Study of Sediments Water Resources System of Zayanderud Dam through Area increment and Area reduction Methods, Isfahan Province, Iran.

Amir hossein Shafiee a*, Majid Safamehr b

a Graduated of Civil engineering, Islamic Azad University, Iran.
b Academic Member, Islamic Azad University, Iran.

Abstract

Zayanderud dam’s lake with the capacity of 1.6 *10^9 CM is located 115 Km from Isfahan city at the center of Iran. The dam adopts water resources from Zayanderud River which originates from western hill slopes of Isfahan Province. The purpose of the dam is to provide drinking water to Isfahan Province, water for agriculture and industry in that province and conservation of historical buildings on the river such as old bridges. At the present time, dam is also used for different tourism purposes. However, the occurrence of drought in recent years reduced the capacity to 150 MCM and had harmful impacts on the different water resources system of the area such as dryness of Gavkhooni swamp, reduction of agricultural and industrial water availability. In this study, the different aspects of Zayanderud dam’s lake utilization and the Investigation of Sediments Water Resources System of Zayanderud Dam through Area increment and Area reduction Methods are evaluated.

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* E-mail: aras68_shafiee@yahoo.com.

1. Introduction

Dam on a river, an important effect on water flow and sedimentation have caused the morphological changes in time. Accumulation of sediment behind the dams reduces storage capacity, thus limiting
useful life of them. Each year approximately 20 billion tons of sediment, moved by the world's rivers and waters, are resident deposits. [1] More than 100 million cubic meters of useful capacity of dams, on sediment accumulation, are reduced each year [2]. Limit useful life of them reservoir sedimentation has different conclusion as reduce of water resource, increase of evaporation water storage capacity for a specific store, and flooded marshes, formed in the lands upstream the dam, increase the power dam downstream river erosion, flood control reservoir volume reduction and in some extreme cases, cause the Rugozary phenomenon created during the flood. The sediment deposition behind a dam wall, the stability of reduced output and performance facilities, valves and flush valves downstream adverse effects. The prediction of distribution for designers of dams, to determine the threshold intake valves, check depth, the balance and the stability of the dam is important [3]. In addition, during the exploitation of dams, the volume of sediment, in the estimated remaining useful repository, is very important. [4] Several methods to estimate the distribution of sediment in the reservoirs of these dams, provided between the two levels of reduction and increased levels, are more common than other methods.

Fig. 1 Map of the Zayanderud Dam lake.
One method for increasing the level of Krystvfanv is available [5] and also for reducing the level of [7], the one offered by Moody in 1962 has been modified [6 and 7].

This study shows that the sediment behind the dam comes up to 12.2 meters. The intention of this study is to examine the sediment distribution in Zayandeh Rud dam reservoir by using the methods for level increase, reducing Borland and Miller levels and modification level by Moody and comparing them with measured values; finally a way is selected to predict sediment distribution in Zayande Rud dam reservoir.

2. Research Methodology

In this study, accuracy of methods of levels increase, reduce [7] modification level elevation data and first volume height of Zayande Rud dam and second level volume height (after sedimentation).

The dam on Zayande has been built between 1965 and 1970 in Isfahan, 115 kilometers West with a catchment area of 4134 squared kilometers. The technical barrier is described in Table 1. [12].

The method here proposed assumes that the curved surface - height secondary (after sedimentation) is parallel to the initial curve. In other words, the assumed sediment level is constant in all heights and sediments volume, it is distributed evenly in upper of the zero height. This mathematical relationship is as follows.

\[ S = A_o (H - Y_o) + V_o \] (1)

in which:
- \( S \): Volume of sediment that must be distributed in the reservoir,
- \( H \): Initial deep reservoir of the river bottom,
- \( Y_o \): Sediment depth at the dam site
- \( A_o \): Primary area of the tank at a height \( Y_o \)
- \( V_o \): Sedimentation height is below.

In this method you need to guess the zero height \( (Y_o) \) and then by the curve level, height, area and volume of the reservoir amounts to be read.

