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ORIGINAL ARTICLE

Simulating Sedimentation Model in Balarood Dam Reservoir Using CCHE2D Software

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ABSTRACT
Sedimentation process and sedimentary currents affect the behavior and morphology of rivers. This research aims to study sedimentation in the reservoirs of dams using CCHE2D model. In this research, the secondary data of Balarood Dam within the analytical framework of CCHE2D model for a period of 50 years has been used. The results showed that the sedimentation model is such that the coarse sediment load tends to settle in the dam upstream and as it moves downstream the bed texture is fine-grained. The results indicate the coordination between sheer stress distribution model on the bed and the flow rate so that the increase or decrease of sheer stress will proportionally reduce the speed. According to the results analysis of velocity and sheer stress it can be inferred that there was not a significant erosion phenomenon within the studied area and what could be observed several time would not be anything except sediments in the path of the studied stream. According to the simulated curves, there is a tangible coordination between the flow rate and the sheer stress on the stream bed. Comparison of the modeling results indicates the proper consistency between the data and thus this model is recommended for other similar studies in other catchment areas with acceptable accuracy.

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INTRODUCTION

One of the main impacts of sedimentation on the dam reservoir is the decrease of (storage) capacity and only the amount of storage on the top of the dead volume of dam sediments is considered as the useful storage. Sedimentation in a dam reservoir has some adverse effects such as:

1. An increase in evaporation for a given storage capacity
2. Sedimentation in the river leading to the reservoir

A review of Domestic and Foreign Resources

Different Researchers including De Cesare *et al.* [1] have studied the impact of turbidity currents on reservoir sedimentation using an experimental model and numerical solution to flow and considering the 1000-year flood of Lavazan reservoir in Alps, Switzerland. The mechanism of erosion due to the changes of cross flow concentrations and have offered an empirical sediment transport model for seepage erosion of stream bank sediment in unbalanced conditions [2]. The model and simulated the flow and sediment pattern in the range of Karun River assuming a constant level [2].Hamid Taebi et al. [3] analyzed the numerical simulation of flow at 90̊ bend using CCHE2D model [5].

MATERIALS AND METHODS

Balaroodis one of the most important branches of the Dez River and downstream of Dez reservoir dam which is originated from the mountains of Gelahor in northwest Khuzestan and after passing a distance of about 100 km southwest it joins the Dez River and its total catchment area is estimated to be 696 km2. The average annual discharge of Balarood at the dam is 43.5million m3/s and its annual volume is about 171 million m3. This dam aims to supply much of the water needed for 12000 hectare lands downstream, to control seasonal floods of Balarood River, to protect the installations and buildings, to prevent damage to the lands downstream, and to generate 11.5 GWH hydroelectric powers per year.

CCHE2D model was prepared by Wang, Sam, and Jiao in 1997 in the International Center for Computational Hydroscience and Engineering, the University of Mississippi, U.S.A. this model has gradually developed in the recent years so that its last version (CCHE2D 3.2) has high potentials to simulate water and sediment. The codes of this program are prepared using Fortran 90 programming language and in general, this set includes two separate models one is mesh generation model and the other one is CCHE2D-GUI model. Mesh generation model is capable of producing structured network from peripheral uninterrupted lines so that they could be discrete in CCHE2D model according to the numerical method of finite elements used in water and sediment equations. CCHE2D-GUI is medium-depth two-dimensional model with unsteady flow conditions and thus can be used for simulation of water flow and sediment based on the finite elements model. Simulation of sediment flow (adherent and non-adherent) is done using non-equilibrium transport models.Three different transport methods are used for simulating the bed load, suspended load and total load. Equations used here include bed load transport equation, suspended load equation, and bed elevation changes equation. The equations are solved using effective elements or exponential differences.

In the present case study in order to enter the reservoir geometry to the model a topographic map of curve is used which can be converted to the required format by one or several other software. The obtained topographic file will include the length, width, and height of the pints located within the reservoir area.

In order to prepare the required CCHE2D computational grid, it is necessary at first to convert the computation range to a regular network of nodes with certain coordinates with the help of CCHE Mesh Generator.

