Determination of Manning's Flow Resistance Coefficient for Rivers in Malaysia

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ABSTRACT
The procedure for selecting values of Manning's coefficient (n) is subjective and requires judgment and skill which are developed primarily through experience. Government agencies and private sectors in the developed countries such as USA are still doing researches on predicting n values for rivers. Since flow and boundary roughness vary with river conditions, the same type of research is therefore pertinent for rivers in Malaysia. Research to determine the Manning's n value has been started by REDAC since 2002 at the Kinta River Basin. In view of the importance of predicting accurately the n value, this type of research should be continued further.

1 Introduction

River engineering is rather a new field of study which has been practiced quite recently in Malaysia. This field of study involves the use of computer models to study flow in open channels. Most hydraulic computations related to indirect estimates of discharge require an evaluation of the roughness characteristic of the channel. For over a century, a number of empirical equations have been formulated but the researches in this field have been continued by the Government Agencies and private sectors in the developed nation such as USA.

Natural channel morphology depends on the interaction between fluid flow and the erodible materials in the channel boundary. Velocity is strongly related to flow resistance, which is one of the most important elements in the interaction between fluid flow and the channel boundary.

The engineers have used a number of flow resistance equations involving grain roughness, form roughness and a combination of both, but the Manning's equation has been widely used internationally for predicting roughness values in natural channels. This paper summarizes the recent results based on field data collection at several rivers in Malaysia.

2 Determination of Manning's Roughness Coefficient, n

These are several available equations to predict values of n (Abdul Ghaffar, 2003):

Strickler (1923): $n = d_{50}^{1/6} / 21.1$ (2.1)

Meyer-Peter & Muller (1948): $n = d_{90}^{1/6} / 26$ (2.2)

Limerinos (1970): $n = (0.113R^{1/6}) / (0.35 + 2.0 \log_{10} \{R/d_{50}\})$ (2.3)

Bray (1979): $n = 0.113y_0^{1/6} / (1.09 + 2.2 \log_{10}\{y_o/d_{50}\})$ (2.4)

Bruschin (1985): $n = (d_{50}^{1/6} / 12.38)(R S_o / d_{50})^{1/7.3}$ (2.5)

Julien (2002): $n = 0.062\, d_{50}^{1/6}$ (2.6)

$n = 0.046\, d_{75}^{1/6}$ (2.7)

$n = 0.038\, d_{90}^{1/6}$ (2.8)

Evaluation of these equations for six cross sections at Kinta River Basin shows that none of the equations gives satisfactory prediction of the flow discharge (Figure 1). Further evaluation was made using the suggested n values by Chow (1959). The results as shown in Figure 2 show that a unique value of n is applicable for each cross section.

3 Development of New Equations

Several relationships were obtained to identify dimensionless variable which are important in determining values of n for river in Malaysia. These dimensionless variables are y_o/d_{50}, R/d_{50}, B/y_o, Dgr, Cv and T_j, where:

y_o = Mean flow depth
d_{50} = Mean sediment size
R = Hydraulic radius
B = River width
Dgr = Dimensionless sediment size
Cv = Volumetric sediment concentration

Table 1 summarizes the resulting equations. It is recommended that the following two equations to be used for determination of n in rivers in Malaysia.

$$n = 2E\text{-}08\,(y_o/d_{50})^2 - 3E\text{-}05\,(y_o/d_{50}) + 0.0511 \quad (2.9)$$

$$n = 3E\text{-}08\,(R/d_{50})^2 - 4E\text{-}05\,(R/d_{50}) + 0.0537 \quad (2.10)$$

