Effects of Dam Break on Downstream Lands Using Gis and Hec-Ras (Case Study: Eyvashan in Lorestan-Iran)

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ABSTRACT
Dams are structures that are used to store large amounts of water. The performance of these structures will increase that reliability of water availability in the downstream, various activities over time at downstream they are formed and will be developed. Furthermore, the structures of other human creations failure or improper performance of a risk they would face. This means that, if destroyed, downstream areas with serious face, that dams are located upstream of sensitive military installations are considered proper. In this regard, the review and evaluation of events and the risk of dam failure Eyvashan Lorestan, an effort to reduce the risk of dam failure is considered. HEC-RAS software is a suitable tool for hydraulic modeling the water flow in the rivers. This software has the ability to analyze the failure of concrete dams and soil. Eyvashan Lorestan dam is set on Horood River and 57 kilometers distance to khoramabad city in Lorestan province. To simulate result Eyvashan Lorestan dam break flood, after the simulation with HEC-RAS model for the Unsteady conditions, the flood water flat map in GIS were prepare for different scenarios. first scenarios for dam break is with war aim and second scenarios with flood for 10000 years period. The deep of water in villages that are set in the downstream of Eyvashan dam for these explained scenarios, were analyzed in 2 scenario the deep of water is 50% more than second scenarios.

INTRODUCTION
Construction of a dam results in disruption in natural balance of its construction area and through water refilling of tank, all obstacles forming reservoir result in a new water regime or system upon water penetration. Features of dam and its foundation materials changes and also lead to changes in simple soil capabilities. Capacity of natural structure for tolerating overloads may highly depends on water penetration effects including erosion (wearing out), dissolution and hole (pore) pressures. Lack of knowledge about such processes results in reduction of security level of such structures and also leads to a range of dangers for downstream lands. Floods in result of big dams’ break led to a range of destructions and damages during two recent centuries. Dam break and its outlet water flow have been considered as one of the most research fields in many countries [1].

Literature Research and background:
Since 1990, a range of models have been presented for danger safety evaluation including hydrodynamic models for river canal, dam break models and flooding models due to dam break, all for downstream lands Hall et al. [9], Wahl [18] showed that numerical modeling of soil dam gradual break should be performed in two stages; firstly, we should pay attention to dam gradual break mechanism and also computing dam outlet hydrograph due to dam break. Secondly, we should study result of this hydrograph in dam downstream. Broich [1] considered previous dam breaks through the world for time of dam breaks and found the following results: Average dam break time is 3.08 hours, Break time zone with 95% probability is between 0.97 to 5.19 hours, Minimum dam break time is measured as 0.1 hour and maximum dam break time is measured as 48 hours. Polglase [14] introduced emergency programming process as a significant factor in saving people’s lives. He concluded that floods of dam break are more dangerous than natural floods of rivers even for small dams and emergency programming can limit a disastrous dam break to a limited disaster in view of human fatalities. Chinnarasric et al. [3] showed that overtopping flow on dam body has three regions. Subcritical flow region from slow flow of reservoir refers to dam head, critical flow region in dam head and supercritical region to...
downstream slope. Vrouwenvelder et al. [16] evaluated water depth and speed parameters for considering susceptibility of dam break. They concluded that water speed plays an important role in dam break phenomenon. And in general form, risky regions are classified into 4 grades including low risky, average, high and very high risky. Cao et al. constructed 1D and 2D low depth water hydrodynamic models to study flood extension of dam break on an erodible sediment bed. Dncergok [4] evaluated three parameters of escape time, speed and depth of annealing as appropriate criteria for risk of dam break. And considering importance of escape time in limiting fatalities for dam downstream areas, times of 30 to 120 min are selected as risk criteria for downstream areas. Hung [10] considered effect of flooding flow speed in dam break. Integrating speed parameter with any of parameters including depth of annealing, dam break possibility or damages percentage of annealing, presented types of risk matrix. Tony [15] showed that simulation of dam break and flood damages can be used for dam operators. Dam operators are able to classify priorities of human and financial resources to improve general safety and to reduce possibilities of dam break upon considering priorities of risks as shown by models. Khodae et al. in study of Golestan dam break used risk matrix to consider effects of flow speed, depth of annealing and its application in crisis management for dam break flood upon creation of an unorganized cellular network in area and integrating HEC-RAS and ARC GIS software. Sohrabi evaluated effects of big dam breaks on downstream lands in case study of Taham dam in Zanjan. He showed that city of Zanjan, Zanjan Airport and Sarmsaghloo village are of the most susceptible places affected by Taham dam in Zanjan. kamanbedast,A [13] in study , Investigated of morphological changing of rivers with using Hec –geo -ras and mike-11 software.

