Comparing the Calculation Method of the Manning Roughness Coefficient in Open Channels

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Abstract*—In hydraulic engineering, Manning roughness coefficient is an important parameter in designing hydraulic structures and simulation models. This equation is applied to both uniform open channel flow, which is used to calculate the average flow velocity. The procedure for selecting the value of Manning n is subjective and requires assessment and skills developed primarily through experience. ManyempiricalformulaMenningthat was developedin order toobtainthe valuekoefsieinManning roughness. Fromseveral studiesincludingthe formulationCowan(1956), ArcementandSchneider(1984), Limerinos(1970), KarimandKennedy(1990), Riekenmann(1994), Riekenmann(2005) andChiariandRiekenmann(2007) Obtainingroughnesscoefficient(n) obtainedfromManninginsome formulationsareobtainedempiricalmethod forthe lowestn=0015andnhighestn =0.0075. AndnValue thecondition ofthenaturalchannel datahighestand lowest,namelyn=0.0027-0.0590. Whilethe study ofEntropyformula(2014), Bojorunas(1952) andWibowo(2015), for theManningroughnessvaluesusingthe highestlaboratory datan=0.0256and the lowestn=0.0171, to which it results stillsatisfy the requirementsforthe value ofnon-cohesive material.with the value of and R^2 0,926 and MNE (Measurement Normaled Errors) = 82% on the method Limerinos (1970)

Keywords*— *Open Channel, Roughness Manning coefficient, Empiricalformula

I. INTRODUCTION

Manning coefficient n is a coefficient that represents the roughness or friction applied to the flow in the channel (Bilgin & Altun, 2008). In hydraulic engineering, Manning roughness coefficient is an important parameter in designing hydraulic structures (Azamathulla et al., 2013; Samandar, 2011; Bilgin & Altun, 2008).

Manning equation is an empirical equation is applied to the uniform open channel flow, which is used to calculate the average flow velocity and the speed function of the channel, the hydraulic radius and slope of the channel (Bahramifar et al., 2013).

In Europe, also known as the Manning formula Gauckler-Manning formula, or formula Gauckler-Manning-Strickler. It was first presented by the French Engineer Philippe Gauckler in 1867, and then re-developed by the Irlandia engineer Robert Manning in 1890 (Bahramifar et al., 2013).

The study of the roughness coefficient has been much research done previously, including Cowan (1956) which examines pengenai hydraulic calculations, the roughness coefficient andAgricutural Engineering. Arcement and Schneider (1984) make modifications to the formulation Cowan (1956) by incorporating the element of stream power. Limerinos (1970) investigating the Manning roughness coefficient of the basic measurements in a natural channel. Brownlie (1983) had developed roughness coefficient n in the flow depth relationship in the form of hydraulic conditions and characteristics of the bed materials in large amounts of data flume and field. Karim and Kennedy (1990) developed a form of relationship to the value of *n* in the form of dimensionless variables in the form of relative depth and friction factor.

Rickenmann (1994) proposed the equation to calculate the total Manning roughness coefficient. Rickenmann (2005) proposed the loss calculation on the flow resistance associated with a form of drag as a function of the slope and depth of the relative flow. Bahramifar et al. (2013) who evaluated the Manning by using ANFIS method approach in alluvial channels. Greco et al. (2014) analyzed using entropy method in order to determine the value roughness coefficient Manning.

The purpose of this paper is to obtain the value of the roughness coefficient (n) Manning on the field by comparing based on existing Manning formula.

II. MATERIAL

2.1 Formulation of Manning

The value of this coefficient can be searched with the knowing flow parameters as that of the equation Equation (2.1).

$$n = \frac{1{,}00}{U} R^{2/3} S^{1/2} \quad \text{...(1)}$$

where U is average flow velocity (m / sec); n is Manning roughness coefficient; R is hydraulic radius (meters) and S is slope of the line.

2.2 Cowan (1956).

Cowan (1956) developed a method to estimate the value of the Manning roughness n, by using the geometry and hydraulic parameters. The value of the roughness coefficient (n) is calculated using Equation (2)

$$n = (n_0 + n_1 + n_2 + n_3 + n_4)m \quad \text{.....................(2)}$$

where n_0 is the value of the basic values of n for which a straight line, according to a uniform and smooth natural ingredients it contains, n_1 value added to n_0 to correct for the effect of surface irregularities, n_2 value for variations in the shape and size of the cross section of the channel, n_3 value for barriers, n_4 value for condition vegetationandflowand n_5 correction factorforchannelbends.

