Bulletin of the *Transilvania* University of Braşov • Vol. 12 (61) No. 1 - 2019
Series I: Engineering Sciences
https://doi.org/10.31926/but.ens.2019.12.61.9

INFLUENCE OF MANNING' ROUGHNESS COEFFICIENT AND ABSOLUTE ROUGHNESS IN VELOCITY CALCULATION

Anca HOȚUPAN[1]

Abstract: *The recommended calculation relations for flow and velocity determination in water supply and sewage systems are different and include parameters taken from tables or catalogs. The results obtained should be the same, regardless of the relations are follow, but applying the two relations for the same network resulted in different values of flows and velocitys. From the analysis of the relations obtained differences are derived from the values adopted from tables, for both the roughness coefficient n and the absolute roughness k. From the analysis effected, values obtine is a justification of the recommendations of the specialists.*

Key words: *water, velocity, absolute roughness, Manning's coefficent.*

1. Introduction

When calculating the velocity in water supply systems it is recommended to use Darcy-Weisbach's relations and for the determination of velocity in free surface channels Chezy's formula, [1], [2], [6].

Since there is no explanation for this recommendation, this paper proposes the analysis of the two relations in order to obtain results that justify the recommendations of the normative acts in force.

Due to the complexity of the phenomena occurring in the two types of networks, mathematically transposed in the two relations, the comparative study done in this paper is based on two comparative studies whose results are:

a) Determining the flows and the velocity based on the two calculation relations, applying Chezy's relationship results a lower flow (respectively velocity) for the same hydraulic slope and the same section as the variant where the velocity is determined by the relationship of Darcy-Weisbach, [4].

b) When determining Chezy's coefficient using 4 types of roughness, the results obtained leads to minimum flow in the variant where Chezy's coefficient is determined

[1] Dept. of Building Services Engineering, Technical University of Cluj-Napoca.

by Manning's relationship and maximum if the Darcy-Weisbach relationship is applied to flows determination [5].

The study on the influence of Manning's roughness coefficient and Darcy friction factor on the velocity in sewage systems was performed for 3 types of materials and the values of the characteristics used in the calculation are presented in Table 1.

This paper proposes a comparative study of the values of Chezy's coefficient that will be determined by two calculus relations, depending on the Manning coefficient and the Darcy friction factor which in turn depends on the absolute roughness.

Characteristic parameters of pipelines, [7], [8], [9] Table 1

Material	*k* [mm]	*n*	*D* [mm]
vitrified clay pipes	0.5	0.0125-0.013	200-800
concrete pipes	0.6	0.011	229-838
GRP pipes	0.01	0.008-0.01	150-550

2. Method

The value of the flows will be determined by the equation of continuity, [1], [2], [5]:

$$Q = A \cdot V,\ [\mathrm{m^3/s}], \tag{1}$$

where: A represents the flow section, in our case a circular section:

$$A = \pi \cdot D^2/4,\ [\mathrm{m^2}], \tag{2}$$

and D is the internal diameter of the pipe, [m].

For determining the velocity value, in relation (1) will be used and Chezy's formula:

$$V = C \cdot \sqrt{R_h \cdot i}\ ,\ [\mathrm{m/s}], \tag{3}$$

where: V - average velocity across the pipe section, [m/s]; R_h - the hidraulic radius, [m]; i - hydraulic slope, [%]; C - the Chezy coefficient, [$m^{0,5}$/s].

Method no 1

The Chezy's coefficient will be calculated with the Manning formula, [2]:

$$C = \frac{1}{n} \cdot R_h^{1/6},\ [\mathrm{m^{0.5}/s}], \tag{4}$$

where: n is Manning's roughness coefficent; R_h - the hydraulic radius; for a circular section, [3]:

$$R_h = \frac{A}{P_u} = \frac{D}{4},\ [\mathrm{m}], \tag{5}$$

where: A represents the flow section; for circular section, $A = \pi \cdot D^2/4$; P_u is the wetted perimeter, $P_u = \pi \cdot D$, [4].

