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Discussions on “Model studies for the design of inlet transition of settling basins of hydropower projects in high sediment yield areas: a review”

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The water wealth and terrain head of the Himalayas are nature’s gift and a bounty. Most of the hydro-power potential of India (1,48,701 MW) lies in the Himalayan region because the rivers in this region descend from an elevation of around 3,500 m to 500 m in a short distance of 200-km stretch. Majority of the hydropower plants (e.g. Naptha Jhakri) in these areas are run-of-the river type. High dams (e.g. Bhakra, Tehri etc.) with huge reservoirs are opposed these days due to environmental and other reasons. Apart from large volume of water, the Himalayan rivers like Indus, Ganga, Brahmaputra and their tributaries carry large quantity of sediments due to fragile nature of Himalayan rocks, avalanches, glacial lake outburst floods and landslides. The rivers in the Indian peninsula like Krishna and the Godavari carry sediments with concentration of about 100 p.p.m. only. Whereas concentration of the sediments carried by the rivers Indus, Ganga, Brahmaputra and their tributaries exceeds 2,000 p.p.m. Silt concentration of the Kosi river is more than 3,000 p.p.m. During severe floods, sediment concentration rises upto 5,000 p.p.m. or more.

In all run-of-the river type hydro-power schemes, settling basins near intakes must be provided in order to arrest and flush out harmful fraction of sediments so that the head race tunnel and the hydro-mechanical parts like turbines are not damaged. The desilting chamber i.e. settling tank is a structure in which the flow velocity is reduced by enlarging the channel cross-section so that the sediments of size more than a permissible value are deposited within the chamber and are flushed out periodically. Water free from sediments of objectionable size (above 0.2 mm), depending upon head on the plant, is then admitted to the head race tunnel and penstocks for power generation. Physical and mathematical model study Olsen and Chandrashekhar (1995) are useful tools for efficient design optimization of settling tanks (Verma et al. 2015). As desilting chambers are very long and costly, innovative and efficient design of such structures can go a long way to solve sediment problems in run-of- the river type hydro-power projects.

The paper under discussion is a significant contribution in the design of settling tanks. It reviews the model studies carried out on the configuration of the inlet transition of settling basin for both open channel and pressure flow conditions and brings out the strengths and limitations of physical and numerical model studies and merits of combining both types of models in specific cases. In clause-2 of the paper i.e. sediment management strategies, author has mentioned four strategies to reduce sediment load. Discusser wishes to add one of the important strategies to eliminate sediment entry by choosing proper location of intake. In hilly areas with steep slope, most of the incoming sediments are of bed load type. Moreover, major part of water in the diversion channel entering into the branch comes from bottom portion in the main channel (rich in coarse sediments) due to low velocity at bottom and high velocity at top in the main. Mosonyi (1991) studied the best location for intake in a diversion channel (B). Figure 1(a–d) indicate sharing of bed load (W) for different locations of intakes in straight and curved reaches of the main (M) for flow diversion to the branch (B) and intake (I) for 50% flow sharing of flow between the main and the branch. 100% of incoming bed load moves into the main channel (M) and practically no bed load enters the branch (B) when intake (I) is located in the outer bank of the main at the midpoint of bend downstream of axis of symmetry as shown in Figure 1(c). Percentage sharing of bed load in the main channel (W_m) and diversion channel (W_B) is also governed by sharing of flow in the main (Q_m) and the diversion channel (Q_B) as illustrated in Figure 2(a). In a straight channel, the best angle (θ) of diversion intake was found to be 120° for 50% sharing of flow (Figure 2(b)). In case it is inevitable to draw water from straight channel, it is advisable to generate artificial flow curvature by suitably offsetting the intake as illustrated in Figure 2(c).