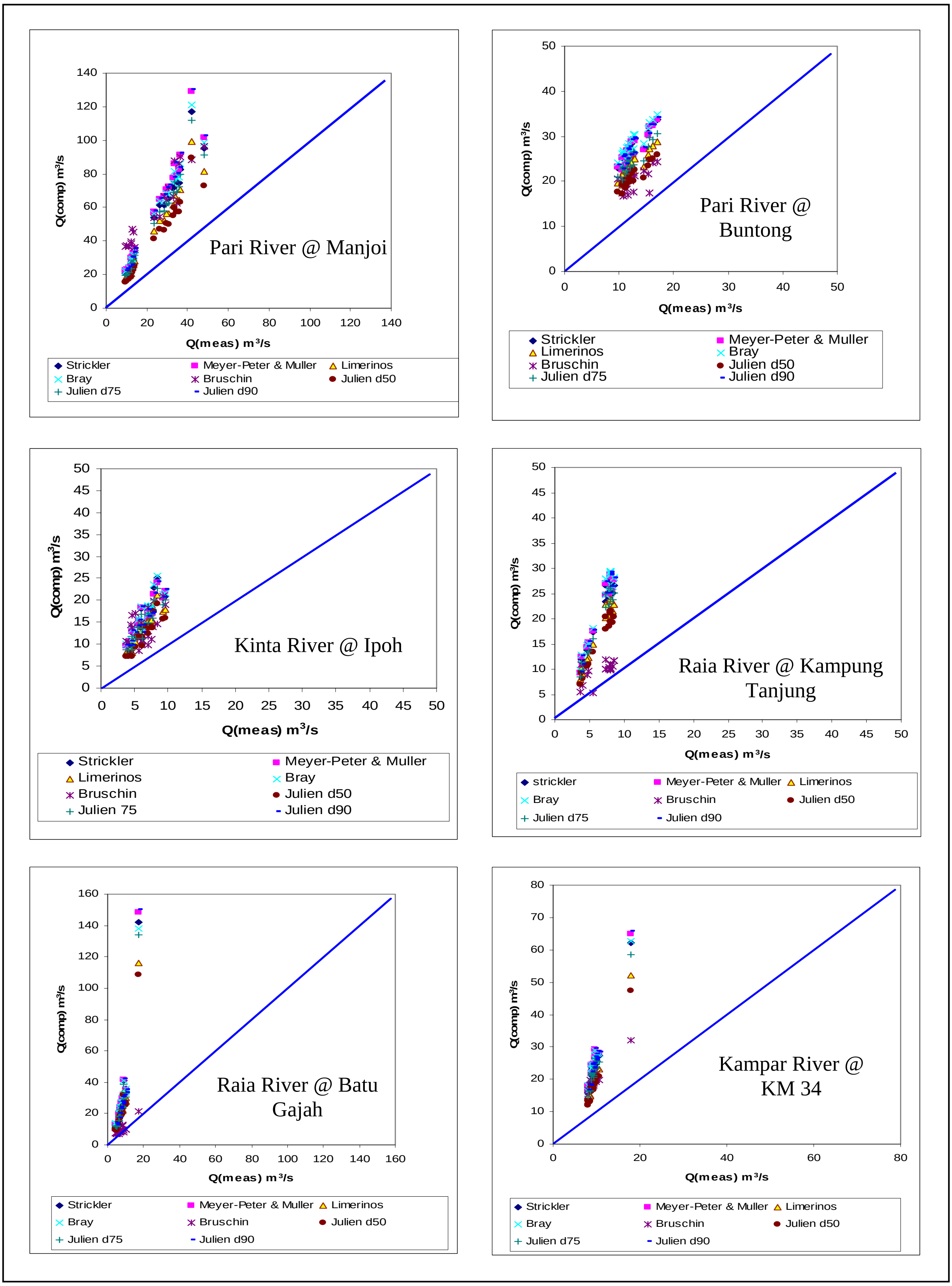

Figure 1 Evaluation of Manning's Equations Using Equations 2.1 – 2.8.

