VELOCITY HEAD ROD FOR MEASURING STREAM FLOW

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INTRODUCTION

The velocity head rod is a simple piece of equipment for measuring depths and velocities in a stream channel. As originally devised by Wilm and Storey (1908), the velocity head rod consists of a five-foot wooden rod covered with copper sheeting to provide a sharp cutting edge, and a flat trailing edge, with accurate depth engravings on both edges. The rod is placed on the channel bottom with the sharp edge facing upstream and the depth of water noted, the rod is then turned with the flat or trailing edge directly upstream and the consequent obstruction to the flow will create a hydraulic jump. The average height of this jump from the bed measures the total energy content of the flow at this point of the stream. The height of the jump minus the depth equals the actual velocity head (h), so that $h = V^2/2g$ and the velocity in the vertical is therefore given by $V = \sqrt{2gh} = 8.02\sqrt{h}$ (g is the gravitational acceleration rate).

EARLY FIELD TRIALS

Trials with this rod disclosed some disadvantages, the major ones being:

(i) It was difficult to engrave accurately.

(ii) The cutting edge, which consists of soft copper, dents very easily resulting in false depth readings.

(iii) The relatively large, flat bottom of the rod makes it difficult to position at exactly the same level for both readings.

(iv) The five-foot long rod is difficult to keep vertical while bending over to take accurate readings in shallow water.

AN IMPROVED HEAD ROD

To overcome the difficulties listed above the Hydrological Survey, Ministry of Works, Whangarei, constructed a smaller and sturdier rod of 10 gauge, stainless steel. This was 2ft long by 1in. wide with a screw-on foot (Fig.1). It was found that this 2ft rod could be readily machine engraved accurately in 0.01 ft divisions.

The importance of accurate engravings is realised when one considers that a velocity of 1ft per sec. produces a head of .015ft. Also, since this rod is made of thin, yet sturdy material, the one engraved face (Fig.1) can be easily read for both the wedge edge and the flat trailing edge.

Another major advantage is the foot screw, which enables the operator to turn the rod independently of the foot, thus ensuring that both readings are made at exactly the same datum point on the stream bed. Trials with this new rod indicate that an average error of less than 10 percent may be expected. In Table 1 some quantitative measurements derived with the head rod are compared with those derived by current meters. In Table 2 comparisons of mean velocities in the vertical are tabulated using the head rod and current meters. In all comparisons meter velocities were taken at .2, .6 and .8 depths. It appears, for the observations taken, that as large an error can be expected between discharges observed by current meters as between discharges observed by the head rod and any current meter. Only the Ott current meter has been rated recently.

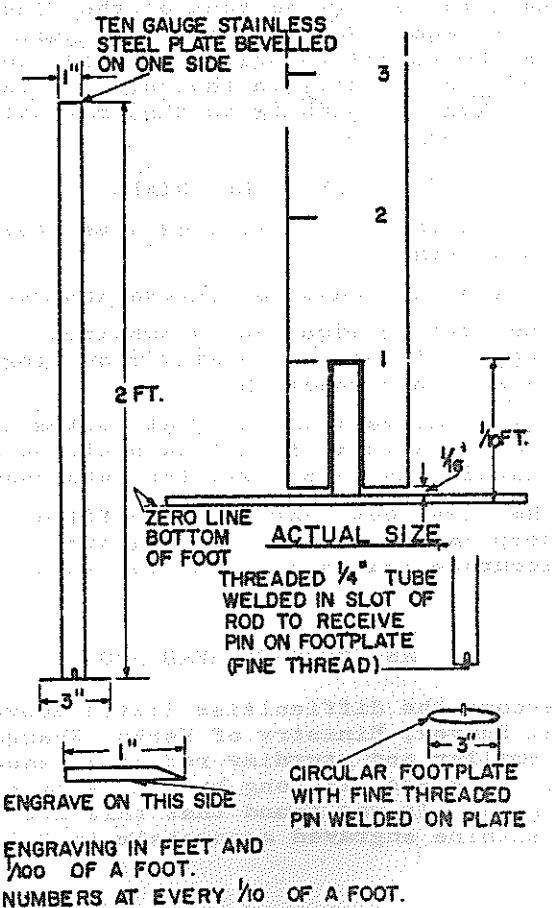

Fig.1 - Details of velocity head rod.

