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An investigation on the impacts of density currents on the sedimentation in dam reservoirs using TCM model; case study: Maroon dam

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Abstract

Sedimentation in dams' reservoirs is one of the most pressing concerns facing dams today. Maroon reservoir dam, located in Khuzestan Province, is one of the most important dams in this region. Since it is a new constructed dam, numerical simulation of sedimentation trend in its reservoirs could significantly help on a better utilization. To this end, TCM model which is capable to simulate density currents was used. The obtained results show that the dam loses about 91 million m3 of its reservoirs during a 50-year exploitation period.

Keywords

study, dam, sedimentation, currents, density, reservoirs, impacts, maroon, investigation, tcm, model, case

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An Investigation on the Impacts of Density Currents on the Sedimentation in Dam Reservoirs Using TCM Model; Case Study: Maroon Dam

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Farhad Fakheri Raof, Mohammad Hossein Naghshine, Ali Khoshrftar: An Investigation on the Impacts of Density Currents on the Sedimentation in Dam Reservoirs Using TCM Model; Case Study: Maroon Dam

ABSTRACT

Sedimentation in dams' reservoirs is one of the most pressing concerns facing dams today. Maroon reservoir dam, located in Khuzestan Province, is one of the most important dams in this region. Since it is a new constructed dam, numerical simulation of sedimentation trend in its reservoirs could significantly help on a better utilization. To this end, TCM model which is capable to simulate *density currents* was used. The obtained results show that the dam loses about 91 million m^3 of its reservoirs during a 50-year exploitation period.

Key words: Maroon dam, sedimentation, reservoir, density currents, mathematical model, TCM.

Introduction

Iran is one of the world's dry places where the crisis of fresh water shortage is highlighted day by day and people sense this problem more and more. The question that "*how we should optimally exploit water reservoirs*?" is one of the most critical challenges of the world's countries including Iran and wide investments have been made on this field.

Building dams in the way of rivers and storing water behind them is one of the best ways of exploiting water resources. Supplying water, controlling torrent, producing hydroelectric power and building entertainment centers around dams' ponds are other applications of dams. On the other hand, precipitation on catchments and rivers is always accompanied with erosion so that water carries the eroded materials. Therefore, building a dam as an obstacle against water movement enables us to control stream and disturb hydrodynamic balance. As a result, remaining whole or parts of sediments in reservoirs would be inevitable. The most important factor restricting and determining the age of dams and their installations is the amount of sediment and the pattern of its distribution in dam's reservoirs. Unawareness of sedimentation status in dam reservoir and predicting no control measures will decrease dams' age which in turn will result in the waste of national capitals. Since reservoir age directly influences its economic efficiency and the age of a reservoir is determined based on the rate of sedimentation, therefore sedimentation is one of the most important factors affecting plan economy. For this reason, in this paper the trend of sedimentation in Maroon reservoir dam is simulated using TCM model.

Materials and Methodologies:

This study was carried out on the newly constructed Maroon reservoir dam built on a river with the same name in the west eastern regions of Khuzestan Province in a place with the name of Tang-e-Takab. With a height of 165m it is one of the tallest reservoir dams of our country. Its reservoir volume is 1200 million m^3 with an area of 24.6 km^2 (normal level) and its deep drainage has two intakes located 420 and 435m above sea level. In this study, all measurements and hydrometery information were practiced on Maroon river catchments in the hydrometery stations of Aidanak, Behbahan and Cham Nezam [1]. This model has the capability of predicting long term sedimentation in huge reservoirs by considering the occurrence probability of one dimensional density currents. It can also analyze the flows of water and deposits in open water Channels. Another feature of this model is quasi two-dimensional distributions of sediments in every section proportional to current depth.

Based on the studies on Maroon River, employing current exchange energy-based approaches was recommended. Among different methods of the model, England-Hansen method was recognized the most appropriate one. Comparing the

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results of this model with other methods confirms this assumption. To approach plan objective i.e. investigating the amount and method of sedimentation in Maroon reservoir and the impacts of density current on it, the model was implemented in two steps in order to compare different states: a) implementing the model for different periods of time ranging from 5 years to 100 years in normal condition i.e. without considering the effects of density currents and b) implementing the model for different periods of time ranging from 5 years to 100 years and considering density current effects. To introduce both options to the model, separate input files were prepared.

