Paper No. 125
Year 1929

HEADLESS CANAL METERS

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Majority of large channels in Punjab don't have a fall with a broad crested weir near the head thus making it imperative to measure discharge through current meters. The object of this paper is to show that the discharge can be obtained nearly as accurately as from a free fall, even without any appreciable fall, with the help of one or more pairs of gauge readings at a suitably designed masonary work. The theory is simple and based on the fact that in a stream with stream line flow, the difference of the squares of velocities at two sections close together is Zgh when h is the depression in water surface between the two sections, and g is gravity. Thus if the breadths are bo and bl and depths are yo and yl, then the discharge Q is given by the equation :

$$Q = 8.025\, b_o y_o b_1 y_1 \quad \frac{h}{b_o^2 y_o^2 - b_1^2 y_1^2}$$

Such a meter was first built near the head of the Dipalpur Canal. In its design following requirements had to be satisfied :

i Reasonable accuracy i.e. sufficient depression in water surface between the upstream and downstream gauges, for discharges ranging form 2357 to 7071 cusecs.

ii The loss of head through the meter was limited to 0.2 ft.

iii The velocity at the upstream gauge had to be well above the assumed critical velocity ratio to ensure that the area here would always be constant.

iv Th two sections where the gauge readings are taken were not to be so far apart that the effect of friction would appreciably affect the accuracy.

v The contraction in plan was not to be so great as to make the convergence and divergence, upstream and downstream too expensive.

vi On closing the canal, it would not be necessary to unwater the canal upstream.

vii The spans were not to be too great for a reinforced concrete bridge.

viii The intensity of discharge upstream and downstream of any span was not to be much different than that of its neighbours so as to avoid excessive eddies.

In a design the first four requirements have to be essentially met, whereas those listed at No. 5 and 8 are not so important.

The design of the meter consisted of 5 spans of 35' each, with 4 side spans having a raised crest 2.5' above bed, without any side contractions. The central span had its floor at bed level, its contraction in area being entirely in plan. In the side spans the length of the crest was made 15'. Gauge holes were situated upstream and downstream in each span, and their siting was so determined as to cause no interference from bending of streamlines. Gauges consisted of plain length of wood with brass tops wre fixed in the gauge wells, and water surface levels were measured down from the brass tops with a boxwood scale.

To check the accuracy of the method, the results were compared with current meter observations. On an average, the discharge bridge gave divergence of 1.187. greater than current meter observations. It was noticed that generally the divergences were more on the windy days than on calm days. In the opinion of the writer, the Discharge Bridge appears to give results which are correct within about 1%, while carefully taken current meter discharges may be as much as 5% in error. It is because there are five possible sources of error with the current meter namely (i) the length of wire (ii) the soundings (iii) the depth of the current meter (iv) the calibration of the current meter and (v) state of the weather. In the discharge flume, however, there is only one vairable source of error : the gauge reading.

The next meter was constructed at the head of the Upper Sohag Branch. This consisted of a single span, 15 ft wide at the site of the downstream gauge with crest raised one foot, and 25' wide at the upstream gauge where the floor was at bed level. In this meter, the crest was all at one level, and a bypass was provided for unwatering the canal when necessary. The cross sectional dimensions of Upper Sohag branch are too large for its new requirements. When it would get silted up, there would be little or no fall at the site of this meter. During the past summer, the meter has been acting as a free fall and discharge can be measured from the broad crested weir formula as well as by the method described in this paper. The comparative results showed that the latter gave discharges which averaged 2.4% less than weir formula.

In this case and in this case of meter at the head of Jallalabad Branch, a new idea is being introduced which may prove useful for flumes in general. A divergence of 1 in 15 will, for the velocities with which we deal, recover all the head which is possible to be recovered, and a divergence of 1 in 10 may be nearly as good. A change in the direction of flow along the side walls is caused by water pressure at right angles to the latter. It should therefore be our aim to keep this pressure constant, and as the velocity of the water drops, the radius of curvature of the side wall should decrease. In the designs of Eastern and Jallalabad meters the initial radius has been made 200 ft. This type of divergence is cheaper than a splay of 1 in 10.

The following factors governed the design of the meter at the head of Jallabad Branch :-

i There must be no appreciable loss of head with half share supply.

ii There may, if otherwise desired, be greater loss of head with maximum supply.

iii Great accuracy is not required with maximum as with half share (one third of maximum) supply.

Experience derivd from Dipalpur Design shows that if we take Fane's coefficient, and a loss of head as shown by him of 0.2 ft, the result will give a design requiring no loss of head. Therefore we may start off by assuming a loss of head of 0.2 ft. with minimum supply. Various crest heights are tried alongwith widths at upstream gauge giving silt clear waters, and finally depression in water surfaces are determined. From the various alternatives the one combining suitability least cost is adopted.

Note :-

Paper No. 125 appeared at pages 1 to 14 of the Proceedings of Punjab Engineering Congress 1929. Vol. XVII. The author has given detailed calculations in Appendix. The discussions on the paper are given at pages 14a to 141. There are 9 Plates and 5 Diagrams.