, this problem can be overcome by reducing the flow velocities in the channel. In order to achieve this aim, an energy dissipater structure is proposed to be constructed in the channel. The objective of this study is to define the capability of discharge channel in the effect of various types of discharge channels, characteristic of flow and flow condition in stepped channel. This study is conducted in Kuantan area. There are five different types of discharge channel used in this study, that is channel without stepped, trapezoidal stepped channel, parabolic stepped channel, rectangular stepped channel and rectangular stepped channel with rock surface. From the graph plotted, a relationship between energy dissipation and different types of channel were gained. The results indicate that rectangular stepped channel with rock surface dissipates more energy compared to other types of discharge channels. Results also show that as the velocity of water increased, the energy dissipation is decreased. Generally, this study has proven that the stepped structure is effective in dissipate energy compared to channel without stepped in the hill area.

ABSTRAK

Pembinaan sistem saluran buatan manusia atau semulajadi sering mengalami pelbagai masalah dan perlu diberi perhatian terutamanya semasa mereka bentuk sistem saluran terbuka. Kehadiran aliran halaju tinggi dalam saluran terbuka boleh memusnahkan fungsi struktur yang disebabkan oleh hakisan didasar saluran. Hasilnya, ia akan melibatkan kos yang tinggi untuk kerja penyelenggaraan. Walaubagaimanapun, masalah ini boleh diatasi dengan mengurangkan halaju aliran. Bagi mencapai matlamat ini, struktur pelesap tenaga perlu dibina di setiap saluran. Objektif kajian ini adalah untuk mengkaji keupayaan saluran terbuka dengan perubahan jenis-jenis saluran, ciri-ciri profil aliran dan keadaan aliran didalam saluran bertangga. Kajian ini dijalankan di kawasan Kuantan. Terdapat lima jenis saluran yang digunakan dalam kajian ini, iaitu saluran tanpa tangga, saluran bertangga berbentuk trapezoid, saluran bertangga berbentuk parábola, saluran bertangga berbentuk segi empat dan saluran bertangga berbentuk segi empat dengan permukaan berbatu. Hubungan antara pelesapan tenaga dan jenis yang berlainan saluran boleh ditentukan dengan memplot graf. Keputusan kajian ini menunjukkan bahawa saluran bertangga berbentuk segi empat dengan permukaan berbatu melesapkan lebih banyak tenaga berbanding dengan jenis saluran terbuka yang lain. Keputusan kajian ini turut menunjukkan bahawa apabila halaju air meningkat, lesapan tenaga akan menurun. Secara umumnya, kajian ini telah membuktikan bahawa struktur bertangga lebih berkesan dalam melesapkan tenaga berbanding dengan saluran tanpa bertangga di kawasan bukit.

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Fr	Froude Number
V	Velocity of flow
y	Hydraulic depth
g	Acceleration due to gravity = 9.81 m/s
Re	Reynold's Number
L	Length
υ	Kinematic viscosity ($\upsilon = \mu/\rho$)
E	Flow energy
ΔE	Energy losses
θ	Slope
h	Height of stepped
Q	Flow rate
A	Flow area
B	Width of stepped
y_c	Critical depth
E_0	Energy at the end of channel
α	Kinetic energy correction factor
N	Number of stepped

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Discharge channels are usually constructed in hill area especially in side of highway. These discharge channels are designed to reduce the velocity flows that move from the high area, also to drain the runoff to minimize water absorption in soil. Soil erosion and landslides may seen due to high water absorption in soil is high. Discharge channels design has been used for a wide range of functions, including dams, overflow channels, public drainage system and many more which aim to reduce the velocity and dissipate energy along the channels.

They also constructed in various shapes. It depends on the slope, type of soil and influences by the rainfall intensity. Design of channels are varies depending on height and slope. In Malaysia, the common shapes of channel that normally constructed are from rectangular, trapezoidal and parabolic shapes as these shapes are the most ideal and easy to maintain. Moreover, rectangular, trapezoidal and parabolic channels are relatively easy to construct and more economical.

