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Manning Roughness Coefficient Study on Bed Materials Non-Cohesive with Parameters Using Entropy to Open Channel Flow

Hari Wibowo
Tanjungpura, University, Department of Civil EngineeringFaculty of engineering
Jalan Ahmad Yani, Pontianak , Kalimantan Barat, Indonesia
hariwibowo13@yahoo.com

Abstract-Application of entropy in open channel models presenting relevant aspects of theoretical issues and practical useful for cross-sectional velocity distribution. The ratio between the average velocity and the maximum depends on the local morphology. Recent research has suggested formulation Manning roughness, n, based on the ratio and the ratio between the position where the velocity is zero and the maximum, y_0/y_{max}, the flow depth of the flow regime. Based on the experience of stable flow, analysis entropy dependence on n parameters, and M for flow depth, proposes an equation y_0/y_{max} to know the bed channel roughness coefficient. The results showed a good linear relationship between estimate *n* and n entropy calculation and n with the bedform. Obtained from linear regression analysis of the data relationships flume $n_{calculate}$= 0,5803n_{etropi} + 0,010 with good correlation (R^2 = 0.864) using the entropy parameter Φ(M) = 0.8197, while for the data in a natural channel $n_{calculate}$ = 0.754 n_{etropy}+ 0.006 with good correlation (R^2 = 0.877) with Φ(M) = 0.914. It also has a fault tolerance (0.005 to 0.293)%, which is still below the tolerance.

***Keywords*:** entropy models, manning's roughness; steady flow, laboratory flume

1. Introduction

In hydraulic engineering, flow resistance coefficient or the Manning roughness coefficient is an important parameter in forecasting the flow in the channel, designing hydraulic structures, the calculation of the distribution of velocities, sediment transport and accuracy in the determination of the energy loss (Bilgil & Altun, 2008).

River flow forecasting is a very important step in order to improve management policies directed to the use of water resources as well as for mitigation, prevention and defense measures against environmental degradation (Greco et al., 2014). In addition, knowledge of the velocity distribution in the cross section of the river is fundamental in hydraulic modeling of the river, sediment and pollutant transport, channel design, river training work and hydraulic structures as well as in the manufacture of curves rating (Greco et al., 2014; Mirauda et al ., 2011b). In relation to the resistance to flow and velocity distribution in alluvial channels is a complication of the two problems. Firstly due to changes in the bedform and second a result of certain conditions of the majority of sediment transport particles acted as a suspension. On the alluvial of bed channels that are not fixed it will change its geometry and dimensional characteristics continuously as a result of the interaction between the flow and the channel bed (Yang & Tan, 2008; Singih, 2000).

In addition, the flow in open channels is limited to the aspect ratio of the width - depth three-dimensional , and wall shear stress are not evenly distributed around the wet cross-section. This is due to the free surface and the secondary flow (Guo & Julien, 2005; Azamathulla et al., 2013). Problems in separating the bed shear stress and the sidewalls are very important in almost all studies on open channel flow in this laboratory flume studies (Guo & Julien, 2005). Boundary shear stress distribution in hydraulic equation concerning the problem of resistance to the flow and sediment transport, (Javid

&Mohammadi, 2012). Method forcorrecting the sidewall (Johnson, 1942; Keulegan, 1938; Julien 1995; Yang & Lim, 1998; Mohammadi, 2004; Javid & Mohammadi, 2012).

A Mathematical model, which is derived from the application of the theory of information entropy maximization on the data collected, used to evaluate the flow field and calculate water discharge (Chiu, 1987,1988 & 1989; Chiu & Said, 1995; Chiu & Hsu, 2006; Moramarco & Singh, 2010, Mirauda et al., 2011b ; Greco et al., 2014).

Velocity distribution entropy, In fact, requires assessment on one parameter, M, which it can be obtained through knowledge of the ratio of the average flow velocity and maximum. In addition, the rules allow the natural flow well enough about the reliability of geometric irregularities and normal flow regime (Greco, 1998; Chiu et al., 2005; Burnelli et al., 2008). Application of the entropic profile in river flows also menawaran good results even for practical purposes.

In order to determine the velocity distribution in the cross section and provide acceleration on the method of calculation of the flow of water and reduce the calculation time of the survey and (Greco & Mirauda, 2004; Mirauda et al., 2011a, b). And also modeling the two-dimensional velocity distributions for open channel flow (Marini et al., 2011). Furthermore, the ratio between average velocity and maximum, Φ (M), it appears to be highly dependent on the riverbed morphology with uniform flow. This shows that the investigation of the entropy parameter depends on the hydraulic and geometric characteristics of the cross section of the river (Moramarco & Singh, 2010, 2011).

Therefore, the study of bed roughness with speed theory of entropy, the proposed formulation in *n* Manning roughness, based Φ (M) and the position in which the velocity of each. The purpose of this paper is the first to investigate the Manning roughness coefficient on entropy parameters in the case of low flow regimes. second to acquire bed calculation on the boundary shear stress in an open channel boundary rectangular shape. Then, assuming a variety of slope sidewalls, as a first approximation, the solution to the boundary shear stress calculations using isovel and ray procedures, ignoring the secondary currents and eddy viscosity is assumed constant value.

2. Study of Theory

2.1. Relationship Roughness (*n*) Manning and Entropy Parameters (M)

The average velocity, $\overline{U}_{\text{rerata}}$ mean and Umaximum velocity, Umax, open channel flow cross section can be expressed in terms of entropy (Chiu and Said, 1995), as Equation (1)

$$\overline{U} = \Phi(M) U_{max} \quad \text{.......}(1)$$

which Φ (M) can be described in the form of Equation (2)

$$\Phi(M) = \left(\frac{e^M}{e^M - 1} - \frac{1}{M}\right) \quad \text{.......}(2)$$

where M expressed entropy parameter (Chao and Lin Chiu, 1988; Moramarco and Singh ,2010; Greco et al., 2014). Eq. (1) shows that $\overline{U}$ and U_{max} together can determine $\Phi(M)$and then the entropy parameter M. It should be pointed out that U_{max} represents the maximum value in the data set of velocity points sampled in the flow area during velocity measurement (Chiu &Said 1995; Greco et al., 2014) The vertical where umax is sampled is defined, henceforth, as the y axis (Chiu 1989).

