THE EFFECTIVENESS OF THE CYLINDER BLOCK ON STILLING BASIN AS ENERGY DISSIPATION SYSTEM

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ABSTRACT

Flow discharge from a spillway to is due to the force of gravity. Therefore, the steeper the outlet spillway, the magnitude of flow velocity will higher. Consequently of high velocity is able to cause erosion and will damage spillway itself. To overcome these problems, the velocity must be reduced. To achieve the purpose, the used of velocity reducing structures are recommended. Many researches have been conducted to identify the effectiveness and economical of velocity reducing structures. Velocity reducing structures is one of the hydraulics structures that reduce high velocity water flow especially at downstream of the spillways. The objective of this study is to determine the performance and effectiveness of velocity reducing structures on the stilling basin through laboratory test. In this study, tests are conducted on cylindrical shape blocks of the velocity reducing structures on the stilling basin. The blocks used in this study have different size and surface roughness, different slope of spillway and different flow rate. The spillway model was erected at the workshop. During the test, the flow depth and velocity are observed before and after the blocks locating on the stilling basin. For concrete blocks size 50×100mm with slope 27˚, the best pattern with a highest percentage reduction in velocity is pattern 3 with 47.03% and for slope 15˚ the percentage reduction in velocity is 50.12%. Based on the results, its shows that the lower slope can increase the percentage of reduction in velocity.

ABSTRAK

Air yang mengalir keluar dari alur limpah yang disebabkan oleh daya graviti. Oleh itu, semakin ke bawah alur limpah keluar, semakin besar magnitud halaju aliran. Halaju yang tinggi mampu menyebabkan hakisan dasar dan tebing saluran alur limpah secara beransur-ansur dan akhirnya boleh merosakkan alur limpah itu sendiri. Untuk mengatasi masalah ini, halaju perlu dikurangkan. Bagi mencapai matlamat ini, struktur pengurangan halaju dicadangkan. Banyak kajian telah dijalankan untuk mengenal pasti keberkesanan dan ekonomi struktur pengurangan halaju. Struktur pengurangan halaju adalah salah satu struktur hidraulik yang mengurangkan aliran air halaju tinggi terutama di hilir alur limpah. Objektif kajian ini adalah untuk menentukan prestasi dan keberkesanan struktur pengurangan halaju di lembangan penenang melalui ujian makmal. Kajian ini melibatkan pengunaan struktur pengurangan halaju berbentuk blok silinder struktur yang diuji di lembangan penenang. Blok-blok yang digunakan dalam kajian ini mempunyai saiz dan kekasaran permukaan blok yang berbeza, berbeza cerun alur limpah dan kadar aliran yang berbeza. Model alur limpah telah didirikan di bengkel. Semasa ujian, kedalaman aliran dan halaju diukur sebelum dan selepas blok disusun di lembangan penenang. Untuk blok konkrit saiz 50 × 100mm dengan kecerunan 27˚, corak yang terbaik dengan pengurangan peratusan tertinggi dalam halaju adalah corak 3 dengan 47.03% dan untuk cerun 15˚ pengurangan peratusan halaju adalah 50.12%. Berdasarkan keputusan itu, menunjukkan bahawa cerun yang lebih rendah boleh meningkatkan peratusan pengurangan halaju.

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LIST OF SYMBOLS

v	Velocity
v_0	Initial velocity
y	Measured flow depth
y_0	Initial flow depth
Q	Flow rate
D	Hydraulic depth
g	Gravity
p	Pressure
γ	Specific gravity of the fluid
E	Energy
p	Density of the fluid
μ	Viscosity of fluid
L	Length or diameter of the fluid
S	Bottom slope of channel
A	Cross-sectional area of flow
R	Hydraulic radius
θ	Angle of channel with the horizontal
P	Wetted perimeter of cross-sectional flow area
n	Manning roughness coefficient
Fr	Froude number
m^2	Meter square
mm	Millimetre
m	Meter
m^3/s	Meter cubes per second
m/s	Meter per second

LIST OF ABBREVATIONS

Symbol	**Item**
USBR	United States Bureau of Reclamation
MSMA	Urban Stormwater Management Manual
SAF	St. Anthony Falls

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Phenomenon of surface runoff, river flow and flooding are a natural event. This phenomenon has given opportunity to engineers to study the accident that happen to find a solution so that incidents such as erosion and scour at hydraulics structure can be avoided. Flow through each open channel of courses involves water velocity and the velocity will depend on the slope of the channel. Channel slope will produce a high water velocity and high kinetic energy that can produce adverse effect such as erosion and scour that can damage the banks and bed of the open channel.