Figures 1 and 2 in the paper show the inlet transitions for open channel free surface flow and closed conduit pressure flow respectively. Unlike classical transitions in the regulating and cross-drainage structures in canals, inlet transition in the settling basin behaves hydraulically as expanding transition both in plan and section. High flow intensity with high velocity (V_1 in Figure 3) is responsible for boundary layer separation and eddy formation from both the side walls and diverging floor of the basin, resulting in energy loss and uneven distribution of flow velocity within the settling basin unless the rate of flaring of side walls as well as the basin floor slope is of the order of 5° (Gibson 1910; Kline et al. 1959; Mazumder 1966). Obviously, it needs very lengthy basin with high cost. Discusser is of the opinion that the flaring of basin floor should be followed by flaring of side walls in free surface flow as illustrated in Figure 3. Short inlet transitions with boundary layer flow control technics (Mazumder 2020) is helpful in flow diffusion to the required width of the settling basin (Figure 3) and found to perform far superior to a classical one with long length. With reduction of flow intensity and flow velocity (V_2), it is believed that the boundary layer

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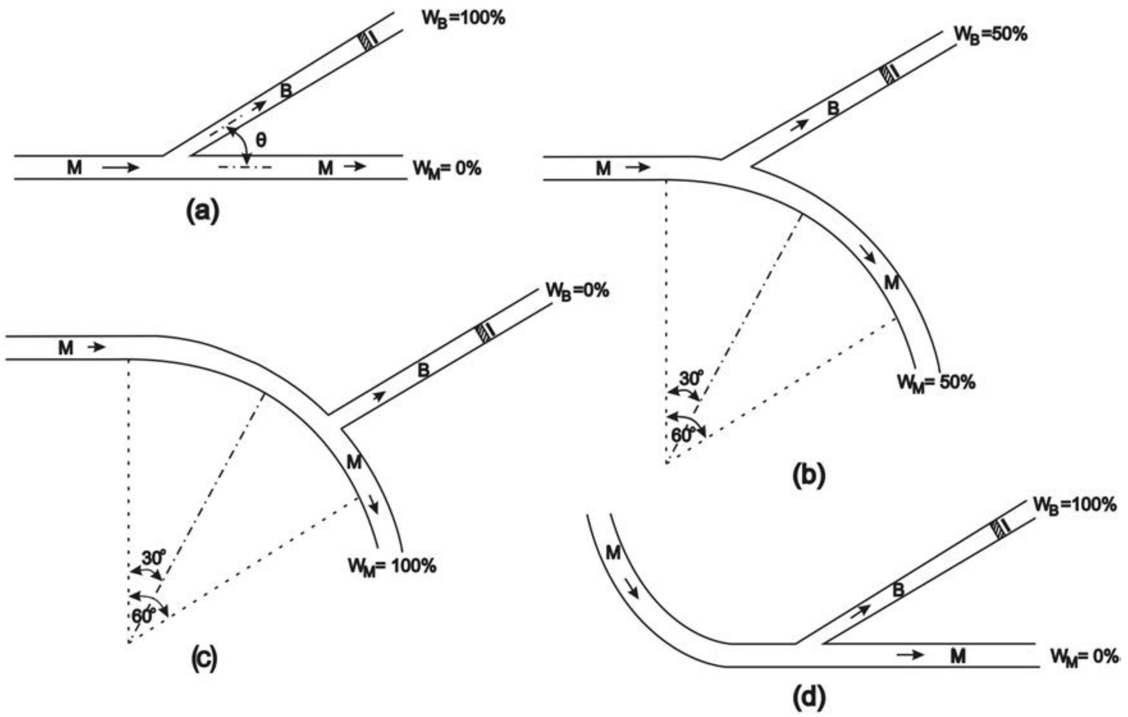

Figure 1. Distribution of sediment load in Main(M) and Branch (B) for 50% flow diversion.