The average velocity on a steady flow in open channel can be estimated by using the Manning formula as Equation (3)

$$\overline{U} = \frac{1}{n} R_h^{2/3} S_f^{1/2} \quad \text{.......}(3)$$

Where n is the Manning roughness coefficient, R_h is the hydraulic radius and S_f is the energy slope. Instead, to determine the maximum velocity the cross section, U_{max}, along the y-axis are assumed to be perpendicular to the bottom, modified logarithmic rule under water (dip) for the velocity distribution in open channel flow uniformly smooth, proposed by Yang et al. (2004), as Equation (4)

$$u(y) = u_* \left[\frac{1}{\kappa}\ln\left(\frac{y}{y_0}\right) + \frac{\alpha}{\kappa}\ln(1 - \frac{y}{h})\right] \qquad (4)$$

Which $u_* = \sqrt{g\ R_b S_f}$ is the shear velocity (g = acceleration of gravity); κ is the von Kármán constant equal to (0.41); y_0 is the distance at which hypothetically velocity is equal to zero; α is the correction factor on the condition of the flow, which depends only on the ratio between the relative distance to the location of the maximum velocity of bed channel, y_{max} and flow depth (h) along the y-axis, which U_{max} location.

Location maximum velocity, based on the hypothesis that the dip phenomenonwith Yang et al. (2004 ; Moramarco & Singh, 2010) can be obtained by separating the Eqs. (4) and differentiation du/dy = 0, which gives the result in Equation (5)

$$\frac{y_{max}}{h} = \frac{1}{1+\alpha} \qquad (5)$$

Experimental study by Greco and Mirauda (2002) have shown that, for channels on various forms of cross-section, the maximum velocity is below the free surface of about 20 ÷ 25% of the maximum depth. This result was also confirmed from the values y_{max} collected in experimental trials of this work and is shown in Fig. (1), which y_{max} is a function of water depth (h)

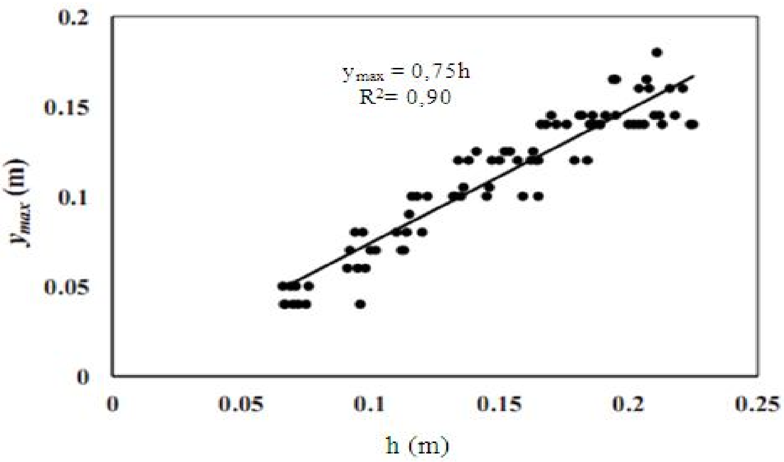


Figure 1. The Relationship between the Location of the MaximumVelocity and maximum y and Depth (Mirauda&Gerco, 2012)

$$U_{max} = \frac{\sqrt{g\ R_b S_f}}{\kappa}\left[\ln\left(\frac{y_{max}}{y_0}\right) - 0{,}4621\right] \qquad (6)$$

By replacing Equation (3) and (1) into Equation (4). it is possible to derive a relationship as Equation (7).

$$\left(\frac{e^M}{e^M - 1} - \frac{1}{M}\right) = \frac{\frac{1}{n} R_h^{2/3} S_f^{1/2}}{\frac{\sqrt{g\ R_b S_f}}{\kappa}\left[\ln\left(\frac{y_{max}}{y_0}\right) - 0{,}4621\right]} \text{ or } (M) = \frac{\frac{1}{n} R_h^{1/6}\sqrt{g}}{\frac{1}{\kappa}\left[\ln\left(\frac{y_{max}}{y_0}\right) - 0{,}4621\right]} \qquad (7)$$

which allows to connect Φ (M) with hydraulic and geometric characteristics of the flow. Finally, from Equation (30) Manning n roughness values obtained as Eq. (8)

$$n = \frac{{R_h}^{1/6}\sqrt{g}}{\Phi\ (M).\frac{1}{\kappa}\left[\ln\left(\frac{y_{max}}{y_0}\right) - 0{,}4621\right]} \quad \text{...(8)}$$

Equation (8) which concluded on the calculation of roughness (n) Manning by using the value of Φ (M) as well as calibrate the value of $\frac{y_{max}}{y_0}$. In fact, to determine Φ (M) in each test and the application of Manning n value, which is obtained by Eq. (3) into Eq. (8), to obtain ($\frac{y_{max}}{y_0}$), as it has been studied by Gerco et al. (2014) and Mirauda and Gerco (2012) the importance of the ymax is equal to ¾ of water depth (h), as in equation (9).

$$\frac{y_{max}}{y_0} = \frac{3}{4}\frac{h}{yo} \quad \text{..(9)}$$

so that Equation (31) can be written in the form of Equation (10)

$$n = \frac{{R_h}^{1/6}\sqrt{g}}{\Phi\ (M).\frac{1}{\kappa}\left[\ln\left(\frac{3}{4}.\frac{h}{yo}\right) - 0{,}4621\right]} \quad \text{...(10)}$$

yo value is near the channel bed which is assumed as the value of equivalent roughness (k_s). There is no clear consensus on the definition $k_s$and not surprisingly, there are a variety of various values of ks values' ($1{,}25d_{35} \leq k_s \leq 5{,}1d_{84}$) has been proposed (Van Rijn, 1982). However Millar (1999) has found that there was no significant difference between using the D35, D50, d84 or d90. In this study, ks suggested by Casey (1935), Shields (1935), Straub (1954) will be used, ie,

$$k_s = d_{50} \text{..(14)}$$

2.2 Shear Stress Relationship and Manning Roughness Coefficient (*n*)

NHC partitioned the bed shear stress into two components, total shear stress (τ_T) and grain shear stress (τ'), and then derived the following relation Equation (15)

