# Using Four Types Of Notches For Comparison Between Chezy's Constant(C) And Manning's Constant (N)

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**Abstract:** In this technical paper, Chezy's and Manning's constant were compared, using four different notches on the plain bed. The first phase of this paper involves designing of the notches, using Auto Cad software followed by fabrication. The second phase involves carrying out Experiments in open channel Laboratory by using hydraulic bench. The final phase involves calculations of Chezy's and manning's constants. It was seen that, Chezy's constant is directly proportional to actual discharge While Manning's constant in inversely proportional to actual discharge. Chezy's constant has higher value compared to Manning's constant value. Also Manning's Standard deviation is smaller compared to that of Chezy's. This indicates the accuracy of the resistance coefficient due to the fact that the smaller the value of standard deviation the higher the level of accuracy. Therefore, the coefficient of resistance is more adaptable, simple and accurate in Manning's constant.

**Key words**: Open channel flow, Hydraulic bench, Coefficients of Resistance, Actual discharge

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## INTRODUCTION

Many Researchers have been working on Open Channel over the years, to discover and upgrade the theory on Hydraulic structures and elements. The results obtained from previous experiment shows how Open Channel have been developed and modified to a large extent and it has become more useful in life than before. For example Resistance Coefficients (Manning's and Chezy's Constant) was discovered after a series of so many experiments. The comparison of these Resistance Coefficients (Manning's and Chezy's Constant) has often been done in Open channel laboratory, using weirs instead of using notches. The aim was to determine the accurate and adaptable coefficient of resistance. In order to come up with new results of the comparison, notches were used instead of weirs. The notches are considered to be more accurate than weirs (ASTM, 1993).

***Table1:*** *Summary of few typical values of manning's (n)*

| Channel type | Surface material and form | Manning's n range |
|---|---|---|
| River | earth, straight | 0.02-0.025 |
| | earth, meandering | 0.03-0.05 |
| | gravel(75-150mm) straight | 0.03-0.04 |
| | gravel(75-150mm) winding | 0.04-0.08 |
| Unlined canal | earth, straight | 0.018-0.025 |
| | rock, straight | 0.025-0.045 |
| lined canal | Concrete | 0.012-0.017 |
| Lab models | Mortar | 0.011-0.013 |
| | Perspex | 0.009 |

***(CIVE 2400 Fluid Mechanics, 2013)***

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## CHEZY'S EQUATION

Chezy's equation is the discharge equation which was improved by a French engineer around the year 1768. Its application is to compute the depth-discharge relationship. It is derived as shown below;

Force producing motion = friction force resting motion

$$pgALS_o = KPLV^2$$

Cancelling L in both sides and rearranging, it gives,

$$V= \sqrt{\frac{pg}{K} \times \frac{A}{P} \times S_0}$$

Grouping all the constants, it gives Chezy's roughness coefficient, C= $\sqrt{\frac{pg}{K}}$ and $\frac{A}{P}$ = R

Hence, substitute C and R into equation (ii) V= $C\sqrt{RS_0}$

This is the standard Chezy's formula (the first formula for uniform open channel flow) Where by V is the mean velocity of water flow, C is chezy's constant, R is hydraulic mean depth and Sois the bed slope. Chezy's constant(C) depends on the nature of Channel walls and with H. (Hamill.L, 2006)

## MANNING'S EQUATION

Manning's Equation was introduced in1890, after a series of studies of evaluation of C (Chezy's constant), so as to help engineers in producing results which are more adaptable compare to Chezy's formula. It is due to the fact that, Chezy's formula wasn't able to provide results which could satisfy the engineers (especially Irrigation Engineers). Standard Manning's formula ($V = R^{2/3}S^{1/2}/n$), is very simple to use and it gives good results, compared to Chezy's formula. Manning's formula is one of the Empirical equations which can replace the variations of C (in Chezy's formula) with m.Below is the formula which shows how the replacement is done.