Stilling basins are often used for smaller velocities while for higher velocities; it can't be used because of concern with cavitation damage, unstable flow, large spray production and tail water wave generation (Vischer and Hager, 1998). Stilling basin is one of the elements that can reduce energy action of water. The common method for dissipating the flow at the toe of spillways is the hydraulic jump. Spillways are the combination of structure and equipment required for safe operation. The function of spillways is to control the water release without effect any erosion.

Energy dissipation at the weir and dam is closely related with spillway design and must ensure discharge of the flow to the river with low residual energy. At high dams with large spillways, the magnitude of energy that must be dissipated is enormous. For example, the maximum energy can be dissipated at the auxiliary spillways and the Tarbela dam service at the site is 40 000 MW which is, 20 times than the planned generating capacity (Locher and Hsu, 1984).

Although there are lots of research on the structure of the energy dissipate were carried out, the on-going studies should be undertaken to produce the most efficient structure and more effective in addition to the economic structure. Therefore, a detailed study carried out on channel model that construct in a laboratory. The focus of the study involves the flow of movement caused by the gravitational force that occurs in the hydraulic system.

1.2 PROBLEM STATEMENT

Nowadays, development of science and high technology has helped in the construction of hydraulic structures such as dams and ambitious. Such structures have create many problems such as water hydraulic detained behind the dam certainly produce high pressure. Therefore, one for ways to reduce the hydrostatic pressure is to build out the shape of the channel spillway.

Transmission water out through the overflow will cause high velocity flow. No doubt, the high flow velocity will cause an impact far into the hydraulic structures and the environment can affect the functioning of the system. Problem that often occurs is that erosion, scour and turbulent flow. Besides that, high flow velocity causes the process of transfer and settling sediment.

Dissipation of the kinetic energy that produced at the base of a spillway is important for bringing the flow into the downstream. Various types of energy release have been developed to suit different conditions but the limits on use are vaguely defined. To protect this hydraulics structure, it is necessary to employ energy dissipaters (Khatsuria, 2005).

1.3 OBJECTIVES

In general, this study aimed to design structures for energy dissipaters of water that may be more efficient and effective. The selection of the structural design of these energy dissipaters is to reduce the energy of water in the stilling basin.

The objective of this study is to:

(i) To determine suitable size of cylinder block and roughness regarding to effective velocity reduction.
(ii) To analyse the effect of cylinder block as energy dissipater.

1.4 SCOPE OF STUDY

This study was focuses on the effectiveness structure to energy dissipate in the cylinder shape to reduce energy in the stilling basin. The experiment of this system was carried out in a laboratory hydraulic, UMP.

The scope of study is:

(i) Fabricated model to the 32 mm, 40 mm and 50 mm diameter of cylinder for stilling basin.
(ii) Roughness between the plastic and concrete cylinder.
(iii) Cylinder arrangement involving pattern for the best design of structure for energy dissipate system.
(iv) The spillway model test at gradient (27^{o} and 15^{o}).
(v) Experiment is conducted in open channel at Hydraulic & Hydrology Laboratory of Faculty of Civil Engineering & Earth Resources, University Malaysia Pahang.

Figure 1.1: Open Channel in Hydraulics & Hydrology Laboratory of Faculty Civil & Earth Resources, University Malaysia Pahang.

1.5 IMPORTANCE OF STUDY

The importance of this study is to observe the effectiveness of using concrete and pipe as energy dissipating structure to create hydraulics jump. This study is important in order to produce an efficiency structural design energy dissipate of the most effective and economic structural. Besides expose civil engineer to various type of energy dissipate that have been design and constructed, it also make them aware of the problem that may be able to happen such as erosion, scour and sedimentation. If the result is satisfactory, then the material can be applied as energy dissipates.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this topic, discussion will focus on the state of the surface flow in an open channel. Structure design in cylinders shaped made from concrete and plastic surface will be test to know the effectiveness as energy dissipate. Therefore, deep understanding should be focused on the flow conditions, the characteristics of the structure, and the structure design of the model used to generate the structure that most efficient and effective manner for energy dissipates.