Table 1. Base value of Manning's n (modified from Aldridge and Garrettm, 1973)

Bed Material	Median size of bed material (in milimeters)	Base n value	
		Straight uniform Channel	Smooth Channel
	Sand Channel		
Sand	0,20	0,012	-
	0,3	0,017	
	0,4	0,020	
	0,5	0,022	
	0,6	0,023	
	0,8	0,025	
	1,0	0,026	
Stable Channel and Flood Plains			
Coarse sand	1-2	0,026-0,035	-
Fine Gravel	-	-	0,24
Gravel............................	2-64	0,028-0,035	-

Source : Aldridge and Garrettm, 1973

2.3 Arcement and Schneider (1984).

Arcement and Schneider (1984) has modified the Equation (2.2) to be used in the calculation of flood plains. Correction factor to form sinusiodal (m) to 1 (one) in this caseand correct the differences in size and shape of the channel n_2 which is assumed to be equal to 0 (zero). Equation (1) in the equation (3).

$$n = (n_b + n_1 + n_3 + n_4)m \quad \text{...........................(3)}$$

which n_b is the basic value of n the openland surface. Selection on the basis of the value of the floodplains are the same as in the channel. Arcement and Schneider (1984) proposed that the effect of resistance to flow (Simons & Richardson, 1966) in the floodplains

2.4 Limerinos (1970)

Limerinos (1970) have examined the determination of manning coefficient of bottom friction measurements in a natural channel, to establish the relationship between the value of the base on the Manning roughness coefficient, n, and the index on the basis of particle size and size distribution of the river, get the value of roughness as Equation (4).

$$\frac{n}{R^{1/6}} = \frac{0{,}0926}{1{,}16 + 2{,}0 \log \frac{R}{d'_{84}}} \quad \text{.......................................(4)}$$

where n is the total Manning roughness coefficient, R is the hydraulic radius of the channel, and d'_{84} diameter riverbed material with a percentage of 84% passes.

Table 2. Value Roughness Coefficient (*n*) is Calculated by Equation Cowan

Variabel	*Desription Channel*	*Recommended Value*
Basic, n_0	*Earth*	*0,020*
	Rock	*0,025*
	Fine Gravel	*0,024*
	Coarse Gravel	*0,028*
Irregularity, n_1	*Smooth*	*0,000*
	Minor	*0,005*
	Moderate	*0,010*
	Severe	*0,020*
Cross section,n_2	*Gradual*	*0,000*
	Occasional	*0,005*
	Alternating	*0,010-0,015*
Obstructions, n_3	*Negligible*	*0,000*
	Minor	*0,010-0,015*
	Appreciable	*0,020-0,030*
	Severe	*0,040-0,060*
Vegetation, n_4	*Low*	*0,005-0,010*
	Medium	*0,010-0,020*
	High	*0,025-0,050*
	Very High	*0,050-0,100*
Meandering, m	*Minor*	*1,00*
	Appreciable	*1,15*
	Severe	*1,30*

Source : Chow, 1959.

2.5Brownlie (1983)

Brownlie (1983) has developed a relationship at a depth of flow in the form of hydraulic conditions and characteristics of the bed materials in large amounts of data flume and field. The relationship shown in equation (5) and (6).

- On the condition of Lower Regime;

$$n = \left[1{,}6940 \left\{\frac{R}{d_{50}}\right\}^{0{,}1374} S^{0{,}1112} G^{0{,}1605}\right] 0{,}034 d_{50}{}^{0{,}167} \ldots.(5)$$

- In conditions of Upper Regime

$$n = \left[1{,}0123 \left\{\frac{R}{d_{50}}\right\}^{0{,}0662} S^{0{,}0395} G^{0{,}1282}\right] 0{,}034 d_{50}{}^{0{,}167} ..(6)$$

which, R = hydraulic radius (ft); S = slope of the line (ft / ft); d_{50} = median particle size of the bed material (ft) and G = coefficient of gradation on the base material. Where

$$G = \frac{1}{2}\left(\frac{d_{84}}{d_{50}} + \frac{d_{50}}{d_{16}}\right)$$

2.6 Karim and Kennedy (1990)

Karim and Kennedy (1990) apply the above procedure on the data field and flume gives the relationship in the form of relationship to the value of n as Equation (7)

$$n = 0{,}037\, d_{50}{}^{0{,}126}\left(\frac{f}{f_0}\right)^{0{,}465} \text{ ....(7)}$$