Method no 2

The Chezy's coefficient will be calculated with formula, [3]:

$$C = \sqrt{\frac{8 \cdot g}{\lambda}}, \text{ [m}^{0.5}\text{/s]}, \tag{6}$$

where: λ - Darcy friction factor, dimensionless.

Equalizing relation (4) with relation (6) results:

$$\Rightarrow C = \frac{1}{n} \cdot R_h^{1/6} = \sqrt{\frac{8 \cdot g}{\lambda}}, \text{ [m}^{0.5}\text{/s]}, \tag{7}$$

From a mathematic standpoint the obtained relation is correct, although numerically the equality is not satisfied, value is pressented in Table 2.

The values of the C coefficient for vitrified clay pipes Table 2

C	$\frac{1}{n} \cdot R_h^{1/6}$	$\sqrt{\frac{8 \cdot g}{\lambda}}$	$\frac{1}{n} \cdot R_h^{1/6}$	$\sqrt{\frac{8 \cdot g}{\lambda}}$	$\frac{1}{n} \cdot R_h^{1/6}$	$\sqrt{\frac{8 \cdot g}{\lambda}}$
D [mm]	*i* = 5 [‰]		*i* = 25 [‰]		*i* = 50 [‰]	
200	46.68	56.39	46.68	57.19	46.68	57.40
250	48.45	58.26	48.45	58.98	48.45	59.17
300	49.95	59.77	49.95	60.44	49.95	60.61
350	51.25	61.04	51.25	61.67	51.25	61.82
400	52.40	62.14	52.40	62.73	52.40	62.88
500	54.39	63.97	54.39	64.50	54.39	64.63
600	56.07	65.45	56.07	65.94	56.07	66.06
700	57.53	66.70	57.53	67.16	57.53	67.27
800	58.82	67.78	58.82	68.21	58.82	68.31

The values of the C coefficient for concrete pipes Table 3

C	$\frac{1}{n} \cdot R_h^{1/6}$	$\sqrt{\frac{8 \cdot g}{\lambda}}$	$\frac{1}{n} \cdot R_h^{1/6}$	$\sqrt{\frac{8 \cdot g}{\lambda}}$	$\frac{1}{n} \cdot R_h^{1/6}$	$\sqrt{\frac{8 \cdot g}{\lambda}}$
D [mm]	*i* = 5 [‰]		*i* = 25 [‰]		*i* = 50 [‰]	
229	56.44	54.85	56.44	55.38	56.44	55.51
300	59.04	57.05	59.04	57.51	59.04	57.62
375	61.27	58.85	61.27	59.27	61.27	59.37
450	63.16	60.32	63.16	60.70	63.16	60.80
534	64.99	61.69	64.99	62.04	64.99	62.13
610	66.45	62.75	66.45	63.09	66.45	63.17
685	67.75	63.68	67.75	64.00	67.75	64.07
762	68.96	64.53	68.96	64.83	68.96	64.90
838	70.06	65.28	70.06	65.57	70.06	65.64

The values of the C coefficient for GRP pipes Table 4

C	$\frac{1}{n} \cdot R_h^{1/6}$	$\sqrt{\frac{8 \cdot g}{\lambda}}$	$\frac{1}{n} \cdot R_h^{1/6}$	$\sqrt{\frac{8 \cdot g}{\lambda}}$	$\frac{1}{n} \cdot R_h^{1/6}$	$\sqrt{\frac{8 \cdot g}{\lambda}}$
D [mm]	*i* = 5 [‰]		*i* = 25 [‰]		*i* = 50 [‰]	
150	64.28	65.59	64.28	70.97	64.28	73.07
200	67.44	68.80	67.44	74.07	67.44	76.11
250	70.00	71.28	70.00	76.46	70.00	78.45
300	72.16	73.31	72.16	78.41	72.16	80.35
350	74.03	75.01	74.03	80.04	74.03	81.94
400	75.70	76.48	75.70	81.45	75.70	83.31
450	77.20	77.78	77.20	82.68	77.20	84.51
500	78.57	78.93	78.57	83.78	78.57	85.58
550	79.83	79.97	79.83	84.78	79.83	86.55