$$\frac{\tau'}{\tau_T} \propto \frac{\lambda'}{\lambda_T} \quad \text{..(15)}$$

Here, λ' and λ_T are the Darcy friction factors associated with grain and total roughness, respectively. Grain roughness, fg, can be computed using the following empirical relation (Henderson, 1966):

$$\lambda' = 0{,}113(d_{84}/R_h)^{1/3} \text{...(16)}$$

In this relation R_h is the hydraulic radius of the channel (in feet) and d_{84} is the particle diameter (in feet) that exceeds 84 percent of the particles sampled. Combining the Manning's and Darcy equations, total roughness, ft , can be computed using the following Equation (17)

$$\lambda_T = 8g\left(\frac{n_T}{1{,}49R^{1/6}}\right) \quad \text{...(17)}$$

According to Einstein (1942) and Meyer-Peter, Muller (1948) and Yang and Tan (2008), the shear stress can be separated into the shear stress due to the side wall and shear stress due to the bed, as written in equation (18)

$$\tau_T = \tau_w + \tau_b = \tau_w + \tau\ ' + \tau\ '' \text{.......................................(18)}$$

Where τ_T is the shear stress limit of the average; $\tau_w$is side wall shear stress; $\tau_b$isbed shear stress =$\tau\ ' + \tau\ ''$.

2.2.1 Average Bed Shear Stress Equation

By considering the steady uniform flow in rectangular open channel. In the flow direction defines the direction x, and y-z cross section is shown in Fig. (2)

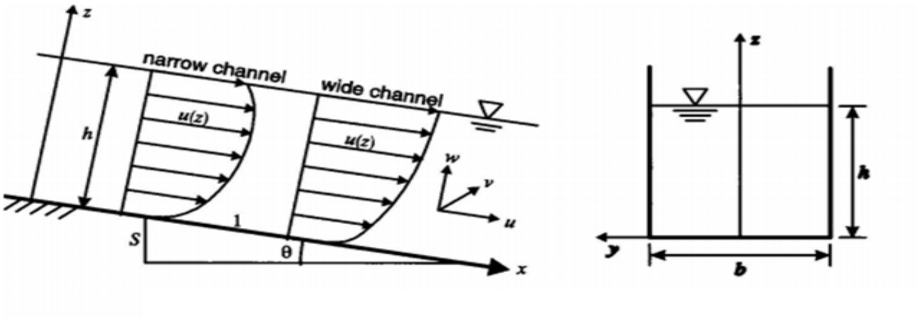


Figure 2. Coordinate Systems in Open Channel Flow (Guo&Julien, 2005)

Guo and Julien (2005) analyzed the methods by considering the volume control BCHGB (Ab) in Figure (1), which has a unit of length. in the flow direction x and assumed in the determination of BG and CH are symmetric with respect to the z axis. In addition, the main flow velocity in each of the x-axis is denoted as u, and the secondary current in the yz plane is v and w. By analysis using the continuity equation and momentum, then the shear stress obtained an average basis. The average shear stress is composed of three terms, namely gravity (I), the secondary current (II), and interfaces (interfaces) shear stress (III) in equation (19)

$$\overline{\tau_b} = \frac{\rho g S A_b}{b} - \frac{2}{b}\int_L \rho u(v\,dz - w\,dy) + \frac{2}{b}\int_L (\tau_{yx}\,dz - \tau_{zx}dy)$$

………………..(19)

(I) (II) (III)

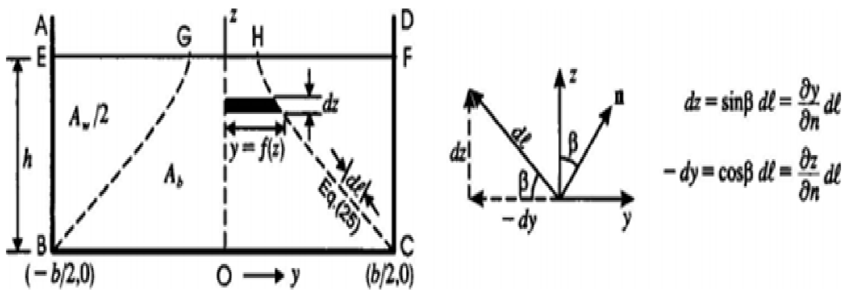


Figure 3 The Cross-section Transverse Partitions Area Separation on Bed Shear Stress and Sidewall (Guo & Julien, 2005)

For the case of a steady uniform flow in open channels in a rectangular shape; where g is the acceleration due to gravity; ρ = mass density of water; S = slope of the channel bottom slope; b is the width of the channel; and $\tau_{yx}$and τ_{zx} = shear stress in the flow direction x is applied to each field z-x and y-x. It can be proved that although Equation (19) is taken to smooth rectangular channels, it is also applicable to all types of cross sections along the BG and CH are symmetrical (Guo & Julien, 2005; Yang et al., 2006).

2.2.2 Average Side-Wall Shear Stress Equation

Similarly, the side wall shear stress on average $\overline{\tau_w}$ can be formulated by applying the equation. $\int_A \rho u\left(\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}\right)dA = \rho gS\,V + \int_A\left(\tau_{yx}\frac{\partial y}{\partial n}+\tau_{yx}\frac{\partial z}{\partial n}\right)\,dA$, with volume control BGEB or CFHC in Fig. (3). The decline in the side wall shear stress formulation average is to consider the overall balance of force in the direction of flow. As defined in Equation (20)

$$2h\overline{\tau_w} + b\overline{\tau_b} = \rho gSA_b = \rho gS\,bh \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(20)$$

Where the first form in the left hand side is the shear force on the two sides of the side walls, the second form is the shear force on the base of the channel, and the right-hand side is the component of gravity in the direction of water flow. Applying Eq. (19) in Eq. (20) give the side wall shear stress averaged as Equation (21).

$$\overline{\tau_w} = \frac{\rho gS\,bh - b\overline{\tau_b}}{2h} = \frac{\rho gS\,A_w}{2h} + \frac{1}{h}\int_{CH}\rho\,u(vdz - wdy) + \frac{1}{h}\int_{CH}\left(\tau_{yx}dz - \tau_{yx}dy\right)\ldots(21)$$

Where $A_w = bh - A_b$. In Equation (19) and (21), it can be seen that the shear stress boundary consists of three components: the first term is the contribution of gravity, the second term is the effect of secondary flow, and the third term is the effect of fluid shear stress, which in turn, reflects the effect of viscosity in a turbulent eddy currents. The first form that is dominant with a small contribution from the second and third forms on the right hand side of the Equation. (19) and (21).

