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SILT EXCLUSION FROM DISTRIBUTARIES

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The paper deals with the subject of silt entry into irrigation channels. It describes different methods of exercising a check on silt entry in a channel where enough water is available to carry away the excluded silt. According to Dupuit silt carrying capacity of flow at any point depends upon the difference in velocity of filaments of flow just above and below that point. A small obstruction over the bed keeps throwing up the silt which falls back and is thrown up again. This motion of silt particle is termed siltation, and depends on bed roughness, velocity and particle size. For a given depth and mean velocity, a channel with rough bed can transport more quantity of silt than one with smooth bed although the smooth bed is capable of transporting silt of coarse grade by rolling. The lower layers of water contain coarse grade of silt and the particles moving along the bed are known as "rolling silt". The smoother the bed of the channel the greater is the depth of rolling layer to carry a particular grade of silt. Silt excluders are devised on this principle.

The proportion of silt charge in an off-taking channel is more as compared to silt charge in the parent channel because, firstly the lower layers of flow in the parent channel containing the coarse silt are easily deflected into the off-taking channel and the upper layers having high momentum pass by. Secondly, water enters an off-take in a curve and because of higher free level on outside of the bend, water at the bottom must be having a tendency to carry gravel, sand etc inwards. Thirdly, there are cross currents generated by the obstructions on the sides. With a straight parent channel, a channel off-taking at an angle can be made to draw smaller proportion of silt if the off-take orifice is kept at mid-depth of parent channel whose bed is thoroughly roughened by constructing transverse low walls over the bed in full width. The placing of low walls can preclude the possibility of throwing up of lower layers of water entering the off-take.

Common causes of excessive silt entry into off-taking channels are: head-regulator projecting into the parent channel, bushes and stakes in parent channel, uneven berms just upstream of the off-take and a cill in set back position. In case of channels off-taking at right angle, the head reach often silts up, thereby regenerating a new slope to carry the silt charge. A skew head or "curved wing" can provide the solution in these conditions. Research by Kennedy and Lacey confirms that deep channel can carry less silt charge. Lacey's 'f' decreases with increase in depth and depends on particle size. The influence of rugosity of bed on mean velocity on a vertical line from the bed is more marked in shallow than in deep channels. For a given mean velocity, velocity of water near the bed in a shallow channel is greater than if the channel is deep. Scour takes place as the silt is thrown up by irregularities on the bed and in addition the bed material is picked up by the vertical eddies. Likewise rough and uneven bank is likely to be eroded more rapidly than a smooth and well dressed bank. Experiments on the Lower Chenab Canal supported the above submissions.

The Author concluded after his experiments that silt vanes and silt vanes-cum-curved wing proved to be the most efficient arrangement of all the devices tested. The use of silt vanes is not benefitting if an off-take draws more than one-third discharge of the parent channel. The parent channel needs steeper slope downstream of the vanes to carry higher silt charge. Silt vanes may cause scouring in an off-take but poorly designed vanes built at a wrong location can aggravate the conditions.

The efficiency of the vanes increases with larger radius. A radius of 40' or so is desirable for short vanes in a small or a medium channel but should not be less than 23' radius. The downstream end of the vanes should be tangential to lines making an angle of 27^0 with the channel. The vane nearest to the off-taking channel (longest vane) should not be within the influence of too strong "draw". The space occupied by the upstream end of the vanes should be about half the width of parent channel and height of vanes is ordinarily kept at 1/4 the depth of parent channel. Thinner vanes are more efficient. The spacing between the vanes should be 1.5 times the height of vanes, and the surfaces should be smooth plastered. Bed and side slopes of the channel on the side of off-take must be pitched in a distance of 50' to 100' upstream. A short distance downstream is also pitched. The upstream end of vanes must slope at 1:3 and be finished in cut water shape.

The channel must be free of all obstruction in a distance of 200-300 ft. upstream of the vanes. The cost of construction can be reduced by either reducing the radius of vanes or reducing the number by increasing inter-spaces. Omission of plastering the vanes and pitching considerably reduces the efficiency of the device. The use of curved silt vanes is not suitable if there is not enough space for constructing them as for a small distributary or in case of a small off-take from a deep parent channel. The experiments showed that in such cases straight vanes built at an obtuse angle not greater than 3:1 or 4:1 and with sloping upstream ends in cut water shape are effective. Low silt vanes are more effective in excluding silt as compared to high vanes.

The contribution of silt vanes is enhanced when curved wing wall is used in conjunction with the former. High vanes especially deflect large proportion of water towards one side, and water from upper layers rushing to take its place produces rotary flow over the vanes. As a result, greater volume of water is enclosed within the wing than required by the off-take. The combination is very useful for a narrow parent channel. Low vanes of 0.4' or 0.8' height may be constructed at first and if conditions warrant, the height may be increased subsequently.

Silt tunnels or silt platform is another effective device for excluding silt. It is a reinforced concrete slab placed horizontally in parent channel opposite the off-take head and supported by walls or piers. A curved extension of downstream wing built on the top of platform to guide the clear water into off-take could be useful. The height of tunnels is not to be kept less than 2 ft. to avoid the risk of their choking since in that case all the silt would be thrown to the surface and would enter the off-take. The top of platform must be set at a level that would allow flow of ample water on its top to feed the off-take even during minimum supply in the parent channel. The width of platform is calculated from discharge that has to pass over it. The upstream end of walls or piers must terminate in 1:3 slope with cut-water noses. The flow into the off-take has considerable velocity which eliminates the tendency of silting in the head reach. A few vanes built just below the exit end of tunnels would lead silt to the middle of the parent channel.

A simple platform without curved wing is difficult to design as the unknown proportion of silt free water is passing into parent channel down the off-take head. In author's opinion, the platform should be wide enough to take over it the discharge of the off-take with 25% extra. Its upstream and downstream edges should be built at an angle of 60^0 to the parent channel. The upstream edge of platform at the edge of parent channel must be kept 5' to 10' upstream of the upstream edge of off-take head.

The curved wing wall is probably the third best device as a silt excluder. It is an extension of downstream wing wall into the parent channel, in a curve concave towards upstream in order to force water from entire depth of parent channel into off-take. The off-take therefore draws same proportion of silt as carried by the parent channel. The projection of wing wall into the parent channel should be enough to enclose the water required to feed the off-take and extend to cover 3/4 width of off-take. This device should be used if both the parent as well as the off-taking channel have same silt transport capacity. An off-taking channel with less silt transport capacity indicates the use of silt vanes or silt tunnels.

A raised cill or a wall across the mouth of off-take head is used to allow a definite discharge into the off-take. It was probably the first device to be used for excluding silt but has not proved effective. This together with skew head and curved upstream wing were introduced in 1908 in Punjab as an improvement on the simple right-angled off-take.

There are of course situations where standard devices cannot be used and such cases have to be dealt with intelligent application of principles of silt exclusion. The Ashford syphon was designed for

Madhopur Headworks for excluding shingle entry into Upper Bari Doab Canal but the device failed to achieve the objective. Gibb's Semi-circular wall built opposite the off-take and completely enclosing it, is a modified form of raised cill. It did not prove to be an effective device either.

Note :

Paper No. 169 appeared at pages 263 to 298 of the Proceedings of Punjab Engineering Congress 1933 Vol. XXi. The discussions on the paper are recorded at pages 299 to 308 and there are illustrations on 11 plates.