The main role of discharge channels is to drain and convey the water from one place to another. Whereas, discharge channels is designed as energy dissipater of high velocity flows. Another purpose in constructing the discharge channel is to improve the water quality and for the aesthetic view. The flow conditions in stepped channel such as skimming flow and nappe flow also can be observed. The formation of skimming flow and nappe flow depend on the change of step height, the discharge and the channel slope.

1.2 Problem Statement

Normally, problem occurs when the downstream velocity is high. Other than that, water that overtopped the roadway affects the damage system due to erosion. This can be observed after a few years been operated. This problem often occurs at the channels end defect such as crack and break can easily be found in culverts that discharge water for rivers and wetlands.

Besides that, another common problem normally occurs is when the channel is unable to accommodate the volume of water. This normally happens in the area with a rapid growth environment. Moreover, with the high volume of water flow, there will be a formation of scour at downstream of a discharge channel due to high velocity that creates hydraulic jump phenomenon. The water will spill out from the channel, due to the above mentioned defect; some amount of water will be absorbed by the soil and reduced the slope stability.

Therefore, this work focused on the study of how is important to provide a proper design of discharge channels. Otherwise, flash flood or overflow of water to the

roads may happen repeatedly. This will cause damage to the road and difficulties for the road users and the authorities.

1.3 Objectives of the Study

The objectives of this research are as:

i. To study the capability of energy dissipater in discharge channels in the effect of changes types of discharge channels.
ii. To identify the characteristic of flow profile for five different type of discharge channel.
iii. To study the flow condition in stepped channel.

1.4 Scope of Study

This study focuses on the aspect of flowing water in discharge channels in hill area. The channel without stepped, trapezoidal stepped channel, parabolic stepped channel, rectangular stepped channel and rectangular stepped channel with rock surface are the types of the selected in this study.

The selected sites are in Kuantan area where there are numbers of discharge channel constructed along the hill area. Five different types of drain system will be conducted with the different on stepped height and channel slope. Observation on the flow profile will be done during heavy rain.

1.5 Significant of study

The significant of this study is to give more exposure to the future engineers to design the suitable channels in slope area. It will give opportunity for engineers to evaluate the channels that should be use in sloping area based on the data obtained.

Moreover, the important of this study is to ensure that the energy dissipated, at the downstream is smaller compared to the energy in the upper channel. Besides that, it is hope that this study will also help and give ideas to engineers to assess the effectiveness of stepped channel and choose the best form of geometric design. Furthermore, it is hope that this work gives clearer information on the differences between channels without stepped and stepped channel. Indeed, damage to the channels structure can be avoided by selecting the most effective form of design. Hopefully, this study will help the researches in the future.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Stepped channel is the channel that has series of stepped on the face of channel. The stepped on this channel can dissipate amount energies carried by the water that flow along the channel. This channel is intended to reduce the velocity of water that flow along the channel.

A stepped channel has been used as an energy dissipater of high velocity in steep slope. According to Chanson.H (2001-2002), the stepped spillways, weirs and channels have been used for over 3500 years since the first structure built in Greece and Crete. The stepped design is recognised for its energy dissipation that required in preventing scour and erosion of the invert and the banks as shown in figure 2.1.

Figure 2.1: Stepped channel that usually seen in hill area.

Moreover, the stepped channel might be utilized for an aesthetic view. According to Chanson.H (2001-2002), the expertise on stepped spillways design was spread around the Mediterranean area by Romans, Muslims and Spaniard successively. Although the early stepped cascades were built in cut-stone masonry or timber, a wider range of construction materials were introduced during 19^{th} century. During 16^{th} to 18^{th} centuries, numerous of 'Grandes Cascades' were built for aesthetic purpose. Figure 2.2 shows the old stepped weir been used in early BC1300.

