

Effects of Stream Tube Numbers on Flow and Sediments using GSTARS-3-A Case Study of the Karkheh Reservoir Dam in Western Dezful

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Abstract—Simulation of the flow and sedimentation process in the reservoir dams can be made by two methods of physical and mathematical modeling. The study area was within a region which ranged from the Jelogir hydrometric station to the Karkheh reservoir dam aimed at investigating the effects of stream tubes on the GSTARS-3 model behavior. The methodologies was to run the model based on 5 stream tubes in order to observe the influence of each scenario on longitudinal profiles, cross-section, flow velocity and bed load sediment size. Results further suggest that the use of two stream tubes or more which result in the semi-two-dimensional model will yield relatively closer results to the observational data than a singular stream tube modeling. Moreover, the results of modeling with three stream tubes shown to yield a relatively close results with the observational data. The overall conclusion of the paper is with applying various stream tubes; it would be possible to yield a significant influence on the modeling behavior Vis-a Vis the bed load sediment size.

Keywords—Karkheh, stream tubes, GSTARS-3 Model, Jelogir hydrometric station.

I. INTRODUCTION

SEDIMENT formation and sedimentation process are considered to be the most important considerations in the feasibility studies of the river engineering and hydraulics projects. Thorough analytical considerations of these important factors would be vital to understand the hydraulic behaviors and as such, to mitigate their undesirable consequences. This is particularly crucial in cases where these sediment loads could pose challenges to the operational performance of water abstraction, conveyance and distribution systems in irrigation and drainage schemes [1], [10], [8], [5].

Investigation of the sediment sizes entering the reservoir dams has attracted attention of the experts. Research has indicated that coarser sediment grains settle furthest from the dam structure. This is based on the understanding that the finer sediment grains are settled downstream fairly closer to the dam structure as is the case behind the Dez regulating Dam in Iran [1] Increased bed loads along the river course will increase the bed level in wider cross-sections which in turn will change the river morphology and hydraulic behavior at that site. There are wide-ranging opinions on ways to

mitigate the effects of sedimentation and reduce the sediment load transport into irrigation and drainage system [4].

II. MATERIALS AND METHOD

The study area constituted a river course between the Jelogir Station and the storage reservoir of the Karkheh hydro-electrical dam, the largest hydraulic structure in Iran. The Karkheh dam is located in approximately 30 km northwest Dezful, on one of a large permanent river s in Iran. The construction of this structure began in 1994 and completed in 1999. The operation of the dam started immediately and with this the flood mitigation and water harvesting began in the water basin. For the purpose of this study data on the geometry of the storage reservoir were collected from the Khuzestan Water and Power Authority. 12 cross sections were introduced in the model. The profile of each cross-section was determined from the distance from the base point in the left bank in line with the flow direction the location of the bed height was determined from its distance from the dam.

The water level measures proportional to daily discharge flow in the storage reservoir for certain periods available in the Jelogir Hygrometry Station were collected. The relation of the sediment discharge flow in terms of a function of a liquid flow discharge, considering the available statistical data were extracted and introduced in the model. The following equation was applied for this purpose:

$$Q_s = 0.0677 Q_w^{2.2529}$$

Where Q_s is sediment discharge in ton/day and Q_w in m^3/sec . sediment grading of the bed loads in different cross-sections, were applied into the model from the suspended load curve and bed loads curve.



Fig. 1 Karkheh Dam Reservoir

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GSTARS-3 is a mathematical model which has the ability to simulate the water flow and sediment load in the rivers. Yang and Mollinos[9] provided this model for the USBR which was then modified and presented by Yang et al (1998), the model which was later became known as GSTARS2 Yang and Simons (2000) presented their improved version entitled GSTARS 2-1, Yang and Simons(2002) further developed their new version which then became known as GSTARS-3. Finally Yang et al (2004) developed their latest version with they called GSTARS-1D.

The GSTARS-3 was used by Yang and Mollinos to simulate the flow behavior in the rivers which was based on the concept of the flow tubes. The procedure involves dividing the total river cross-section into several tubes and calculates the flow hydraulic and their conveyance in each separately. The maximum tube flow was 5. The model consisted of four major parts as follows:

- application of the energy and momentum equations and the use of the step by step standards for calculating the water level profile. In this case the Manning, Chezy and Darcy-Weisbach are applied to estimate the energy line slope. The model was also able to estimate the hydraulic parameters with constant and variable borderlines and calculating the water level profile in the various flow regimes.
- based on the various sediment relations and the flow tube concepts sedimentation trends were carried out.
- application of the minimum consumed flow energy theory as a method for forecasting the variations in the cross-sections.
- sustainability of the waterway walls was based on the static angle of the wall materials. [3]

