CHANNEL ROUGHNESS OF EARTHEN CHANNEL FOR TROPICAL CONDITIONS

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Universiti Malaysia Sarawak
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Approval Sheet

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Abstrak

Tujuan disertasi ini ialah mendapatkan nilai *Manning n* atau fator rintangan aliran air untuk saluran bumi di kawasan tropika. Nilai yang didapati kemudianya dibandingkan dengan dokumentasi yang berkaitan, terutamanya dari buku *Open Channel Hydraulic* oleh Chow.

Penentuan nilai Manning n ialah dengan menggunakan program komputer yang bernama *HEC-RAS*. Pengunaan utamanya ialah untuk mengukur profil permukaan air dengan keadaan aliran air yang sudah diketahui. Nilai *Manning n* adalah diperlukan dalam pengiraan profil permukaan air. Nilai sebenar Manning n adalah didapati dengan kaedah cuba-cuba. Ini adalah dengan menyamakan nilai profil yang didapati dari pengiraan dengan nilai sebenar dari kerja ukur.

Keputusan akhir dibandingkan dengan hasil analisis yang menggunakan satu lagi program komputer yand dinamakan Flow Master dimana pengiraan adalah berpandukan persamaan *Manning* untuk satu keratan rentas.

Abstract

The aim of this dissertation is to find the Manning *n* or friction factor of flow for earthen channel of different tropical conditions. These findings are than compared with the documented information regarding value of Manning *n* by Chow(1959).

Determination of Manning *n* by using computer program named HEC-RAS. Which main usage is in the computation of water surface profile base on known flows. Manning *n* value is one of the pre requirement to able the water surface calculation. The actual value of Manning *n* is calculated by trial and error method, in an attempt to match the observed water surface profile observed in the field.

The final result is then cross checked with the analysis using another hydraulic computer program called Flow Master which able to calculate Manning n for a particular cross-section using Manning Equation.

CHAPTER 1

INTRODUCTION

1.1 Overview

The study of open channel flow is one of the major topics that effect or govern the works of hydraulic engineering and water resources engineering. Besides the design of hydraulic structures such as culvert, bridges and etc, the study of open channel flow is also important for design in water supply and flood estimation.

The flow of a channel or river can be measured provided that we have the information that will contribute to the flow conditions. For practical purposes, the main parameters that are taken into considerations for the channel flow are:

a) ***Dimension of the channel*** that is the cross-sectional profile that can be used to calculate the area of flow, wetted perimeter of flow, and hydraulic radius for a channel;
b) ***Channel slope*** which give the value of difference in energy to allow the flow to happen;
c) ***Channel roughness***, which represents the friction between the surface of water volume and the contact materials.

For the above three main parameters that govern the flow of a channel, the first two are relatively easier to measure where as the last one taking into consideration of

longitudinal channel shape/profile, obstruction, soil type, grain size of soil, vegetation etc which may differ quite significantly from one site to another. It is nearly impossible to generate a straightforward formula to calculate the channel roughness. Most of the equation which had been documented are subject to empirical consideration, in other word, those formulae can only be used with additional local physical information. Therefore, the value of channel roughness can only be tabled according to the surrounding condition which is more to descriptive and the users of these tables have to take consideration of local conditions in order to obtain a accurate result.

1.2 The Purpose

This project is concentrated in finding out the channel roughness for earthen channel for tropical conditions. Based on the channel pattern, different soil, vegetation, and other surrounding physical condition. The result will be compared with the existing documentation, which were obtained from non-tropical countries, such as Britain, Unite State, Canada, Australia and West Europe.

The channel roughness or friction factor, usually annotated as n is one of the main parameter in calculation of river flow or open channel flow. The value n for different conditions had been tabulated by researcher from different places which had advanced hydraulic engineering. Most of these finding of value n are base on local condition, and most probably located at the developed countries. The developing contries, especially those at the tropical area are subject to different physical (Weather, Geology, hydrological) conditions compared to the developing countries which have been

mentioned above. It is necessary to tabulate a list of n values which are based on the tropical condition.