(d_{50} in meters) and $\frac{f}{f_0} = 1{,}20 + 8{,}92\,\frac{\Delta}{h}$

2.7 Riekenmann (1994)

Riekenmann (1994) proposed the equation to calculate the total Manning roughness coefficient, as shown in Equation (8).

$$\frac{1}{n_{tot}} = \frac{0{,}56\, g^{0{,}44} Q^{0{,}11}}{S^{0{,}33} d_{90}^{0{,}45}} \text{ ....(8)}$$

2.8 Riekenmann (2005)

Rickenmann (2005) proposed the loss calculation on flow resistance associated with the drag shape as a function of the slope and depth of flow relative, as in Equation (9).

$$\frac{n'}{n_{tot}} = 0{,}083 S^{-0{,}35}\left(\frac{h}{d_{90}}\right)^{0{,}33} \text{ ....(9)}$$

2.9 Chiari dan Rickenmann (2007)

Chiari and Rickenmann (2007) proposed Manning on the surface roughness values for total roughness that produces Equation (10).

$$\frac{n'}{n_{tot}} = \frac{0{,}0756\, Q^{0{,}11}}{g^{0{,}06} d_{90}{}^{0{,}28} S^{0{,}33}} \text{ ....(10)}$$

2.10. Moramarco dan Singh (2010), Mirauda et al (2011), Mirauda dan Greco (2014) dan Greco et al. (2014).

Moramarco and Singh (2010), Mirauda et al (2011), Mirauda and Greco (2014) and Greco et al. (2014) who examined the Manning roughness coefficient in open channel parameters based on entropy, which has resulted in Equation (11)

$$n = \frac{\mathrm{R_h}^{1/6}/\sqrt{g}}{\Phi\,(\mathrm{M}).\frac{1}{\kappa}\left[\ln\left(\frac{y_{max}}{y_0}\right) - 0{,}4621\right]} \text{ ....(11)}$$

2.11 Formulation Manning based on Linear Separation

Borojunas (1952) also states the linear separation of the Manning roughness coefficient into two (2) parts: first, the basic channel resistance granules associated friction on the surface (skin friction) known as grain roughness (n '), the basic flow resistance in relation to the existence of bedform and roughness changes known with the form (n"). His formulation shown in Equation (12).

$$n = n' + n'' \text{ ....(12).}$$

in which n' = resistance due to friction surface (skin friction) or grain roughness; $n' = \frac{d_s{}^{1/6}}{29{,}3}$ and n " = resistance due to form drag or roughness shape. $n'' = \phi\left(\frac{R' S_f}{1{,}68 d_{35}}\right)$

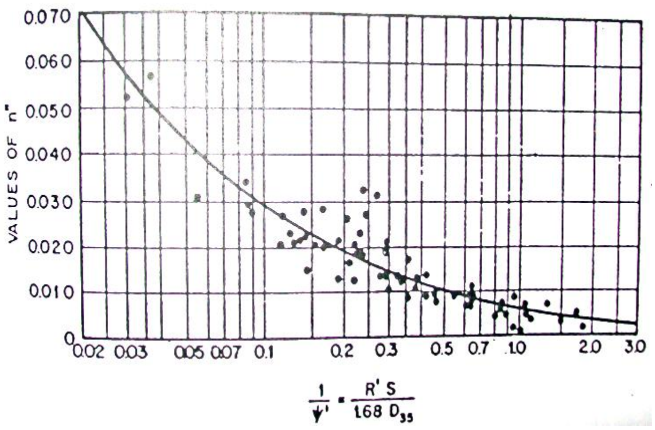

Figure1. n'' as a function of $\left(\frac{1}{\psi'}\right)$ Bajorunas(1952)