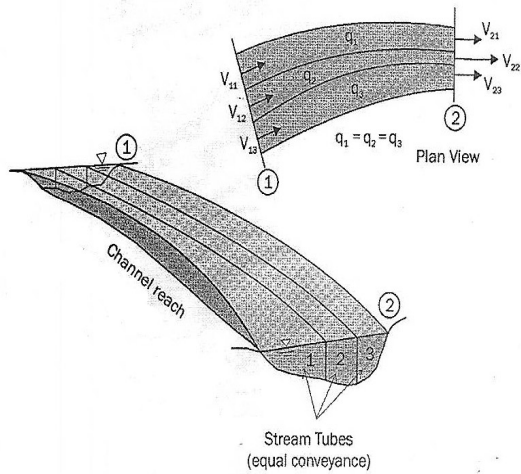


Fig. 2 Schematic representation illustrating the use of stream tubes by GSTARS-3

III. RESULTS

Five replicas with one to five stream tubes (figure 3) indicated that experiments with one stream tube yields one-dimensional model which shows inappropriate results. However, experiments with two stream tubes or more will

yield semi-two-dimensional which are more appropriate than those with one-dimensional modeling. Results further indicated that in a scenario which the numbers of stream tubes are not known, the modeling will be executed automatically on three stream tubes. Comparison of the results of three stream flow modeling with those of observations indicate a close proximity between the two sets of data and as such shows its appropriateness in simulating the reality. A similar pattern can also clearly be seen at a cross-section point some distance about 41,562 ft upstream of the Karkheh reservoir.

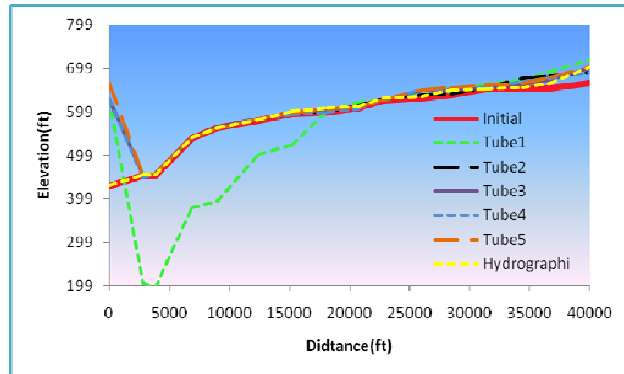


Fig. 3 sensitivity analysis of the GSTARS-3 based on various stream tubes and longitudinal profiles

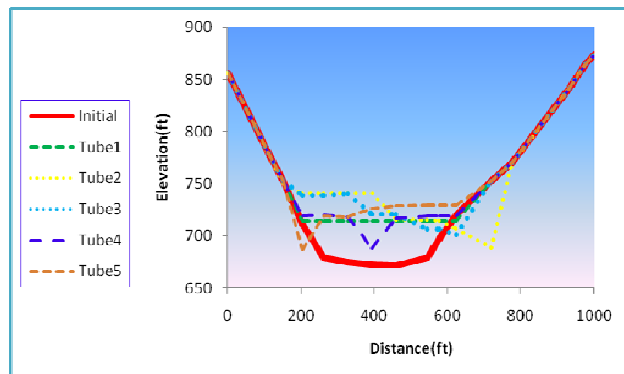


Fig. 4 sensitivity analysis of the GSTARS-3 based on various stream tubes and cross-section

Results also indicated that by varying the numbers of stream tubes and by altering the model from one-dimensional to semi-two-dimensional, a significant difference in flow velocity will be observed. The reason for this is explained by variation in flow velocity and the cross-sections. Analysis of the results (figure 6) indicated that by setting the model on a one stream tube the results will show in one-dimensional form, in which case there will not be a significant difference in the bed load grain size. This indicated that modeling with a three stream tubes will yield an accurate results. The overall conclusion being that the GSTARS-3 is a powerful analytical tool which can be applied in the feasibility studies and the operation and maintenance phases of the hydraulic structures to simulate the flow behavior particularly the sedimentation process and their complex features in river engineering projects.

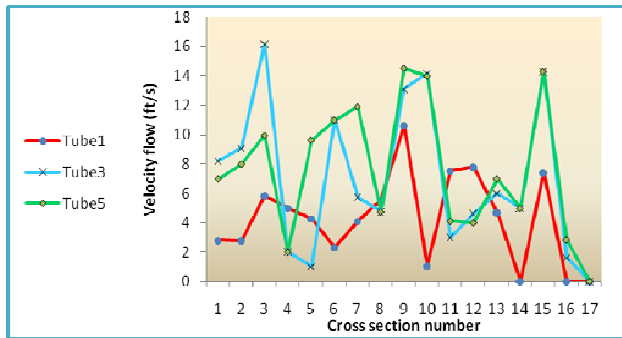


Fig. 5 simulation of flow velocity in various tubes

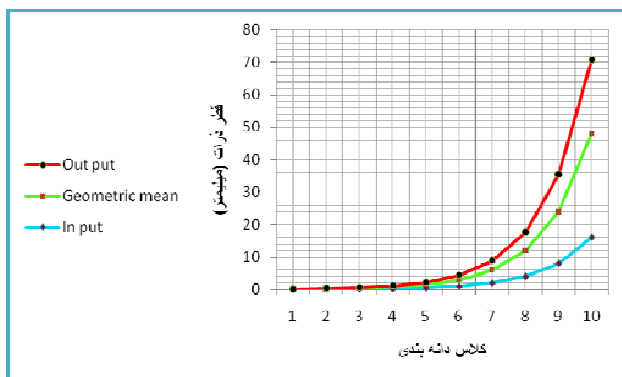


Fig. 6 simulation of the bed load grain size based on three stream tubes scenario

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