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Analytical Study of Sedimentation Formation in Lined Canals using the SHARC Software- A Case Study of the Western Intake Structure in Dez Diversion Weir in Dezful, Iran

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***Abstract*—**Sedimentation is a hydraulic phenomenon that is emerging as a serious challenge in river engineering. When the flow reaches a certain state that gather potential energy, it shifts the sediment load along channel bed. The transport of such materials can be in the form of suspended and bed loads. The movement of these along the river course and channels and the ways in which this could influence the water intakes is considered as the major challenges for sustainable O&M of hydraulic structures. This could be very serious in arid and semi-arid regions like Iran, where inappropriate watershed management could lead to shifting a great deal of sediments into the reservoirs and irrigation systems. This paper aims to investigate sedimentation in the Western Canal of Dez Diversion Weir in Iran, identifying factors which influence the process and provide ways in which to mitigate its detrimental effects by using the SHARC Software.

For the purpose of this paper, data from the Dezful water authority and Dezful Hydrometric Station pertinent to a river course of about 6 Km were used.

Results estimated sand and silt bed loads concentrations to be 193 ppm and 827ppm respectively. Given the available data on average annual bed loads and average suspended sediment loads of 165ppm and 837ppm, there was a significant statistical difference (16%) between the sand grains, whereas no significant difference (1.2%) was find in the silt grain sizes. One explanation for such finding being that along the 6 Km river course there was considerable meandering effects which explains recent shift in the hydraulic behavior along the stream course under investigation. The sand concentration in downstream relative to present state of the canal showed a steep descending curve. Sediment trapping on the other hand indicated a steep ascending curve. These occurred because the diversion weir was not considered in the simulation model.

***Keywords*—**SHARC model, sedimentation, Western canal, Dez diversion weir.

I. Introduction

SEDIMENT formation process and their consequences for the river engineering are emerging as important aspects of the project feasibility study. Much of the sediments that move along the river streams emerge as a result of poor watershed management in arid and semi-arid regions where as research studies [1] , [2] ,[5] showed can have a considerable impact on the operation and maintenance of the hydraulic structures involved. Because of such considerations, the present paper aims at investigating analytically the processes by which sedimentation is formed and the ways in which this could have impacts on the operation of water intakes of the diversion weirs using the SHARC model. This is particularly important as the study focuses on the water abstraction for a canal which is an important life-support for the croplands in the command area which the Eastern Canal feeds.

Three processes of soil erosion, sediment transport and sedimentation are important considerations, the analysis of which is crucial aspect of any study which is needed to mitigate the detrimental consequences.

In the process of erosion, sediment particles are moved from the river bed by the shear force of water flow.

The conditions for sediment transport and the rate by which this takes place depend on sediment particle characteristics such as particle size, sediment concentrate and its shape. It also depends on flow characteristics such as flow velocity, dept of water, and the fluid hydraulic characteristics such as the viscosity, the unit mass volume of the fluid and the geometric shape of the canal such as the hydraulic radiant, gradient and so on. Under circumstances where the force exerted by the water flow is reduced sedimentation deems to start at that point.

Sedimentation has been an important consideration since the ancient times when the Egyptians are reported to have taken measures to counter its impacts such as the sediment islands. The latter has particularly emerged as a major challenge in river engineering particularly as far as the hydraulic structures like the diversion weirs and the water abstraction structures such as the intakes are concerned. It is consequences of sediment formation within the vicinity of these vital structures which is reportedly led to reduction of conveyance capacity in these structures particularly during the flood periods. Sediment formation and transport upstream of the storage reservoirs can not only causes reduction of the nominal capacity of such structure but might also lead to operational and maintenance problems which in turn threaten the sustainability of the structures.

The aim of present study is to investigate the sedimentation rate along the concrete canals of the Western water intake in

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the Dez Irrigation and Drainage scheme using the SHARC software. This would make it possible to suggest measures for improving the operational efficiency of these hydraulic structures and as such to ensure sustainable water supply regime for the western canal that is designed to feed a vitally-important croplands of the Karkheh flood plain [1] .

For this reason, data were collected from the Dezful hydrometric station about sediment hydraulics along a river course of about 6 km using the SHARC software in order to estimate the suspended load and bed load sediment concentrations.

II. Materials and Methods

Background of the study site

The Dez irrigation and drainage scheme is the largest surface irrigation network under operation in Iran consisting of a gross command area of about 125,000 ha and a net command area of about 90,000 ha. It supplies water to a vast variety of croplands which are cultivated with a modern farming system [3] , [4] , [5] , [6] . It irrigates a wide-ranging land size having different land tenure system, all of which compete for a cash crop market [1] .

The water abstraction system in the Dez irrigation and drainage scheme starts with the Dez hydro-electrical storage reservoir about 30 km north of Dezful having a nominal capacity of about 3.4 billion m3. A regulating dam is constructed about 28km downstream of this structure with 14 mm3 that incorporates 7 sludge gates and a discharge capacity of about 6000 m3/sec. A diversion weir is also constructed about 5 km downstream of the regulating dam at a height of 4m having a concrete overflow discharge structure of about 394 m length and 8 double-arc sliding gates on the right bank to flush out the sediment and further 2 intake structures at the right and left banks feeding two canals of 157 m^3/sec and 94 m^3/sec respectively [1] .