2.11 Formulation Manning Based on Linear Separation Based on Bed Configuration (Wibowo-Manning).

Wibowo (2015) also states the linear separation of the Manning roughness coefficient based on the flow resistance in the field of bed moves, equal as Equation (12). n' As in the following Equation (13) and (14).

$$n' = \frac{R^{1/6}}{\left[6{,}0 + 5{,}75\log\left(\frac{R'}{k_s}\right)\right]\sqrt{g}} \text{ ....(13)}$$

and

$$n'' = \frac{\tau_*{}''\left(\frac{1}{\kappa}\ln\left(\frac{R'}{k_s}\right)\right)^2 n'^2 k_f{}^2}{2\rho\lambda d\ (S_r - 1)(\cos\,\alpha \tan\,\emptyset - \sin\,\alpha) k_3} \text{ ....(14)}$$

Where $\tau_*{}''$ is theshear stressrelativedue tothe basic form($\tau_*'' = \tau_* - \tau_*'$), $\tau_* = hS/(\rho_s - \rho)d_s$;$k_f$ is shape form (=1);k_3 is the correction factor (0,20 to 0,90),λ length of bedform; d is grain diameter; $\tan\emptyset$ is dynamic friction coefficient and α is the angle of the bed channel.

Table 3. Value Factor Correction on Alluvial Material (Corey, 1956)

Number	Shape material	Shape Factor
1	□	0,20 – 0,39
2	o	0,40 – 0,59
3	•	0,60 – 0,79
4	▪	0,80 – 0,99
5	Δ	1,00

Table 4. Angle Angle pupose ($\emptyset$) on Non Cohesive Soil (Piere, 2010)

Number	Class name	ϕ (deg)
1	Sand Very Coarse	32
2	Sand Coarse	31
3	Sand medium	30
4	Sand Fine	30
5	Sand Very Fine	30

III. METHODS

3.1 The Field research

The method implemented by comparing the results of experiments in laboratoritum and pitch of each empirical formula.

Figure 2. The Location Field Research Pontianak

a. Data Field

The field data is taken based on the results of field research on the cross-section of the river in the city of Pontianak (Trenches Bansir) as listed in the Table (5).

Table 5. Results FlowVelocity Measurementin the Field

Symbol	Unit	P1	P2	P3	P4
B	meter	9,000	8,400	9,000	8,500
h0	meter	0,800	0,900	0,700	0,700
U	m/s	0,116	0,098	0,139	0,121
bo	meter	1,125	1,050	1,125	1,063
Qo	m^3/s	0,039	0,057	0,046	0,027
Qtotal	m^3/s	0,929	0,857	1,019	0,757
Total wide	m^2	9,763	8,638	7,465	6,593
velocity	m/s	0,116	0,098	0,139	0,121
Hydraulic radius		0,888	0,834	0,717	0,665
Slope		0,0000209	0,0000209	0,0000209	0,0000209
Roughness		0,044	0,041	0,027	0,030
Average value n			0,036		

source: field Results

b. Data Laboratory.

Results ofsecondary dataandprimary datafromdirect measurementsinthe laboratorycan be seen inTable (6)

Table 6. Results FlowVelocity Measurementinthe Laboratory

Slope	Qoutflow	width	h	Uoutflow	Δ	λ
	liter/s	m	cm	cm/s	cm	cm
0,006	3,000	0,40	5,20	14,423	0,14	7,53
0,006	4,000	0,40	6,50	15,385	0,29	7,42
0,006	5,000	0,40	7,70	16,234	0,38	9,68
0,006	6,000	0,40	9,20	16,304	0,42	10,56
0,006	7,000	0,40	10,20	17,157	0,46	8,44
0,006	8,000	0,40	11,15	17,937	0,49	10,17
0,007	3,000	0,40	4,20	17,857	0,13	12,22
0,007	4,000	0,40	4,60	21,739	0,25	14,78
0,007	5,000	0,40	6,60	18,939	0,31	13,44
0,007	6,000	0,40	8,15	18,405	0,67	7,33
0,007	7,000	0,40	9,90	17,677	0,69	10,56
0,007	8,000	0,40	10,05	19,900	0,77	11,00
0,008	3,000	0,40	5,05	14,851	0,36	7,56
0,008	4,000	0,40	7,60	13,158	0,37	9,74

