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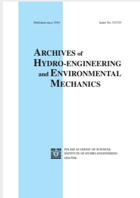

Chezy's Resistance Coefficient in a Round-cornered Rectangle Channel

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Abstract. The determination of resistance coefficients, such as Chezy's or Manning's coefficients, requires a great deal of sensible thought in order to express these coefficients better and more extensively in free-surface channels and aqueducts. This can be achieved if the expression of the resistance coefficient is well stated and takes into account the maximum number of parameters for governing flows in channels. However, in most practical cases, if these coefficients are not expressed by implicit models, they are generally taken as constant and arbitrary. To this end and in a rational manner, the dimensioning and design of channels requires the expression of the resistance coefficient in an easily and explicit form by adopting numerous flow parameters, namely the roughness of the walls, the aspect ratio, the slope of the channels and essentially the viscosity of the liquid. To achieve this aim, the Chezy's resistance coefficient C is identified using the rough model method (RMM), which gives the discharge under uniform flow conditions appropriate to a round-cornered rectangle channel.

Key words: Chezy's resistance coefficient, RMM, round-cornered rectangle channel, uniform flow

1. Introduction

In artificial canals or natural watercourses, and particularly under uniform conditions, the notion of resistance during flow is expressed by a factor known as the "resistance coefficient". According to the experts, this coefficient is due to the roughness of the walls or the friction produced by the layers of liquid between them. Since the first appearance in 1775 of this coefficient C in Chezy's general velocity formula (1) (Carlier 1972, Chow 1973, French 1986), many hydraulic engineers have contributed to expressing this coefficient, each in their own way, depending on the nature of the channel walls, the shape of the cross-section, the longitudinal gradient, etc. In terms of the coefficient C, the flow velocity V is given by

$$V = C\sqrt{R_h i}, \tag{1}$$

where R_h is hydraulic radius and i is longitudinal slope. Among these expressions we can cite the best known, such as Prony's expression (Carlier 1972):

$$\frac{1}{C^2} = \frac{0.000044}{V} + 0.000309, \tag{2}$$

where V is pipe velocity.

Bazin (1897) proposed an expression for C as a function of hydraulic radius R_h and a tabulated roughness γ:

$$C = \frac{87}{1 + \frac{\gamma}{\sqrt{R_h}}}. \tag{3}$$

However, the formula (4) of Ganguillet and Kutter (1869) depends on more parameters: R_h, the slope i and the roughness n, where its values are also shown in a table:

$$C = \frac{23 + \frac{0.00155}{i} + \frac{1}{n}}{1 + \left(23 + \frac{0.00155}{i}\right)\frac{n}{\sqrt{R_h}}}. \tag{4}$$

In relation to expression (4), in a simpler aspect, Kutter has proposed another formula (Carlier 1972) which is easier to use than the one established by Ganguillet:

$$C = \frac{100\sqrt{R_h}}{b + \sqrt{R_h}}, \tag{5}$$

where b is roughness of the inner wall of the channel.

Manning (1895) has proposed another formula for C as a function of R_h and n, the latter parameter being the same as that seen in the Ganguillet-Kutter formula, hence

$$C = \frac{1}{n} R_h^{1/6}. \tag{6}$$

This expression is the most widely used in the calculation and design of channels and pipes in free-surface flow.

From what has been presented, we can see that none of the expressions already explained has taken account of the Reynolds number Re. However, in 1949 and in an implicit form, Thijsse expressed the formula (7) (Carlier 1972), and Powell (1950) expressed the formula (8). In these two formulas, the Chezy coefficient depends on the viscosity of the liquid interpreted by the Reynolds number Re, in addition to the absolute roughness ε and the hydraulic radius R_h:

$$C = -18 \log \left[\frac{\varepsilon}{12R_h} + \frac{C}{3Re} \right], \tag{7}$$

$$C = -42 \log \left[\frac{\varepsilon}{R_h} + \frac{C}{4Re} \right]. \tag{8}$$

Again, in order to have a general expression for the resistance coefficient C which applies to all pipe shapes and which takes into account all the flow parameters, Swamee and Rathie (2004) proposed the summary formula (9). However, it may have the disadvantage of being implicit in the case where the linear dimension of the pipe is not a given Achour (2015a, 2015b) Loukam et al(2018) and Loukam et al (2020). Hence,

$$C = -2.457\sqrt{g} \ln \left[\frac{\varepsilon}{12R_h} + \frac{0.221\nu}{R_h\sqrt{giR_h}} \right], \tag{9}$$

where ν is the kinematic viscosity and g is the acceleration of gravity.