The resulting network enters CCHE2D as a file and the inlet and outlet boundaries are specified. The model has high potential to use a variety of boundary conditions such as the discharge hydrograph at the inlet boundary or water level hydrograph at the outlet boundary. Moreover, it can use the simple conditions.

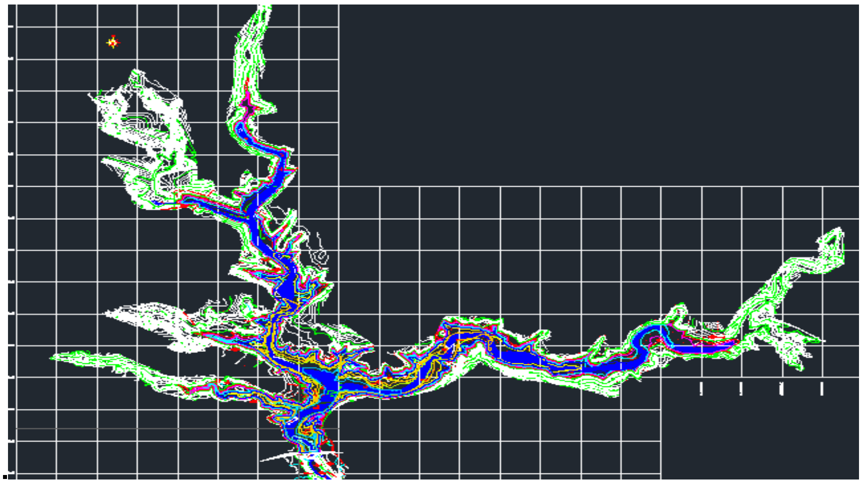

Figure (1): Network with Mesh_XYZ format

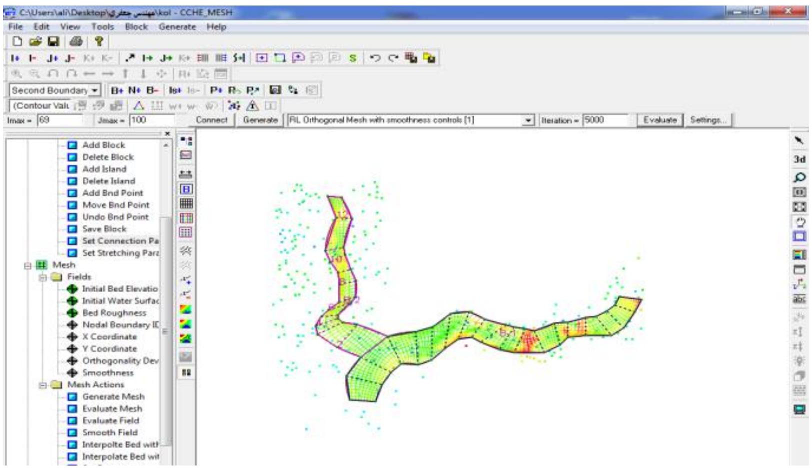

Figure (2): Mesh generation for Balarood dam reservoir

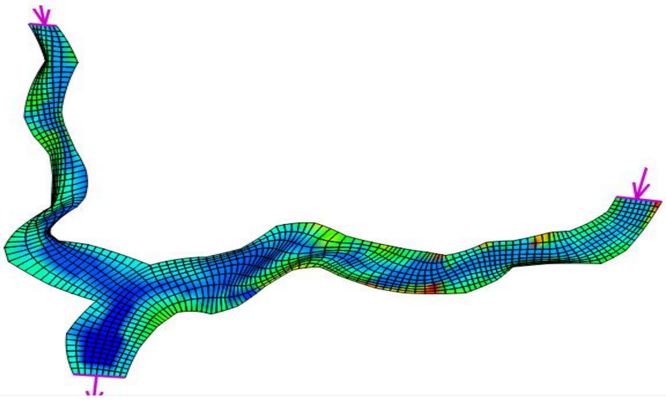

Figure (3): Mesh network of Balarood dam reservoir with geo. Formatting

It is necessary to determine the classes of sediment particles size and the percentage of each class for different samples of the bed materials and discharges of suspended sediment and bed for simulating non-uniform sediment. Defining four classes of particle size in accordance with the terms of this project seems to be logical. In this study, the determined size classes to be introduced to the model are as the following table.
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Table (1): classification of sediment particles size

4	3	2	1	Number of class
0.001125	0.0000175	0.0000025	0.0000006	Diameter (m)

RESULTS AND DISCUSSION

The obtained results for a period of 50 years include the results of the flow and transport of sediment in the forms of graphics and diagram.

