Bangladesh University of Engineering & Technology

Department of Water Resources Engineering

Course No. :WRE 302
Course Title: Open-Channel Hydraulics Sessional

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Level: 3 ;Term: I

Hydraulics & River Engineering Laboratory.

Objective:

- To determine the total discharge and mean velocity of the flow.
- To measure Mannig's 'n' and Chezy 'C'
- To plot 'n' and 'c' against depth of flow and sbaerve the relationship.

Experimental Setup:

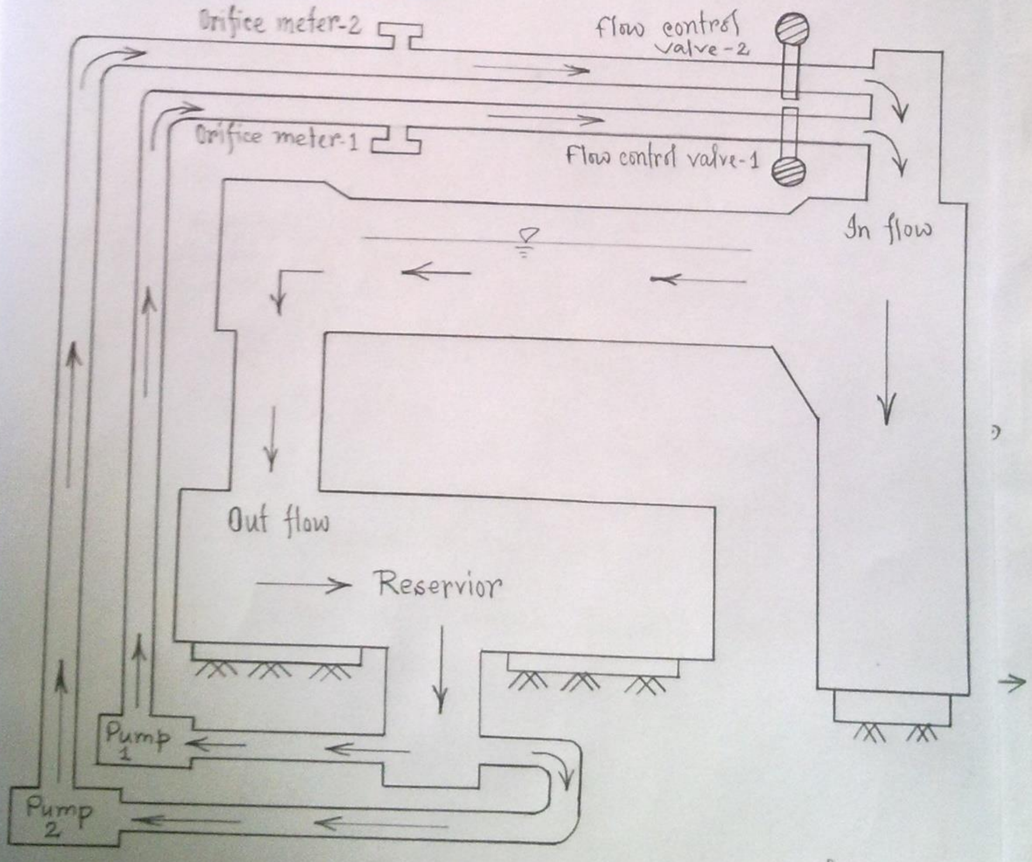

figure: Setup for determination of discharge and mean velocity of an open channel.

⊞ Related formula :

* Depth mean velocity :

The velocity along a vertical varies from zero at the steam bed to maximum at or near the water surface. Normally when the depth of flow in a vertical is greater than 0.61m, then the depth mean velocity determined by averaging velocity at 0.2 and 0.8 depth otherwise at 0.6 depth taken as average velocity. So,

Depth mean velocity, $V = \frac{v_{0.2} + v_{0.8}}{2}$ when, $y > 0.61m$

$= v_{0.6}$; when, $y \leq 0.61\,m$

* Discharge of flow :

discharge through a strip is given by,

$$Q_i = V_i \Delta A$$

where, V_i = mean velocity at i^{th} strip.