Briefly, we can also cite other works carried out to determine the Chezy resistance coefficient, namely that of Streeter (1936), Ead et al (2000), Pyle and Novak (1981), Marone (1970), Perry et al (1969), Naot et al (1996) and Giustolisi (2004).

In summary, and following what has been presented, enormous efforts have been made to better express the resistance coefficient. However, each of these works has a drawback, either because it does not take into account all the parameters governing the flow, or because the established expression is implicit, requiring an iterative calculation.

With this in mind and with the aim of avoiding these shortcomings, this work is a contribution that consists of developing the expression for calculating the Chezy coefficient C so that it is more manageable and easier to use. Based on the rough model method (RMM) Achour and Bedjaoui (2006) for calculating pipes and channels, we establish a general relationship for the explicit form resistance coefficient, taking into account all the hydraulic parameters and valid for all states of turbulent flow in round-cornered rectangle channel (Figure 1). For this geometric shape, the determination of the Chezy resistance coefficient by RMM can be carried out practically when the upper width of channel is a given or not in the problem, and can also reveal to us singularities of variation of this coefficient, different from those of the traditional geometric shape of the rectangular channel, where the walls are perfectly straight.

2. Methods

2.1. Round-cornered Rectangle

Round-cornered rectangle (Chow 1973) is a profile that is frequently used in channels to discharge wastewater, rainwater and in the irrigation water systems. Compared to the rectangular profile with straight corners, the rectangle profile with rounded corners allows better evacuation of dirty water by preventing solids from settling at the bottom of the channel.

The profile of the round-cornered rectangle is shown in Figure 1. It is a simple rectangular profile with rounded corners at the bottom of the channel where the normal depth of the liquid is $y_n(y_n > r)$. The hydraulic characteristics, specifically, the wetted perimeter P, the wetted cross-section A and the hydraulic radius R_h, can be obtained as functions of the aspect ratio $\eta = y_n/T$ and $\alpha = b/r$.

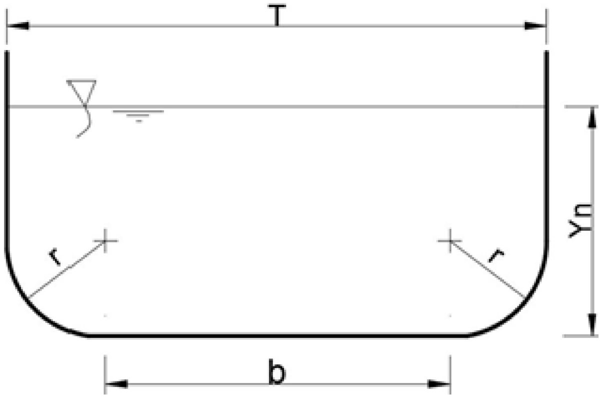

Fig. 1. Round-cornered rectangle profile

$$A = T^2 \times \varphi(\eta, \alpha), \tag{10}$$

$$P = T \times \sigma(\eta, \alpha), \tag{11}$$

$$R_h = T \times \frac{\varphi(\eta, \alpha)}{\sigma(\eta, \alpha)}, \tag{12}$$

where:

$$\varphi(\eta, \alpha) = \left(\frac{1}{2+\alpha}\right)^2 \left(\frac{\pi}{2} - 2\right) + \eta, \tag{13}$$

$$\sigma(\eta, \alpha) = \left[\frac{(\pi - 4)}{(2+\alpha)}\right] + 1 + 2\eta. \tag{14}$$

2.2. Chezy's Resistance Coefficient

2.2.1. General Expression

Taking into account the velocity expressed by Chezy, the discharge for the flow is given by the following formula:

$$Q = CA\sqrt{R_h i}. \tag{15}$$

The aim of this work is to express the resistance coefficient of equation (15) using the RMM. The coefficient C, in addition to depending on the aspect ratio η, also depends on other hydraulic parameters, such as the flow discharge Q, the longitudinal slope i, the absolute roughness ε of the internal wall of the channel, and the kinematic viscosity ν of the liquid. To do this, relationship (16) can be used to give the resistance coefficient C, established in 2006 by Achour and Bedjaoui for turbulent flow for all geometric profiles of pipes and channels:

$$Q = -4\sqrt{2g}A\sqrt{R_h i}\log\left[\frac{\varepsilon}{14.8R_h} + \frac{10.04}{Re}\right], \tag{16}$$

where Re, the Reynolds number, is given by the formula (17)

$$Re = 32\sqrt{2}\frac{\sqrt{giR_h^3}}{\nu}. \tag{17}$$

By (15) and (16), C can be given as

$$C = -4\sqrt{2g}\log\left[\frac{\varepsilon}{14.8R_h} + \frac{10.04}{Re}\right]. \tag{18}$$