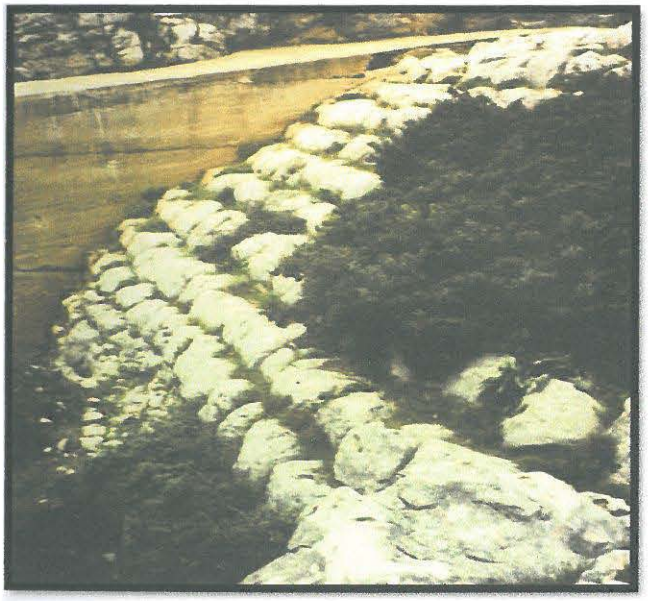

Figure 2.2: Old stepped weir (dam) in Akarnania, Greece B.C. 1300

2.2 Open channel

Open channel flow is also known as a free surface flow. A free surface is subjected to atmospheric pressure. According to Chow.V.T. (2008), open channel flow is a branch of hydraulic, is a type of liquid flow within a conduit with a free surface, known as a channel.

A diagram for open channel flow is shown in figure 2.3. This is simplified by assuming parallel flow with a uniform velocity distribution and that the slope of the channel is small. In this case the hydraulic gradient is the water surface as the depth of water corresponds to the piezometric height. Flow conditions in open channels are complicated by the position of the free surface which will change with time and space.

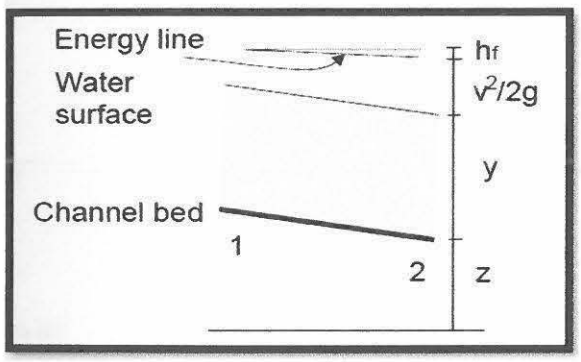

Figure 2.3: Open channel flow

2.3 Type of flow

Open channel flow can be classified and described in various ways based on the changed in flow depth with respect to time and space.

In a time as a criterion, flow can be divided into two types that are steady flow and unsteady flow. In steady flow, the depth of flow does not change over time, or if it can be assumed to be constant during the time interval under consideration. If the depth of flow does change with time, the flow is considered as unsteady flow.

In a space as a criterion, flow can be divided into uniform flow and varied flow. Uniform flow is happen when the depth of flow is the same at every section of the channel. Uniform flow can be steady or unsteady, depending on whether or not the depth changes with time. Varied flow is happen when the depth of flow changes along the length of the channel.

2.4 States of flow

2.4.1 Effect of Gravity

Froude number is a dimensionless number defined as the ratio of characteristic velocity to a gravitational wave velocity. Froude number also may define as the ratio of a body's inertia to gravitational forces. Froude Number is written as;

$$Fr = \frac{v}{\sqrt{gy}} \tag{2.1}$$

where,

V = velocity of flows (m/s)

y = hydraulic depth (m)

g = acceleration due to gravity

When Froude Number is less than 1.0, the flow is classified as subcritical flow. It is called critical flow when Froude Number is equal with 1. If Froude Number is greater than 1, the flow is supercritical flow. When the supercritical flows meets the subcritical flows, and then the hydraulic jumps will occurred.