ΔA = area of the strip.

The sum of the discharges through all the strips is the total discharge. i.e

$$Q = \Sigma Q_i$$

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* Mean velocity of the stream:

The mean velocity of the whole section is equal to the total discharge divided by the whole area and given by,

$$V = \frac{Q}{\Sigma \Delta A}$$

* Manning's and Chezy's roughness coefficient:

Manning's 'n' can be determined by the following equation given as,

$$n = \frac{(x-1)R^{1/6}}{6.78(x+0.95)}$$

where, $x = \frac{v_{0.2}}{v_{0.8}}$

R = hydraulic radius.

Using the above value of 'n' Chezy's C is determined by the following relation,

$$C = \frac{1}{n} R^{1/6}$$

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10.8 Data sheet:

Measurement total discharge

Flume Width, m B= 0.762 m Width of each strip, = B/3= 0.254

Total depth of flow, m Y= 0.385 m Area of each strip, ΔA =(B/3)*Y= 0.0978 m²

Current meter constants, a= 0.1334 b= 0.029

Location of Current meter		Current meter reading			Point velocity v (m/s)	Depth mean velocity V_i (m/s)	Discharge through the strip $Q_i=\Delta A*V_i$ (m³/s)	Total discharge $Q=\Sigma Q_i$ (m³/s)
Horizontal	Vertical	No of revolution N (rev)	Time of observation t (sec)	Revolution per second n (rev/sec)				
At middle of first strip	At 0.2 Y	83	14.7	5.646	0.782	0.800	0.078	0.235
	At 0.6 Y	86	14.9	5.780	0.800			
	At 0.8 Y	82	14.9	5.503	0.763			
At middle of second strip	At 0.2 Y	83	14.7	5.646	0.782	0.803	0.079	
	At 0.6 Y	87	15.0	5.800	0.803			
	At 0.8 Y	83	15.1	5.495	0.762			
At middle of third strip	At 0.2 Y	83	14.7	5.646	0.782	0.800	0.078	
	At 0.6 Y	86	14.9	5.780	0.800			
	At 0.8 Y	83	14.9	5.570	0.772			

So, mean velocity of the stream $= V = \frac{Q}{\sum \Delta A} = \frac{0.235}{0.29337} = 0.801\ ms^{-1}$

15.03

Calculation of n and C

Strip	Point velocity	x	Average x	Manning's n	Chezy's C
1	$V_{0.2}$	1.025	1.0213	1.21×10^{-3}	627.48
	$V_{0.8}$				
2	$V_{0.2}$	1.026			
	$V_{0.8}$				
3	$V_{0.2}$	1.013			
	$V_{0.8}$				

Plotting n and C vs depth of flow:

Depth of flow	Manning's n	Chezy's C
0.354	2.0×10^{-3}	375.053
0.34	3.0×10^{-3}	271.2
0.325	4.5×10^{-3}	166.07
0.385	1.21×10^{-3}	627.48
0.365	4.6×10^{-3}	164.25

Sample Calculation:

Flume width, $B = 0.762$ m

Width of each strip, $= B/3 = \frac{0.762}{3} = 0.254$ m

Total depth of flow, $Y = 0.385$ m

$\therefore$ Area of each strip, $\Delta A = (B/3) * Y$

$= 0.254 * 0.385$

$= 0.0978\ m^2$

Current meter constants, $a = 0.1334$

$b = 0.029$

Calculation at middle of second strip (at $0.6Y$):

No. of revolution, $N = 87$

time ellapsed, $t = 15.0$ sec.