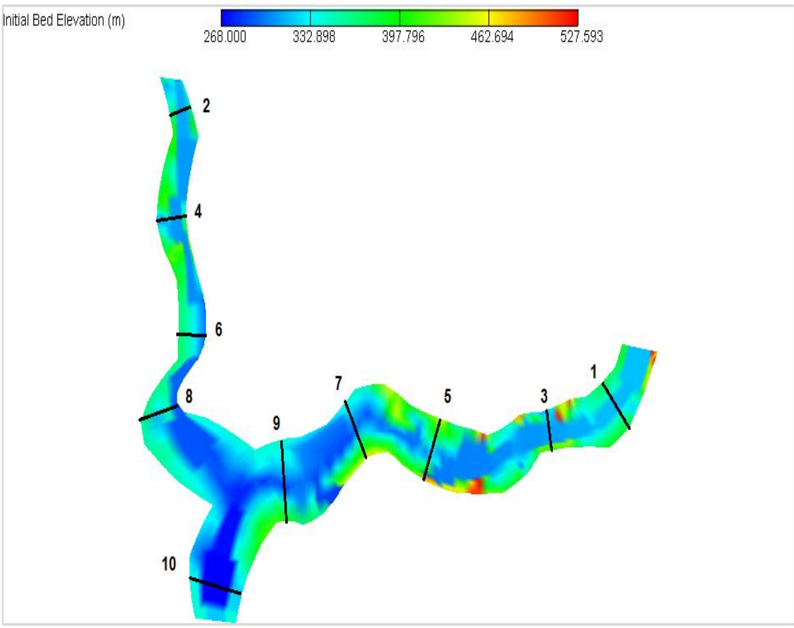

Figure 4: Locating points in the computational domain

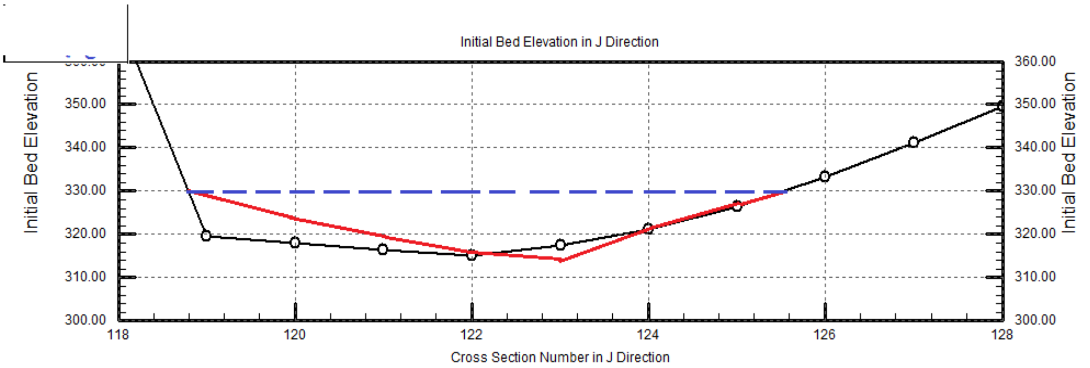

Figure (5): Cross section No. (1) 6800 m away from the dam axis

With respect to the speed at cross section 1 (6800 m away from the dam axis) and also low sheer stress in the left and right sides of the cross, the sedimentation trend has intensified so that the sediments height has reached the water surface while in the middle of the cross due to higher speed and sheer stress, credibility is more intensified.