It would appear from the equation (18) that C depends on ε, R_h, and Re, which moreover to equation (17) depends on hydraulic radius R_h, the slope i, and the kinematic viscosity ν. Equation (12) gives the hydraulic radius R_h as a function of the aspect ratio η, the top width T and α. In dimensionless terms, Equation (18) becomes

$$\frac{C}{\sqrt{g}} = -4\sqrt{2}\log\left[\frac{\varepsilon}{14.8R_h} + \frac{10.04}{Re}\right]. \tag{19}$$

By equations (12) and (17), we find that

$$Re = 32\sqrt{2}\frac{\sqrt{giT^3}}{\nu}\left[\frac{\varphi(\eta,\alpha)}{\sigma(\eta,\alpha)}\right]^{\frac{3}{2}}, \tag{20}$$

where we write

$$Re = Re^*\left[\frac{\varphi(\eta,\alpha)}{\sigma(\eta,\alpha)}\right]^{\frac{3}{2}}, \tag{21}$$

with

$$Re^* = 32\sqrt{2}\frac{\sqrt{giT^3}}{\nu}. \tag{22}$$

According to equations (12) and (21), relation (19) can be rewritten as follows:

$$\frac{C}{\sqrt{g}} = -4\sqrt{2}\log\left[\frac{\dfrac{\varepsilon}{T}}{14.8\dfrac{\varphi(\eta,\alpha)}{\sigma(\eta,\alpha)}} + \frac{10.04}{Re^*\left[\dfrac{\varphi(\eta,\alpha)}{\sigma(\eta,\alpha)}\right]^{\frac{3}{2}}}\right]. \tag{23}$$

2.2.2. *Calculation of Chezy's Resistance Coefficient Using the Rough Model Method*

If the top width T is a data in the relationship (23), the resistance coefficient can be explicitly calculated. Otherwise, if T is unknown, equation (23) is no longer valid. For this purpose, we can use the rough model method (RMM) to determine the resistance coefficient C.

The rough model is mainly characterized by $\bar{\varepsilon}/\overline{D}_h = 0.037$ (Achour 2007) as the arbitrarily assigned relative roughness value, where $\overline{D}_h$ is the hydraulic diameter. Thus, the friction factor is $\bar{f} = 1/16$, according to the Colebrook-White relationship for $Re = \overline{Re}$, tending to an infinitely large value. For Re tending to infinity, Colebrook-White's relationship leads to the Nikuradse formula as follows (Achour 2007):

$$\bar{f} = \left[-2\log\left(\frac{\dfrac{\bar{\varepsilon}}{\overline{D}_h}}{3.7}\right)\right]^{-2}. \tag{24}$$

By introducing the value $\bar{\varepsilon}/\overline{D}_h = 0.037$, we have

$$\bar{f} = \left[-2\log\left(\frac{0.037}{3.7}\right)\right]^{-2} = 4^{-2} = \frac{1}{16}. \tag{25}$$

For a coefficient of friction $\bar{f} = 1/16$ defined by the reference rough model (Achour 2007), $\overline{C}$ can be written as

$$\overline{C} = \sqrt{\frac{8g}{\bar{f}}} = 8\sqrt{2g} = \text{constant}. \tag{26}$$

In RMM, the channel is distinct by the dimension $\overline{T}$ of the cross-section, the discharge $\overline{Q}$, a longitudinal slope $\bar{i}$, liquid kinematic viscosity $\bar{\nu}$ and a aspect ratio $\bar{\eta}$. Hence our model is governed by the following conditions: $\overline{D} \neq D$; $\overline{Q} = Q$; $\bar{i} = i$; $\bar{\eta} = \eta$; and $\bar{\nu} = \nu$.

Using equations (10) and (12), equation (15) will become:

$$Q = \frac{\varphi(\eta,\alpha)^{3/2}}{\sigma(\eta,\alpha)^{1/2}}\sqrt{C^2T^5i}. \tag{27}$$

We put

$$Q^* = \frac{\varphi(\eta,\alpha)^{3/2}}{\sigma(\eta,\alpha)^{1/2}}, \tag{28}$$

so that

$$Q^* = \frac{Q}{\sqrt{C^2T^5i}}. \tag{29}$$

In accordance with formula (29), the relative conductivity of the rough model is defined by

$$Q^* = \frac{Q}{\sqrt{\overline{C}^2\overline{T}^5 i}}. \tag{30}$$

By applying formula (26), equation (30) becomes

$$Q^* = \frac{Q}{\sqrt{128g\overline{T}^5 i}}. \tag{31}$$

By equalisation of (28) and (31) we get

$$\frac{Q}{\sqrt{128g\overline{T}^5 i}} = \frac{\varphi(\eta,\alpha)^{3/2}}{\sigma(\eta,\alpha)^{1/2}}.$$

As a result, we obtain:

$$\overline{T} = 0.379\,[\sigma(\eta,\alpha)]^{0.2}\,[\varphi(\eta,\alpha)]^{-0.6}\left[\frac{Q}{\sqrt{gi}}\right]^{0.4}. \tag{32}$$

The dimension $\overline{T}$ of the rough model is explicitly calculated by equation (32) if the parameters η, Q, i and α are known.