2.2 HYDRAULIC JUMP

Hydraulic jump analysis is the most common application of the momentum in open channel flow. Hydraulic jump occurs in the transition from supercritical to subcritical flow. The abrupt change in of the intense turbulence condition will cause mixing and energy dissipater. It is often used at downstream of spillways and drop structure to prevent erosion and dissipate energy in the downstream channel. Figure 2.1 show the hydraulics jump in a river.

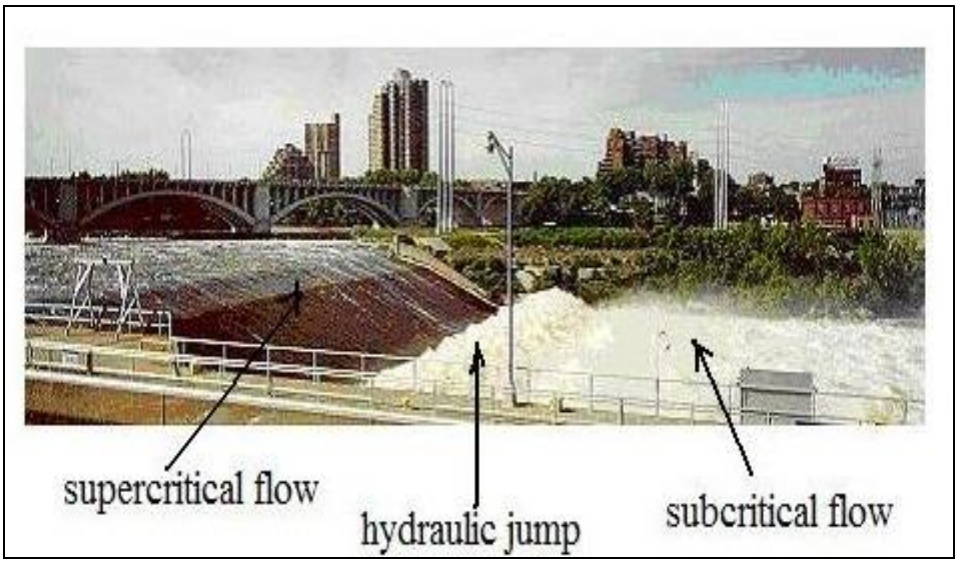

Figure 2.1: Hydraulics Jump at St. Anthony Falls on the Mississippi River

Source: Matthiasb (2001)

2.2.1 Types of Jump

Hydraulics jumps on horizontal floor could result different type of jump. Hydraulics jump can be classified according to the Froude number, Fr. The flow is critical when Fr = 1 and no jump can form. While for Fr = 1 to 1.7, it called as undular jump because the water surface is shoes undulations.

Next, for Fr = 1.7 to 2.5, on the surface of the jump, occur a series of small rollers , but the downstream water surface remains smooth, the jump can be called weak jump. The velocity is fairly uniform and the energy loss is low. Fr in range 2.5 to 4.5 is when there is an oscillating jet entering the jump bottom to surface and back again with no periodicity. Each oscillation will produces large wave of irregular period which very commonly in canals. Energy loss can be between 25 to 50%.

Furthermore, Fr = 4.5 to 9.0 which the downstream extremity of the surface roller and the point at which the high velocity jet tends to leave the flow occur at practically the same vertical section may be called a steady jump. The energy dissipaters range from 50 to 70%. The action and position of this jump are least sensitive to variation in tail water depth.

For the highest range Fr = 9.0 and larger, the high-velocity jets grabs intermittent slugs of water rolling down the front face of the jump, generating waves downstream and a rough surface can prevail. This jump can be called a strong jump because the rough action but effective since the energy dissipater can be more than 70%. Figure 2.2 shows flow profile according to Froude number as stated in Table 2.1.

