Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 2, Number 8; April-June, 2015 pp. 751-753

http://www.krishisanskriti.org/jceet.html

Trapping Efficiency of the Tunnel Type Silt Extractor

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Abstract—*A tunnel type silt extractor is commonly used for extracting the sediment from the canal. They extract sediment from a canal by extracting the bottom layer of the flow, which carries a large quantity of bed and suspended material. Sediment extractors are constructed in the canal and extract the sediment or sand from the canal. The tunnel type silt extractor is suited for the Indian condition. In tunnel type silt extractor the tunnels are constructed in the full width of the canal. This paper deals with the efficiency of silt extractor.*

1. INTRODUCTION

River water diverted to irrigation canals can contain high concentration of sediment. As the sediment transporting capacity of canals is usually lesser than of rivers, sedimentation in irrigation canal systems can be a major problem. It can cause a significant loss of conveyance capacity in an irrigation canal, and removing of the sand is expensive as well as it can further interrupt irrigation supplies. Similar problem occurs due to the ingress of sediment to power channels supplying water to hydroelectric plants where the conveyance capacity reduces, in addition to damage of turbine blades. If the canal systems are to remain stable, excess sediment must either be excluded at the head works or removed from the canal.

The methods of sediment control can be broadly classified into two groups depending upon whether the control is affecting at the canal head works or in the canal downstream. If possible an attempt is made to exclude the sediment from entering into the canal at diversion headwork. This method is preventive measure in nature and sand excluding device used for this purpose is in conjunction with diversion head regulator of the canal on the upstream in the river. However efficient an excluder at the head of the canal may be, yet a large quantity of sediment material does enter into the main canal system. So, some structure needs to be built in the main canal to extract the excess sediment from it. This method is curative in nature and structure used for this purpose in known as extractor. Both the devices recognize the fact that flowing stream carrying sediment in suspension, the concentration of sand in the lower layer is greater than in the upper one.

In the sand excluder, the sand-laden water carrying bed loads is allowed to flow through the excluder tunnel which discharges through under sluice bays into the stream or into a separate outfall channel. An extractor on the other hand removes (escape) the excess sediment from lower depth after it has entered the canal. Fig.1 shows a sectional elevation and plan of a tunnel type silt extractor.

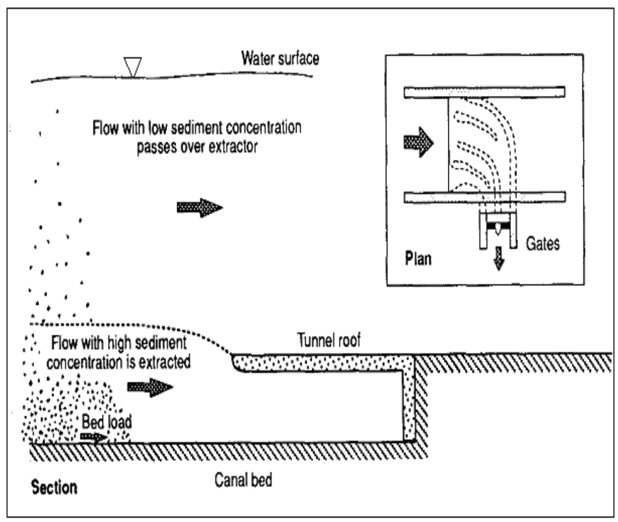

Fig. 1: Sectional Elevation and Plan of a Tunnel type Silt Ejector

The first sediment extractor was constructed in 1934 for extracting gravel and shingle on the Salempur feeder of the Upper Bari Doab canal. In Uttar Pradesh, a sediment extractor was constructed on Sarda Main canal due to troubling of sanding and thereby reducing discharge capacity across on Sarda Main canal which is an irrigation as well as power channel. Sediment extractor similar to the Sarda Sediment ejector have been designed by U.P Irrigation Research Institute, Roorkee and constructed on Yamuna Power Channel, Ahsan power Channel, Western Gandak Canal and Kosi Supply Channel.

2. EXPERIMENT SETUP

Experiments were conducted in NIT Kurukshetra Hydraulic Laboratory in a recirculating flow canal. A discharge of 20 l/s is used while width of canal and depth of water are taken as 45 cm and 30cm respectively. Silt extractor is placed across the full width of the canal and consists of 3 main tunnel and 4 sub-tunnels.