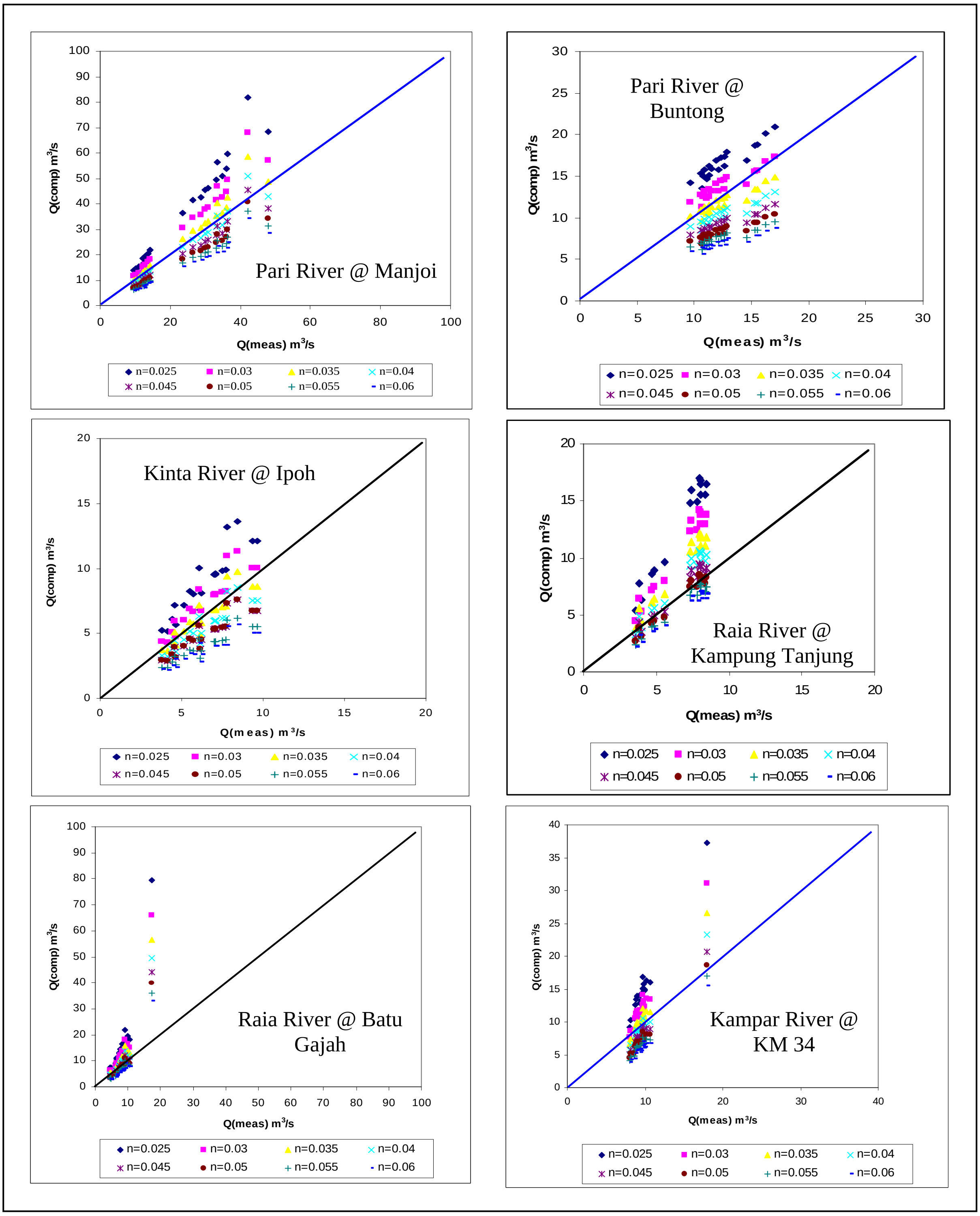

Figure 2 Evaluation of Manning's Equation (n = 0.025 – 0.06).

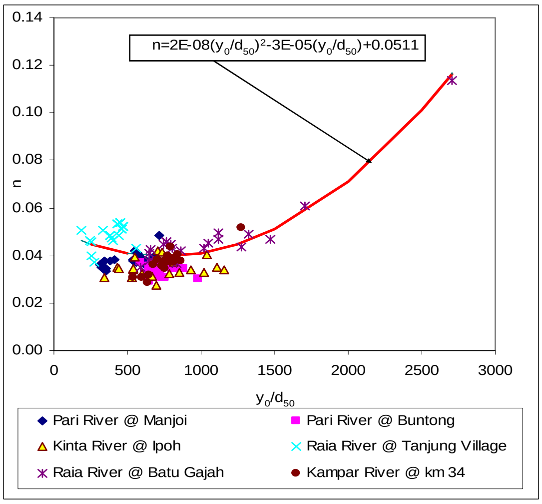

Figure 3 Development of Equation to determine the value of n based on y_o/d_{50}

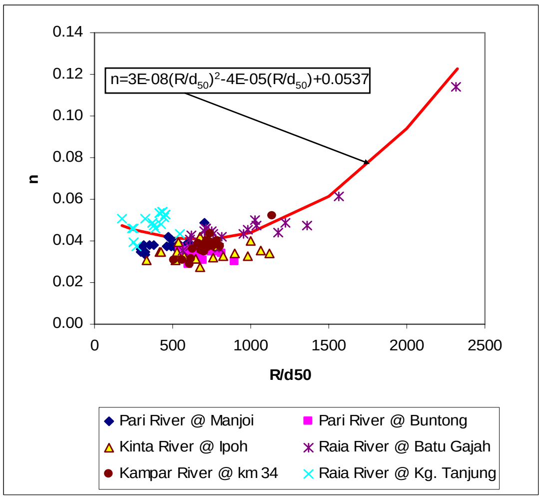

Figure 6 Development of Equation to the value of n based on R/d_{50}.