On the basis of the two relationships, different values were obtained for the coefficient *C* because, if we determine *C* with the relation (6), the Darcy friction factor varies depending on the absolute roughness, the viscosity of the fluid and the diameter of the pipe, while in the relationship (4) Chezy's coefficient depends on the diameter of the pipe and the coefficient *n* is determined experimentally and taken from the tables according to the type of material.

Because the obtained differences are not negligible, we still intend to determine the values of the coefficient *n* for the four types of materials based on the absolute roughness *k*, values that will be compared with the values recommended for calculation provided by the material producers and presented in Table 1. Thus, the relation 7 results for *n* calculus relation:

$$n = \frac{R_h^{1/6}}{\sqrt{\frac{8 \cdot g}{\lambda}}}. \qquad (8)$$

The values of the n coefficient for vitrified clay pipes, k = 0.5 mm Table 5

	n calculating	*n* from the table	*n* calculating	*n* from the table	*n* calculating	*n* from the table
D [mm]	*i* = 5 [‰]		*i* = 25 [‰]		*i* = 50 [‰]	
200	0.011045	0.0125-0.013	0.010914	0.0125-0.013	0.010882	0.0125-0.013
250	0.011092	0.0125-0.013	0.010977	0.0125-0.013	0.010949	0.0125-0.013
300	0.011141	0.0125-0.013	0.011037	0.0125-0.013	0.011012	0.0125-0.013
350	0.01119	0.0125-0.013	0.011094	0.0125-0.013	0.011071	0.0125-0.013
400	0.011237	0.0125-0.013	0.011148	0.0125-0.013	0.011127	0.0125-0.013
500	0.011325	0.0125-0.013	0.011247	0.0125-0.013	0.011228	0.0125-0.013
600	0.011406	0.0125-0.013	0.011335	0.0125-0.013	0.011318	0.0125-0.013
700	0.01148	0.0125-0.013	0.011415	0.0125-0.013	0.0114	0.0125-0.013
800	0.011549	0.0125-0.013	0.011489	0.0125-0.013	0.011474	0.0125-0.013

The values of the n coefficient for concrete pipes, k = 0.6 mm Table 6

	n calculating	*n* from the table	*n* calculating	*n* from the table	*n* calculating	*n* from the table
D [mm]	*i* = 5 [‰]		*i* = 25 [‰]		*i* = 50 [‰]	
200	0.011318	0.011	0.011211	0.011	0.011185	0.011
250	0.011384	0.011	0.011292	0.011	0.011269	0.011
300	0.011453	0.011	0.011372	0.011	0.011352	0.011
350	0.011519	0.011	0.011446	0.011	0.011428	0.011
400	0.011589	0.011	0.011522	0.011	0.011506	0.011
500	0.011648	0.011	0.011586	0.011	0.011571	0.011
600	0.011702	0.011	0.011645	0.011	0.011631	0.011
700	0.011755	0.011	0.011701	0.011	0.011688	0.011
800	0.011805	0.011	0.011753	0.011	0.01174	0.011

The values of the n coefficient for GRP pipes, k = 0.01 mm Table 7

	n calculating	*n* from the table	*n* calculating	*n* from the table	*n* calculating	*n* from the table
D [mm]	*i* = 5 [‰]		*i* = 25 [‰]		*i* = 50 [‰]	
150	0.008821	0.009	0.008153	0.009	0.007917	0.009
200	0.008822	0.009	0.008194	0.009	0.007974	0.009
250	0.008837	0.009	0.008239	0.009	0.00803	0.009
300	0.008859	0.009	0.008282	0.009	0.008082	0.009
350	0.008883	0.009	0.008325	0.009	0.008132	0.009
400	0.008908	0.009	0.008365	0.009	0.008178	0.009
450	0.008933	0.009	0.008403	0.009	0.008221	0.009
500	0.008959	0.009	0.00844	0.009	0.008262	0.009
550	0.008983	0.009	0.008474	0.009	0.008301	0.009

2. Conclusion

As shown in Tables 5-7 for the values of the differences calculated in comparison with the recommendations of the manufacturers of pipe are very low, differs from the fourth decimal place. These small differences, however, lead to different velocities, as shown in Table 8.