The width of each main tunnel is kept 15cm while width each sub-tunnel is kept 3.75cm such that velocity in tunnel is maintained for non-sanding and non-scouring. The height of diaphragm slab at mouth of the extractor is kept as 7.5cm which is 1/4th of the total water depth while at end of the extractor. Diaphragm height is kept 12cm to maintain sub critical flow for preventing negative pressure at the end. The discharge of the canal is regulated by valve shown in figure2.0. Tests were conducted under three different flow velocities at time variation of 10, 15 and 20 minutes for each velocity. Sand is used in the experiment to find the efficiency of the extractor. Three different size of sand is used in the experiment these are 0.150mm, 0.300mm, and 0.425mm. 3 kg sand is used for a particular experiment run.

The design criteria for the tunnel type silt extractor are given by the Indian Standard IS: 6004-1980. The laboratory setup is shown in figure.2. The following steps can be followed for the design of the silt extractor.

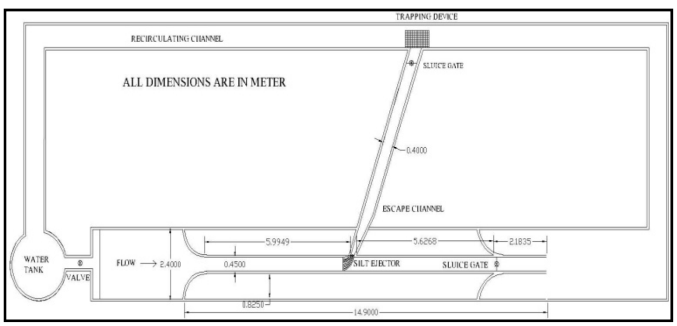

Fig. 2: Experimental Layout

2.1 Approach Channel

The approach channel upstream of the extractor should be straight and without any barrier because anything in the form of curve shall change the sediment concentration across the channel and disturbed the uniform distribution of the flow in the front of the ejector.

2.2 Escape Discharge

A study of the model performance of existing extractor shows that an escape discharge equal to 20% to 25%of the canal discharge passing below the extractor is usually adequate.

2.3 Location of the Extractor

The extractor should not be sited very near the head regulator or should not be very far downstream from the canal head because if it is very near to the head regulator turbulence may cause the sediment load to remain in suspension or if it is very far from the canal head, the sediment would tend to settle down earlier and reduce the channel capacity. The distance required for placing an extractor can be obtained from the consideration of size, fall velocity of the sand to be extracted, channel geometry and shear velocity.

2.4 Height and Position of Diaphragm

The diaphragm should be so placed that it causes least disturbance in front of the ejector tunnel so as not disturb the normal distribution in the vertical plane at its edge when the ejector is drawing its due share discharge. Model measurements of the sediment distribution in channels have indicated that concentration of coarse sediment usually persists in 1/3rd to1/4th of the depth of flow.

2.5 Main tunnels and Sub-tunnels

The extractor should normally span the entire width of the canal and should be divided in to 3to5 compartments, called main tunnels and the main tunnels is sub-divided into sub-compartments, called sub-tunnels. This division reduces the cost of the slab over the tunnels. The section of the sun-tunnel is so chosen that the head loss in each sub-tunnel is the same.

2.6 Losses in Tunnels

The losses of the tunnels are also calculated. In tunnels losses are due to friction, bend, contraction, and due to expansion shall be evaluated.

3. RESULT AND DISCUSSION

The efficiency of the extractor may be defined as the percentage reduction in the quantity of sediment which would have entered the canal had there been no such structure. Figure.3 shows the efficiency for 0.150 mm size of sand at different velocities for different duration of flow.