By considering Chezy's equation, V= $C\sqrt{RS_0}$

Replacing C with $Mm^{1/6}$ or $MR^{1/6}$ therefore the equation becomes V = $Mm^{2/3}s^{1/2}$

$M$ Can also be replaced by $\frac{k}{n}$ or $\frac{z}{n}$. Hence the equation will be, V= $\frac{k}{n} m^{2/3} s^{1/2}$ or V= $\frac{z}{n} R^{2/3} S^{1/2}$

Where:
V is Velocity, k or z is conversion constant, n is Manning's roughness Coefficient, m or R is hydraulic radius and S is slope of the energy grade line. It is used in determining the Channel Uniform flow capacity. (J.B Calvert, 2007)

## MATERIALS AND METHODS

### MATERIALS

**Acrylic plastic**
The Notches are made of Acrylic plastic (in form of a sheet) instead of using metal. Grinder machine was used in the cutting work of the plastic according to the given specifications as shown below.

- $60^0$ V-notch: opening (depth:121mm and angle: $60^0$), size of 160mm(H) x 243mm(W)
- $90^0$ V-notch: opening (depth:120mm and angle: $90^0$), size of 160mm(H) x 243mm(W)
- Rectangular notch: opening (depth:121mm and width: 46mm), size of 160mm(H) x 243mm(W)
- Trapezoidal notch: opening (depth:91mm and width:137mm), size of 160mm(H) x 243mm(W)

## METHODS
There were three types of quantitative variables used during the experiment, namely; Independent variable (water flow or discharge), controlled variable (width) and dependent variable (Height). The machine used in the experiment was hydraulic bench because the notches can be easily installed. Its length and width are 1000mm and 250mm respectively.

## APPARATUS USED:
Hydraulic bench, Stop watch, Wing Nut screw Flow meter, Pump,Rectangular notch, Trapezoidal notch, $60^o$ and $90^o$ V-notch. The required apparatus were cleaned before proceeding with the experiment. Flow meter, stop watch and other required equipment were well checked and calibrated before starting the experiment. The rectangular Notch was clamped to the hydraulic bench by using the wing nut Screw. The discharge valve was adjusted into 0.5l/s and then the hydraulic bench was switched on and water was allowed to discharge. The water was left to flow within 2 minutes so as to get a steady water flow. Then Several readings of flow rate (Q), time, water level upstream/water head above the notch(H) and Channel width(B) were then taken while increasing the flow rate each time at an interval of 2 minutes. The rectangular notch was replaced by $60^0$ V-notch and then the above procedures were repeated. Then $60^0$ V-notch was replaced by $90^0$ V-notch and the above procedures were repeated. Finally the $90^0$ V-notch was replaced by Trapezoidal notch and the above procedures were repeated.

## EMPERICAL STUDY
The **Actual Discharge** was obtained directly from the experiment. Hence the Actual Discharge was used to find Chezy's and Manning's Constant using the formulas shown below.

$$Q = AV$$

## Chezy's Constant equation

$$C = \frac{V}{\sqrt{RS}}$$

Where by $R = \frac{A}{P}$, A= wetted area in a channel while P= wetted perimeter in a channel.

### Manning's Constant equation

$$n = \frac{R^{2/3} S^{1/2}}{V}$$

Whereby,
Q = Actual Discharge, A = Flow cross section area, V = Mean velocity, R = Hydraulic mean radius, S = Bed slope, c = Chezy's constant and n = Manning's constant

### Standard deviation equation

$$S.D = \sqrt{\frac{\sum (xi - x)^2}{N - 1}}$$

Whereby; S is Standard deviation, Xi is each value in the sample, X is mean of the values and N is number of samples

## RESULTS AND DISCUSSION

| Run | Q($m^3$/s) | B(m) | H(m) | V(m/s) | C | n |
|---|---|---|---|---|---|---|
| 1 | 0.0005 | 0.0225 | 0.041 | 0.36134 | 2.3394 | 0.2265 |
| 2 | 0.00067 | 0.0225 | 0.047 | 0.48419 | 3.1347 | 0.169 |
| 3 | 0.00083 | 0.0225 | 0.052 | 0.59982 | 3.8833 | 0.1365 |
| 4 | 0.001 | 0.0225 | 0.057 | 0.72267 | 4.6787 | 0.1133 |
| 5 | 0.00117 | 0.0225 | 0.06 | 0.84553 | 5.4741 | 0.0968 |
| 6 | 0.00133 | 0.0225 | 0.064 | 0.96116 | 6.2227 | 0.0852 |
| 7 | 0.0015 | 0.0225 | 0.068 | 1.08401 | 7.0181 | 0.0755 |
| 8 | 0.00167 | 0.0225 | 0.071 | 1.20687 | 7.8135 | 0.0678 |
| 9 | 0.00183 | 0.0225 | 0.074 | 1.32249 | 8.5621 | 0.0619 |
| 10 | 0.002 | 0.0225 | 0.078 | 1.44535 | 9.3575 | 0.0566 |
| | Average V,C&n | | | 0.90334 | 5.8484 | 0.1089 |

This part indicates sample of calculation of Manning's constant, Chezy's Constant and tables of results for each notch and discussion.

