SEDIMENT DELTA AND FLUSHING MODELLING FOR PROPOSED SINDH BARRAGE RESERVOIR

by

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ABSTRACT

After the construction of Kotri barrage the flows downstream of Kotri subsequently reduced and sea water intrusion increased. Population living in riverine area faces many problems like non-availability of sweet water for drinking and irrigation, negative impact on fisheries, river channel deterioration, loss of nutrients rich sediments, reduction in riverine forests, impact on coastal stability and flooding in adjoining area. Hence, the need of a barrage at Kotri downstream was initially felt by Ex- Chief Engineer of Sindh Irrigation Department and later on its pre-feasibility (2019) and inception report (2020) was prepared by WAPDA.

Due to the construction of reservoir, flow depths increases and velocity of flow decreases, which reduces the turbulence in the water and suspended sediments start depositing in the reservoir. Bigger sediment particles deposit at the start of reservoir, whereas, smaller particles settle close to the dam. Globally reservoir sedimentation is a problem that results in loss of storage capacity of a reservoir. The loss in storage capacity needs to be minimized in order to fulfill future demands and to increase the life of reservoir on safer side. Various methods either to be used independently or by combination in the world to conserve the life of reservoir are watershed management, dry excavation, sediment routing/sluicing, sediment bypassing, hydro-suction, density current venting, conventional dredging, and sediment flushing. Sediment flushing techniques could be drawdown flushing, emptying and flushing and pressure flushing, and are practiced based on the basis of location of the deposited sediments in the reservoir. The formation of sediment delta in reservoir results in reduced live and gross storage capacities of a

reservoir, raises the bed levels and hence stages at the same discharge which may require raising of the soffit of the bridges to pass design floods safely. In addition to that if the pivot point of sediment delta in a reservoir is close to dam face then it may cause choking of low level outlets of dam.

In the present study, delta modelling has been carried out by two approaches, i.e., by an empirical approach and by HEC-RAS 5.0.7 for proposed Sindh barrage. After that flushing modeling has been carried out using HEC-RAS 5.0.7 on 10 years deposited sediments and then the flushing strategies are proposed which were necessary for flushing operation. Sediment delta and flushing modelling for proposed Sindh barrage is a challenging job due to flatter bed slope of the reservoir and very fine bed material and in suspension.

For Delta modelling using empirical approach, the suspended sediment load has been computed using data of nearby gauging stations of Sehwan (1968-1983) and Dadu-Moro (1981-1998). Suspended sediment discharge data of Sehwan stream gauging station was transformed to Dadu-Moro stream gauging station using a developed regression model using three years concurrent data (1981-1983). After that the suspended sediment load (SSL) of four canals (Kalri Baghar, Old Fuleli, New Fuleli and Akram wah) taking off from Kotri barrage were subtracted from SSL of Dadu-Moro to get the barrage site SSL. The bed load was computed using Modified Einstein guidelines. Trap efficiency of the reservoir was computed using Brune's curve. The mean annual total Sediment inflow towards the barrage site was computed as 1638 M Tons (4638.29 Mm^3). Life of reservoir was estimated based on the 80% of reservoir capacity occupied by the sediments and was computed as 19 years. The delta modelling by an empirical approach showed that after 19 years, delta approaches 35 km from barrage face. Delta modelling was also carried out using HEC-RAS 5.0.7 the delta profile was generated by quasi-unsteady analysis for 100 years (1968-2068) and the sediment deposited within 10 years of deposition in reservoir (1968 to 1977) was found as $217Mm^3$.

Sediment flushing modelling for the reservoir was carried out to flush the deposited sediments during 10 years of the reservoir operation. Downstream boundary condition was provided as the oceanic low and high tide data observed by Intergovernmental Oceanographic Commission (IOC) at Karachi. Results of the flushing modelling reveal that suitable flushing season is July to August, suitable flushing discharge is 5000 to 15000 cumecs and flushing duration required to flush the 10 years deposited sediments would be around 39 days for 15000 cumecs flushing discharge. Maximum instantaneous discharge data of Kotri barrage show that even higher discharges are also available which require a lesser flushing duration, and can be utilized as flushing discharges. Hence, it is recommended that reservoir operator should remain vigilant on availability of suitable flushing discharges preferably on Sukkur Barrage. Moreover, developed sediment delta should also be monitored to assess the need of flushing operation for better recovery of the reservoir capacity.