Investigation of inlet sediment discharge through river using software (reservoir and river)

By

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Research Article

Investigation of inlet sediment discharge through river using software (reservoir and river)

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Abstract:
After building a Dam at the upstream of a river, sediments will move through the reservoir and after a while, the reservoir will be full. Its beneficial age will be over subsequently. Due to complicity of sediment movement and lack of knowledge of the real rules of sediment transportation, all related formula is concluded empirically. Recently, some numerical methods were gradually substituted and accompanied to physical model. One of these models is semi steady and two dimensions models such as Gstar-3. This model is capable of simulating sediment bed profile using 14 different formula and methods. In this study, the accuracy of different methods on the reservoir of Karkheh Dam has been investigated carefully. As a result, the young formula (young, 1999) had better result in field of hydraulic and morphological simulation of reservoir. In contrast, GSTAR-3 has low predictability for fine coarse sediment movement, but coarse size sediments, had better results.

Key words: Karkheh, young, sedimentation, GSTAR-3

INTRODUCTION

A Sedimentation process is one of the most important and effective section in order to study and operate a construction project, especially in the field of river engineering. This process is really essential, because all challenging process to use water is related to this topic. Besides, investigation of Sediment distribution algorithm of inlet discharges. In order to determine a sediment bed profile, the bottom outlet position and location of water intakes are very important. During sediment deposition, before entrance to dam Reservoir, coarse particles are deposited at a long distance from reservoir (which is known as the dead zone of the reservoir, this phenomenon could be seen behind Dezful diversion Dam). Sediment existence not only decreases nominal volume of the reservoir, but also has a great effect on the reservoir usage program (regime) [4]. Generally, soil erosion and sedimentation are reasons of strange behavior of sediment and water through reservoir subsequently. In other words, sediment studying is important, because of the building of reservoirs to save reservoir capacity.

In addition, to study sediment transportation algorithm, some numerical software have been used recently. Some of these are listed as below: SHARC, HEC-6 and GSTAR-3 CCHE.

Present Knowledge and Governing equations:

Bardossy et al (1990) used fuzzy pattern for regression calculation at hydrology. (Kindler, 1992) tried to use this method at water resource program, (copra, 1994) have utilized different methods for drought classification, (Russel, 1996) Used this program at optimizing usage of hydro power plant and compared these results with other optimizing methods (linear method). This study didn’t show much difference from the previous methods, (shresta et al, 1996) had worked on reservoir modeling with using fuzzy logic. (Brion & lingiredly, 1992) , (Hori kama et al 1992) , (Keller et al, 1992), (Kosko, 1992) and (Jang 1993) have used this program in order to distinguish algorithm and classifications (Bezdal) in order to enter issues about uncertainty of belonging of data to groups, tried to combine fuzzy theory relative belonging methods with algorithm and a new fuzzy methods (type C) presented (Jang, 1993), at study of convening sediment through rivers. Knowing a suitable & actual transformed sediment and its times changing at different mephthes of the season or different years, is very important. Kamanbedast et al (2009) tried to determine the Sediment result of flood using fuzzy methods (case study: karoon river) .
METHOD AND MATERIALS:

Study zone- Geographic location of dams

The study zone (case study) is section of Karkheh River from Jelogir station to inlet of the Karkheh reservoir Dam. Karkheh dam is one of the biggest dams in the world and the biggest in Iran. The location of the Dam is 20 km at north-west direction from the Andimeshk city. Operation of dam body and dam spillway started in 1997. In July 1998, water in taking process was started. Data and information was gathered from the hydrometric station of Jelogir. Earth dam of Karkheh was located at the west of Andimeshk city and 170 kilometers length far from Ahwaz city. Its longitude is 48°7.8’ and latitude is32°, 29.6’. Karkheh River is the third River of Iran, after Karoon and Dez River. (From discharge view) Hydro potential (based on Hydrometric statistical data) is about 5.6x109 m3 Annually and average flow rate is 177 m3/s and from this resource, more than 4.6x109m3 (without any using) falls to Hoor Alazim and Hoor Alhowiezeh swamps, this river comes from the Middle and south west of the zagros mountains and after 900 kilometers, ends at the Khuzestan boundary line. Its watershed is about 5*10^3 square kilometer (3% of the total area of Iran).

Annual rainfall is about 200 to 800 mm and its average is 290 mm, minimum and maximum temperature range is from 25 and 53.6 (respectively). Annual average temperature is about 24.6 centigrade.

Geographic location of Rivers

The study zone (case study) is one length of Karoon River from Ahvaz station to inlet and Farsiat as downstream. Fig (2).Investigation shows that, from morphological view, river bed is alluvial with some particle size such as: fine materials (silt & clay).