- ## Rectangular notch

### Sample of calculation to find C and n
Bed slope (S) = 1 since is a plain bed

$$C = \frac{V}{\sqrt{RS}}$$

$$V = \frac{Q}{A} = \frac{0.0005}{0.0003} = 1.68 m/s$$

$$R = \frac{A}{P} = \frac{0.0003}{0.000124} = 0.24m$$

$$C = \frac{1.68}{\sqrt{0.24 \times 1}} = 3.4293$$

$$n = \frac{R^{2/3} S^{1/2}}{V} = \frac{0.24^{2/3} \times 1^{1/2}}{1.68} = 0.2288$$

***Table 2:** shows the results of Rectangular notch*

| Run | Q($m^3$/s) | B(m) | H(m) | V(m/s) | C | n |
|---|---|---|---|---|---|---|
| 1 | 0.0005 | 0.0248 | 0.0404 | 1.6801 | 3.4295 | 0.2288 |
| 2 | 0.00067 | 0.0248 | 0.0496 | 2.2513 | 4.5955 | 0.1707 |
| 3 | 0.00083 | 0.0248 | 0.0582 | 2.789 | 5.693 | 0.1378 |
| 4 | 0.001 | 0.0248 | 0.0683 | 3.3602 | 6.859 | 0.1144 |
| 5 | 0.00117 | 0.0248 | 0.0779 | 3.9315 | 8.025 | 0.0978 |
| 6 | 0.00133 | 0.0248 | 0.0874 | 4.4691 | 9.1225 | 0.086 |
| 7 | 0.0015 | 0.0248 | 0.0956 | 5.0403 | 10.289 | 0.0763 |
| 8 | 0.00167 | 0.0248 | 0.1038 | 5.6116 | 11.455 | 0.0685 |
| 9 | 0.00183 | 0.0248 | 0.1104 | 6.1492 | 12.552 | 0.0625 |
| 10 | 0.002 | 0.0248 | 0.1184 | 6.7204 | 13.718 | 0.0572 |
| | Average V,C&n | | | 4.20027 | 8.5739 | 0.11 |

- **90° V-notch**

Table 3: shows the results of 90o V-notch

- **60° V-notch**

***Table 4:** shows the results of $60^0$ V-notch*

| Run | Q($m^3$/s) | B(m) | H(m) | V(m/s) | C | n |
|---|---|---|---|---|---|---|
| 1 | 0.0005 | 0.0136 | 0.05 | 0.61275 | 4.3539 | 0.1179 |
| 2 | 0.00067 | 0.0136 | 0.057 | 0.82108 | 5.8343 | 0.088 |
| 3 | 0.00083 | 0.0136 | 0.063 | 1.01716 | 7.2276 | 0.071 |
| 4 | 0.001 | 0.0136 | 0.069 | 1.22549 | 8.7079 | 0.059 |
| 5 | 0.00117 | 0.0136 | 0.074 | 1.43382 | 10.188 | 0.0504 |
| 6 | 0.00133 | 0.0136 | 0.079 | 1.6299 | 11.582 | 0.0443 |
| 7 | 0.0015 | 0.0136 | 0.084 | 1.83824 | 13.062 | 0.0393 |
| 8 | 0.00167 | 0.0136 | 0.089 | 2.04657 | 14.542 | 0.0353 |
| 9 | 0.00183 | 0.0136 | 0.091 | 2.24265 | 15.935 | 0.0322 |
| 10 | 0.002 | 0.0136 | 0.096 | 2.45098 | 17.416 | 0.0295 |
| | Average V,C&n | | | 1.53186 | 10.885 | 0.0567 |