Findings:

Studying the curves obtained from implementing the model in two states i.e. with and without considering density current effects, gives the following results which will be discussed separately:

1) Sediments Distribution Pattern:

Investigations show that the geometric properties of Maroon reservoir dam like steep, having narrow valley shape in most parts, large vestibules, narrowing and expansions affect sediments distribution inside the reservoir so that they are distributed decentralized and are spread longitudinally and delta is not formed especially in early years. After 40 years, the progress of sedimentation is almost stopped and the height of sediments continues to increase so that after 70 years the length of dam's pound is decreased by 6 to 7 km. Since a considerable volume of fine-grained sediments are discharged by density currents, the deposited sediments would be large-grained particles compared with the previous state. For this reason, this time the progress of sediment deposition will result in the formation of delta. After 50 years, the head of delta will be stopped at 5 km to dam site and sedimentation will be continued at upstream. On the other hand, since large-grained sediments exist in bed loads, which could be transferred by the river, they will be directed into reservoir. As water speed decreases at the start point of the reservoir sediments are accumulated in this point so that after 50 years the height of sediments will be about 16m to 17m. This will result in the rise of water level which discharges to upstream lands. The investigation of those components forming reservoir bed in different periods of exploitation reveals that the trend of sedimentation has been changed from large-grained sand and gravel to fine-grained silt and clay at downstream and near to dam wall. In some sections, especially at reservoir's upstream areas, this typical trend is changed due to the alternating of sedimentation process and erosion because of their geometrical variations.

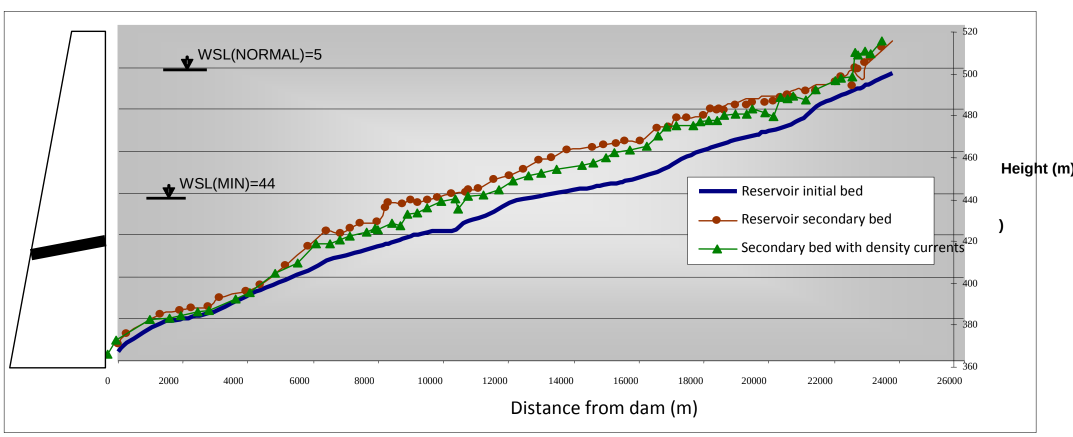

Fig. 1: longitudinal profile changes of the bottom of Marron Dam's Reservoir after 70 years exploitation.

Generation of density currents in reservoirs significantly influence transferring and discharging of silt particles from the reservoir and generally increases the progress of large size particles towards dam wall. Figures 1 and 2, show the variations of longitudinal profile of the reservoir bed of Maroon dam after a 20-year and 40-year exploitation period, respectively.

2- Sediments Volume and Trap Efficiency:

The investigations of sediments volume and trap efficiency of the reservoir show the following results:

- The mean annual sediment input of Maroon River in a 50-year period is 2.92 million m^3.
- The maximum fraction of the sediments is related to silt particles. Next ranks belong to clay, sand and gravel, respectively.
- Comparison of the ratio of outlet sediments to inlet ones shown in Fig. 3, indicate the significant

influence of density currents on sediment discharge from the reservoir. The mean difference of the ratio of outlet to inlet sediments in a 100-year period where the effects of density currents is taken into account is 60% compared with 30% of normal condition.