Because of specific conditions such as topography, morphology, constructive bed material and because of unknown factors, this kind of river behaves with meander. The specific study length is 74 kilometer from North of Ahvaz city,. Position of karoon river, had been shown at figure (2) . Specific morphological form of Karoon River and some part location of hydrometric station and river branch are shown in figure (2) and (3).
Figure (3): formation of sediment hill development at some satellite of Karoon River

Necessary data in reservoir:

Geometric data of reservoir and cross section information are provided from electricity and water authority organizations of the Khuzestan province. In total, 17 cross sections are introduced to model. Moreover; other information such as hydraulic description are outlined below:

Water table with inlet discharge for a specific period from 2000 to 2008 that is obtained from different hydrometric stations.

Suitable equation of sediment discharge from inlet discharge is shown below:

\[ Q_s = 0.0677Q_w^{2.25} \]

In which: \( Q_s \): sediment discharge (ton/day), \( Q_w \): inlet discharge(m3/sec)

Sediment particles size is introduced to model. Besides, statistics which are related to water - elevation are illustrated at figure 4 and 5.
Necessary data in rivers:

Geometric data of river and cross section information are provided from electricity and water authority organizations of the Khuzestan province. Totally, 20 cross sections are introduced to model and total length of branch is about 50km (length of one cross section is 2500m). Moreover; other information such of hydraulic description are shown below:

Water table with inlet discharge, for a specific period from 2000 to 2008, which is obtained from different hydrometric stations.

Suitable equation of sediment discharge from inlet discharge has been evaluated which are as below: Fig (6).

\[ Q_s = 0.0202Q_w^{2.1318} \]

In which: \( Q_s \): sediment discharge (ton/day), \( Q_w \): inlet discharge(m3/sec)

![Figure 6- graph discharge-sediment(Ahvaz st.)](image)

Software introduction (GSTAR-3)

GSTAR-3 is a numerical and software which has the ability to mathematically simulate flow and sediment at rivers condition. This model was produced by Young and Molines. For simulation of river behavior, flow tube concepts have been used carefully for this purpose. Total cross section was divided in some flow-tubes; afterwards, flow hydraulic and conveying calculations were done consequently. Totally, this model consists of 4 basic sections:

Energy and momentum equation was applied and water surface profile calculated by using standard steps models.

Besides, this model has the ability to estimate hydraulic parameters at fixed and movable boundary conditions at different flow range.

According to varieties of sediment movement methods, sediment prediction profile was calculated.

Minimum consuming energy method is used in predicting cross sectional profile.

Stability flow wall is based on material disposed angle which has been investigated.

Validation:

Validation analysis for initial bed and observed after 8 years is show in fig7.

![Figure 7- validation analysis for initial bed and observed after 8 years](image)
Discussion and conclusions in reservoir:

One of the most important characteristic of GSTAR-3 is the type of sediment transport equation. In this software, 14 different equations with different applied domains were used. Another factor, which is so important, is unbalance diffusion sediment coefficients which are included at sediment transport equation. In other words under equilibrium condition of sediment profile, these coefficients are used to calculate the rate of sediment deposit. The results of these simulations are shown in figure 8. It is obvious that the young equation result has better convergence to observed data.

![Figure 8 - Senility analysis for different Equation of sediment transportation](image)

In figure 9 and 10 two different cross sections, from kilometer 25+265 ft and one from near reservoir section were shown. Sedimentation process and observed data (according to young equation (young, 1996)) has been illustrated, besides, some errors demonstrated as well. It means that; GSTAR-3 model had better result due to coarse size transportation, however, when flow moves through reservoir, sediment particles are transformed to fine size and accuracy externally decline. Also output data from reservoir is shown in fig 11, 12, 13.

![Figure 9 - cross section along from reservoir (5 section)](image)

![Figure 10 - cross section at reservoir position(17 section)](image)
DISCUSSION AND CONCLUSION:

Another factor which is so important is the unbalance diffusion sediment coefficient which is included at sediment transport equation. In other words, under equilibrium condition of sediment profile. This coefficient is used to calculate rate of sediment deposit and erosion. The results of simulation are shown in figure 14. It is obvious that the Tofalleti equation has better convergence to observed data.
Figure 14- sensitivity analysis for different equation of sediment transportation

Figure 15- length profile of river in 50km

Figure 15 shows the result of software at study length from kilometer 32 to 46 in comparison to observed data (Toffaleti method). Sedimentation process and observed data (according to Toffaleti equation), means that; GSTAR-3 model had better result for coarse size transportation. However, when we move through downstream, sediment particles are transferred and fine size accuracy extremely declines.

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