- **Trapezoidal notch**

***Table 5:** shows the results of Trapezoidal notch*

| Run | Q($m^3$/s) | B(m) | H(m) | V | C | n |
|---|---|---|---|---|---|---|
| 1 | 0.0005 | 0.0244 | 0.049 | 0.29586 | 4.3599 | 0.0919 |
| 2 | 0.00067 | 0.0244 | 0.061 | 0.39645 | 5.8422 | 0.0686 |
| 3 | 0.00083 | 0.0244 | 0.072 | 0.49112 | 7.2374 | 0.0554 |
| 4 | 0.001 | 0.0244 | 0.084 | 0.59172 | 8.7197 | 0.0459 |
| 5 | 0.00117 | 0.0244 | 0.096 | 0.69231 | 10.202 | 0.0393 |
| 6 | 0.00133 | 0.0244 | 0.108 | 0.78698 | 11.597 | 0.0345 |
| 7 | 0.0015 | 0.0244 | 0.122 | 0.88757 | 13.08 | 0.0306 |
| 8 | 0.00167 | 0.0244 | 0.137 | 0.98817 | 14.562 | 0.0275 |
| 9 | 0.00183 | 0.0244 | 0.152 | 1.08284 | 15.957 | 0.0251 |
| 10 | 0.002 | 0.0244 | 0.167 | 1.18343 | 17.44 | 0.023 |
| | Average V,C&n | | | 0.73965 | 10.9 | 0.0442 |

Table 1 to 5 indicates the results of Velocity, chezy's and manning's constant obtained after the completion of the calculations. Chezy's increases in all the tables while manning's decreases.

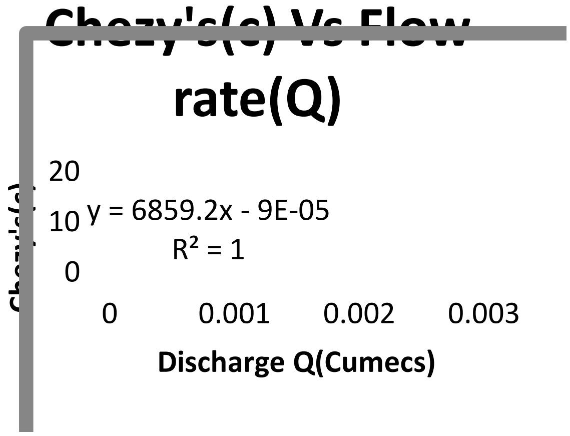
## Resistance Coefficients Statistical Analysis

***Table 6:** shows Average **c** and **n** and **variances** for the type of notches*

| | Type of Notches | c | n | $(Xi-X)^2$ | $(Xi-X)^2$ |
|---|---|---|---|---|---|
| **1.** | **Rectangular notch** | 8.5739 | 0.11 | 0.2284 | 0.0009 |
| **2.** | **90 v-notch** | 5.8484 | 0.1089 | 10.2619 | 0.00084 |
| **3.** | **60 v-notch** | 10.885 | 0.0567 | 3.3605 | 0.00054 |
| **4.** | **Trapezoidal notch** | 10.90 | 0.0442 | 3.4158 | 0.00128 |
| | Average of C & n | 9.0518 | 0.07995 | | |
| | Sum | | | 17.267 | 0.0036 |

The above table signifies variances of Manning's and Chezy's constant. Manning's has smaller value of variance compare to that of chezy's. Likewise the standard deviation of Manning's constant (n) is 0.035 while that of Chezy's constant (c) is 2.399.