1.3 Commercial Value

The value of n greatly effects the design of the hydraulic engineering works such as flood mitigation, irrigation system, hydrological studies for hydraulic structures, etc. The alternated value n for a design will cause cost saving and ensures greater factor of safety. Besides that this will give the designer of the above works a better confidence in their design.

1.4 Output

The main aim of this project is to find an actual n value for a specific condition; n value may differ greatly from one location to another due to difference in soil condition, vegetation and channel shape. In addition, the project also aims to develop a sound method to establish the value n .The channel or river conditions are differing from one site to another, for this project, survey had been done at the part of the channel which has a straight stretch. Basically it is only valid for the design for the artificial channel which are designed as straight channel to ease the work design, construction, operation and maintenance. For the work of flood estimation, hydrological analysis, the value n has to be used by taking into different consideration which might greatly alter the value.

CHAPTER 2

LITERATURE REVIEW

2.1 Determination of Manning's Roughness Coefficient

In order to give guidance in the proper determination of the roughness coefficient, four general approach have to be consider according to Chow(1959):

a) Understand the factors that affect the value of n and that affect the value of n and thus to acquire a basic knowledge of the problem and narrow the wide range of guesswork.

b) Consult a table of typical n value for channels of various types.

c) Examine and become acquainted with the appearance of some typical channels whose roughness coefficients are known.

d) Determine the value of n by an analytical procedure based on the theoretical velocity distribution in the channel cross section and on the data of either velocity or roughness measurement.

This dissertation is a topic under open channel flow. The fundamental open channel flows are as follow.

2.2 Open Channel flow

Open channel flow is the flow of a conduit with a free surface. The concept that relating to flow in channels with a free surface probably is the most complex ones of the

science of hydraulics. Yet, it is too important to know this topic in order to understand the behavior of water in creeks, rivers, and artificial channels.

2.2.1 Open Channel Vs Pipe flow

Flow in an open channel or a duct in which the liquid has a free surface differs from flow in pipes in so far as the pressure at the free surface is constant (atmospheric) and does not vary from point to point in the direction of flow, as the pressure can do in a pipeline. A further difference is that the area of cross-section is not controlled by the fixed boundaries, since the depth can vary from section to section without restraint.

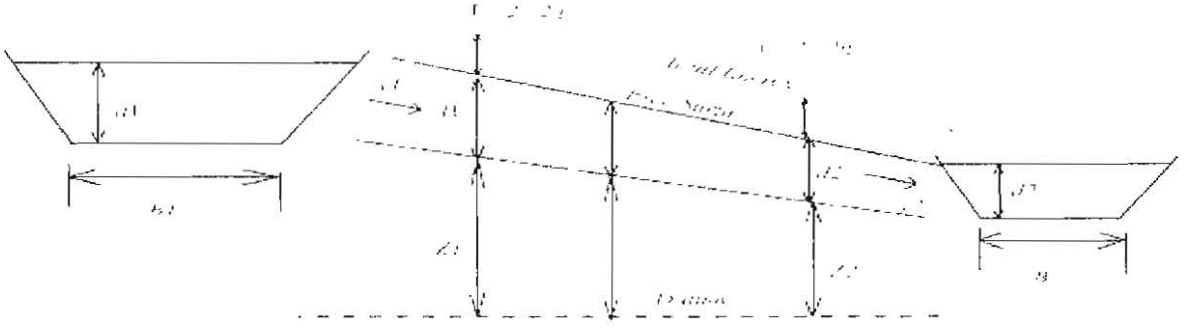

Figure 2.1 Open channel flow

The continuity, momentum and energy equation can be applied to channel flow in the same way as for pipe flow.

2.3 Classification of Open Channel

A channel may be classified either natural or artificial according to its origin. Most of the natural channels are irregular, empirical assumptions are needed parallel to theoretical hydraulic for studies of these channels. Artificial channels are constructed

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directly or indirectly by human effort. The hydraulic properties of artificial channels can be control and designed according to certain requirements, therefore, theoretical hydraulic can be fitted to the actual condition of the channels Therewith, the application of hydraulic theories to artificial channels will produce fairly accurate results for practical design purpose.