The initial guess is correct if the calculated volume and the measured one are the same, otherwise you need to change the zero height to a bore condition is established.
<table>
<thead>
<tr>
<th>River</th>
<th>Dam site</th>
<th>Dam Type</th>
<th>Crest length (m)</th>
<th>Following Elevation (m)</th>
<th>Total tank capacity (million cubic meters)</th>
<th>Useful Capacity (million cubic meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zayandeh Rud</td>
<td>IC Su Shahrekord</td>
<td>Concrete arched</td>
<td>450</td>
<td>100</td>
<td>1450</td>
<td>1240</td>
</tr>
</tbody>
</table>

Table 2 - Standard Tank Brigade [3]

<table>
<thead>
<tr>
<th>Standard Type</th>
<th>Tank Type</th>
<th>Parameter m</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Normal Lake (Lake)</td>
<td>3.5-4.5</td>
</tr>
<tr>
<td>II</td>
<td>Flood plains hill (Flood Plain)</td>
<td>2.5-3.5</td>
</tr>
<tr>
<td>III</td>
<td>Foothills (Hill)</td>
<td>1.5-2.5</td>
</tr>
<tr>
<td>IV</td>
<td>Highland (Gorge)</td>
<td>1-1.5</td>
</tr>
</tbody>
</table>

3. Reduction of the level

Experimental methods Level reduce the level, first presented by Borland and Miller was subsequently revised by Moody [6, 7]. This method determines the distribution of precipitation in the form of a reservoir tank and the volume of sediments deposited on it. The coefficient “m” is simply a repository of images of the capacity depth of the slope line drawn in a logarithmic paper. Vessels classified accordingly, are presented in Table 2. A substantial reduction in the level equation is as follows [7]

\[
S = \int_{0}^{H} Ay + \int_{0}^{Kady} \frac{H}{Y_o}
\]

where:

- \( S \): Total volume of sediments deposited by
- \( H \): Initial depth of the reservoir

\[ (2) \]
Homogenous approach: Sediment depth behind the dam

A: Reservoir levels at different levels

d_y: Component height

a: The relative level of return for different values of the sediment depth is calculated relative depth “P”;

K: Proportionality factor to convert the relative level of sediment to the surface is real and the following equation is obtained.

\[ K = \frac{A_0}{a_o} \quad (3) \]

where:

\( A_0 \): initial level in the reservoir level \( Y_o \)

\( a_o \): relative level of the reservoir level \( Y_o \)

The relative area of sediment types, for each reservoir, is presented in Table 3. Column three of the table shows relations reported by Moody. Shape two shows that curves are used to determine the depth of sediment behind the dam.

Reduction in the level: the following steps determine how the distribution of the sediment in the reservoir should be followed [3]:

Step 1: reservoir depth vis a vis its capacity is drawn in a logarithmic paper. The shape of the reservoir is determined and finally the type of reservoir is specified in table 1.

Step 2: the values of F dimensionless function, for different values of the relative depth “P”, is calculated by this relation.

\[ F = (S - V_h)(HA_h) \quad (4) \]

where:

\( F \): dimensionless function from total deposited sediment, the capacity, the depth and reservoir area.

S = Total volume of sediment deposited by

\( V_h \): Tank capacity in the nation, \( h \)

\( H \): Initial depth of the reservoir

\( A_h \): \( h \) in the reservoir area is digital.

The third step: \( F \) values according to \( P \) relative depth and relation F-P is obtained by shape 1 and drawn in a coordinate system. Intersection point of two curves specifies a new zero digit in dam mel.

The fourth step: the depth of the reservoir, the existing sedimentation volume under zero level is determined by the capacity curve, then the sedimentation volume in different depths is estimated.
Figure 2 - Curves to determine the depth of sediment behind dams [14]

Figure 3 - The amount and type “m” reservoir sedimentation survey Zayandeh Rud River during 1999
Table 3 - Relationships obtained by Borland and Miller and Moody for the relative area of sediment [13]

<table>
<thead>
<tr>
<th>Tank Brigade</th>
<th>Borland and Miller</th>
<th>Moody</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>$a = \frac{3}{417} p^{1/5} (1 - p)^{0/2}$</td>
<td>$a = \frac{5}{074} p^{0/85} (1 - p)^{0/35}$</td>
</tr>
<tr>
<td>II</td>
<td>$a = \frac{2}{324} p^{0/5} (1 - p)^{0/4}$</td>
<td>$a = \frac{2}{487} p^{0/57} (1 - p)^{0/41}$</td>
</tr>
<tr>
<td>III</td>
<td>$a = \frac{15}{8820} p^{1/1} (1 - p)^{2/3}$</td>
<td>$a = \frac{16}{967} p^{1/15} (1 - p)^{2/32}$</td>
</tr>
<tr>
<td>IV</td>
<td>$a = \frac{4}{2324} p^{0/1} (1 - p)^{2/5}$</td>
<td>$a = \frac{1}{486} p^{-0/25} (1 - p)^{1/34}$</td>
</tr>
</tbody>
</table>