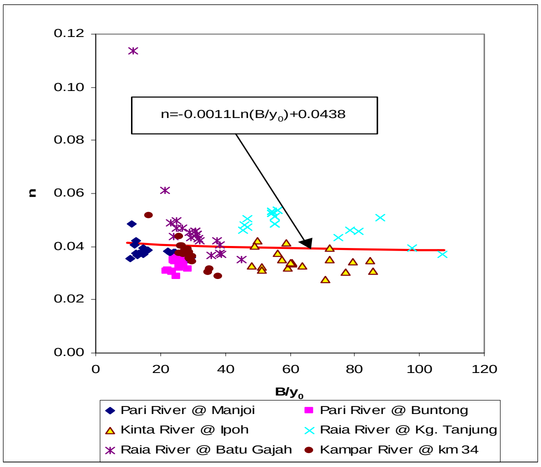

Figure 4 Development of Equation to determine the value of n based on B/y_o.

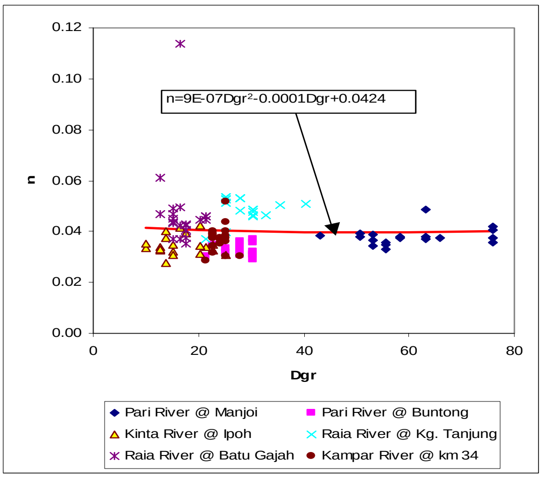

Figure 7 Development of Equation to determine the value of n based on Dgr.

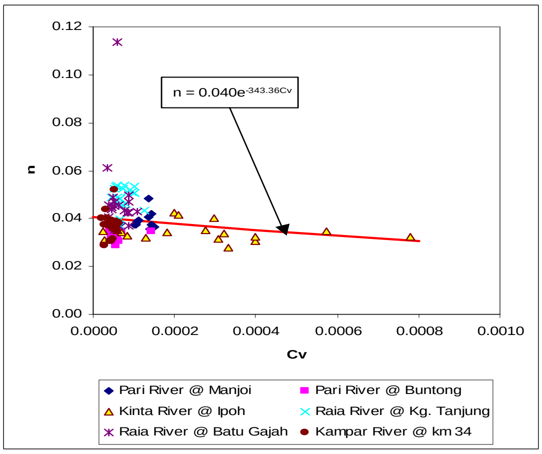

Figure 5 Development of Equation to determine the value of n based on Cv.

4 Conclusion

For the initial research, only simple methods have been used to determine the value of n. The computed discharges are much bigger compared to the measured discharges by using the existing equations. So the use of new equations is recommended because they can predict the discharges satisfactorily. The discrepancy ratios obtained are almost equal to one.

Table 1 Development of Manning's Roughness Coefficient for Kinta River Basin.

Dependent Variables	Independent Variables	R^2	Reference to Figure	Equation No.
n	$2E\text{-}08(y_o/d_{50})^2 - 3E\text{-}05(y_o/d_{50}) + 0.0511$	0.6094	3	2.9
n	$3E\text{-}08(R/d_{50})^2 - 4E\text{-}05(R/d_{50}) + 0.0537$	0.6085	6	2.10
n	$0.001Ln(B/y_o) + 0.0438$	0.0037	4	2.11
n	0.0404 e –343.36Cv	0.61	5	2.12
n	$9E\text{-}07\ Dgr^2 - 0.0001Dgr + 0.0424$	0.61	7	2.13

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Notation

The following symbols are used in this paper:

A x-sectional area
B width of channel
C Chezy's coefficient
C_v Sediment Concentration in ppm by volume
d_s Diameter of sediment
d_{50}, d_{75}, d_{90} = d_i = Size of particle intermediate axis for which i% of sample of bed material is finer
Dgr Dimensionless grain size
Fr Froude Number
F Darcy-Weisbach friction factor
g Acceleration due to gravity
K Relative Roughness
n Manning's roughness coefficient
P Wetted Perimeter
Q Discharge
R Hydraulic Radius
R^2 Square of correlation coefficient
Re Reynold Number
S Energy Gradient
S_o Channel Slope
Ss Relative Density of sand
T_j Total Load of Bed Materials
t Time
V Average Velocity of flow
y_o Depth of water
ν kinematic viscocity
ρ density of water
τ Shear stress
μ dynamic viscosity

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