$\therefore$ Revolution per seccond, $n = \frac{N}{t}$

$= \frac{87}{15} = 5.8$ rev. sec^{-1}

$\therefore$ Point velocity, $v_{0.6} = an + b$

$= 0.1334 * 5.8 + 0.029$

$= 0.803\ ms^{-1}$

Depth mean velocity, $V_i = v_{0.6}$

$= 0.803\ ms^{-1}$

Discharge through the middle strip, Q_i

$= \Delta A * v_i$

$= 0.0978 * 0.803$

$= 0.079 \ m^3/sec.$

Total discharge, $Q = \Sigma Q_i$

$= 0.078 + 0.079 + 0.078$

$= 0.235 \ m^3/sec.$

$\therefore$ Mean velocity of the stream, $V = \frac{Q}{\Sigma \Delta A}$

$= \frac{0.235}{0.762 * 0.385} = 0.801 \ ms^{-1}$

Verification of mean velocity with meter reading:

Total discharge, $Q = (320 + 457) \ m^3/hr$

$= 777 \ m^3/hr$

$= 0.2158 \ m^3/sec.$

$\therefore$ Mean velocity of the stream, $V = \frac{Q}{A}$

$= \frac{0.2158}{0.29337}$

$= 0.736 \ ms^{-1}$

Hydraulic radius, $R = \frac{A}{T} = \frac{0.762 * 0.385}{0.762 + 2 * 0.385}$

$= 0.1915 \ m$

Calculation of 'n' and 'c' :