2.2.3 First Approximation Without Secondary Currents

To estimate the boundary shear stress, using Equation (19) and (21), we must know the main velocity u and secondary currents, v and w, shear stress $\tau_{yx}$and $\tau_{zx}$and and integration path BG and CH. On the other hand, to solve for the velocity field, we must know the boundary shear stress. Interaction between velocity and shear stress makes the solution to the boundary shear stress or velocity profiles are very complex profile, as shown by Chiu and Chiou (1986). As an approach, we can ignore the effects of secondary flow and fluid shear stress. Thus, equation (19) into Equation (22a) and (22b)

$$\overline{\tau_b} = \frac{\rho gSA_b}{b} \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(22a)$$

or

$$\frac{\overline{\tau_b}}{\rho ghS} = \frac{A_b}{bh} \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(22b)$$

And Equation (19) into Equation (23a) and (23b).

$$\overline{\tau_w} = \frac{\rho gS\,A_w}{2h} \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(23a)$$

$$\text{or}\frac{\overline{\tau_w}}{\rho gSh} = \frac{A_w}{2h^2} \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(23b)$$

The remaining problem is to find an area of Ab and Aw, which is equivalent to finding the determination of BG and CH in Figure (3).

2.2.4 Delimitations BG and CH

By showing that the momentum equation corresponding to the flow direction x is as Equation (24)

$$\rho\left(v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z}\right) = \rho g S + \frac{\partial \tau_{yx}}{\partial y} + \frac{\partial \tau_{yx}}{\partial z} \quad \text{..........................(24)}$$

Convective acceleration on the left side of Equation (24) accounted for the secondary flow. The first form on the right side is the component of gravity in the direction of flow, and the other two are a potential flow (net) shear stress is applied to the fluid differential element. The first approach assumes that: (1) secondary current is not negligible; and (2) eddy viscosit v_t is constant. Applying these two assumptions to Equation (24) gives Equation (25)

$$\frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2} = -\frac{gS}{v+v_t} = constant \quad \text{..(25)}$$

Where $\tau_{yx} = \rho(v + v_t)\,\partial u/\partial y$; $\partial u/\partial y$; $\partial\tau_{zx} = \rho(v + v_t)\,\partial u/\partial z$and υ = kinematic viscosity of water. Equation (25) is called the Poisson equation and can be solved by means of Laurent series (White, 1991; Guo & Julien, 2005). That is, orthogonal velocity contours are used to describe the BG and CH in Figure (3). Although the solution to Equation (24) provides a laminar velocity profile, and orthogonal provide a first approximation to the boundary shear stress. To determine the limits of the potential lines and flow lines. Its solution using the Schwarz-Christoffel transformation (Driscoll el al., 2002, Spiegel, 1993) by using an assumption of rectangular cross section channel width b and depth h flow of figure (3) and the aspect ratio of the channel side walls.

By using formulation Transformation Schwarz-related Chistoffel the physical domain flow (plane -ω) and middle upper field (plane -ζ) as Equation (26a) and (26b).

$$\omega = A + B\int (z - x_1)^{-\frac{\alpha_1}{\pi}} (z - x_2)^{-\frac{\alpha_2}{\pi}}\, dz \quad \text{...................................(26a)}$$

or

$$\frac{\partial\omega}{\partial z} = B\,(z - x_1)^{-\frac{\alpha_1}{\pi}}(z - x_2)^{-\frac{\alpha_2}{\pi}} \quad \text{...(26b)}$$

In the form of orthogonal and isotropy as Equation (26c)

$$\frac{\partial\omega}{\partial\zeta} = B\,(\zeta - x_1)^{-\frac{\alpha_1}{\pi}}(\zeta - x_2)^{-\frac{\alpha_2}{\pi}} \quad \text{...(26c)}$$

by taking$x_1 = -b/2$; $x_2 = b/2$; $w_1 = -\pi/2$; $w_2 = \pi/2$; dan $\alpha_1 = \pi/2$, $\alpha_2 = \pi/2$, then Equation (26c) will be Equation (27)

$$\frac{\partial\omega}{\partial\zeta} = B\left(\zeta + \frac{\pi}{b}\right)^{-\frac{1}{2}}\left(\zeta - \frac{\pi}{b}\right)^{-\frac{1}{2}} \quad \text{..(27)}$$

Where z = y + iz and ω = ζ + iη; B is a constant change of form; -b / 2 and b / 2 is any value in each of the left and right ends of the cross section in the channel changes. In other words, the value of which crossed at an angle equal to -b/2 and + b/2. Applying the theorem of integration in Equation (27) can be solved by several methods, namely Hipergeometri (Javid & Mohammadi, 2012), using the Laurent series (Guo & Julien, 2005) and entropy (Chao-Lin Chiu, 1986 & 1988; Houjou et al., 1990; Samani el al., 2013).