Further, using equation (20), the Reynolds number characterizing the flow in the rough model is:

$$\overline{Re} = 32\sqrt{2}\frac{\sqrt{gi\overline{T}^3}}{\nu}\left[\frac{\varphi(\eta,\alpha)}{\sigma(\eta,\alpha)}\right]^{\frac{3}{2}}, \tag{33}$$

or

$$\overline{Re} = \overline{Re}^*\left[\frac{\varphi(\eta,\alpha)}{\sigma(\eta,\alpha)}\right]^{\frac{3}{2}}, \tag{34}$$

and

$$\overline{Re}^* = 32\sqrt{2}\frac{\sqrt{gi\overline{T}^3}}{\nu}. \tag{35}$$

According to the RMM (Achour and Bedjaoui 2006), Chezy's coefficient C is given as follows.

$$C = \frac{\overline{C}}{\psi^{5/2}}, \tag{36}$$

where ψ is a dimensionless parameter defined by the following expression (Achour and Bedjaoui 2006, 2012):

$$\psi = 1.35\left[-\log\left(\frac{\frac{\varepsilon}{\overline{R}_h}}{19} + \frac{8.5}{\overline{Re}}\right)\right]^{-\frac{2}{5}}. \tag{37}$$

By equations (12) and (34), relationship (37) becomes:

$$\psi = 1.35\left[-\log\left(\frac{\frac{\varepsilon}{\overline{T}}}{19\frac{\varphi(\eta,\alpha)}{\sigma(\eta,\alpha)}} + \frac{8.5}{\overline{Re^*}\left[\frac{\varphi(\eta,\alpha)}{\sigma(\eta,\alpha)}\right]^{\frac{3}{2}}}\right)\right]^{-\frac{2}{5}}. \tag{38}$$

From (36), (26) and (38) we have:

$$C = -5.343\sqrt{g}\log\left(\frac{\frac{\varepsilon}{\overline{T}}}{19\frac{\varphi(\eta,\alpha)}{\sigma(\eta,\alpha)}} + \frac{8.5}{\overline{Re^*}\left[\frac{\varphi(\eta,\alpha)}{\sigma(\eta,\alpha)}\right]^{\frac{3}{2}}}\right). \tag{39}$$

In dimensionless form, equation (39) can be rewritten as follows:

$$\frac{C}{\sqrt{g}} = -5.343\log\left(\frac{\frac{\varepsilon}{\overline{T}}}{19\frac{\varphi(\eta,\alpha)}{\sigma(\eta,\alpha)}} + \frac{8.5}{\overline{Re^*}\left[\frac{\varphi(\eta,\alpha)}{\sigma(\eta,\alpha)}\right]^{\frac{3}{2}}}\right). \tag{40}$$

3. Results and Discussion

Using the expression (23), we have produced Figures 2, 3 and 4 which show the variation curves of the Chezy's coefficient C as a function of the aspect ratio η in the channel, where $\alpha = 0.5$, $\alpha = 3$ and $\alpha = 18$. The curves were plotted for tow roughness values ($\varepsilon/T = 0$; $\varepsilon/T = 0.05$) by assigning to the Reynolds number Re^* several values ranging from 10^4 to 10^8.

For all curves, the maximum value of η is set to 1, because even if values of η above 1 are assigned, the increase in the coefficient of C is negligible and not crucial.

In Figures 2, 3, 4, the variation of $C/\sqrt{g}$, as a function of the aspect ratio η, is directly proportional, $C/\sqrt{g}$ increases rapidly below $\eta = 0.4$, and above this value the increase becomes slow. It can be deduced that when η reaches the value of 0.4 in the channel, the rate of increase of the resistance coefficient is approximately 87% of the total rate of increase between the minimum and maximum values. The curves tend to converge even as the Reynolds number increases in the case of high roughness ($\varepsilon/T = 0.05$). $C/\sqrt{g}$ has much higher values in all zero roughness curves than in the high roughness curves ($\varepsilon/T = 0.05$), mainly because the Reynolds number Re^* increases. In practice, this is due to the effect of the Reynolds number, which becomes more dominant at low roughness.

