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SILT EXCLUDERS

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The basic principle upon which the design of silt excluders is based lies in the fact that in a flowing stream carrying silt in suspension, the concentration of silt in the lower layers is greater than in the upper ones. Thus if lower layers of water can be escaped without interfering with silt distribution, the remaining water will have less silt in it per unit volume. Elsden's design, who first floated the idea in 1922, consisted of a regulator divided into two portions by means of a horizontal diaphragm over which the upper water passed into the canal while the heavy silt laden lower layers escaped through the tunnels to waste. With modification in detail this form of silt excluder was constructed at Khanki Headworks in 1926. A smooth approach channel is an important feature of silt excluder design. Its object is to permit the silt to settle more effectively and hence to increase the efficiency of its exclusion.

The construction of the first excluder at Khanki was followed by construction of other such devices including three extractors and two excluders on Upper Jhelum Canal. An excluder is at the head of the canal and this excludes a proportion of the silt, while the extractor being placed at some distance down the canal extracts or ejects silt which has entered the canal.

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The first point to be considered in the design of such devices is the approach conditions. A long straight approach channel should be provided in which silt can settle into the lower layers. If the approach is not straight but curved or the bed or sides are rough then silt concentration will be disturbed. Optimum silt distribution can be obtained when some of the silt is rolling along the bed and with this condition it would be immaterial whether the bed was lined or not. It is possible that a narrow deep section would have a greater efficiency than a shallow wide one. The approach channel should be designed with the flattest slope which will suffice to carry the heaviest grade of silt, likely to approach the work. However for reasons of economy approach channel should be kept as short as possible. An approach channel can easily be provided in case of an extractor but in case of excluder, it is usually necessary to turn the water through a right angle bend to draw the canal water from the outer curve. In any case, the approach channel, which consists of a natural river bed, will probably have curves in it and will certainly have very irregular boundaries.

The proportion of escapage from the canal supply is also to be decided very carefully. The efficiency of an excluder may be defined as the reduction per unit of the silt intensity in the canal supply when compared with that of the water approaching the work. This, though practical, is a false criterion. The true measure of the efficiency of an excluder is unity minus the ratio of the silt entering the canal to that which would enter were the excluder is not working. The point about this distinction is that the addition of the escapage discharge to the canal discharge increases the silt approaching the canal and increases it in a proportion greater than that of the discharge. It was demonstrated by Crump that an increase of the escapage discharge is always accompanied by a marked reduction in the ratio of the silt to the water i.e. intensity. We must not, therefore, assume that the greater the escapage the greater the efficiency. More research is necessary on this. For the present, however, about 20% is considered reasonable.

Another problem is the separation of escapage from canal supply. The separation of the escapage water from the canal supply at the edge of the diaphragm should be arranged without disturbing the silt distribution. It is easy enough to arrange this for fixed canal and escapage discharges by placing the diaphragm at a height such that it divides the normal stream into the correct proportion. In practice, however, it is always necessary to vary both the canal supply and escapage and if the height of the diaphragm is fixed it will generally not suit the proportions of the two.

Another component of silt excluder is the tunnels. The tunnels must be arranged to evacuate the escapage at a high velocity not less than 10 f.p.s. They must also provide control of the discharge so that the same velocity is secured at the entrance to each tunnel. This may be done by keeping the same tunnel dimensions and varying the width of canal served by each tunnel or vice versa The low velocity at separation is to be transformed to the high tunnel velocity at the entrances. This must be done without effecting the velocity distribution upstream of separation. Moreover when escapage head is valuable a gentle transformation is necessary to avoid its loss. The former point can be secured by placing the entrances at a sufficient distance downstream from the edge of the diaphragm. Thus the tunnel roof should be designed to take the full water pressure above it with the maximum pressure which may occur inside it assuming the entrance to be blocked. If the tunnels act as a weir for the canal supply, the possibility of uplift occurring with the tunnels closed at the downstream end and/or velocity depression over the roof should be studied for design. The escapage if less than full supply is regulated by gates on the downstream end of the tunnel. Tunnels can also be provided with trash racks to prevent jungle/debris blocking them.

If the canal is flumed then the crest of the canal flume can not be below the diaphragm level but may be above it. By varying the section of the canal the diaphragm level may be varied over a large range. When the canal flume forms a control point it is necessary that the downstream edge of the weir should be normal to the stream. The inclination of the upstream edge resulting from the triangular tunnel plan is immaterial except that the crest level may be varied to counteract the varying co-efficient of discharge resulting from the varying length of crest.

A tail race is provided to pass the escapage back to the river if necessary. It might be expected that a steep slope would be necessary to carry the heavily silt charged escapage. However tail race is found to work with a flatter slope and with a C.V.R which is much the same as that of the canal.

Silt excluders have so far been applied and used in a primitive fashion. Wherever silt entry was affecting the regime of the canal to a dangerous extent, a silt excluder was built to be as efficient as local conditions would permit at reasonable cost. If an excluder was too effective and resulted in too rapid retrogression of the canal, it could be disused or worked intermittently. No attempt was made to regulate the silt at entry to a grade or a quantity suited to the slopes for which the canal had been designed but such regulation must be the aim in the case of an established canal system. When the silt contents of a stream running in a bed of self borne material is reduced, retrogression results which also flattens the slope until a new canal regime is established. The delay involved in this process can be eliminated by artificially regrading the channel to a flatter slope. Such regrading is necessary as otherwise the retrogression may effect the safety of masonary works etc.

In order to study the working of excluders, the discharges and silt contents of the water passing them are observed periodically. Silt observation may be made by various methods as below;

(a) Trapping the whole silt of the stream for a period.
(b) Sampling from turbulence
(c) Sampling from the normal stream from points spread over the section horizontally and vertically
(d) Sampling from single points on verticals.

The first methods is difficult but most correct and my be used as cross-check on other method.

The method of calculating efficiency in general use gives the reduction of silt intensity in the canal water as compared with that of approach flume. The factors which affect efficiency are:

(a) The proportion of the supply escaped. As discussed earlier the efficiency will not vary directly with the escapage. Since the intensity decreases rapidly with depth, additional escapage will increase the efficiency but slowly.

(b) The grade of material carried by the water. The same excluder may be expected to work more efficiently where the proportion of coarser silt is greater. On the other hand, the coarser and heaviest grade of silt carried, the greater the slope and velocity will be, and consequently the lesser the concentration of silt in the lower layers. It seems probable that the coarser the silt present, the greater the efficiency would be when based on the same grade, but this is by no means proven by our present knowledge of the subject.

Note :

Paper No. 211 appeared at pages 53 to 72 of the Proceedings of Punjab Engineering Congress, Vol. It has 5 plates. The discussions are recorded at pages 72a to 72w. The discussions were mainly regarding the design options and the behaviour of various silt excluders mentioned in the paper.