- **Dengan prinsip Isovel**

By taking$\zeta = \frac{b}{\pi}$dan$z = \frac{b}{2}\exp\left(-1{,}261\frac{y}{b}\right)$..............................(28)

And the cross-sectional area average shear as Equation (29)

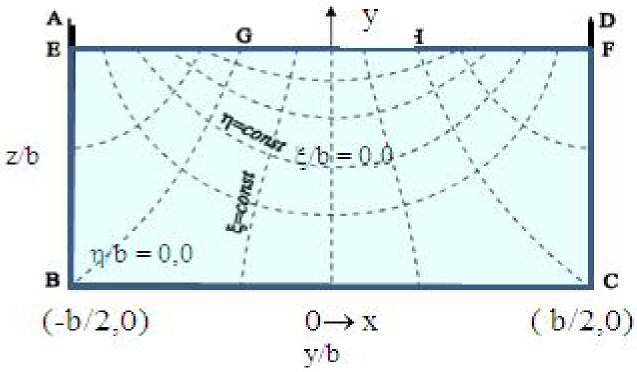
$A_b =$  ....(29)

Figure 4. Calculation Form Isovel and Orthogonal

Use of the software Mathcad will obtain Equation (30)

$$A_b = 0{,}793b^2(\exp(-1{,}261\,h/b) - 1) \quad (30)$$

By substituting Equation (30) in equation (22b), the shear stress resulting an average bed as Equation (31a)

$$\frac{\overline{\tau_b}}{\rho ghS} = \frac{0{,}793b^2(-1+\exp(1{,}261h/b))}{bh} =$$

$$0{,}793\frac{b}{h}(\exp(-1{,}261\,h/b) - 1) \quad (31a)$$

Similarly to the side wall shear stress on average, by substituting Equation (30) into Equation (23b) the importance of the equation (31b)

$$\frac{\overline{\tau_w}}{\rho gSh} = \frac{(bh - A_b)}{2h^2} = \frac{(bh - 0{,}793b^2(-1+\exp(-1{,}261h/b)))}{2h^2} \quad (31b)$$

2.2.5 Second Approximation with Correction Factors

The first approach implies that the maximum velocity occurs at the surface of the water. However, research by Javid (2011) and Javid and Mohammadi (2011) illustrates that specific performance on the secondary flow cell in a rectangle channel changing pattern of flow lines and potential lines, especially in the corners and the surface of the water. Thus, the second approach aims to improve on the first approach by introducing two empirical correction factors are lumped in the first approach.

By substituting Equation (29) into equation (22b) gives Equation (32)

$$\frac{\overline{\tau_b}}{\rho ghS} = 2\int_0^h \frac{b}{2}\exp\left(-1{,}261\frac{z}{b}\right)dz \quad (32)$$

Application integration theorem in further section and the mean value theorem for integration in the above equation gives Equation (33)

$$\frac{\overline{\tau_b}}{\rho ghS} = 0{,}793b^2(1 - Exp\,(-1{,}261\;h/b) \quad (33)$$

By including the effect of secondary flow, variable flow viscosity and perhaps other effects, two empirical correction factor that is $\lambda_1$and λ_2. Equation (33) can be assumed to be the Equation (34).

$$\frac{\overline{\tau_b}}{\rho g h S} = \exp\left(-1{,}261\frac{h}{b}\right) - \lambda h \frac{-1{,}261}{b} Exp\left(-1{,}261\frac{\lambda h}{b}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(34)$$

Where λh is located at a point such that 0 <λ <1 and to satisfy the value theorem average conditions, numerical evaluation shows that the first form on the right side of the meruoakan main form and provide only a small effect on the first form. This is analogous to Guo and Julien (2002), so that Equation (34) can be fixed into Equation (35).

$$\frac{\overline{\tau_b}}{\rho g h S} = \exp\left(-1{,}261\frac{h}{b}\right) - \lambda_1\left(\frac{h}{b}\right) Exp\left(-1{,}261\frac{\lambda_2 h}{b}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(35)$$

By substituting Equation (35) into Equation (22b) and provides a second approach on the side wall shear stress on average. In rectangular channel sidewall aspect ratio, Equation (23b) reduces to Equation (36).

$$\frac{\overline{\tau_w}}{\rho g h S} = \frac{1}{2}\frac{b}{h}\left(1 - \frac{\overline{\tau_b}}{\rho g h S}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(36)$$

To get the value of λ_1 and λ_{21}, the calibration of the Equation (34) so that it will comply with the empirical formula.

3. Experimental Data

The experimental tests were carried out in the Hydraulics Laboratory of Bandung Institute of Technology, on a free surfaceflume of 3,0 m length and with a cross section of 0,1 x 0,4 m2 (Fig. 1a), whose slope can vary from 2/300 % 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 0,45mm to 0,85mm. Picture design can be found at Fig.5

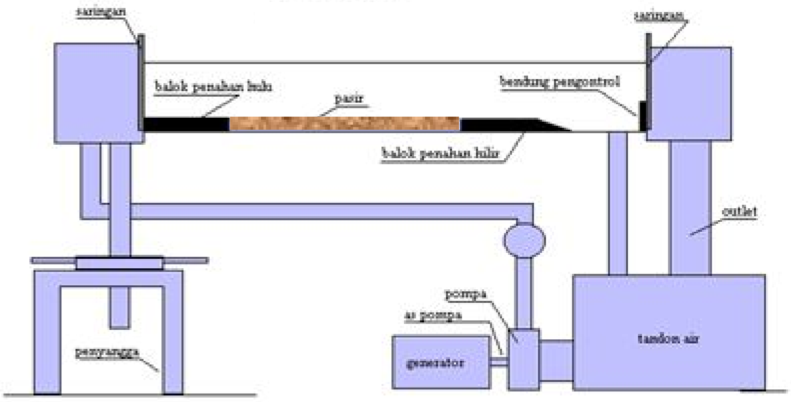


Figura 5. Flume Conditions along with AdditionalEquipment used

4. Experimental Data Analysis

The data used for the analysis of experimental results of Choo et al. (2011) and Greco et al. (2014) as in Table (1).

Table 1. Results of Linear Regression Analysis between U_{rerata} and U_{max}

Data Source	Data	Relationship Equation	Φ (M)	R^2
Laboratory	Abdel=Ael,F.M(1969)	U_{mean} =0,8657 U_{max}	0,8657	0,9998
	Govt. of W. Bengal(1965)	U_{mean} =0,8197 U_{max}	0,8197	0,9987
	Chyn, S.D(1935)	U_{mean} =0,8521 U_{max}	0,8521	0,9998
	Costello, W.R.(1974)	U_{mean} =0,8667 U_{max}	0,8667	0,9998
	Greco el al. (2014)	U_{mean} =0,7314 U_{max}	0,7300	0,8840
River	Acop Canaldata of Mahmood, et al. (1979)	U_{mean} =0,911 U_{max}	0,9110	0,999
	Hii River data of Shinohara, K. and Tsubaki, T.(1959)	U_{mean} =0,882 U_{max}	0,8820	0,992
	Leopold, L.B.(1969)	U_{mean} =0,914 U_{max}	0,9140	0,999
	Greco el al. (2014)	U_{mean} =0,702 U_{max}	0,7060	0,8957

Table 2. Results of Laboratory Experiments.