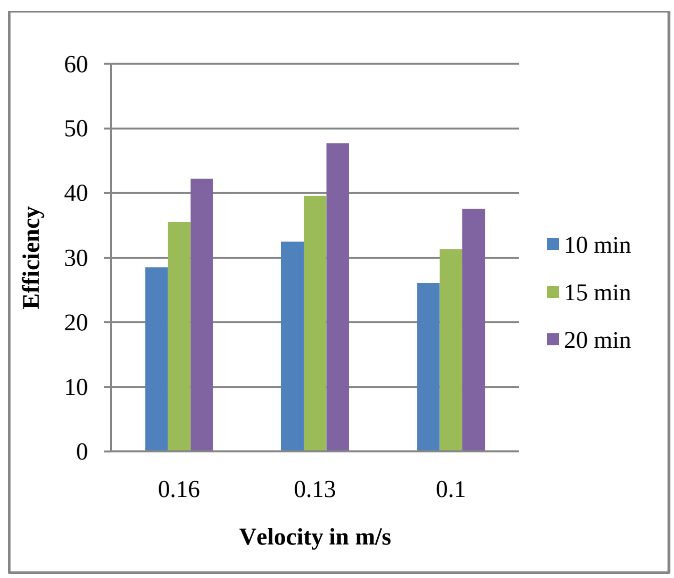

Fig. 3: For 0.150mm sand

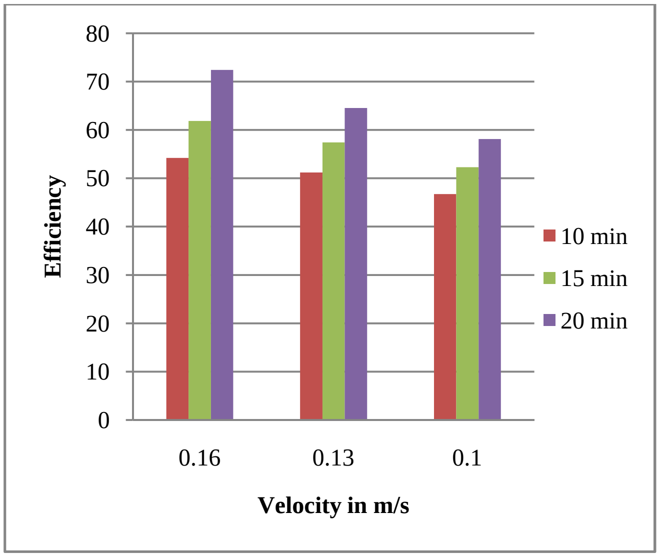

Fig. 4: For 0.300mm sand

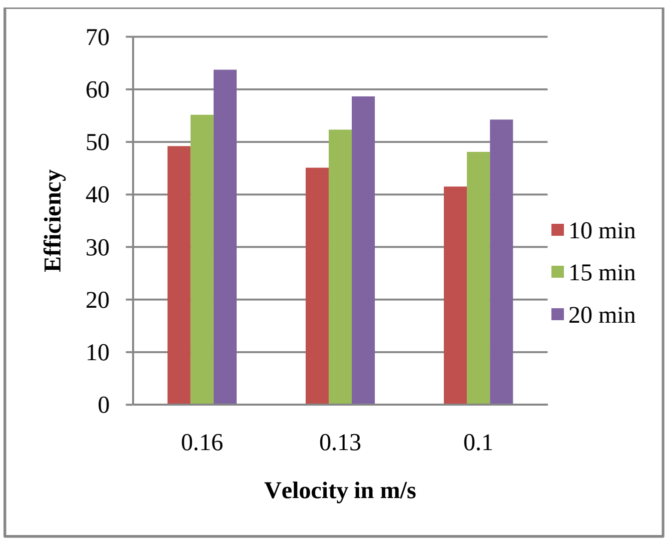

Fig. 5: For 0.425mm sand

It can be observed that the efficiency is increasing with increase in time. In figure.3 the maximum efficiency for the 0.150 mm sand size is achieved at a velocity of 0.13 m/s and the minimum efficiency is at a velocity of 0.10 m/s. In figure.4 the maximum efficiency for the 0.300 mm size of sand is achieved at a velocity of 0.16 m/s and the minimum efficiency is at a velocity of 0.l0 m/s. By analyzing the figure.5 the maximum efficiency for the 0.425 mm size of sand is achieved at the maximum velocity of 0.16 m/s so it is clear that the efficiency of the silt extractor depends on the size of the sand and the velocity of flow and as well as the time.

The maximum efficiency of the extractor is achieved in medium size of sand i.e. 0.30 mm and as the size of the sand particles further reduces the efficiency of the silt extractor also decreases.

4. CONCLUSION

The trapping efficiency of the sediment extractor was presented. From the experiment it observed that the efficiency of the silt extractor depends on the diaphragm height of silt extractor, size of sand, velocity of flow and the concentration. The maximum efficiency is achieved at a velocity of 0.16 m/s for sand of size 0.30 mm. A more rigorous study can be carried out to increase the efficiency of silt extractor by varying the parameters such as height of the diaphragm of silt extractor, number of main tunnels, number of sub tunnels and angle of deviation of silt extractor from main tunnel to escape channel.

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