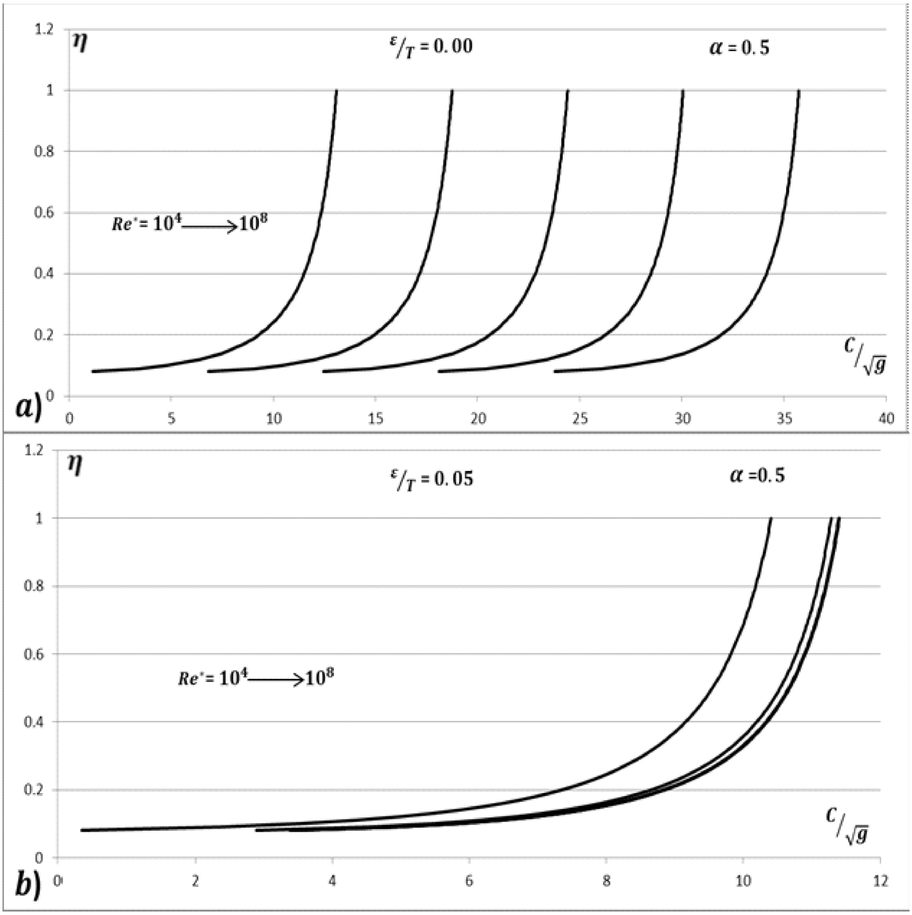

Fig. 2. Variation in $C/\sqrt{g}$ as a function of aspect ratio η and $\alpha = 0.5$ according to relation (23) for fixed values of relative roughness and Reynolds number Re^*: a) $\varepsilon/T = 0.0$, b) $\varepsilon/T = 0.5$

Case of $\varepsilon/T = 0.05$

For low η, the minimum value of $C/\sqrt{g}$ varies for the Reynolds number values variation in an interval of (0.34 to 3.44); (0.50 to 3.56); and (1.42 to 4.24), respectively, for α equal to 0.5; 3 and 18, the Chezy coefficient has an increase with the increase of α, this increase is about 0.8 from $\alpha = 0.5$ to $\alpha = 18$.