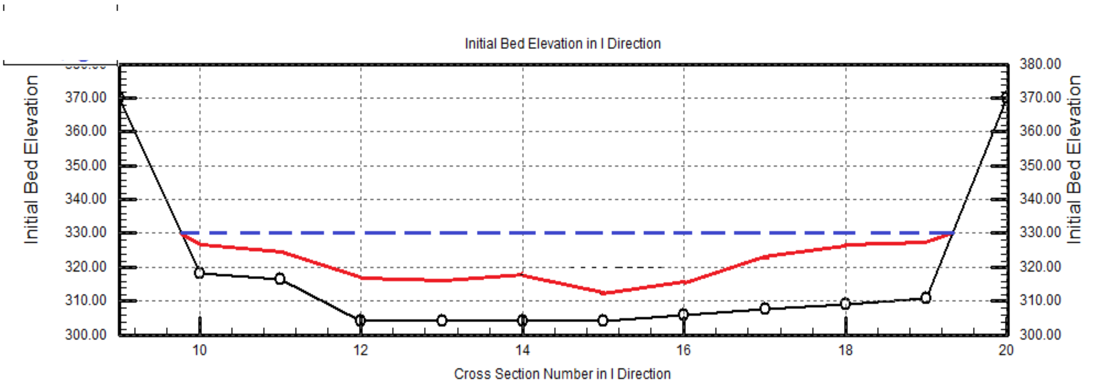

Figure (6): Cross section No. (2) 6300 m away from the dam axis

With regard to the speed at cross section 21 (6300 m away from the dam axis) and also low sheer stress in the left and right sides of the cross, the sedimentation trend has intensified while in the middle of the cross due to higher speed and sheer stress, sedimentation is about 9 m in this section. .

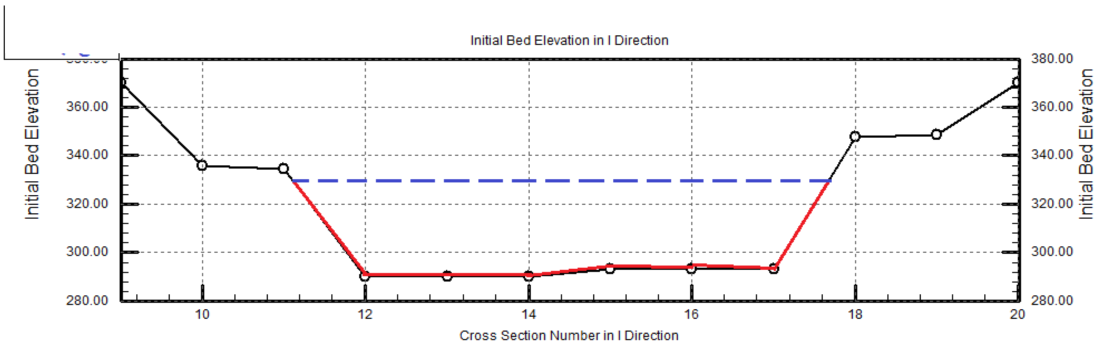

Figure (7): Cross section No. (8) 1600 m away from the dam axis

Due to the increase of water depth, the speed of flow and sheer stress has reduced which provides the condition for the deposition of the finest suspending particles in the flow. Due to the deposition of much of the sediment load upstream, a little amount of sediments will transport downstream through the flow. The diagram of the details can be observed in cross section 8 which is 1600 m away from the dam axis.

