STUDY ON ROUGHNESS COEFFICIENT AT NATURAL CHANNEL

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ABSTRACT

Roughness coefficient for open channel has been study widely to alleviate engineers to manage flood problem or to design the hydraulic structures. Dissimilarity of n values occurs especially at two or more different locations due to channel properties, geometry and other factors. The study was carried out Parit Karjo channel to determine a range of value for roughness coefficient and its relationship with flow rate. In-situ measurement was carried out at 10 stations along Parit Karjo channel in order to determine velocity of flow. The result shows the range of roughness coefficient, n is ranged from 0.04 to 0.48. As conclusion, the states of flow for Parit Karjo channel are located between transitions to turbulent flow region.

Keywords: Parit Karjo river; Roughness coefficient

INTRODUCTION

In hydraulic engineering, the friction coefficient is a crucial parameter in designing water structures, calculation of velocity distribution and energy losses determination [1]. Besides that, flow profile calculation, velocity and discharge plays significant roles in water resources project, flood management planning and the determination of hydraulics effects for river conservation. In several cases, a sufficient variety of channel roughness coefficient is needed in these calculations [2]. There several formula are used to determine the roughness coefficient, *n* for open channels such as Manning formula The *n* values are used to measure surface roughness and flow resistance even though small errors of this value can effected to the calculations [3]. The coefficient is not easy to determine and is varying constantly. Due to related parameters, the roughness of the channel is not equally distributed over the channel, the banks and the floodplains [4].

Referring to Fu-Sheng [5], the flow resistance in open channels with non-submerged rigid vegetation is related with hydraulic characteristics where vegetation will cause flow resistance, rise of water level and reduction of discharge capacity. Due to that, the n values cannot be computed equally for all types of open channel because the value must be referred factors that influenced the coefficient of roughness both artificial and natural channel such as surface roughness, vegetation, sedimentation and at cetera [3][4]. The roughness coefficient values provided in reference books or previous research normally based on study of selected rivers or ditches in a foreign country. In addition, high technology also caused westerners capable of developing database as ways to ease the determination of n values.

In ways to ensue this study, some objectives were outlined to determine a range of roughness coefficient for selected channel and to identify the states of flow by using obtained values. The determination of open channel roughness coefficient leads more accurate hydraulic

calculation, to increase the usage of engineering structures, to improve design works of water storage and to control flood. These advantages were used to solve hydraulic problems easily.

MATERIALS AND METHODS

Case Study. The study was located at Parit Karjo river in Batu Pahat district (latitude: 1° 52' 0" N, 103° 4' 0" E and longitude: 103° 11' 28.4" T, 103° 16' 40.7") as shown in Figure 1.

Data Collection. Data was measured at 10 selected locations along the Karjo channel by in-situ measurement within two months (December 2009 – January 2010). The distance between the stations is about 500 to 1900 meters. *In-situ measurement*: This work was carried out to measure channel characteristics such as channel cross-section, velocity and depth of water for 5 times. Beside that, width and distance between cross section also have been determined. *Velocity:* The velocity was measured at 0.2 and 0.8 of water depth since the depth of water is between 0.5 m to 1.0 m. Current meter (Valeport BFM001) was used as a tool in measuring the velocity. Therefore, flowrate of river can be calculated by mean-section method.

Manning Formula. Manning's equation was used to calculate cross-sectional average velocity flow. In applying the Manning Formula, the greatest difficulty lies in the determination of roughness coefficient, *n* for there is no exact method of selecting the *n* value. The equation of Manning formula is stated at equation (1) [6].

$$Q = AV = \frac{1}{n}AR^{2/3}S_o^{1/2} \tag{1}$$

where:
Q = volume flow (m^3/s)
v = cross-sectional average velocity (m/s)
A= cross sectional area of flow (m^2)
n = Manning coefficient of roughness
R = hydraulic radius (m)
S = slope of bed channel (m/m)

The dimensions of open channel change relatively due to several factors such as channel roughness, erosion and others. This situation leads to changes of depth of flow and gives effects to parameter that contribute in calculating Manning Formula.