Continue……

Slope	Qoutflow	width	h	Uoutflow	Δ	λ
	liter/s	m	cm	cm/s	cm	cm
0,008	5,000	0,40	7,35	17,007	0,50	10,94
0,008	6,000	0,40	7,05	21,277	0,71	9,00
0,008	7,000	0,40	8,40	20,833	0,73	9,22
0,008	8,000	0,40	9,50	21,053	0,76	10,17
0,010	3,000	0,40	4,55	16,484	0,37	7,94
0,010	4,000	0,40	5,30	18,868	0,39	9,06
0,010	5,000	0,40	6,78	18,437	0,45	10,39
0,010	6,000	0,40	6,53	22,971	0,52	9,71
0,010	7,000	0,40	7,40	23,649	0,56	7,50
0,010	8,000	0,40	8,50	23,529	0,78	10,17
0,00667	2,514	0,10	8,00	31,430	0,75	12,5
0,00667	2,868	0,10	11,00	26,071	1,70	10,0
0,00667	2,680	0,10	12,50	21,438	0,50	9,0
0,00667	4,521	0,10	14,00	32,296	0,90	10,0
0,01333	3,061	0,10	12,00	25,508	0,80	8,0
0,01333	3,708	0,10	13,00	28,525	1,50	7,5
0,01333	3,817	0,10	14,00	27,266	1,70	10,0
0,01333	4,345	0,10	15,00	28,966	0,25	8,0
0,00667	2,811	0,10	11,00	25,555	0,80	6,5
0,00667	4,260	0,10	12,10	35,205	2,00	24,0
0,00667	2,866	0,10	12,50	22,929	1,20	9,5
0,00667	4,104	0,10	14,00	29,316	0,80	9,5
0,01333	2,902	0,10	10,00	29,015	0,50	8,0
0,01333	4,993	0,10	13,00	38,405	0,80	10,0
0,01333	5,448	0,10	14,00	38,913	1,40	6,5
0,01333	6,429	0,10	15,00	42,857	2,20	9,0

Source : Laboratory Results

Figure3. The Location Laboratory Research in Solo

The Composition ofExperiment

The experimental tests were carried out in the Hydraulics Laboratory of Bandung Institute of Technology, on a free surface flume of 10,0 m length and with a cross section of 0,4 x 0,6 m2 (Fig.2), whose slope can vary from 10/1000 % up to 4/300 %. at a distance of 1 from the upstream timber bulkhead installed upstream so that the sand does not exit. An example of a sample of sand with a maxsimum grain diameter of 0,25 mm to 0,5 mm. Picture design can be found at Fig.3

IV. DATA ANALYSIS

4.1 Calculation Results Manning Roughness on Empirical formula

- Example Method Cowan (1956)

The formula used $n=(n_0+n_1+n_2+n_3+n_4)m_5$ n_o = 0.020 (channel-forming material is ground) n_1 = 0.005 (degree of irregularity, in the channel of small (minor), slightly eroded or on cliffs eroded channel), n_2 = 0.000 (cross-sectional variation in channel, channel varies and forms cross-section is considered phased (gradual) that changes the shape channel occur slowly). n_3 = 0.000 (relative effect and the digolong barriers can be ignored). n_4 = 0.000 (because there is only a small grass. m = 1.00 degrees of bend, take the small (minor). From these analysis results obtained value of *n*

$n=(n_0+n_1+n_2+n_3+n_4)m$ = (0,020 + 0,005 + 0,000 + 0,000 + 0,000) x 1,000 = 0,025.

Furthermore, The calculation is then performed in the Table (7).

Tabel 7.Summary Calculation Results From Table 5 &6

Roughness Coefficient	Data on Cross Section Width			
(n)	B=8-9 m	B =10 cm		B= 40 cm
Wibowo	-	0,0256	0,0246	0,0232
Bojurunas (1952)	0,0218	0,0220	0,0233	0,0192
Metode Entropi	0,0590	0,0171	0,0184	0,0213
Cowan (1956)	0.0250	n from Manningtable = 0,033		
Arcement& Schneider (1984)	0.0325	-	-	-
Limerinos (1970)	0,0147	-	-	-
Brownlie (1983)	0,0144	0,00895	0,00939	0,009827
Karim & Kennedy (1990)	0.00815	0.0278	0.0247	0.0270
Riekenmann (1994)	0.0027	0.0017	0.0023	0.0021
Riekenmann (2005)	0.0051	0.0126	0.0170	0.0206
Riekenmann &Chiari (2007)	0.0126	0.0493	0.0652	0.0618