Discharges (c.f.s.)						Percentage Deviation					
Pygmy	Ott	Gurley	Watts	Amsler	H. rod	H. rod / Pygmy	H. rod / Ott	H. rod / Gurley	Pygmy / Watts	Gurley / Watts	Pygmy / Amsler
-	-	146.2	-	-	148.7	-	-	+ 1.7	-	-	-
-	-	265.2	-	-	258.1	-	-	- 2.7	-	-	-
-	-	52.34	-	-	47.38	-	-	- 9.1	-	-	-
5.52	-	-	-	-	5.18	- 6.2	-	-	-	-	-
-	0.222	-	-	-	0.201	-	- 9.5	-	-	-	-
205.9	-	-	-	211.2	-	-	-	-	-	-	- 2.5
151.6	-	-	163.3	-	-	-	-	-	- 7.2	-	-
-	-	68.82	73.20	-	-	-	-	-	-	- 6.0	-

Table 1 - Comparison of discharges

Velocities					Percentage Deviation							
Pygmy	Gurley	Watts	Amsler	H. rod	H.rod / Pygmy	H.rod / Gurley	H.rod / Watts	H.rod / Amsler	Pygmy / Watts	Gurley / Watts	Gurley / Amsler	Watts / Amsler	Pygmy / Gurley
-	2.05	2.51	2.19	2.12	-	+ 3.4	-15.5	- 3.2	-	- 18.3	- 6.4	+14.6	-
-	3.74	3.87	3.68	3.67	-	- 1.9	- 5.2	- 0.3	-	- 3.4	+ 1.6	+ 5.2	-
-	4.29	4.34	4.34	4.24	-	- 1.2	- 2.3	- 2.3	-	- 1.2	- 1.2	0	-
-	3.85	3.67	3.72	3.59	-	- 6.8	- 2.2	- 3.5	-	+ 4.9	+ 3.5	- 1.3	-
2.078	1.87	2.00	-	2.12	+ 2.0	+13.4	+ 6.0	-	+ 3.9	- 6.5	-	-	+11.1
3.987	3.56	3.63	-	3.50	-12.2	- 1.7	- 3.6	-	+ 9.8	- 1.9	-	-	+12.0
3.391	2.92	2.99	-	2.66	-21.6	- 8.9	-11.0	-	+13.4	- 2.3	-	-	+16.1

Table 2 - Comparison of mean velocities in verticals

FIELD OPERATION

The following points should be observed when operating the rod:

(i) It should be held only on stable points of the river bed. Most errors in reading can be attributed to a shift in height between two readings due to unstable support.

(ii) Especially in turbulent water, surges can be as much as 0.12ft and some time in reading the scale should be allowed to establish the mean height on the trailing edge.

(iii) Any ripples on the cutting edge should be neglected.

(iv) The rod should be held vertically.

(v) When reading either the cutting edge or the trailing edge, the edge should face directly upstream.

EFFECT OF READING INACCURACIES

From the equation ($V=\sqrt{2gh}$) it follows that the percentage error of velocity is only one-half the percentage reading error; hence the higher the velocities, the better are likely to be the results.

* Examples (each with a reading error of 0.01ft)

A. $h1 = 0.10$ $V1 = 2.54$)
$h2 = 0.09$ $V2 = 2.41$) low velocities

% diff. $h1/h2 = 10\%$ % diff. $V1/V2 = 5\%$

B. $h1 = 1.00$ $V1 = 8.02$)
$h2 = 0.99$ $V2 = 7.98$) high velocities

% diff. $h1/h2 = 1\%$ % diff. $V1/V2 = 0.5\%$

* A maximum reading error around 0.01ft is reasonable with low velocities but with medium to high velocities it will frequently be possible to determine h only to within 0.05 to 0.10ft at the best. This introduces a velocity error around 5% which, under difficult flow conditions, may become closer to 10%. Ed.

COMMENTS

The velocity head rod is a suitable instrument for the casual determination of discharge in small streams, grassed waterways, graded channels, irrigation canals and the like. It can be carried clipped to a 3in x 2in piece of wood in the back of a car. It may be used to great advantage in debris or silt-laden streams, where the moving parts of a current meter would fail; and it is probably very suitable for calibrating small measuring structures. However, the head rod has also some limitations:

(i) In flows much below 1ft per sec. the head of water cannot be read accurately.

(ii) In velocities over 7ft per sec. it will be hard to hold the rod steady.

(iii) Its depth range is only from 0.1 to 2ft; its length could possibly be increased by 1ft but it has been found that in most, if not all, streams where the rod would be used, a 2ft range is ample.

For measurement in deep water further tests are now in progress in which the same rod is set into the sliding bracket on the Watts gauging rods.

ACKNOWLEDGMENT

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REFERENCE

Wilm, H.G.; Storey, H.C. 1944: Velocity Head Rod Calibrated for Measuring Stream Flow. Civil Engineer, 14: 475-6.