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Seven new link canals with discharges varying from 6500 to 21700 cusecs, designed on Lacey's approach, and with slopes of 1/8000 to 1/10,500 are being constructed as a part of Indus Basin Project as a consequence of the Indus Water Treaty. The heavy withdrawals will create turbulance and disturb the desired silt exclusion. Mailsi canal, a scouring channel, silted up by 2' above the design bed due to change in river regime. Similarly in the first 20 miles of M.R. Link the average silt deposit is 4' above the designed bed. Among the canals taking off from sukkur designed originally at a slope of 1/120000, right bank canal silted up increasing the slope to 1/7300 and left bank canal retrograded flattening its slope to 1/19800. A steeper slope is required by a channel to transport an excessive charge entering into it and necessitates a higher pond level. River approach and slope in vicinity of the Head Works should be controlled to prevent river regime from changing, otherwise headworks will have to be remodelled periodically.

Previously the author had analysed LCC channels and Laurson flume data, and derived functions relating to silt intensity for corse and medium sands with hydraulic perimeters. The scope of present paper includes lower as well as higher regime of flow. The data of LCC stable channels with discharge varying from 40 to 10000 cusecs, river Ravi discharges from 10,000 to 100,000 cusecs and experimental flume data from Albertson, et al has been analysed to obtain two more functions. One of these functions relates silt intensity with discharge, slope and sand dia. and the other to shear stress with silt charge. these relations can be used to determine the silt carrying capacities of existing channels and also for designing new channels. The calculated silt carrying capacities of designed links indicate that slopes of these channels cannot be physically steepened to make them carry the silt charge entering into them. The silt charge in excess of their capacities has, therefore, to be ejected. The ejector channels can also be designed with the help of the derived functions. This paper emphasizes the need of giving proper consideration to the suspended sediment for the design of new channels.

In 1896 Kennedy produced the velocity depth relation from the analysis of data of UBDC system.

$$V = 0.84\ D^{0.64}$$

Lindley analysed the data of LCC system and produced in 1919 the following relations;

$$V + 0.95\ D^{0.57} \quad ,V = 0.57\ B^{0.355} \quad \text{and } B = 3.80\ D^{1.61}$$

In 1927 Lacey produced equations in which depth was replaced by R, his silt factor f takes the form of Froude number and is equal to 0.75 V^2/R.

The value of 'f' used in the design of a channel depends on the size of bed material. There is no explicit relation given by Lacey for silt transporting capacity of channel. However channels with steeper gradients are presumably capable of carrying greater silt charge. Inglis incorporated the effect of silt charge in his formulae but he did not determine the constants used in his equations. Bose made statistical analysis of data obtained from LCC stable channels in 1933 and presented a set of relations. Blench advanced the concept of bed and side factors to modify Lacey's equations without including silt charge.

The data of stable channels checked with slope relations of Lacey and Bose in Irrigation Research Institute showed divergence of ± 10-20%. Lacey explained this divergence with the help of his shock theory. The equations have been examined afresh and compared with silt charge observations made during 1940, 1942 and 1943 and data from other large channels. The variation of the coefficients in the following equations has been studied.

$$V = 16\, R^{2/3} . S^{1/3} \qquad V/R^{2/3} . S^{1/3} = K1$$

$$S x 10^3 = 2.09 \; d^{0.86} / Q^{0.21} \qquad S.Q^{0.21} / m^{0.86} = K2$$

Plottings show that K1 varies from -17 to +14% and Lacey's coefficient of 16.02 is applicable for a channel carrying silt load of 0.33 gr/litre. Bose coefficient K2 shows a divergence of -16.4 to +36.5% indicating that K2=2.09 may be applicable in case of channels transporting 0.3 gr/litre. These plottings also reveal that the divergence from mean velocity is due to silt charge.

The data of LCC and other channels and Laurson flume data was tested for silt carrying capacity as a function of (V^3/R and (V^2/S) respectively. It was found that following equations were valid for silt charge upto 2gr/litre;

(i) $C = 0.1 + 0.1 (V^3/R\text{-}1.5)^{4/3}$

(ii) $C = (8g\, V^2.S)^{2\ 1.25}$

Field data from LCC and other channels and published data of renowned hydraulic engineers namely Simons, et al has been plotted against 7 different variable functions. Plots for function V^3/D, $8gV^2/S$ and VS show wide divergence. The relation in terms of tractive force and silt diameter ranges from 0.14 to 3.0 for regimes of C= 1ppm to 30.000 ppm suggesting that form roughness and silt intensity are similar problems.

The plots of functions $q^{2/3}.s$ and $q^{2/3}.{}^{S}/_{W}$ indicate individual trends for each range of different diameters. The plot of C against the function $q^{2/3}. S/W^{1/2}$ gives a representative curve that covers a wide range of silt charge from 'ppm to 40000 ppm. The equation of the curve is:

$$q^{2/3}.S/Wq^{1/2} = 0.5 + 5C^{2/3}$$

Where C is silt intensity in grams/litre, q is discharge intensity in cusecs, S is slope per thousand and W is fall velocity of mean size of bed material. The above formula is similar in its form to Meyer Peters bed load formula. If the left side quantity of the above equation is greater than 5, it can be reduced to:

$$C = 0.1\, q.S^{2/3} / W^{3/4}$$

Conclusion derived from this equation are;

(i) For two channels with same bed silt size their carrying capacities are:
$C1/C2 = a1/q2\,(S1/S2)^{3/2}$

(ii) For channels with same value of $S/W^{1/2}$, silt carrying capacities are in ratio of their discharge intensities
$C1/C2 = q1/q2$

(iii) Also when C1/C2 and W1/W2 are both equal to 1,

$S1/S2 = (q1/q2)^{3/2}$

Lacey's slope relation $S=0.39f^{5/3}/q^{1/3}$ gives the above conditions for channels having same value of f.

(iv) Two models with different distortion vertical and horizontal scales, may give similar results if scale ratio of silt intensities is same in both of them.

Note :

Paper No. 351 appears in the Proceedings of Engineering Congress 1962, at pages 1 to 18. There are 4 tables and 13 figures/graphs. For various formulae and their derivation the reader may refer to the original paper.