In sewer systems, the value of the minimum velocity must not fall below 0.7 m/s, [6]. Since the values of the velocity calculated from Chezy's relation are smaller they provide safer operation.

In calculating water supply systems, checking the pressure required by consumers also involves determining load losses. These vary directly proportional to the square of velocity in the rough-pipe turbulent regime. Low velocity leads to low load losses or if they are not real, pressure provided for the consumers may be insufficient.

The values of the discharge (l/s) and velocity (m/s) for vitrified clay pipes Table 8

	Chezy		Colebrook-White		Chezy		Colebrook-White	
i [‰]	5		5		25		25	
D [mm]	*V*	*Q*	*V*	*Q*	*V*	*Q*	*V*	*Q*
200	0.74	23.18	0.87	27.28	1.65	51.83	1.97	61.74
250	0.86	42.03	1.00	49.26	1.92	93.98	2.27	111.30
300	0.97	68.34	1.13	79.75	2.16	152.82	2.55	179.99
350	1.07	103.09	1.25	119.77	2.40	230.52	2.81	270.11
400	1.17	147.19	1.36	170.28	2.62	329.12	3.06	383.78
500	1.36	266.86	1.56	306.33	3.04	596.73	3.51	689.74
600	1.54	433.95	1.75	494.60	3.43	970.35	3.94	1112.85
700	1.70	654.59	1.93	741.23	3.81	1463.70	4.33	1666.89
800	1.86	934.57	2.09	1051.98	4.16	2089.76	4.71	2364.69

Thus, for optimal operation of the two types of networks, the recommendations regarding the relations used are justified.

References

1. Ianculescu, O., Ionescu, Gh.-C., Racoviţeanu, R.: *Canalizări* (*Sewerage Systems*). Bucureşti. Ed. MATRIX ROM, 2001.
2. Ionescu, Gh.-C.: *Sisteme de canalizare* (*Sewerage Systems*). Bucureşti. Ed. MATRIX ROM, 2010.
3. Marian, L., Muste, M.: *Hidraulică şi maşini hidraulice, volumul I* (*Hydraulics and Hydraulic Machines, volume I*). Cluj-Napoca. Ed. Lito Institutul Politehnic, 1993.
4. Hoţupan, A., Vitan, E.: *Studiul privind alegerea relației de calcul pentru dimensionarea conductelor de canalizare (Study on the relationship of choice for dimensioning sewage pipes)*. In: Conferința „Instalații pentru începutul mileniului trei”, Sinaia, 2015, vol II, ISBN 978-606-25-0200-3, p. 350-358.
5. Hoţupan, A.: *Alternative methods for dimensioning gravitational sewer pipes.* In: Proceedings of the International Scientific Conference, Brașov, 2017, p. 391-396.
6. NP 133-2013: *Normativ privind proiectarea, execuţia şi exploatarea sistemelor de alimentare cu apă şi canalizare a localităţilor* (*Norms regarding the design, execution and functioning of municipal water and sewerage systems*), Vol. 2. Bucureşti. Ed. MATRIX ROM, 2013.
7. *** *Linee quida per la progettazione e la realizzazione di fognature in gres ceramico* (*Guide for the design and construction of sewerage systems using vitrified clay pipes*).
8. http://geotas.com/media/products_top/culvert_stormwater/PDF/Humes%20Concrete %20pipe%20manual.pdf.
9. http://www.hobas.ro/ghid-tehnic/caracteristicile-produsului/rugozitatea-hidraulica. html.