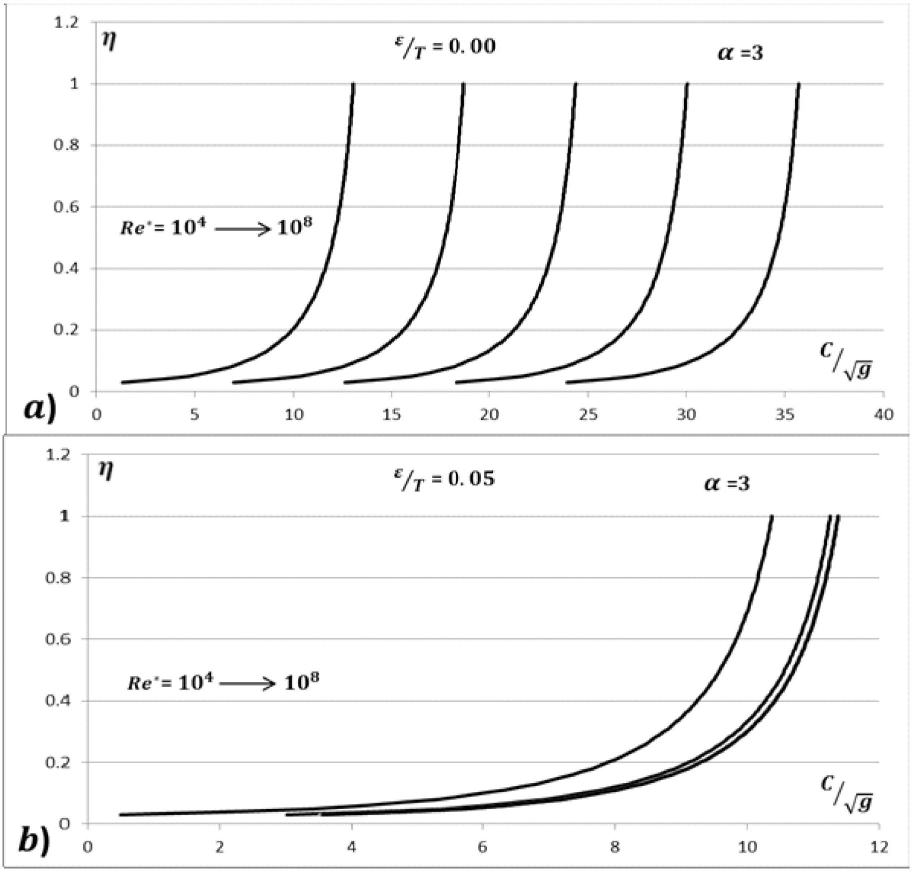

Fig. 3. Variation in $C/\sqrt{g}$ as a function of aspect ratio η and $\alpha = 3$ according to relation (23) for fixed values of relative roughness and Reynolds number Re^*: a) $\varepsilon/T = 0.0$, b) $\varepsilon/T = 0.5$

At very high η, $C/\sqrt{g}$ varies for the variation of the Reynolds number values in an interval of (10.40 to 11.40); (10.38 to 11.38); and (10.30 to 11.3), respectively, for α equal to 0.5; 3 and 18. For a given Reynolds number , the reduction in $C/\sqrt{g}$ is 0.1 from $\alpha = 0.5$ to $\alpha = 18$, giving a small average reduction of 1%.This indicates that at very high η, the variation of Chezy's coefficient is not significant to the variation of α, and the maximum value of $C/\sqrt{g}$ in the channel is obtained when $\alpha = 0.5$ and $Re^* = 10^8$.

Case of $\varepsilon/T = 0.00$

When η is very small, the $C/\sqrt{g}$ takes minimum values for the variation of the proposed Reynolds number values in an interval of (1.16 to 23.8); (1.34 to 23.96); and (2.35 to 24.97) for α equal to 0.5; 3 and 18, respectively. However, the variation of the maximum values of $C/\sqrt{g}$ is steady, approximately from about 13 to 35 for the given variation of the Reynolds number ($Re^* = 10^4$ to $Re^* = 10^8$), hence, for any given Reynolds number, the reduction of $C/\sqrt{g}$ from $\alpha = 0.5$ to $\alpha = 18$ is 0.13, giving a small reduction rate of 1%; this reduction of the maximum Chezy coefficient is negligible for the variation of α.

