VORTEX TUBE SAND TRAP[a]

Closure by A. R. Robinson

A. R. ROBINSON,[6] A. M. ASCE.—The discussion of sediment ejectors by Mustaq Ahmad is much appreciated. The slit vortex-type excluder described by Ahmad is not the same as the vortex tube examined in the original paper. Actually, this excluder consists of a slit across the channel with a collection chamber underneath to convey the effluent. An excluder of this design should not be troubled with sediment being thrown out of the tube and re-entering the channel because of the vortical action of the tube. However, it is possible for the slit-type ejector to remove a greater percentage of flow because of the horizontal orifice. The quantity of flow removed would be a function of length and size of the collection chamber.

In the discussion, Fig. 21 presents a comparison of the efficiencies from the vortex-type ejector as compared with the frontal-type. The marked low efficiency of the frontal ejector seems to be characteristic of this design. The writer is aware of instances in which the frontal-type ejector has been a complete failure.

The material presented in Fig. 23 shows the effect of a variable Froude number on the efficiency of trapping. As the crest is raised for a constant discharge, the Froude number of the flow over the raised portion increases. If a Froude number of unity is assumed and the energy relationship written between a point upstream and the crest, as shown in Fig. 22, a crest elevation of 435.9 is determined. The optimum elevation of 435.0 then results in a Froude number of approximately 0.8 at design discharge and 66% contraction.

A question arises as to why each of the two vortex types of sand traps operate at maximum efficiency when the Froude number is near 0.8. Because the design and principle of operation of each trap are entirely different, the answer possibly lies in the manner in which the sediment moves across the section. In the discussion of sediment transport in the original paper, it was pointed out that, for optimum operation, the section containing the tube should be designed so that a specific flow regime and alluvial bed roughness would exist. The plane bed roughness and associated movement of bed load seemed to be desirable. For the sediment having a mean diameter of 0.45 mm, this regime exists at a Froude number of the flow of 0.6 to 0.7. For larger size material, the plane bed is maintained at greater Froude numbers. The sediment in Ahmad's study had a mean diameter of 0.75 mm. With this size of

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sediment, the Froude number range of 0.7 to 0.8 would seem to be optimum for highest trapping efficiency.

The effect of fluming (percentage of contraction) from the original channel width is shown in Fig. 25. The results are given for different percentage of extractor ratios at a constant Froude number. It is difficult to explain the increase in efficiency with decrease in percentage of fluming except on the basis of relative tube length. It was found in the vortex tube study that length of tube was very important. Beyond a certain length, the tube was inoperative because the capacity of the tube is limited. In Ahmad's study, even at 50-% fluming, the 75-ft tube lengths used are far in excess of recommended lengths. Tubes not exceeding 25 ft in length would have given much higher efficiencies. This length is based on the results presented in the original paper.

A study was reported in 1961 by S. S. Karaki of Colorado State University (17) to develop and test a sediment ejector system to protect the Trimmu-Sidhnai Canal from excessive bed-material concentrations. The canal is one of several link canals in the Indus Basin of West Pakistan. The maximum discharge is 11,000 cfs and the bottom width is 240 ft. The median diameter of bed material in this canal is 0.26 mm.

This study resulted in a recommended design of ejector system which is a series of 30 ft-by-30-ft-by-9 ft deep bins placed both laterally and longitudinally along the canal. The top of the bin is set at the canal bottom. Discharge pipes with control valves are attached to the V-shaped bottom of the bins and convey the flow and sediment back to the river below the point of diversion.

A unique feature of this ejector is the use of a curve in the canal to create secondary circulation and move the bed load to the inside of the curve. With appropriate location of collector bins along the inside of the curve as well as laterally across the canal bottom, efficiency of trapping is near 70%, with 10% of the flow being removed.

Errata.—In the original paper on the Vortex tube, a change was made in the variable term for depth, d, without the writer's knowledge. This change, appearing as d_μ in Eqs. 2, 3, and 4 and in the parameters in this section, is in error. Eqs. 1 and 5 and all succeeding equations contain the correct symbol for depth, d. In Appendix II - Notation, there appears a definition for d_μ which also was added incorrectly and should be disregarded. The velocity is always the average velocity so that $\overline{V}$ is the correct symbol and should be used throughout the paper.

Two typographical errors were noted in Ahmad's discussion. The velocity head that he introduces is $V^2/50$. In Eq. 21, the first term is the Froude number $V/\sqrt{gd}$.

Additional Bibliography.—

17. "A Final Report on a Model Investigation of the Sediment Ejector for the Trimmu-Sidhnai Link Canal, Indus Basin Project, West Pakistan," by S. S. Karaki, Report CER61SSK81, Colorado State Univ. Research Foundation, Civ. Engrg. Sect., Fort Collins, Colo., December, 1961.