for first strip - $v_{0.2} = 0.782\ ms^{-1}$

$v_{0.8} = 0.763\ ms^{-1}$

$\therefore$ ratio of $v_{0.2}$ to $v_{0.8}$, $x = \frac{v_{0.2}}{v_{0.8}}$

$= \frac{0.782}{0.763}$

$= 1.025$

Average value of $x = \frac{1.025 + 1.026 + 1.013}{3}$

$= 1.0213$

$\therefore$ Manning's 'n' $= \frac{(x-1) R^{1/6}}{6.78(x+0.95)}$

$= \frac{(1.0213-1) * (0.1915)^{1/6}}{6.78\ (1.0213+0.95)}$

$= 1.21 \times 10^{-3}$

$\therefore$ Chezy's c $= \frac{1}{n} R^{1/6}$

$= \frac{1}{1.21 \times 10^{-3}} * (0.1915)^{1/6}$

$= 627.48$

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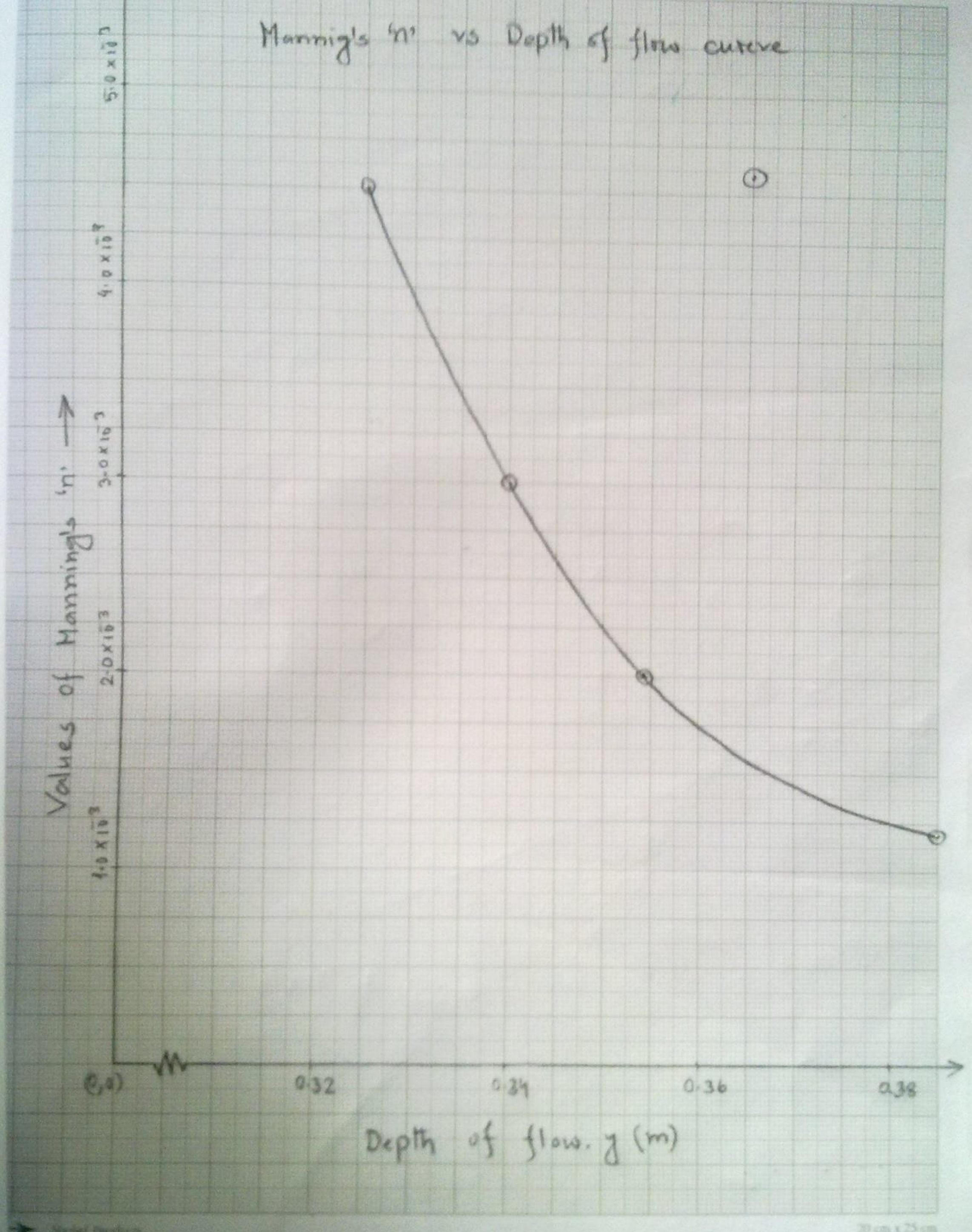