No.	Slope	$Q_{outflow}$		h	$U_{outflow}$	Kecepatan rerata					Δ	λ
		l/dt	cm3/dt	cm	cm/dt	pelampung	high speed type current meter (hz)				cm	cm
						cm/dt	dasar	1/3h	2/3h	permukaan		
A.1.1.1	0,00667	2,51440	2514,40	8,00	31,43	36,5672	45,00	62,00	60,00	67,00	0,75	12,5
A.1.1.2	0,00667	2,86780	2867,80	11,00	26,07	22,4427	38,00	41,00	40,00	43,00	1,70	10,0
A.1.1.3	0,00667	2,67970	2679,70	12,50	21,44	24,6498	35,00	38,00	36,00	40,00	0,50	9,0
A.1.1.4	0,00667	4,52140	4521,40	14,00	32,30	31,0127	47,00	59,00	58,00	62,00	0,90	10,0
A.1.2.1	0,01333	3,06100	3061,00	12,00	25,51	27,7620	38,00	58,00	63,00	60,00	0,80	8,0
A.1.2.2	0,01333	3,70830	3708,30	13,00	28,53	28,4056	68,00	68,00	65,00	72,00	1,50	7,5
A.1.2.3	0,01333	3,81730	3817,30	14,00	27,27	30,3093	68,00	67,00	46,00	56,00	1,70	10,0
A.1.2.4	0,01333	4,34490	4344,90	15,00	28,97	32,0611	43,00	55,00	43,00	68,00	0,25	8,0
B.1.1.1	0,00667	2,81110	2811,10	11,00	25,56	28,3510	46,00	42,00	41,00	43,00	0,80	6,5
B.1.1.2	0,00667	4,25980	4259,80	12,10	35,20	39,0438	11,00	70,00	65,00	68,00	2,00	24,0
B.1.1.3	0,00667	2,86610	2866,10	12,50	22,93	28,1340	34,00	44,00	47,00	46,00	1,20	9,5
B.1.1.4	0,00667	4,10420	4104,20	14,00	29,32	28,0438	46,00	73,00	56,00	58,00	0,80	9,5
B.1.2.1	0,01333	2,90150	2901,50	10,00	29,02	32,3789	44,00	57,00	54,00	53,00	0,50	8,0
B.1.2.2	0,01333	4,99270	4992,70	13,00	38,41	40,4959	75,00	81,00	61,00	95,00	0,80	10,0
B.1.2.3	0,01333	5,44780	5447,80	14,00	38,91	39,5693	78,00	80,00	80,00	92,00	1,40	6,5
B.1.2.4	0,01333	6,42860	6428,60	15,00	42,86	39,0957	63,00	103,00	98,00	72,00	2,20	9,0

Source data : Singih (2001)

Table 3. Results of Calculation Manning with the basic form

Q (l/dt)	**h(m)**	**R(m)**	**u1(m/dt)**	**Slope**	**Fr**	**u***	**u/u***	**d50**	**n**	**np**
2,51440	0,08	0,26	0,314	0,007	0,355	0,072	5,055	0,001	0,0196	0,0166
2,86780	0,11	0,32	0,261	0,007	0,251	0,085	2,646	0,001	0,0367	0,0166
2,67970	0,13	0,35	0,214	0,007	0,194	0,090	2,726	0,001	0,0354	0,0166
4,52140	0,14	0,38	0,323	0,007	0,276	0,096	3,241	0,001	0,0298	0,0166
3,06100	0,12	0,34	0,253	0,013	0,232	0,126	2,207	0,001	0,0438	0,0166
3,70830	0,13	0,36	0,285	0,013	0,253	0,130	2,178	0,001	0,0443	0,0166

Q (l/dt)	h(m)	R(m)	u1(m/dt)	Slope	Fr	u*	u/u*	d50	n	np
3,81730	0,14	0,38	0,273	0,013	0,233	0,135	2,240	0,001	0,0431	0,0166
4,34490	0,15	0,40	0,290	0,013	0,239	0,140	2,289	0,001	0,0421	0,0166
2,81110	0,11	0,32	0,256	0,007	0,246	0,085	3,343	0,000	0,0290	0,0152
4,25980	0,12	0,34	0,352	0,007	0,323	0,089	4,389	0,000	0,0175	0,0152
2,86610	0,13	0,35	0,229	0,007	0,207	0,090	3,112	0,000	0,0311	0,0152
4,10420	0,14	0,38	0,293	0,007	0,250	0,096	2,931	0,000	0,0329	0,0152
2,90150	0,10	0,30	0,290	0,013	0,293	0,114	2,831	0,000	0,0344	0,0152
4,99270	0,13	0,36	0,381	0,013	0,336	0,131	3,094	0,000	0,0312	0,0152
5,44780	0,14	0,38	0,389	0,013	0,332	0,135	2,924	0,000	0,0330	0,0152
6,42860	0,15	0,40	0,429	0,013	0,353	0,140	2,791	0,000	0,0345	0,0152

n = Manning roughness values calculate; np = Manning roughness values with bedform
n with parameter estimation results can be seen in the graph entropy

Comparison with Experimental Data

Calculate the prediction accuracy by using the average normal faults (MNE) is

$$MNE = \frac{100}{N}\sum_{i=1}^{N}\frac{\left|X_{ci} - X_{mi}\right|}{X_{mi}}, \quad \text{...}(37)$$

with$N$ = many of data, X_{mi} = measurement data in the laboratory andX_{ci}= Data results of numerical calculations.