Source: calculation results

4.2 Application of Flow Coefficient of Roughness on Discharge

The general formula used as According Soewarno (1995) discharge or magnitude of flow of the river / channel is flowing through the volume flow through the a river cross section / channel unit time. Usually expressed in units of cubic meters per second (m3 / s) or liters per second (l / sec). Flow is the movement of water in the river channel / channels. In essence discharge measurement is a measurement of the wet cross-sectional area, flow velocity and water levelEquation (15).

$$Q = U.A \quad ......(15)$$

where;
Q = discharge (m^3/s)
A = cross-sectional area the wet (m^2)
U = average flow velocity (m/s)

Which U as in Equation (16)

$$U = \frac{1{,}00}{n} R^{2/3} S^{1/2} \quad ......(16)$$

Roughness coefficientbecause oftheirsidewalls, expressed inbedformEquation(8).

$$n_w = \frac{R^{1/6}}{\sqrt{g}}\left(\frac{u_{*w}}{\bar{U}}\right) \text{and } u_{*w} = \sqrt{\tau_w/\rho} \quad ......(8)$$

- Equation of Average Bed and Sidewall Shear Stress

Shear stress bed ($\overline{\tau_b}$) and sidewallsaverage $\overline{\tau_w}$can be formulatedtoimplementusingthe overall balance offorceinthe direction of flow(Guo &Pierre, 2005). As definedin Equation(17)

$$2h\overline{\tau_w} + b\overline{\tau_b} = \rho g S A_b = \rho g S b h \quad ......(17)$$

wherethe amount ofshear stress bed($\overline{\tau_b}$) byformulatedbyJavid&Mohammadi(2013) as Equation(18a) and(18b)

$$\frac{\overline{\tau_b}}{\rho g H S} = \exp\left(-0{,}57\frac{h}{b}\right) - 0{,}33\frac{h}{b} exp\left(-0{,}57\frac{h}{b}\left(4{,}25 + 3{,}04\ln\left(\frac{h}{b}\right)\right)\right) \quad ......(18a)$$

$$\frac{\overline{\tau_w}}{\rho g H S} = 0{,}5\frac{b}{h}\left(1 - \frac{\overline{\tau_b}}{\rho g H S}\right) \quad ......(18b)$$

Keulegan(1938) suggested that thebisectorsofthe internal angles ofthe polygonalchannels can beusedas adividing lineto illustratethe extent ofthethe bed ofandside wallarea. asEquation(19).

$$A = A_b + A_w \quad ......(19)$$

The drainagearea ofthe bed(A_b) formulatedbyJavid&Mohammadi(2013) as Equation(20a) anddrainagearea ofthe side wall(A_w) inEquation(20b)

$$A_b = 2\int_0^h y\,dz = 1{,}7544b^2[1 - \exp(-0{,}57\ h/b)] \quad ......(20a)$$

$$A_w = bh - A_b; \quad A_w = bh - \int_0^h y\,dz = 1{,}7544b^2[1 - \exp(-0{,}57\ h/b)] \quad ......(20b)$$

The flow rate calculation results are presented in graphical form. Data used in the calculation of this flow rate

1. Data experimental Wang and White (1993) : This data set consists of 108 running and experiments have been conducted on the transition regime characterized by resistance coefficient decreases rapidly with increasing strength of the current.
2. Data from experiments Guy et al. (1966) 340 is also included
3. Data Bronwnie experimental results (1981).
4. Research data Sisingih (2000).