State of Flow. The friction factor of an open channel flow is generally affected by the Reynolds number and the roughness conditions, and can be decided by laboratory or field measurements [7]. Depending on the effect of viscosity relative to inertia, the flow may be laminar, turbulent or transitional. The flow is laminar if the viscous forces are strongly relative to the inertial forces that mean viscosity plays a significant part in determining flow behaviour [4]. If the viscous forces are weak relative to inertial forces, the flow is turbulent where the water particles move in irregular paths which are neither smooth nor fixed. While, transitional flow located between laminar and turbulent. The effect of viscosity relative to inertia can be represented by the Reynolds number, defined as shown in equation (2).

$$Re = vL/v \tag{2}$$

where,
L = Characteristic length (m)
V = Velocity (m/s)
ν = Kinematics viscosity of water (m^2/s)

Figure 1: Location of Study Area

RESULTS AND DISCUSSION

The characteristics of channel have been collected in order to determine the flow rate and n value. The value of bottom slope was determined as 0.0005. Figure 2 (a) shows the value of hydraulic radius, R is ranging from 0.14 to 0.59m. While values of wetted parameter, P and area, A in Figure 2 (b) both show a similar pattern which is ranging from 20.93 to 61.21m and 5.05 to 35.28m^2 accordingly. The average value for hydraulic radius, area and wetted parameter are 0.38m, 17.6m^2 and 45.43m. From this graph, the values of geometry elements are slightly vary according to date of sampling.
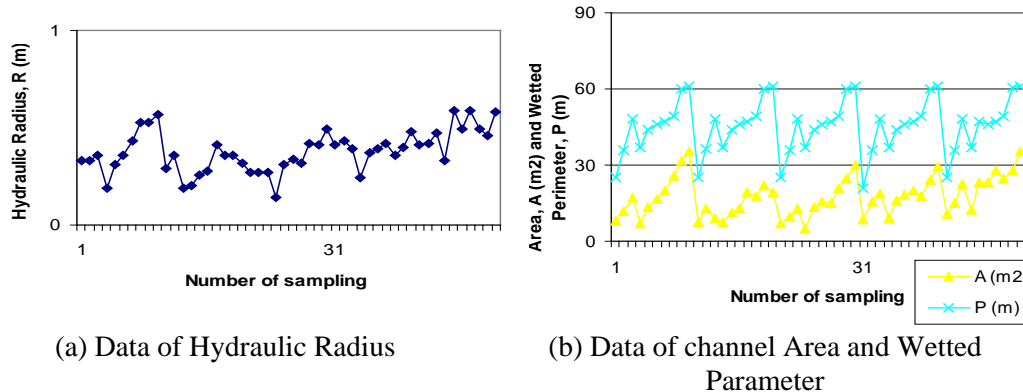

(a) Data of Hydraulic Radius

(b) Data of channel Area and Wetted Parameter

Figure 2: Data of Geometry Elements

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Velocity, V of water was calculated based on geometry element findings in Figure 2. 10% of velocity data are located at ranged of 1.5 to 3m/s but in overall the data is ranging between 0.28 to 1.5m/s as shown in Figure 3. In addition, the average value of velocity is 0.71m/s.
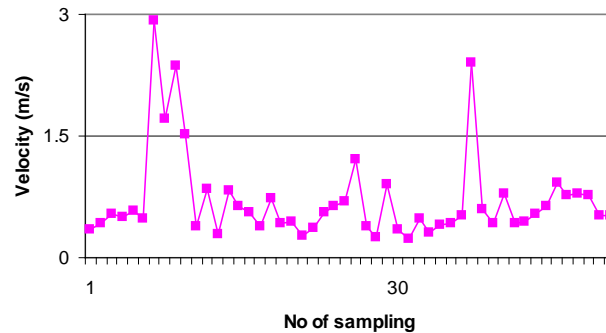

Figure 3: The Data of Velocity

Figure 4 shows values of flow rate at station 1 to station 6 are not reached 20m^3/s. Furthermore, the values at station 7 to station 10 ranged from 45 to 75m^3/s on 8 December 2009. This is because of the tides effect during the measurement. Overall, the values are ranging from 1.81 to 75.21m^3/s.