2.4.2 Effect of Viscosity

Reynolds number, Re is a dimensionless number that gives a measure of the ration of inertial force to viscous forces. Reynolds number is defined by;

$$\mathrm{Re} = \frac{vL}{\upsilon} \tag{2.2}$$

where,

v = mean velocity (m/s)

L = length of fluid (m)

υ = kinematic viscosity ($\upsilon = \mu/\rho$) (m^2/s)

For an open channel the limits for each type of flow become laminar flow when the Reynolds Number is less than 500. It is consider as turbulent flow when the Reynolds Number is greater than 12500. It is called transitional flow when $500 < \mathrm{Re} < 12\,500$.

2.5 Velocity Flow

Velocity is the total flow rate per unit area of channel section or total distance per unit time where the velocity is expressed in unit m/s. Flow is reached high velocity if water is passing through a narrow section along the channel where the capacity of water is larger than the channel area.

According to Amat Sairin Demun in his book ' Hidraulik Saluran Terbuka' (1997), when the water driven at high velocity a lower zone of velocity, the water level immediately increased followed by violent turbulence, whirlpool and wave. This is called as hydraulic jump. Hydraulic jump usually occur when the supercritical flows meets the subcritical flows. There is no jump happen if the water flows below the critical speed. For the initial flow speed which is not significantly above the critical speed, only an undulating wave in water will appear.

2.6 Energy Dissipater Structure

Energy dissipater is a structure to reduce the fast moving flow, in order to prevent erosion at the downstream channel.Water flow along the channel is driven by the gravitational force. Therefore, with the increasing of height in stepped channel, the magnitude of the flow velocity would be large. This may produce a very high kinetic energy which can erode the banks and downstream channel gradually and in the long term could damage the structure itself. To prevent this from happen, the energy need to be reduced. This can be done with the construction of energy dissipater structure along the channel.

According to Locher and Hsu (1984) the energy dissipater structure is a structure that can change the flow velocity as it is able to reduce the high kinetic energy produced from the critical speed to low energy with a slower flow. Generally, the

energy dissipater structure is used in each section which has high velocity either in the upstream or downstream flow.

2.7 Shape and Type of Flood Discharge Channel

There are various type of structures have been design for the purpose to reduce the very high velocity flow in sloped area. Structure that commonly found in sloping area is channel without stepped and stepped channel.

2.7.1 Channel without stepped

This channel usually used to convey water with low discharge as this channel cannot dissipate energy and reduce the flow velocity. Moreover, this channel also usually built at the river banks. To design this channel, there are no specific calculations that have been used. Figure 2.4 shows example of channel without stepped in Portugal.

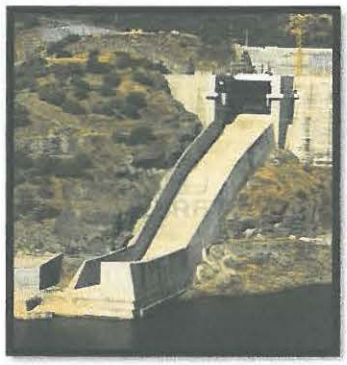

Figure 2.4: One of Alqueva dam chute spillway, in Portugal.

2.7.2 Stepped Channel

Stepped channel can be divided into five types, trapezoidal stepped channel as shown in figure 2.5, rectangular stepped channel as shown in figure 2.6, parabolic stepped channel as shown in figure 2.7, circular stepped channel and triangular stepped channel.