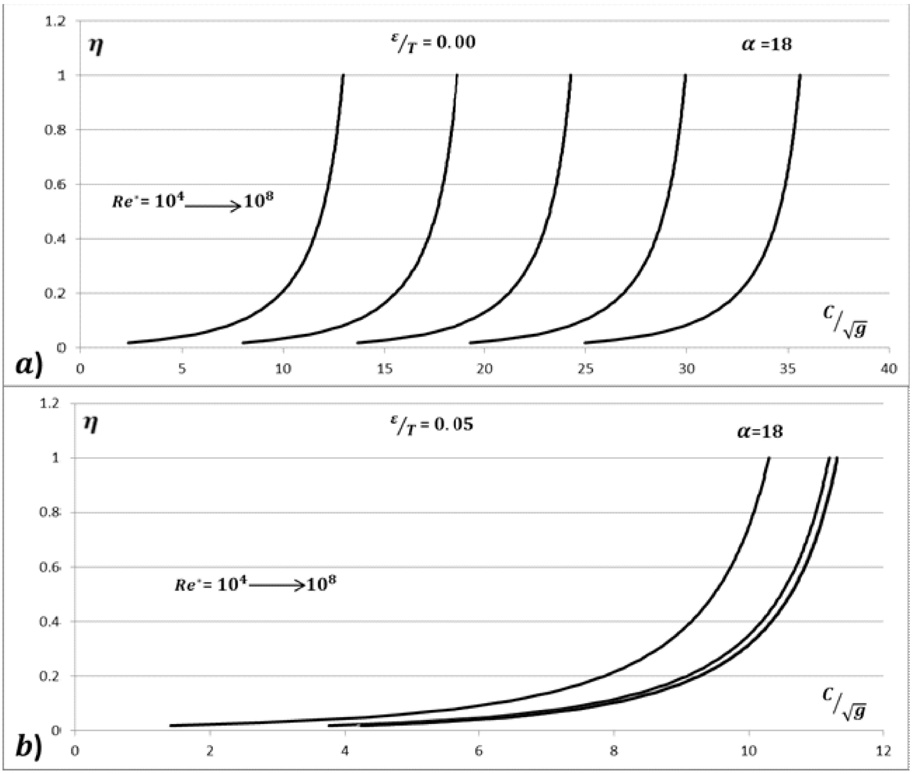

Fig. 4. Variation in $C/\sqrt{g}$ as a function of aspect ratio η and $\alpha = 18$ according to relation (23) for fixed values of relative roughness and Reynolds number Re^*: a) $\varepsilon/T = 0.0$, b) $\varepsilon/T = 0.5$

When the roughness is zero, the $C/\sqrt{g}$ reaches higher values than those in case where the relative roughness is high; for very small η, the minimum values of $C/\sqrt{g}$ are about 2 to 7 times larger, as shown in Figure 5, where the curves obtained represent the variation $R_{\min}$, the ratio between the minimum values of $C/\sqrt{g}$ of zero roughness and high roughness ($\varepsilon/T = 0.05$) for the previously proposed variation of Reynolds

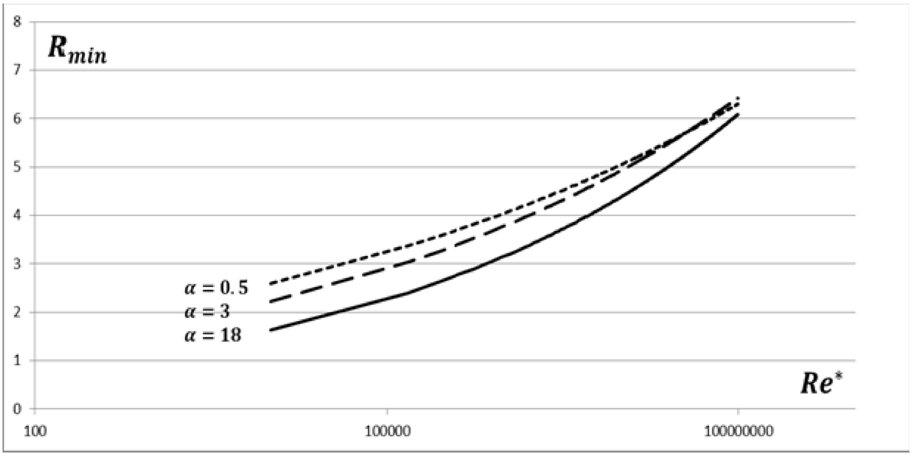

Fig. 5. Variation of the ratio $R_{\min}$ as a function the Reynolds number Re^* or fixed values $\alpha = 0.5$, $\alpha = 3$ and $\alpha = 18$

number, for the three cases of $\alpha = 0.5$, $\alpha = 3$ and $\alpha = 18$. In fact, the curves show that $R_{\min}$ decreases at a remarkable rate of 10% to 50% with increasing value of α. For very high η; the ratio between the maximum values of $C/\sqrt{g}$ of roughness equal to zero and high roughness ($\varepsilon/T = 0.05$) for the variation of Reynolds number ($Re^* = 10^4$ to $Re^* = 10^8$) varies approximately in the range of 1.25 to 3.13 which remains constant regardless of the value of α.

Formula (23) can be used to calculate the coefficient C in a clear and explicit way if these parameters are given: the Reynolds number Re^*, the relative roughness ε/T, the aspect ratio η of the channel and the α. Though, without the top width T of channel being known, using the rough model method, equation (40) can calculate C by the following steps if $\overline{Re^*}$, $\overline{T}$, ε, η and α are given:

- First, the calculation of $\varphi(\eta, \alpha)$ and $\sigma(\eta, \alpha)$ is done using equations (13) and (14);
- Then, the calculation of the dimension $\overline{T}$ is done by relationship (32);
- Following, relationship (35) is used to determine the Reynolds number $\overline{Re^*}$;
- Finally, C can be simply calculated by equation (40).

An application is shown below for calculating the resistance coefficient C using the rough model method (RMM).