**Below are the graphs showing the relationship between Chezy's, Manning's and Flow rate.**



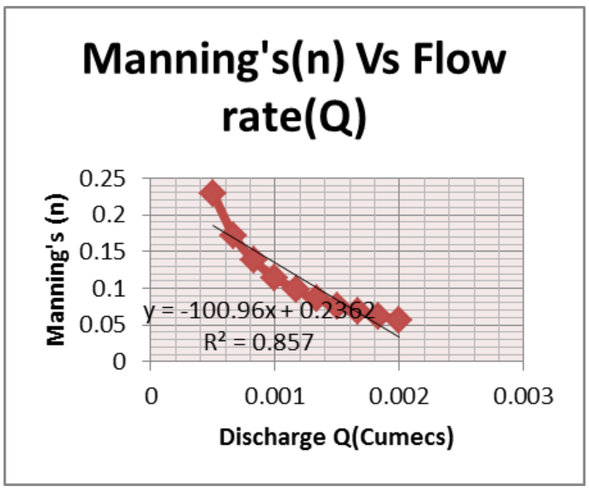
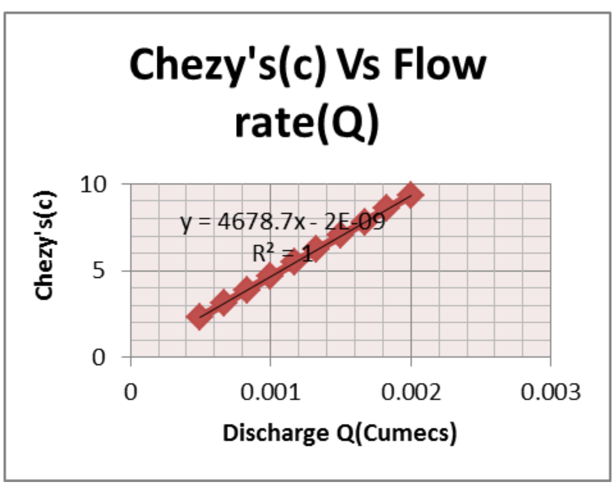




***Figure1:*** *Chezy's and Manning's Vs Actual Discharge of rectangular notch*



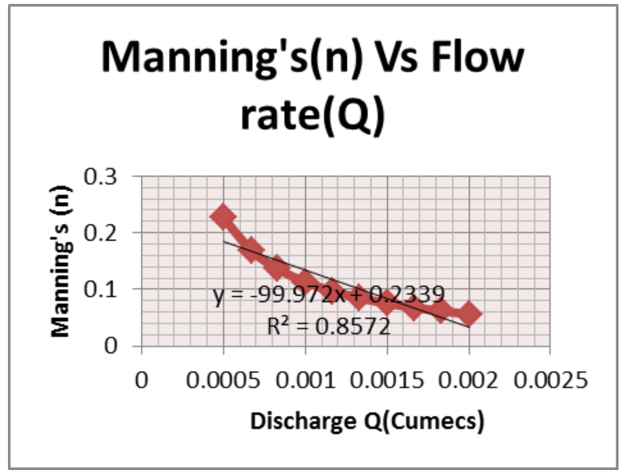
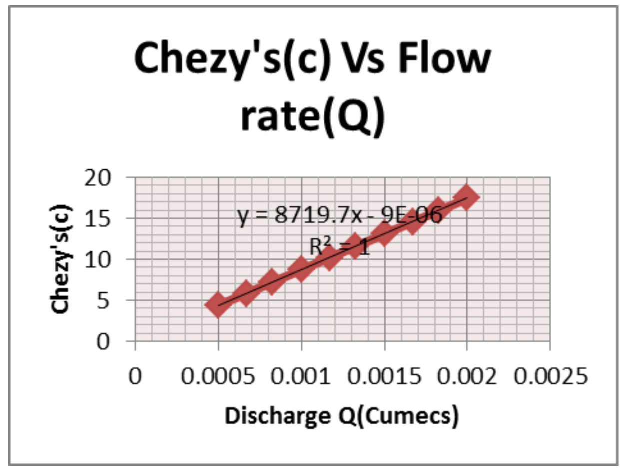