**Fig. 1:** GIS map of annealing level of flood due to Woolwich dam break in Elmira city area.

Dam break includes any type of partial or general damages in dam body which leads in occasional outlet of uncontrollable water volume in river.

**MATERIALS AND METHODS**

**Studied area:**

Construction area of Eyyashan dam in Lorestan is in about 447 km distance to south Tehran and 57 km to Khorram Abad city and in eastern longitude of 4948 and northern latitude of 2833. Eyyashan dam is constructed on Harrod River.

Area of the river water shed to construction area of Eyyashan dam in Lorestan is about 120 sq. km and average annual precipitation value is 500 mm and average annual flow of river in dam area for index period of 50 years is 37 cubic meter per second. Also, annual yield of this river is 39.29 million cubic meter. In table 2, Peak flow rate of flood with different return periods is presented in place of Eyyashan dam. Hydrograph volume of 10000 years floods in place of dam is 370 million cubic meter Table 2.

<table>
<thead>
<tr>
<th>Return period</th>
<th>Peak flow rate (m³/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10000</td>
<td>1060</td>
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<tr>
<td>10000</td>
<td>100</td>
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<tr>
<td>10000</td>
<td>30</td>
</tr>
<tr>
<td>10000</td>
<td>19</td>
</tr>
</tbody>
</table>

Table 2: peak flow rate of flood (m³/s) with different return periods - Eyyashan Lorestan.

Design of Eyyashan dam in Lorestan with 70 m height is of rock fill dam with clay core.
Introduction to different patterns of dam breaks:

One of major steps in evaluation of dam break risks is to determine parameters related to place and type of break, in a way that these factors have significant effect on outlet hydrograph and time of reaching water to downstream installations.

HEC-RAS hydraulic model is capable to model both types of break in soil dams including overtopping and piping phenomenon. This software cannot compute form and time of break and user is responsible to compute it. Software suppliers suggest application of experimental methods [12], Froehlich [8]. Each of these methods presents different results in form and time of break and also for outlet flood hydrograph.

Method of Froehlich (1995):

\[
B = 0.1803 k_0 V_w^{0.32} h_b^{0.19}
\]

\[
k_0 = \text{constant} = 1.4 \text{ if overtopping} \text{And} 1 \text{ if else}
\]

\[
t_f = 0.000254 V_w^{0.53} h_b^{-0.9}
\]

\[
k_0 = \text{constant} = 1.4 \text{ if overtoppingAnd} 0.9 \text{ if else}
\]

\[
B_{ave} : \text{average width of break (m)}
\]

\[
V_w : \text{volume of reservoir when break occurs (mcm)}
\]

\[
h_b : \text{final depth of break (m)}
\]

\[
t_f : \text{time length of break formation (hr)}
\]

\[
H_w : \text{Height of water in reservoir when break occurs (m)}
\]

Method of MacDonald-Langridge-Monopolis (1984):

\[
V_{er} = 0.0261 V_{out}^{0.705} H_w^{0.769}
\]

\[
t_r = 0.0179 V_{out}^{0.364}
\]

\[
Q_p = 1.175 V_{out}^{0.41} H_w^{0.41}
\]

\[
V_{er} : \text{volume of washed materials of soil dam (m3)}
\]

\[
V_{out} : \text{volume water discharged from reservoir (m3)}
\]

\[
h_w : \text{water level at the end of rupture when break occurs (m)}
\]

\[
H_w : \text{Height of water in reservoir when break occurs (m)}
\]

In current model, this simulation tends to dam break due to sabotage operations in form of overtopping. Therefore, type of break is piping, located in high level of dam and dam break time is about 2 hours. On the other hand, place of break is in center of dam and fracture is up to balance of 10 m from the bottom.

Required information for zoning of Eyvashan dam break is as follows:

A. Cross sections of Harrod River
B. Topographical map of reservoir and downstream of Eyvashan dam in Lorestan
C. Structural information of Eyvashan dam in Lorestan
D. Flow rate of monthly flows for Harrod River in Lorestan

Fig. 2: Location of Eyvashan dam in Lorestan province and Iran.
Providing 3D map of the region in GIS environment:
To do this, Triangular Irregular Network (TIN) was provided in pre-processing step with topographical map of the region in GIS environment. Then, flow orientation, cross sections, dam and its reservoir and any other geographical information, extractable from river model, are defined using information related to river plan. Result of information related to this stage is transactional file ASC II containing information, defined in GIS environment.