Table 4. Function Error on the Value of n Manning

n ent M(Φ)=0,866	n	n bed	error Function	
0,021	0,0196	0,0166	0,094	0,154
0,040	0,0367	0,0166	0,085	0,548
0,038	0,0354	0,0166	0,074	0,533
0,031	0,0298	0,0166	0,036	0,444
0,056	0,0438	0,0166	0,272	0,622
0,050	0,0443	0,0166	0,124	0,626
0,055	0,0431	0,0166	0,281	0,616
0,053	0,0421	0,0166	0,262	0,607
0,034	0,0290	0,0152	0,173	0,477
0,025	0,0175	0,0152	0,408	0,135
0,042	0,0311	0,0152	0,338	0,511
0,033	0,0329	0,0152	0,000	0,539
0,042	0,0344	0,0152	0,224	0,559
0,035	0,0312	0,0152	0,125	0,514
0,035	0,0330	0,0152	0,076	0,540
0,033	0,0345	0,0152	0,049	0,561

n ent M(Φ)=0,820	error Function	
0,023	0,155	0,154
0,042	0,146	0,548
0,040	0,134	0,533
0,033	0,094	0,444
0,059	0,344	0,622
0,053	0,188	0,626
0,058	0,353	0,616
0,056	0,333	0,607
0,036	0,239	0,477
0,026	0,487	0,135
0,044	0,413	0,511
0,035	0,057	0,539
0,045	0,293	0,559
0,037	0,188	0,514
0,037	0,136	0,540
0,035	0,005	0,561

n ent M(Φ)=0,852	error Function	
0,022	0,111	0,154
0,040	0,102	0,548
0,039	0,091	0,533
0,031	0,052	0,444
0,057	0,293	0,622
0,051	0,142	0,626
0,056	0,301	0,616
0,054	0,282	0,607
0,035	0,192	0,477
0,025	0,431	0,135
0,042	0,360	0,511
0,033	0,016	0,539
0,043	0,244	0,559
0,036	0,143	0,514
0,036	0,093	0,540
0,033	-0,034	0,561

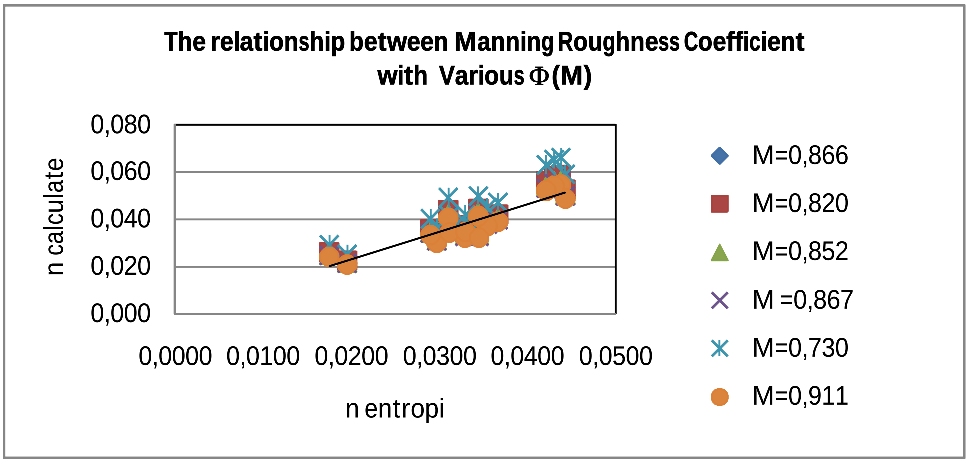


Figure 6. Relationship Between Manning Coefficient between ncalculation and n entropy

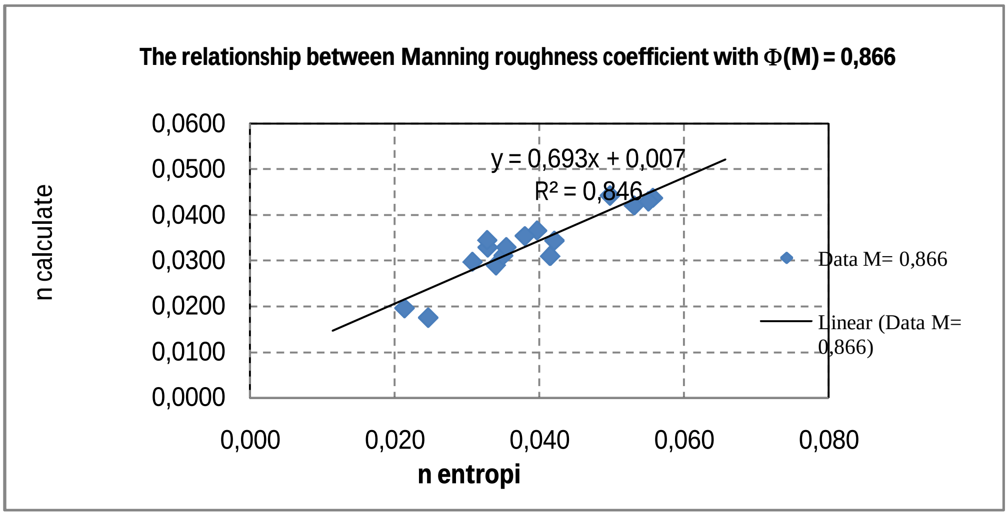


Figure 7. Linear Relationship between the Manning coefficient n entropy and n calculate

The next calculations carried Tabelaris

Table 4 The Results of Calculations with DifferentValuesΦ (M)

Data Source	Data	Relationship Equation n	Φ (M)	R^2
Laboratory	Abdel=Ael,F.M(1969)	$n_{hitung} = 0{,}693 n_{etr} + 0{,}007$	0,8657	0,846
	Govt. of W. Bengal (1965)	$n_{hitung} = 0{,}5803 n_{etr} + 0{,}010$	0,8197	0,864
	Chyn, S.D(1935)	$n_{hitung} = 0{,}682\ n_{etr} + 0{,}007$	0,8521	0,846
	Costello, W.R.(1974)	$n_{hitung} = 0{,}694\ n_{etr} + 0{,}007$	0,8667	0,846
	Greco el al. (2014)	$n_{hitung} = 0{,}584\ n_{etr} + 0{,}006$	0,7300	0,846
River	Mahmood, et al. (1979)	$n_{hitung} = 0{,}729\ n_{etr} + 0{,}0067$	0,9110	0,846
	Shinohara&Tsubaki(1959)	$n_{hitung} = 0{,}7058\ n_{etr} + 0{,}0067$	0,8820	0,846

	Leopold, L.B.(1969)	$n_{hitung} = 0{,}754\ n_{etr} + 0{,}006$	0,9140	0,877
	Greco el al. (2014)	$n_{hitung} = 0{,}5649\ n_{etr} + 0{,}0067$	0,7060	0,846

Source Data : Results Calculate

The results are plotted in Table (3) and Figure (6) and (7) and showed a good acceptance pda good roughness coefficient of using entropy as well as with the bedform. Relationships between variables in both methods showed a good correlation with the variation of entropy parameters Φ (M) = 0,706 to 0,911 for the natural river that gives the correlation value of R^2 = 0.846 to 0.877. While in the laboratory flume entropy parameter value Φ (M) = 0,730 to 0,867; with a correlation value of R^2 = 0,846 to 0,864.