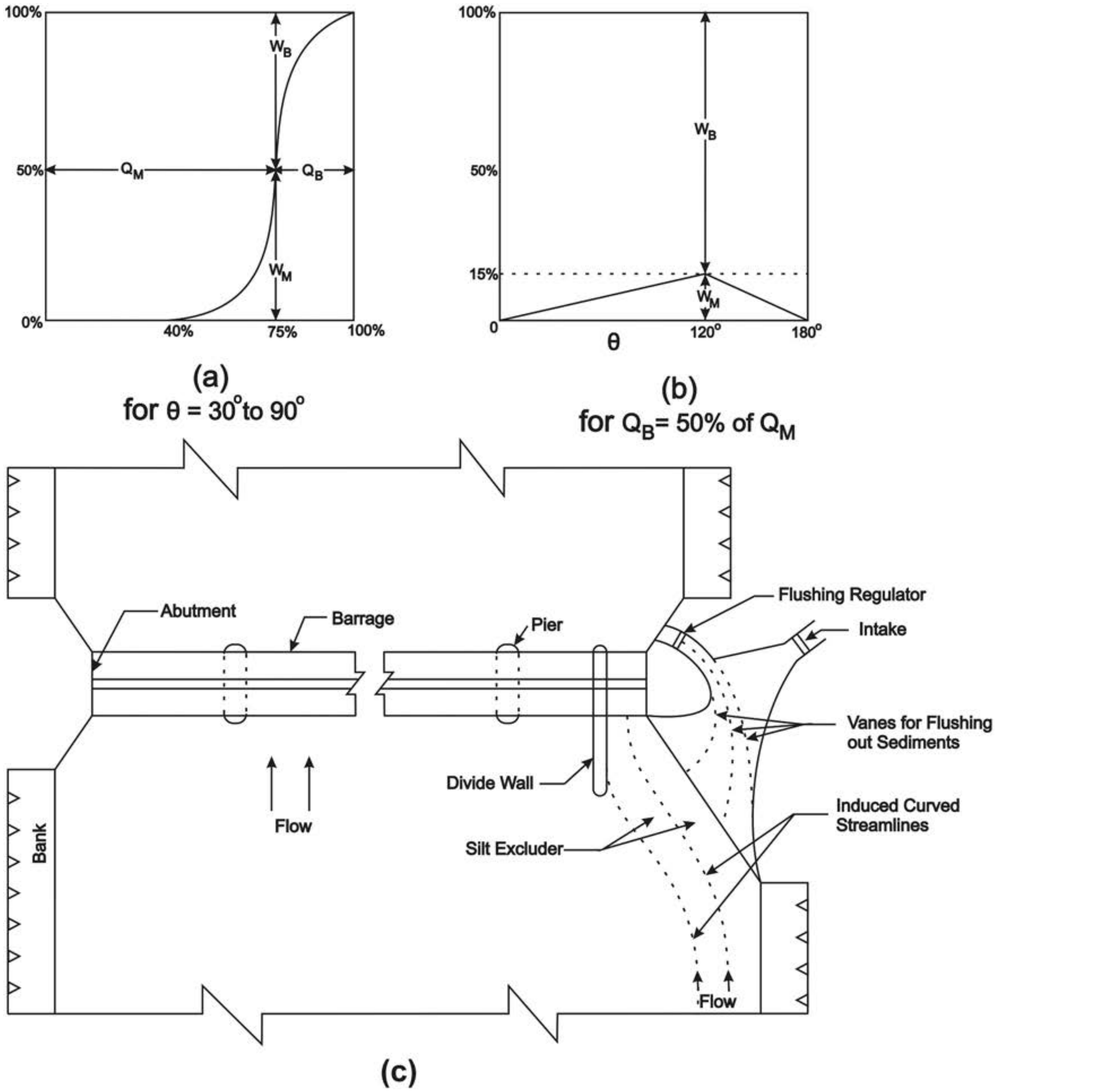

Figure 2. Sharing of sediment Load. (a) for W_B and W_M for varying flow distribution Q_N and Q_M; (b) Sharing of sediment load for varying Angle (Θ) of Offtake (Q_B=Q_M) (c) Bank offset to induce flow curvature near intake.