2.4 Channel Geometry

A channel could be either prismatic channel with fixed cross-section (perpendicular to flow) and constant bottom slope or non-prismatic channel, which doesn't, has above properties. Natural channels have varying form of section while artificial channels are usually designed with sections of regular geometric shapes.

2.4.1 Geometric Elements of Channel Section

Geometric elements are properties of a channel section that can be defined entirely by the geometry of the section and the depth of flow. These elements are very important and are used extensively in flow computations.

2.4.2 Definitions of channel geometry

Table A2.1 shows the channel geometry.

2.5 Velocity Distribution in a Channel Section

Velocity in an open channel flow is not uniformly distributed in the section. This is due to the presence of a free surface and the friction along the channel wall. The maximum velocity usually occurs at a distance of 0.05 to 0.25 of the depth of flow, the acloser to the bank the deeper the maximum Besides depth, other factors such as the unusual shape of the section, channel roughness of channel, presence of bends etc. *As a result of distribution of velocities over a channel section, the velocity head of an open channel flow is generally grater than the value computed according to the expression V2/2g.* If the energy principle is used in computation, the true velocity head may be expressed as $\alpha V/2g$, where α is known as energy coefficient or Coriolis coefficient. The value of α varies from 1.03 to 1.36. This value is generally higher for small channels and lower for large streams of considerable depth.

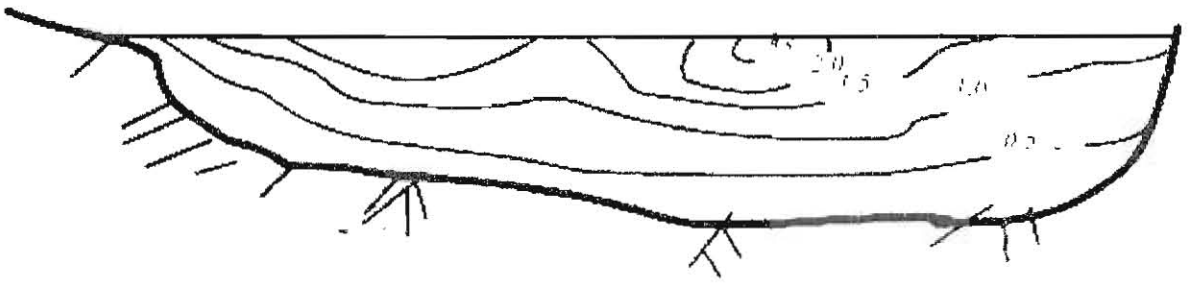

Figure 2.2 Velocity distribution

2.6 Open channel flow formulation

In channel other than those of rectangular shape the depth of the water is variable in each cross section along the flow line. For this reason, it is convenient for

computational reasons to introduce the concept of average depth. Average depth is computed by dividing the cross-section area of the flow by the width of the water surface, B. Both of these values are to be measured in a plane that is perpendicular to the direction of the velocity. Hence, the average, or hydraulic, depth is defined as

$y_{ave} = A/B =$ flow area / surface width

By such averaging irregular channels may be considered as rectangular in shape. The velocity in any channel is variable across the flow area because of the boundary layer effects along the channel boundaries. In practice, the magnitude and direction of the velocity measured at various points in the cross-sectional area are rarely found to be uniform and parallel to the direction of the channel. For the purpose of hydraulic computations an average flow velocity is used; this is defined as the discharge of the flow divided by its cross-sectional area.