Therefore, at low depth or low regime, the use of Eq. (10) together with the assumption verified ymax in ¾ h from the bottom of the channel, will provide a better assessment and faster than the Manning roughness against perhitung on Moramarco and Singh (2010) with a constant value at y0, and the observed values of ymax, it will be difficult to be evaluated in field measurements. Furthermore, important to be underlined that is how, with a regime of low or shallow depth, giving effect to the parameter M on geometric and hydraulic characteristics of the flow, and provide valid results through analysis performed on the experimental data presented here.

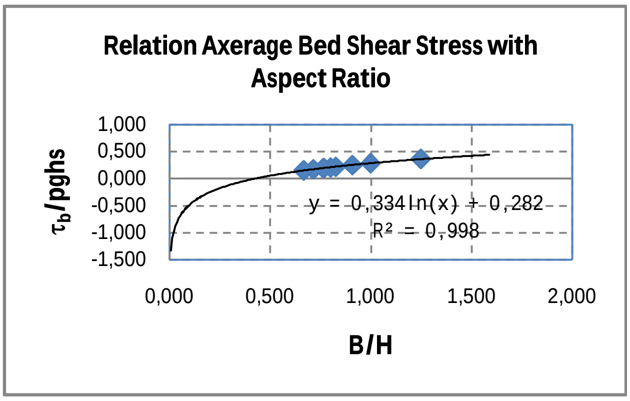


Fig.8 Value of first approximation and second approximationfor average bed shear stress with experimental data

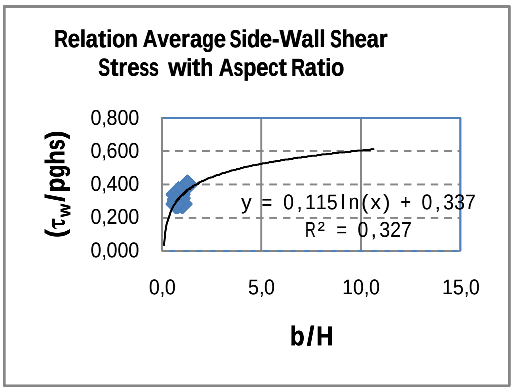


Fig.9 Value of of first approximation and second approximationfor average side-wall shear stress with experimental data

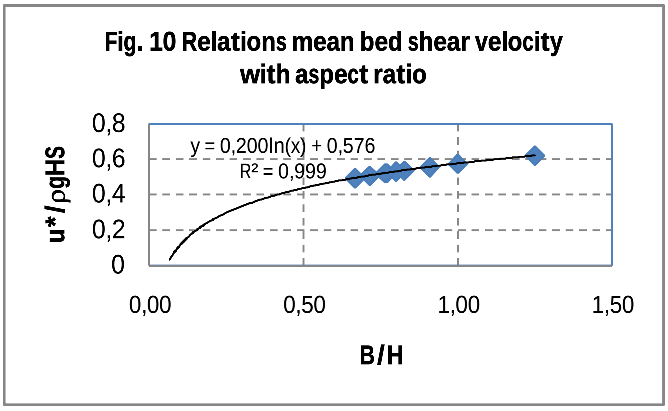


Fig.10 Value of of first approximation and second approximationfor average mean bed shear velocity with experimental data

Thisanalysisdefinesthe sidewallshear stressandthe averagebaseona steadyuniformflowinasmoothrectangularchannels. Analysis ofthe continuityandmomentumequationsproduceformulationsfor the averageshear stressin Eq. (19) andthe sidewallshear stressonaveragein Eq. (21). Bothformulationsshowed the importance ofthe threemaintermsin theshear stressanalysis: (1) the form ofgravity; (2) forms ofsecondaryflow; and(3) stressshear at the interface. Ananalyticalsolutionsarepossiblefor the casein whichthe eddyviscosityisconstantandthe secondaryflowthatcanbe ignored. Thisanalyticalsolutionis obtainedafterconsidering theSchwarz-Christoffeltransformation. Thisleads to afirst approximationin terms ofthe seriesexpansionforthe shear stressin Eq. (31.a) andsidewallshear stressin Eq. (31b).

In figure (8) above results show the relationship of non-dimensional shear stress there is the aspect ratio B / h on the wall showed good results, while the side walls showed poor correlation. Traditionally the bed shear velocity is determined by fitting the near bed velocity pro fi le to the logarithmic law when studying turbulent velocity profiles in flume experiments (Nezu and Nakagawa 1993). In relation with the aspect ratio resulting a good correlation between these variables, it is shown by the Figure (10) the relationship$\frac{U_*}{\rho ghS}$ = 0,2007 ln($\frac{B}{h}$) + 0,999 with correlation R^2 = 0,9999.

5. Conclusion

- Application entropic on the velocity profile to the river, can be used in evaluating the flow rate, reducing the time and trouble in the fluvial control and monitoring activities.
- In addition, the formulation of n Manning roughness, which is based on entropy parameter (M), and the ratio between the position where the velocity is zero and the maximum velocity, y_0/y_{max}, which could be useful to overcome the uncertainty in the evaluation of the resistance parameters, especially the existence of roughness relatively large.
- The analysis shows how y_0/y_{max}dependence on bed roughness value h/yo in promoting the Manning roughness n, through the formulation proposed by Moramarco Singh (2010) and modified by considering ymax for ¾ of water depth (h). The results of that impose on the relationship between entropy and the parameters of hydraulic and geometric characteristics of the flow.

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