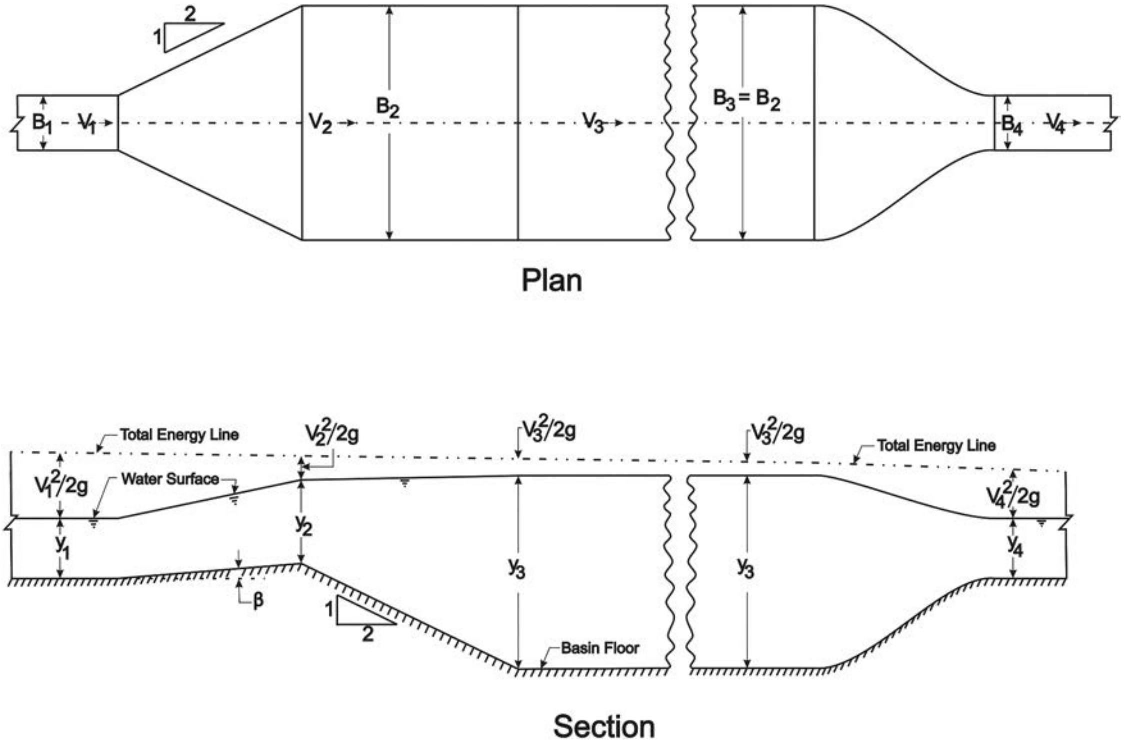

Figure 3. Plan and section of proposed inlet and outlet transition of a settlilng basin.

separation in the bed floor transition will be controlled sufficiently to ensure uniform distribution of velocity (V_3) in the tank. If needed, one or two rows of screens may be provided at the exit end of sloping floor. No doubt, it may cause some head loss in the basin but it is insignificant compared to the high head in a remote type run-off the river type installation with large terrain head at which the plant operates.

Mazumder and Rao (1971) and Mazumder and Naresh (1988) developed appurtenances for efficient flow diffusion in a short expansion. Mazumder and Deb Roy (1999) used adverse slope to floor of the expanding transition in a flow meter to control flow separation and achieve uniform velocity distribution at the exit of expansion. Equation (1) gives the angle of inclination of the expansion floor (β) to the horizontal (Figure 3).

$$\beta = \tan^{-1}\left[2\tan\phi\left(y_1^2 + y_2^2 + y_1 y_2\right)/\left(B_1 y_2 + B_2 y_1 + 2B_2 y_2 + 2B_1 y_1\right)\right] \quad (1)$$

where,

B_1 and B_2 are widths of basin, y_1 and y_2 are flow depths at the entry and exit of the expansion respectively; ϕ is the angle of divergence of the side walls shown in Figure 3.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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