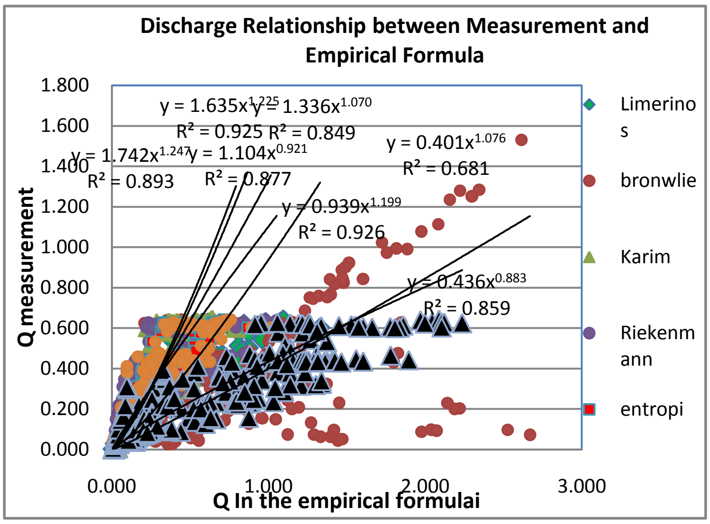

Fig 3RelationsDischargeMeasurementsandCalculationsFrom the All data

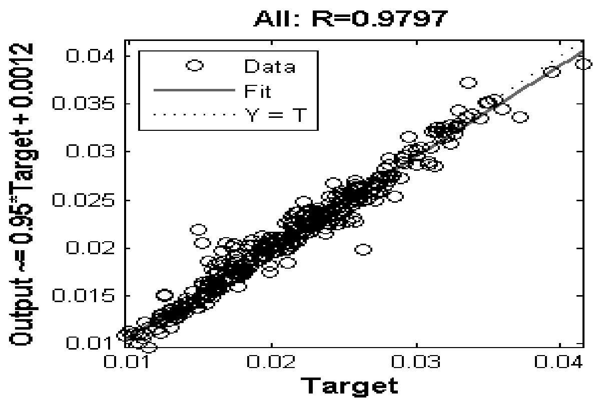

Fig 4RelationsDischargeMeasurementsandCalculationsFrom the All data with Nash Method.

Tabel 8.Summary Calculation Results from the All Data

No	Investigator	Roughness Coefficientt (n)		
1	Limerinos (1970)	0.011	-	0.018
2	Brownlie (1983)	0.012	-	0.024
3	Borujnas (1952)	0.012	-	0.023
4	Karim dan Kennedy (1990)	0.013	-	0.038
5	Riekenmann (1994)	0.008	-	0.090
6	Riekenmann (2005)	0.012	-	0.031
7	Chiari dan Rickenmann 2007	0.025	-	0.043
8	Metode Entropi - Wibowo	0.017	-	0.026
9	Wibowo (2015)	0.017	-	0.027

4.3. Discussion

Based on this analysis, the coefficient calculation is done perhitung this prediction accuracy using the average normal faults (MNE), namely

$$MNE = \frac{100}{N}\sum_{i=1}^{N}\frac{\left|X_{ci} - X_{mi}\right|}{X_{mi}}$$

Where the results of with the formula estimate manning, X_{mi}, and X_{ci}= empirical calculation results.

Table 8. Resume Calculation Result Error Correction

Investigator	Mean Normalized Errors MNE	Correlation Coefficient R^2
Limerinos (1970)	82.220	0.926
Brownlie (1983)	58.613	0,681
Borujnas (1952)	52.036	0,849
Karim dan Kennedy (1990)	69.821	0,893
Riekenmann (1994)	39.989	0,877
Riekenmann (2005)	68.551	0,846
Chiari dan Rickenmann 2007	61.168	0,894
Metode Entropi - Wibowo	82.189	0,925
Wibowo (2015)	69.058	0,859

Results of analysis of the Manning roughness coefficient calculation (n) obtained the highest and lowest values of n for each method, for empirical method obtained the lowest n = 0008 and n highest n = 0.0071, this shows that by using laboratory data obtained results are still within reach Manning roughness table for sand = 0,020. On the condition of with the natural channel data highest n= 0.0590 and lowest n = 0.0027 (In natural conditions n = 0,025- 0,033).

In the study of the entropy formula, bojorunas and Wibowo, for the Manning roughness values using laboratory data the highest n = 0.012 and the lowest n = 0.027.

For the third method in the Manning roughness coefficient results showed results that approached with the table Manning to a grain of sand (n = 0,020). While the field data showed that are less good results.

Similarly to the empirical formula. This is because the analysis used in the form of uniform flow, while the flow field is not uniform.