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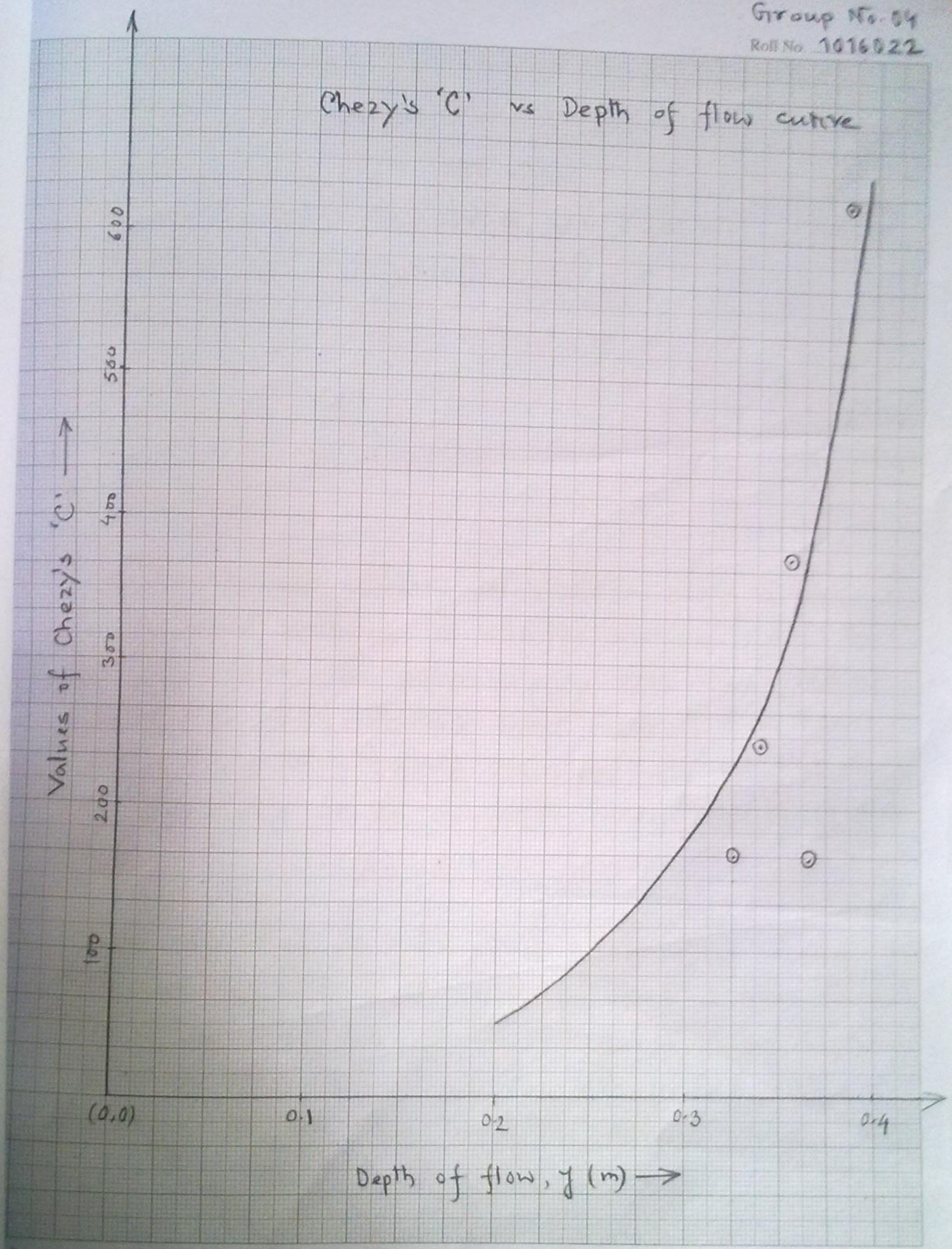

20 cm x 25 cm

Result :

- Total discharge, $Q = 0.235 \ m^3/sec$
- Mean velocity of the stream, $V = 0.801 \ ms^{-1}$
- Mannig's 'n' $= 1.21 \times 10^{-3}$
- Chezy's 'C' $= 627.48$

Discussion :

- In open channel, velocity distribution along a vertical do not found uniform as velocity change along the depth increment. The point velocity was measured at 0.2Y, 0.6Y and 0.8Y. As the total depth of flow was 0.385 m (less than 0.61 m) point velocity at 0.6Y depth was considered to be as depth mean velocity of that strip.

- Total discharge is measured 0.235 m³/sec using area-velocity method. Again, meter reading was found 0.216 m³/sec as value of discharge. Therefore, applying this area-velocity method, the computed value of discharge is too close with the actual value.

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- Mean velocity of the laboratory flume for the given discharge is measured to be 0.807 ms^{-1} whereas using the meter reading of actual discharge mean velocity is computed to be 0.735 ms^{-1}.

- The value of Manning's 'n' is measured as 1.21×10^{-3} whereas the typical value of Manning's 'n' for open channel having bed surface to be concrete is measured 0.013

- The value of Chezy's C is found 627.48. But the numerical value of Chezy's C varies from 30 to 80 $m^{1/2}/sec$.

- Manning's 'n' vs depth of flow curve is convex to the origin. It represents the value of 'n' decrease with the depth of flow increases.

- Chezy's C vs depth of flow curve is concave to the origin. With the increase of depth of flow the value of ~~the depth~~ C is also increase. Comparing these two curve there found an inverse relationship between Manning's 'n' and Chezy's 'C'. →