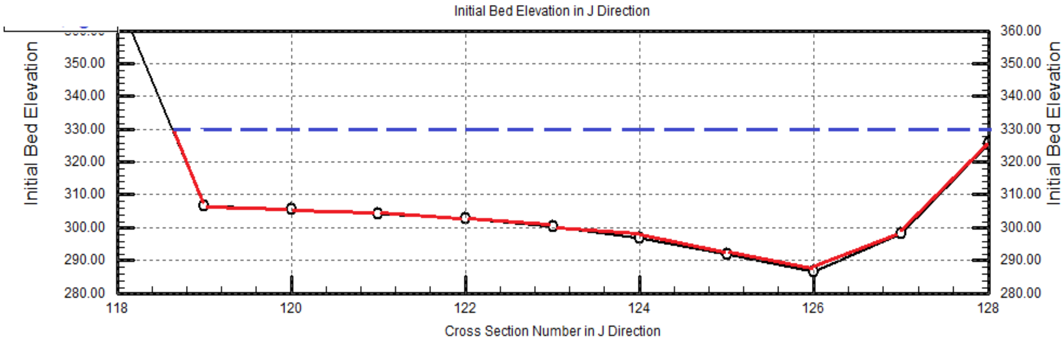

Figure (8): Cross section No. (9) 1750 m away from the dam axis

Due to the increase of water depth, the speed of flow and sheer stress has reduced which provides the conditions for the deposition of the finest suspending sediment load. Due to the deposition of much of the sediment load upstream, a little amount of sediments will transport downstream through the flow. The diagram of the details can be observed in cross section 9 which is 1750 m away from the dam axis.

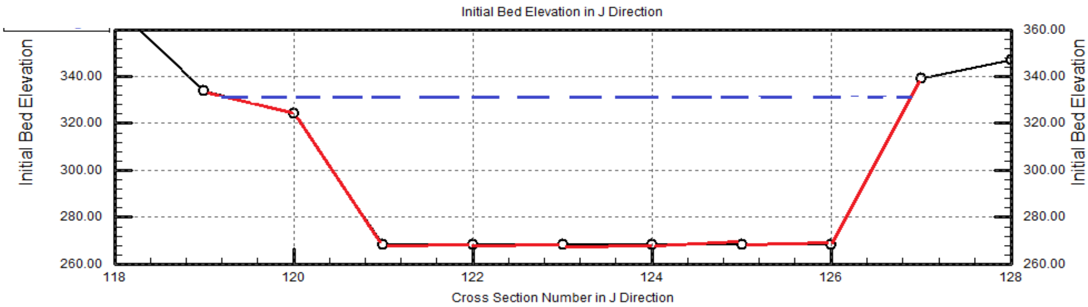

Figure (9): Cross section No. (10) 350 m away from the dam axis

Due to the increase of water depth, the speed of flow and sheer stress has reduced in cross section 10 that is 350 m away from the dam axis which provides the condition for the deposition of the finest suspending particles in the flow. Due to the deposition of much of the sediment load upstream, little amount of sediments will transport downstream through the flow.

CONCLUSION

The results of the combination of bed sediment load with the separation of sediment classes represent the non-significant and trivial amount of fine-grained sediment load upstream while the coarse material can be dramatically seen across the stream. For class 0.0006 mm lower domain of density is observed upstream and higher domain of density is observed downstream and their difference cannot be related to the difference between the rate of erosion and sedimentation of fine-grained materials above or below the dam reservoir. Perhaps the logical reason is that the bed is covered by the layers of coarse sediments such as silt, etc which overshadow the fine-grained sediments to a large extent. This analysis can be generalized for the coarse sediment load, too. Classes 2 (0.0025mm), 3 (0.0175mm), and 4 (1.125mm) showed the highest and the lowest development upstream while the fine-grained sediments in these areas form a small percentage of the bed materials since they are buried under the coarse sediment load. Therefore, it can be inferred that the model used in this study is capable of simulating the composition changes of bed materials resulting from sedimentation and bed armouring process. The results in all forms shoed that in the reservoir lake the percentage of sediment load composition for each type of the river materials had a uniform pattern which could be due to the stability of the main composition of bed material in this particular point.

The results of sedimentation in the dam reservoir based on the obtained findings indicate that since the bed is armoured with coarse sediments it is obvious that most of the river material sedimentation is formed by sand sediments (class 3: 0.0175 mm). The simulation results also indicate the extensive simulation upstream and filling the holes by the vortex flows. The relatively high consistency and approximation between them can imply the accuracy of the model to simulate hydraulic phenomena.

Considering all the point described above, it can be concluded that flow modeling and the analysis of the results associated with the size of sediments and their sedimentation in the channel route or adjacent to the structure of Balarood Dam have led to some results which are considerably close to the observed data and thus shows the accuracy of one of them or both.

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