Discussion and Conclusion:
In second step, armed attack scenario and 10000 years floods were considered as analytical sample:

First Scenario: Dam break due to armed attacks:
In modern wars, destruction of critical centers of target country is of the most important principles of offensive military doctrine. In critical centers destruction strategy, attacking country concentrates on bombing and destructing critical, sensitive and significant bases of target country in order to destroy political, armed and economical powers of target nation.

Dam break features:
The most item related to dam break in result of armed attacks and in fact is difference of this analytical method with other analytical methods of dam break in result of natural events is determination of form and amount of fracture in dam body due to armed attacks. This dam fracture or break due to armed attacks is affected by a range of factors and some of their most important include type of bombs (explosive power bombs, penetration capability, and angle and impact velocity of bomb with dam body), materials of dam, type of dam structure design, height and volume of reservoir. In this research in order to simplify, break of a soil dam due to armed attacks is considered as rectangular fracture and this assumption and its dimensions with regard to historical backgrounds and experiences is important in the field of terroristic attacks against soil dams through the world. For this scenario, rectangular break section and features are shown in fig. 4,5.

Fig. 3: Flooded area, provided using cross sectional layers.

Fig. 4: Cross section and features of Eyvashan dam break in Lorestan for armed attacks.
Fig. 5: Outlet flood hydrograph from Eyvashan dam in Lorestan after dam break.

Zoning flood of dam break:

Maximum depth of regional water in HEC-RAS in this step should be determined with regard to software outputs exposed to flood due to dam break in order to discharge risky regions and lower fatalities in downstream regions. Figure 6 shows maximum water level in downstream of Eyvashan dam in Lorestan and villages susceptible for possible damages. Figure 7 shows water depth of villages located inside flood passing way resulted from dam break.

Fig. 6: zoning flood of dam break for Eyvashan dam in Lorestan in downstream and for villages inside flood passing way.

Fig. 7: Depth of annealing for villages inside flood passing way resulted from Eyvashan dam break in Lorestan.

Also figures 8 and 9 show water depth in time of Eyvashan dam break in Lorestan within 20 hours after Eyvashan dam break in Lorestan for rocket and armed attacks scenarios.
Second scenario: Dam break due to floods with 10000 years return period:

Design flood is considered as a flood with certain return period, a historical flood or percentage of flood. Selection of design flood is basically performed to define a certain and special protection grade for structure. To prevent dam destruction, dam body design is based on design floods with 10000 years return period, considering that an occasional flood may have higher risk of dam break. Graph 10 shows flood hydrograph with 10000 years return period. This hydrograph estimates maximum input flow rate to reservoir with the rate of 370 cubic meters per second.

Features of dam body break:

Eyvashan dam in Lorestan is of soil-rock fill dam with clay core. It is to be noted that RCC dams are resistant against overtopping and cavity phenomenon is the cause of break in these types of dams. In this scenario, in addition to trapezoid form break with 40 m height, occurrence of flood with 10000 years return period has been considered. Fig. 11 shows cross section and features of dam break for this scenario.

In time of dam break for this scenario, a flood with peak flow rate of 12000 cubic meters per second was transferred to downstream. Outlet flood hydrograph of Eyvashan dam break in Lorestan is shown in fig. 12.
Fig. 10: flood hydrograph with 10000 years return period input to dam reservoir of Eyvashan dam break in Lorestan.

Fig. 11: cross section and features of dam break for this scenario.

Fig. 12: Flood hydrograph of dam break for this scenario.

Discussion and summary:
- If Eyvashan dam break occurs due to natural factors, 4895 people will be in danger of dam break flood.
- If Eyvashan dam break in Lorestan occurs due to flood with 10000 years return period, 7130 people will be in danger of this flood.
- Variations of water depth in dam break due to natural factors are between 1 to 24 meters.
- Variations of water depth in dam break due to 10000 years flood is between 1 to 35 meters.
- Total villages which will be flooded in dam break due to natural factors are 33 villages.
- Total villages which will be flooded in dam break due to 10000 years flood are 43 villages.

ACKNOWLEDGEMENTS

This paper is taken from the research, of Hydraulic Structures, Ahvaz Branch, Islamic Azad University (IAU), and the authors would like to Special thanks to Office of Researches which helped us in research process of this paper.

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