Application
Calculate the Chezy's resistance coefficient in round-cornered rectangle channel using the rough model method (RMM): $\alpha = 3$, $Q = 0.6\ \text{m}^3\text{s}^{-1}$, $i = 2 \times 10^{-4}$, $\varepsilon = 10^{-4}$ m, $\eta = 0.8$, $\nu = 10^{-6}\ \text{m}^2\text{s}^{-1}$.

Solution

- For $\eta = 0.8$ and $\alpha = 3$, equations (13) and (14) can respectively give $\varphi(\eta, \alpha)$ and $\sigma(\eta, \alpha)$:

$$\varphi(\eta, \alpha) = \left(\frac{1}{2+\alpha}\right)^2 \left(\frac{\pi}{2} - 2\right) + \eta = \left(\frac{1}{5}\right)^2 \left(\frac{\pi}{2} - 2\right) + 0.8 = 0.7828,$$

$$\sigma(\eta, \alpha) = \left[\frac{(\pi - 4)}{(2+\alpha)}\right] + 1 + 2\eta = \left[\frac{(\pi - 4)}{5}\right] + 1 + 2 \times 0.8 = 2.428$$

- Calculation of $\overline{T}$ by relationship (32):

$$\overline{T} = 0.379\,[\sigma(\eta, \alpha)]^{0.2}\,[\varphi(\eta, \alpha)]^{-0.6} \left[\frac{Q}{\sqrt{gi}}\right]^{0.4}$$

$$= 0.379[2.428]^{0.2}[0.7828]^{-0.6} \left[\frac{0.6}{\sqrt{9.81 \times 2 \times 10^{-4}}}\right]^{0.4} = 1.487 \text{ m}$$

- Relationship (35) calculates the Reynolds number $\overline{Re^*}$:

$$\overline{Re^*} = 32\sqrt{2}\frac{\sqrt{gi\overline{T}^3}}{\nu} = 32\sqrt{2} \times \frac{\sqrt{9.81 \times 2 \times 10^{-4} \times (1.487)^3}}{10^{-6}} = 3634803$$

- Finally, C can be calculated using equation (40):

$$C = -5.343\sqrt{g}\log\left(\frac{\dfrac{\varepsilon}{\overline{T}}}{19\dfrac{\varphi(\eta, \alpha)}{\sigma(\eta, \alpha)}} + \frac{8.5}{\overline{Re^*}\left[\dfrac{\varphi(\eta, \alpha)}{\sigma(\eta, \alpha)}\right]^{\frac{3}{2}}}\right),$$

$$C = -5.343 \times \sqrt{9.81} \times \log\left(\frac{\dfrac{0.0001}{1.487}}{19 \times \dfrac{0.7828}{2.428}} + \frac{8.5}{3\,634\,803 \times \left[\dfrac{0.7828}{2.428}\right]^{\frac{3}{2}}}\right),$$

$$C = 77.38 \text{ m}^{0.5}\text{s}^{-1}$$

4. Conclusion

The Chezy resistance coefficient in round-cornered rectangle channel is represented by the two expressions (23) and (40). Given the profile of the channel, the geometric characteristics were obtained as function of the aspect ratio η and the α, namely, the wetted cross sectional area A, the wetted perimeter P and the hydraulic radius R_h. Therefore, the relationship (23) was developed to explicitly express the Chezy resistance coefficient C as a function of the aspect ratio η, the α, the relative roughness ε/T and the Reynolds number Re^*. However, the relationship (40) has been established using the Rough Model Method (RMM) to express C as a function of $\overline{Re^*}$, $\overline{T}$, ε, η and α without knowing the upper width T of the profile channel.

From equation (23), curves are drawn in Figures 2, 3 and 4 to show the variation of Chezy resistance coefficient as a function of the aspect ratio η and the α by assigning fixed values to the relative roughness $\varepsilon/T = 0$ and $\varepsilon/T = 0.05$, with the Reynolds number increasing from 10^4 to 10^8. These curves also show that the Chezy resistance coefficient increases rapidly below the value of 0.4 of the aspect ratio η with the increase in the Reynolds number and increases slowly above this value. It can be concluded that when η reaches the value of 0.4 in the channel, the rate of increase of the resistance coefficient is approximately 87% of the total rate of increase between the minimum and maximum values.

It's also clear that when the roughness of the inner walls of the channel is zero, the coefficient of resistance takes on higher values than when the roughness is high. This can be explained by the dominant effect of the Reynolds number induced by the viscosity ν of the liquid.

Finally, the variation of $C/\sqrt{g}$ is very remarkable when η takes small values, it increases with the increase of α. However, when η is high ($\eta = 1$), the variation of the resistance coefficient with the variation of α is insignificant.

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