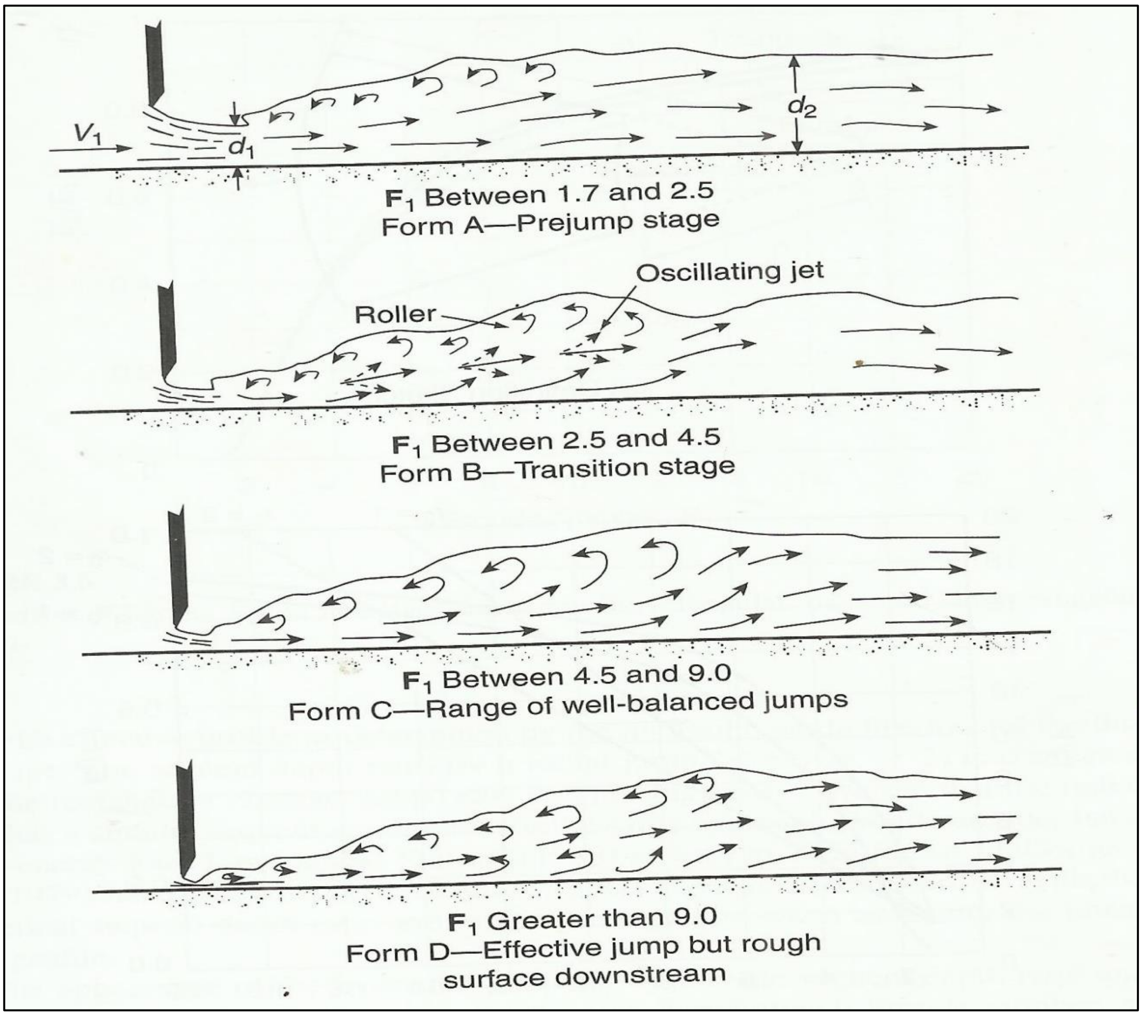

Figure 2.2: Flow profile according to Froude Number

Source: Nile Basin Capacity Building Network (2010)

Table 2.1: Jump characteristics according to Froude Number

Froude Number, Fr	Jump Characteristics
1.0-1.7	Surface waves (Undular)
1.7-2.5	Weak jump. Low energy loss
2.5-4.5	Oscillating. Large irregular waves
4.5-9.0	Steady jump
>9.0	Strong jump

Source: Nile Basin Capacity Building Network (2010)

2.3 SPILLWAYS

Spillways are structures constructed to provide safe release of flood waters from a dam to a downstream, normally the river on which the dam has been constructed. Spillway is usually used to remove water from a reservoir to prevent overflow and to release pressure on a dam from increasing quantities of water.

Many parameters need consideration in designing a spillway. These include:

(i) The inflow design flood hydro-graph.
(ii) The type of spillway to be provided and its capacity.
(iii) The hydraulic and structural design of various components.
(iv) The energy dissipation downstream of the spillway.

The topography, hydrology, hydraulics, geology and economic considerations all have a bearing on these decisions to design the spillways. Figure 2.3 shows one example of spillways on Claerwan Dam in Mid-wales.