Formulation development Manning coefficient of linearseparationin relation to theflow ratecan be seenin Figure(5)Table 8 presents a comparison of MNE from all studies show varying results between 39, 989 % - 82,220%. In the method of data Limerinos and Entropy Method shows the model fit a large proportion of the 82% which means the value is quite satisfactory, because it is still the case that small forecasting error of 18%

From Table 9, It is also seen that, the correlation coefficient between the actual and the forecast has a direct relationship Strong positive as indicated by the value of R^2 ranging from 0.681 to 0.926. If used best linear fitting as shown in Figure 2, obtained the highest coefficient of determination Limerinos method that R^2 approximately 0.926; or in other words that the accuracy of the linear regression model between observation is very strong with a forecast of 0.926.

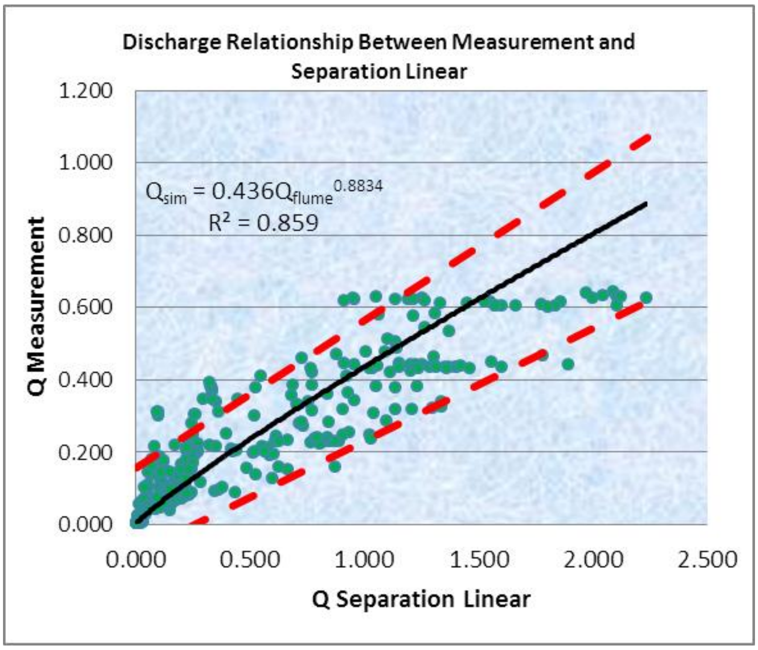

Fig5 elationsDischargeMeasurementsandCalculations

V. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

In the discussion of the previous chapter, we conclude some results as follows:

- Effect of resistance form can not be ignored n''/n' = -17,316 n + 0,6807, meaning that large semangkit roughness value relative basis, the value of the Manning roughness coefficient (n) small semangkin thus obtained a large flow rate.
- The value of the roughness coefficient (n) obtained from Manning in some formulations are obtained empirical method for the lowest n = 0,008 and highest n = 0.090. and the condition of with the natural channel data n highest and lowest namely 0.0590 and 0.0027.
- obtained simulating the relationship between Q and Q flume Qsim = $0,436Q_{flume}^{0,8834}$ with R^2 = 0,859 which shows the model results correlate very well.
- By using the relationship obtained by the method Nash
  Qsim = $0,950Q_{flume}$ +0,0012 with R^2 = 0,9797 ,which shows a very good correlation results.
- In a study of entropy formula, bojorunas and Wibowo, for the Manning roughness values using the highest laboratory data n = 0.0256 and the lowest n = 0.0171, which results still meet the requirements for the value of non-cohesive material.
- Development of the Manning formula can be applied in the field by the presence of a correction value.
- Resultsbetween the dischargeand thedischargemeasurementresultscorrelatedonlinearseparationis good,whichis shown by thecorrelation coefficient(R^2) 0,859.
- In the method of data Limerinos and Entropy Method shows the model fit a large proportion of the 82% which means the value is quite satisfactory, because it is still the case that small forecasting error of 18%
- Linear separation method by taking into account the basic shape can be used in predicting the flow in natural river..

5.2 Recommendations

- To obtain optimal results in the research study manning coefficient should be used as much as possible the data.
- The amount of data retrieved should be quite a lot, both with respect to the number of observation points and the number density of the vertical point of channel cross section.
- Development research can be carried out with the a cross-channel conditions in other places.

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