For a given discharge, there exist some characteristic depth values that serve as guideposts describing the flow. For instance, when only the effect of gravitation is considered the law of minimum energy manifests itself in the form of the *critical depth*. Another set of guideposts are the *conjugate depths*, which refer to the two possible depths at which a given discharge may flow given the same amount of hydraulic energy The third important characteristic depth is the *normal depth*. This one refers to the depth at which the given discharge would flow down the channel such that the energy ained by gravity would balance the energy lost by friction. In hydraulic design these values are often needed as parts of the computational procedure. However, they should not be construced to be actual flow depths associated with the discharge given. The real depth of the flow at any point of the channel is controlled by upstream

2.7 Manning Equation

In regard to the computational difficulties associated with the analysis of flow in open channels, a simple methods for discharge calculations have developed formulas for the case when the energy grade line is assumed to be parallel with the bottom slope of the channel. In this simplified case the energy gained by the water at any point equals exactly the energy lost through friction. Since there is no acceleration or deceleration along the channel, the depth as well as the kinetic energy term ($v^2/2g$) remains constant. In turn, this means that the slope of the energy grade line S_e must equal the slope of the channel bottom, S; that is, we assume for such flow that

$$S_e = (H_2 - H_1) / L \qquad (2.1)$$

In which H_2 and H_1 are the downstream and upstream channel-bottom elevations, respectivelyu, and L is the length of the channel.

In natural, the channel-bottom slope is rarely uniform; the roughens and the cross-section area of the channel vary form section to section. Thus, it is clear that this zero acceleration condition rarely occurs in practice, but the savings in computation as well as the uncertainty associated with the determination of the true expected discharge undoubtedly make the approach worthwhile. The flow with no acceleration or deceleration is called *normal flow*.

Normal flow in open channel is computed by the Chezy formula which states that:

$$v = C(RS)^{1/2} \qquad (2.2)$$

where: C = Chezy's resistance coefficient

v = average velocity

S = slope of the channel ($S = S_e$)

The depth corresponding to such flow is called normal depth y_n. R in above equation is called hydraulic radius, which is,

$$R = A/P \qquad (2.2.1)$$

Where P is the wetted perimeter of the channel, that is, the length of the line along which the water is in contact with the channel bottom in the cross-sectional area A of the flow. In reality, R is not a radius at all. It is a geometric parameter indicating the efficiency of the cross section; A is a positive and P a negative contributor to the movement of the water, since the more bottom surface there is the create frictional resistance, the more the flow is retarded. Conversely, the larger the flow area is compared to P, the easier the water will move.

C in the equation 2.2 above is Chezy's channel resistance coefficient, an experimentally determined factor. Based on a great deal of measurements in the field and in laboratory channels since the beginning of the nineteenth century, the value of C was determined in metric units to be

$$C = (1/n)\ R^{1/6} \qquad (2.3)$$

In which n is Kutter's coefficient, a resistance factor referring to the condition of the channel. Combining the equations 2.2 and 2.3, we obtain the following equation:

$$V = \frac{1}{n} R^{2/3} S^{1/2} \tag{2.4}$$

V = velocity	S = Slope of energy line
R = Hydraulic Radius	*n* = Coefficient of roughness

Which is called Manning equation.

2.8 Factors Affecting Manning's Roughness Coefficient

Table A2.2 states the factors that affecting the Manning Roughness Coefficient

2.9 Table of Manning Roughness

Table A2.3 in the Appendix shows the values of roughness coefficient developed by Chow.

2.10 Manning Roughness for Tropical Condition

The values provided in the books are mainly based on the book Open-Channel Hydraulic by Chow. These values are only for the quick reference that may not give accurate values. The reference in the related book has to be used vary carefully since it is base on channel from particular site. The user of this table also have to consider the locality effects which includes weather condition, bank and bed materials, suspended materials and etc.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The project requires field works and desk analysis/computer analysis to obtain the results. The basic process that need to be gone through are as follow:

- Selecting the appropriate channels for analysis.
- Survey work or field work which include cross sectional survey/profile survey, water slope, flow velocity, taking soil sample at the selected site which are required by the method of analysis.
- Transfer the raw data from the fieldwork into the computer for calculation.
- Calculation of Manning *n* with two different methods.
- Comparison of the result for different method of analysis with the existing documentation.