According to Figure 5, the distribution of roughness coefficient, n is ranging from 0.04 to 0.48 based on number of sampling. According to Chow [4], the suitable range of n for this channel is between 0.025 to 0.033 for clean open channel, straight and no rifts. Compared to previous reference or study, the ranged of data obtained is lesser than Adib et al [8] but slightly bigger than Chow [4].
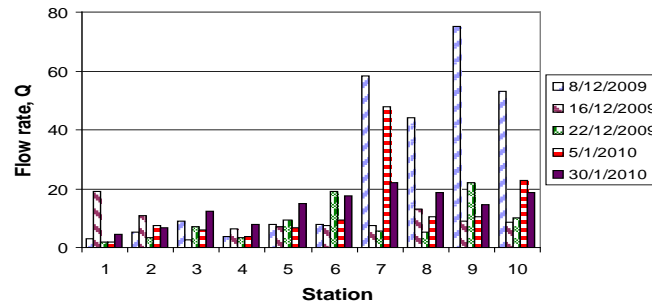
**Figure 4: Value of Flow Rate According to Date of Sampling**

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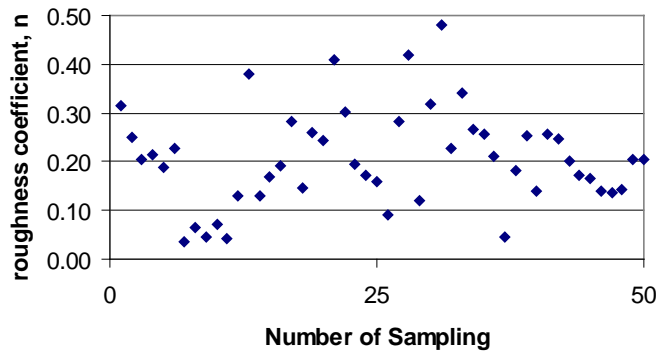
Figure 5: The Distribution of Roughness Coefficient
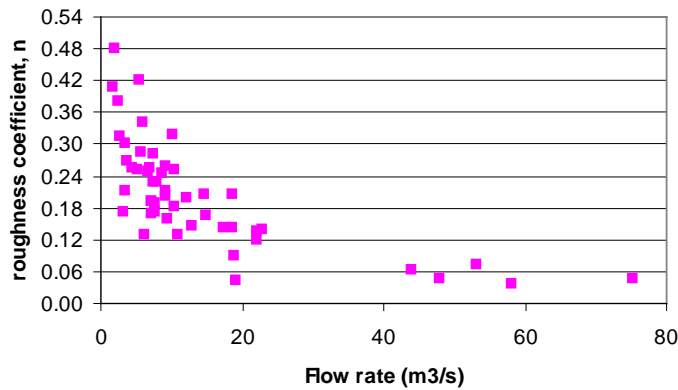
Figure 6: Relationship between Roughness Coefficients and Flow Rate

The relationship between roughness coefficients, n and flow rate, Q is shown in Figure 6. The data are scattered mostly when flow rate is lesser than 24 m^3/s. Overall, the data ranging from 1.81 to 75.21 m^3/s. The Q minimum is figured as 1.98 m^3/s at n = 0.48 (maximum) while Q maximum is 75.21 m^3/s at n = 0.05 (minimum). Furthermore, the *n* values are proportionally inversed to Q values.
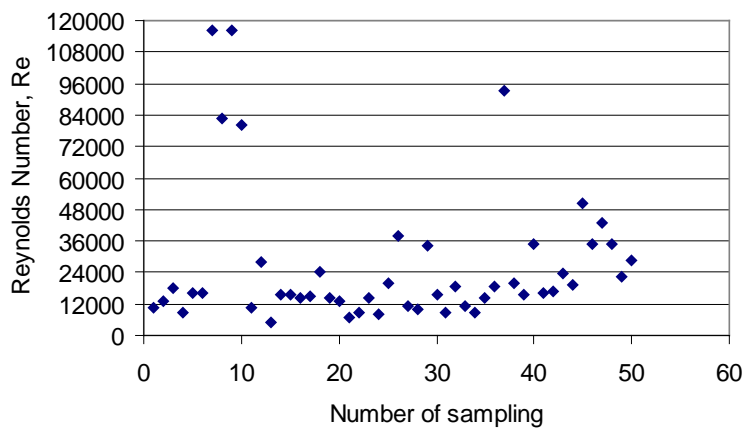
Figure 7: The Distribution of Reynolds Number

Based on Figure 7, the states of flow for Parit Karjo channel was calculated by Reynolds Number where kinematics viscosity, ν is 1.08 x 10^{-5} m^2/s. About 15% of data findings located at transitions region; overall the data are situated at transitions and turbulent region.

CONCLUSIONS

As conclusion, the range of roughness coefficient, *n* is from 0.04 to 0.48. Besides that, the n values were founded proportionally inversed to Q values. The states of flow for Parit Karjo channel are located between transitions to turbulent flow region.

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