***Figure 2:*** *Chezy's and Manning's Vs. Actual Discharge of 90° V-notch*



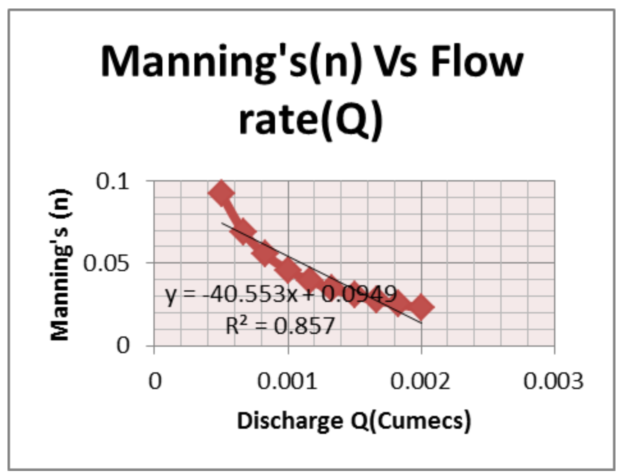
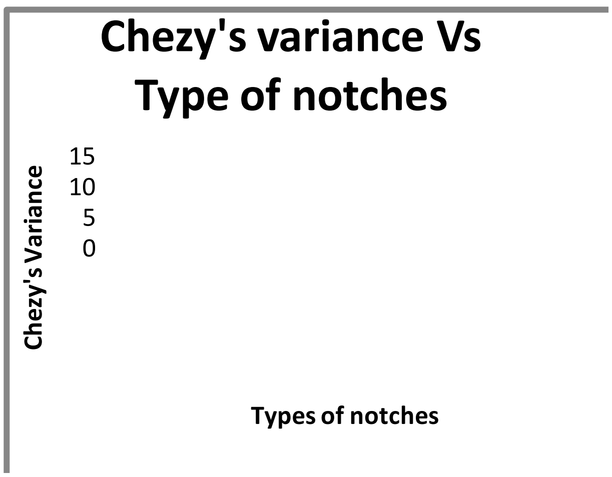




***Figure 4:*** *Chezy's and Manning's Vs. Actual Discharge of Trapezoidal notch*

The above graphs of Chezy's against Flow rate and Manning's against Flow rate shows how Chezy's and Manning's relates with the flow rate. Chezy's constant increases when actual discharge increases (ascends). While Manning's constant decreases when actual discharge increases (descends). This indicates that the higher the discharge value, the higher the Chezy's constant and vice versa. Unlike Manning's constant, the higher the discharge value, the lower the Manning's value. This implies that Chezy's constant is inversely proportional to Manning's constant.

### Relationship between Chezy's& the type of notches and Manning's & types of notches



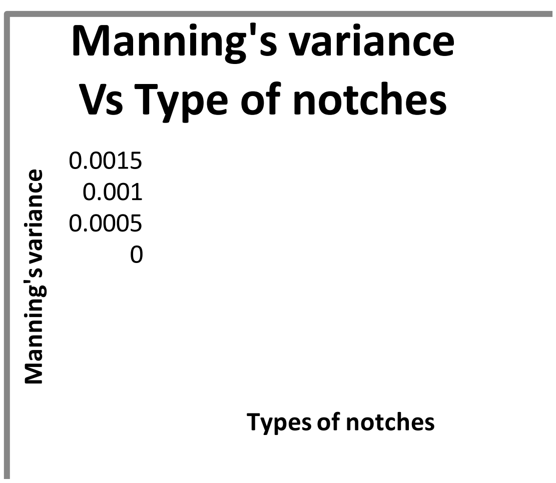




***Figure 5:*** *Average Chezy's and Manning's variance Vs Type of notches*

By referring to the obtained standard deviation results of Chezy's and Manning's, the highest standard deviation is seen on Chezy's while the lowest standard deviation is seen on Manning's. This also helps to verify the level of accuracy between the two coefficients of resistance. Therefore, Manning's has high level of accuracy than chezy's because it has smaller value of standard deviation. In addition to that, the highest variance of chezy's average is obtained on 90 v-notch and the lowest variance is obtained on rectangular notch. While highest variance of Manning's average is obtained on trapezoidal notch and the lowest variance is found on 60 v-notch. This indicates how Chezy's and Manning's are indirectly related.

## CONCLUSION

The fundamental objectives of this paper were accomplished. The results verified that Chezy's constant increases as actual discharge increases while Manning's constant decreases as the actual discharge increases. It was observed from the graphs and the data that Chezy's constant and Manning's constant varies indirectly. This means that when chezy's constant increase manning's constant decrease. Also Chezy's has big value of standard deviation compare to manning's. The smaller the value of standard deviation the higher the level of accuracy, therefore Manning's has high level of accuracy than chezy's constant. In addition to that, it was discovered that the Coefficient of Resistance is more adaptable, simple and accurate in Manning's constant. This is due to the fact that it gives small value which satisfy majority of the researchers. The evidence is seen from the record of the generally recognized tables and figures and from the standard deviation. These records help in giving a clear prove about Manning's constant.

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