- The ratio of outlet to inlet sediments increases progressively up to the 40th year and reaches its maximum level and then continues with an almost constant ratio If the ratio is increased by 38.52% and 61.47% for the cases of taking/not taking into account the effects of density current.
- In a 50-year period, the density currents of Maroon dam reduce trap efficiency from its average value i.e. 66.7% to 37.4%. In other words, density currents increase trap efficiency by 43.935 in average which is a considerable value.
- In a 100-year exploitation period, the maximum reduction of trap efficiency is predicted for silt particles with an amount of 31.26%. Next rank belongs to clay particles with an amount of 29.95%. The minimum reduction is predicted for sand and gravel particles with an amount of 0.8%.

3- Variation of Reservoir Volume versus Time:

The curves of surface, volume and height were derived by the implementation of the model in different periods in the presence and absence of density currents after different sedimentation periods. Fig. 4 shows the curves. This figure indicates that the reservoir volume decreases as the exploitation time increases.

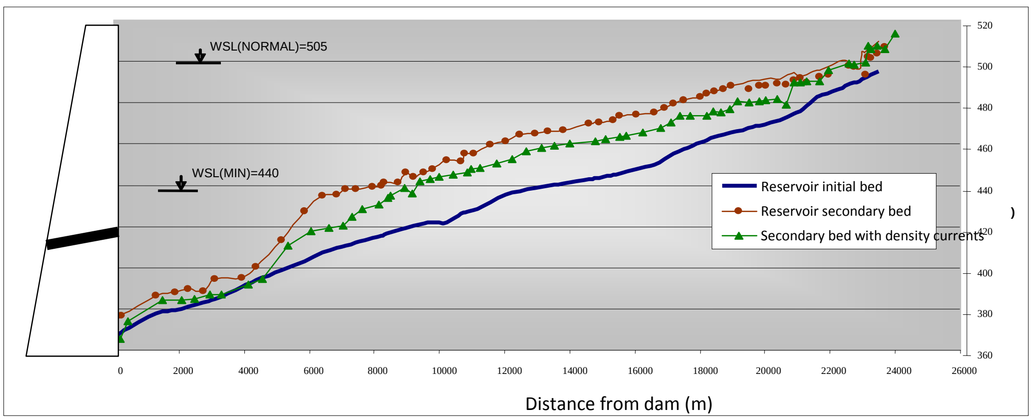

Fig. 2: longitudinal profile changes of the bottom of Marron Dam's Reservoir after 40 years exploitation

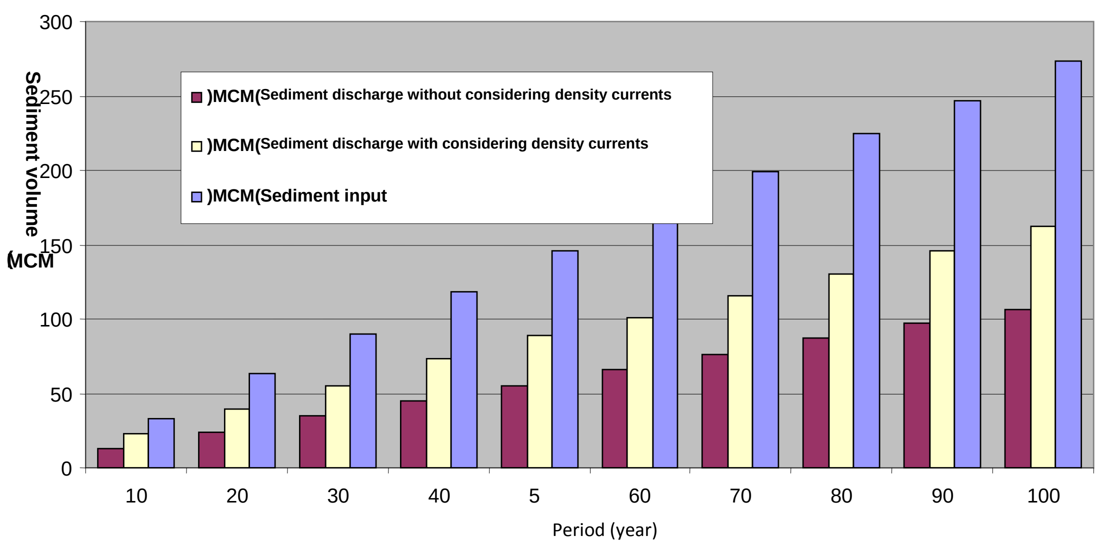

Fig. 3: variations of the ratio of outlet to inlet sediments in different exploitation periods in normal condition and in the presence of density currents