4. Results and Discussion

The relation of Zayandel Rud dam capacity and depth shows that the majority of reservoir is $m = 2.5$ of type $\eta$ [12]. After 18 years, the type of reservoir with $m = 2.47$ has not changed in the sediment survey in 1988. Sediment survey in 1999 shows $m = 2.02$ but the type of the reservoir has been constant (shape 2). Until 1988, 4.25 million cubic meters of sediment has entered the Zayandeh Rud reservoir each year. The sediment survey in 1999 shows 5.89 million cubic meters. On the assumption that, the amount of sediment entering the reservoir was constant in 1999, the calculation is carried out for estimating reservoir sediment in later years. Accordingly, the reservoir has become full by sediment after 215 years since 1999. $F$ values correspond to $P$ different values is obtained by relation 4 for different years. Chart relate to given points is drown on shapes.

The intersection points of these curves with curve of type $\eta$ specify zero digit relative depth $P$ in dam place. Sedimentary digits are obtained by this way and summarized in table 4. Error mean and standard deviation of the remaining useful volume of reservoir, for the increase level and reduced modes of [7] and [7] are shown in table 5.

Table 4 - Sedimentation behind the dam Zayandeh Rud

<table>
<thead>
<tr>
<th>Year</th>
<th>$P_o$</th>
<th>$Y_o (m)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>0.113</td>
<td>9.38</td>
</tr>
<tr>
<td>2020</td>
<td>0.25</td>
<td>20.75</td>
</tr>
<tr>
<td>2045</td>
<td>0.4</td>
<td>33.2</td>
</tr>
<tr>
<td>2070</td>
<td>0.51</td>
<td>42.4</td>
</tr>
</tbody>
</table>

The level reduce Model [7] was chosen for predicting sediment distribution in reservoir of Zayandeh Rud dam. The curves of dam capacity depth in the years 1970 and 1999 and also the curves of the predicted depth capacity in the years 1999, 2020, 2045, 2070 are presented in shape 5. Comparison of predicted capacity – the depth curve for 1999 with real curve - shows that level reduce method of Boorland and
Miller can estimate sediment volume further of real state in the lower depth of reservoir but in the higher level of depth. level reduce Method estimates sediment volume less than real state.

Figure 4 - Characteristic curves of the relative depth of sediment behind the dam Zayandeh Rud

<table>
<thead>
<tr>
<th>Method of reducing the level of</th>
<th>Borland and Miller method of reducing the level of</th>
<th>Moody level of reduction</th>
<th>Method of increasing the level of</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>47.11</td>
<td>84.61</td>
<td>51.62</td>
</tr>
<tr>
<td>Eadj</td>
<td>11.16</td>
<td>24.98</td>
<td>21.18</td>
</tr>
<tr>
<td>Se</td>
<td>42.08</td>
<td>87.18</td>
<td>123.04</td>
</tr>
<tr>
<td>Seadj</td>
<td>30.03</td>
<td>82.76</td>
<td>138.37</td>
</tr>
</tbody>
</table>

Table 5 - average error (E) and SD (Se) estimated remaining useful volume Zayandeh Rud River reservoir to increase the level models and lower level; *Eadj and * Seadj value and standard deviation error models regardless 5 m above the reservoir is digital zero.

5. Conclusions

The level reduce Model [7] is the best model for estimating distribution of sediment in Zayandeh Rud dam reservoir because it has the lowest error and standard deviation. This model has an error equal to 47.11 percent and a standard deviation of 42.08. Five meters of reservoir depth is deleted after of each sediment survey for reducing the error estimation of sediment.
Thus, the amount of sediment estimation error is reduced to 11.16 percent for level reduce model of [7].

Thus, level reduce Model [7] will be chosen for predicting sediment distribution in reservoir of Zayande Rud dam. The curves of dam depth capacity in the years 1970 and 1999 and also the curves of predicted depth capacity in the years 1999, 2020, 2045 and 2070 are presented in Fig. 5. A comparison of predicted capacity-depth curve for 1999 with real curve shows that level reduce method [7] can estimate sediment volume further of real state in the lower depth of reservoir but in the higher level of depth level reduce method estimates sediment volume less than real state.

References