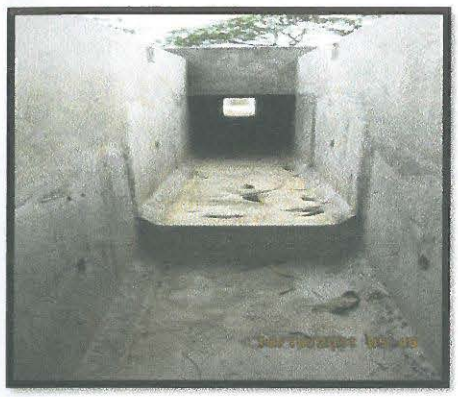

Figure 2.5: Trapezoidal stepped channel

Figure 2.6: Rectangular stepped channel

Figure 2.7: Parabolic stepped channel

2.8 Local phenomena

A local phenomenon occurs when the flow changes in a short period of time and at a short distance, from supercritical flow to subcritical flow and vice versa. It can be seen from the changes of flow from low levels to high levels and vice versa. There are two local phenomena that are hydraulic jump and hydraulic drop.

2.8.1 Hydraulic Jump

Hydraulic jump is a phenomenon when water is flow at high velocity discharge

into a zone of lower velocity, a rather abrupt rise occurs in the surface of water as defined in figure 2.8.

Hydraulic jump occur when the flow of water is change from the supercritical flow to a subcritical flow, in which when the height increase, the velocity will decrease. Hydraulic jump does not occur from subcritical to supercritical flow. Hydraulic jump for stepped channel is shows in figure 2.9.

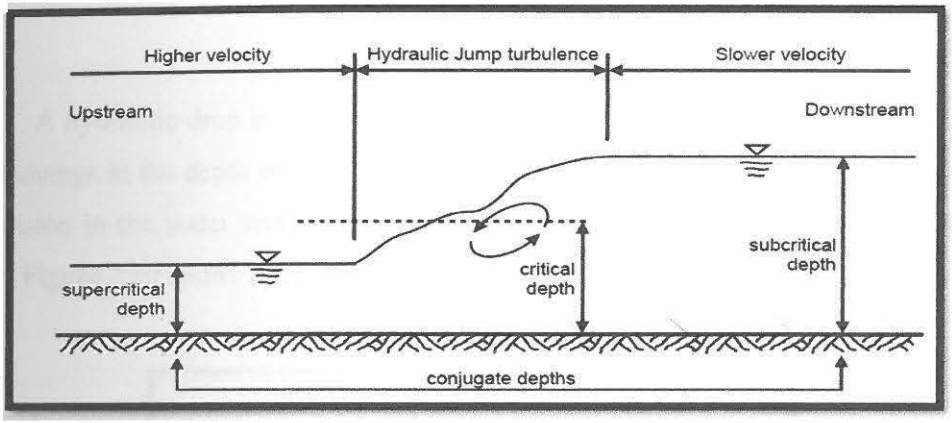

Figure 2.8: Side view of hydraulic jump (flow is from left to right)

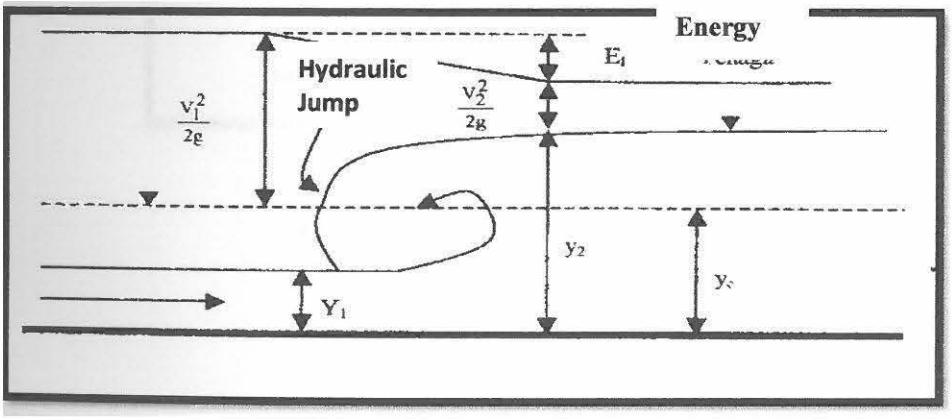

Figure 2.9: Hydraulic jump phenomenon