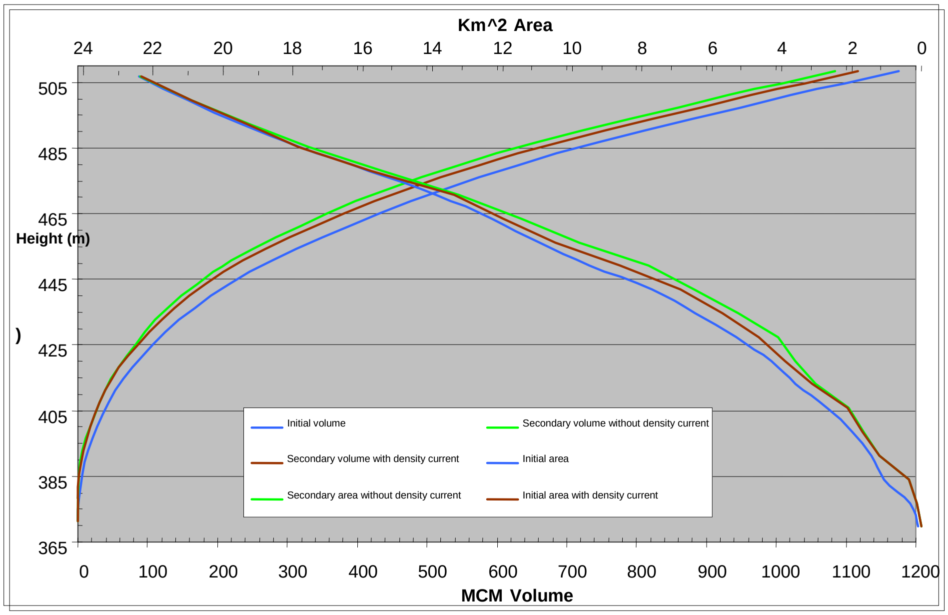

Fig. 4: graphs of area, volume and height of Maroon dam's reservoir afrer 30 years exploitation

Conclusion:

The volume of Maroon dam with an initial capacity of 1.2 milliard m^3 in normal water level from dam foot (5.5 m above sea level) was predicted for a 50-year period of exploitation. Entering sediments with an average volume of 2.92 million m^3/year, results in the decrease of its volume by 91 million m^3. In other words, it loses about 7.75% of its capacity so that at the end of a 50-year exploitation period sediments will fill about 48% of the dam's volume.

Based on the results, it could be argued that it is unlikely that the reservoir could not perform its task during the considered life cycle especially when we know that the mentioned values have been determined regardless of the actions which should be made to decrease sediments input or facilitate their discharge from the reservoir.

The investigations of the results of the model in both states i.e. by considering and not considering the effects of density currents, indicate significant impact of this phenomenon on the trend of sediment discharge from the reservoir as well as considerable decrease of trap efficiency. To discharge sediments through density currents it is necessary to discharge parts of input water flow [3]. On the other hand, employing this method is restricted by the fact that the base flow of the river is low especially in dry seasons. Therefore, the best choose is one that let the sediments discharge along with torrents and at the same time the reservoir saved volume could supply the required water even in the worst climate condition. Preparing such a managerial program for optimal use of dam's reservoir requires accurate studies on water resource programming as well as sedimentation studies and taking into account the management of density currents inside the reservoir. The considerable decrease of trap efficiency by 43.93% (from 66.7% to 37.4%) in a 50-year exploitation period in the presence of density currents, indicate that if exploitation operations are managed properly and reservoir's water level is controlled and discharging bottom valves placed for discharging density currents are appropriately maneuvered the age of the dam's reservoir will be increased considerably.

4.

References

1. Khuzestan Water and Power, 1984. a report from Maroon Dam project.
2. Torabi Pode, H., 1999. Rate equations for estimating sediment of the rivers of khuzestan, Master's thesis, University of Chamran. Ahvaz.
3. Fathi-Moghadam, M., M. Ghomshi, M. Shafaei, 2008. The density current head velocity in expansion, Lakes & Reservoirs Magazine.