The water depth in the western canal is estimated at 4.62 m, the base of the canal is 12 m, the slope of 1.5 to 1, the canal slope at the beginning of 0.000161, the canal width at the top at 25.86 m and the canal height of about 5.98 m where the slope increases along the canal length.

The sedimentation study using the SHARC software

The SHARC software is considered as a powerful analytical tool that incorporates various instructions using design tools and sub-menus entitled Dossbas, Dacse and Dorc in order to estimate suspended and bed loads sediments separately.

Calibration of the Manning Co-efficient

The Manning menu in the software is used to calibrate the Manning Co-efficient obtained for the regime equation menu Dorc (by Simmons-Albertson method) using 0.0156 as the coefficient. The reason for using the Simmons-Albertson as opposed to Lacy method was the fact that the former incorporates the canal bed characteristics which was assumed to have better results.

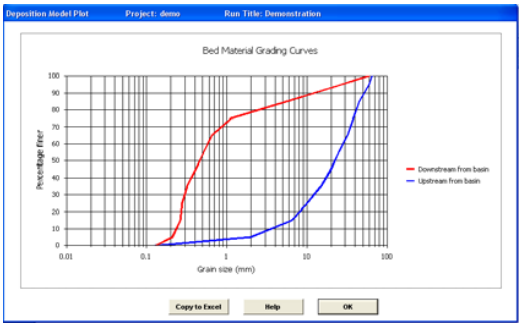

Fig. 1 Bed loads sediment grain curve

Results indicated that the upstream sediment materials are greater in size than their corresponding ones in upstream of the water intake (figure 1). They further showed a close proximity between the model data and the corresponding observed data for the upstream whereas no such proximity was found for downstream of the water intake.

Results also indicated sediment trapping efficiency of 54.1% which suggests a settlement of an approximately more than half the sediment load entering into the canals. This seems to be a serious challenge for sustainable operation of the feeding, conveyance and distribution canal networks, the continuity of which will undoubtedly undermine the water supply system of the Karkheh Flood Plain [1] . It further highlights the importance of the emerging phenomenon for the water agencies not only from the technical stance but also from the political, economic and environmental standpoints that have recently emerged as the major concerns of the stakeholders.

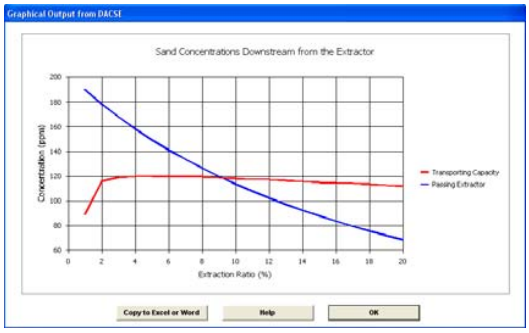

Fig. 2 upstream sand concentration curve

Results (figure 2) suggest that the position of the diversion weir at the beginning of the western water intake and the sudden entry of water into the intake will in turn increase the sediment transport velocity in the canal. As a result the sediment transport capacity at the beginning of the canal (immediately after the diversion weir) is increased and as the flow velocity in the canal is uniformed there would be an opportunity for the suspended loads to reduce and therefore settlement of considerable particles along the canal route.

Given the smaller particle sizes in downstream, and given that the software has considered the study area without incorporating the diversion weir in the modeling(assumed an

open channel), the transported suspended loads can be seen in the form of a descending curve(figure 2). It was further observed that at a certain point (9% of the extraction ratio axis) an equilibrium point is achieved after which as the extraction ratio increases the passing extractor and transporting capacity shows a decreasing trend.

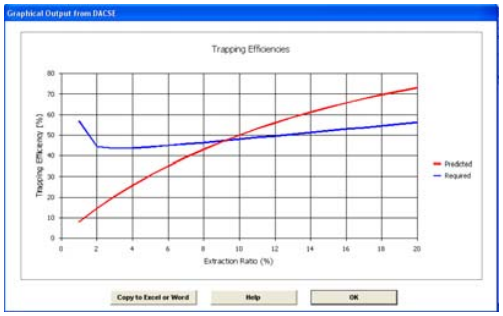

Fig. 3 Trapping efficiencies

Results predict the sediment trapping without including the diversion weir in the study to be a steeper curve. The real observed data indicate a considerable reduction of sediment trapping when the gates are opened in the beginning of the canal or during flooding. But as water flow reaches a steady state, the sediment trapping downstream start to increase gradually (figure 3).

Consideration of these findings becomes analytically important when it is crucial to prevent the entry of sediment loads into the hydraulic structures. Given the relatively high proximity between the model findings and observed data, it could be deducted that the software could be applied by the hydraulic engineers in feasibility studies with relatively high precision. That would make it possible to estimate the sediment loads and enables them to take appropriate proactive measures to ward-off the sediment transport which can be potentially challenging not only in operation but also maintenance of the total irrigation and drainage system.

Given that sediment concentration have a converse relation with trappings, it can be seen from figure 2 that the sediment concentration at 9% has a decreasing trend whereas this in figure 3 indicates an increasing trend. This suggests the crucial need for the hydraulic engineers to incorporate a stilling or sediment basin as an auxiliary structure less than 9% extraction ration in order to prevent the entry of potentially destructive sediment loads into irrigation network. The overall conclusion being that the SHARC software can apply as a powerful analytical tool in the feasibility studies with high accuracy and easy operation.

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